CENTER FOR GLOBAL DEVELOPMENT

The Future of Natural Resources and Development

WHITHER LOW AND MIDDLE-INCOME COUNTRIES?

Augustin Kwasi Fosu and Dede Woade Gafa

Abstract

This paper discusses the importance of non-renewable resources in the developing world and the expected future trends in the demand and supply of minerals, metals, and hydrocarbon resources. It examines how these trends would potentially influence growth and development trajectories in low- and middle-income countries. The impact will be heterogeneous: some countries will see new opportunities from mineral extraction related to renewable production, but for countries with extreme dependence on oil, gas and coal—predominantly middle-income economies—the outlook does not augur well as the decreasing demand for hydrocarbons in the next decades may mean poorer economic growth and shrinking fiscal revenue.

WORKING PAPER 664 • NOVEMBER 2023

The Future of Natural Resources and Development: Whither Low and Middle-Income Countries?

Augustin Kwasi Fosu
ISSER, University of Ghana, Ghana; CBE, University of Johannesburg, S. Africa; EMS, University of Pretoria, S. Africa; and CSAE, University of Oxford, UK

Dede Woade Gafa
African School of Economics, Benin

The Center for Global Development is grateful for contributions from the Bill & Melinda Gates Foundation in support of this work. The authors are most grateful to Charles Kenny for extremely helpful guidance, to anonymous reviewers for their useful suggestions, and to their research assistants—Gifty Blay, Samuel Kpe, and Firdaws Traore—for valuable research assistance.

Augustin Kwasi Fosu and Dede Woade Gafa. 2023. "The Future of Natural Resources and Development: Whither Low and Middle-Income Countries?" CGD Working Paper 664. Washington, DC: Center for Global Development. https://www.cgdev.org/publication/future-natural-resources-and-development-whither-low-and-middle-income-countries

CENTER FOR GLOBAL DEVELOPMENT
2055 L Street, NW Fifth Floor
Washington, DC 20036

1 Abbey Gardens
Great College Street
London
SW1P 3SE

www.cgdev.org

Center for Global Development. 2023.

The Center for Global Development works to reduce global poverty and improve lives through innovative economic research that drives better policy and practice by the world's top decision makers. Use and dissemination of this Working Paper is encouraged; however, reproduced copies may not be used for commercial purposes. Further usage is permitted under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License.

The views expressed in CGD Working Papers are those of the authors and should not be attributed to the board of directors, funders of the Center for Global Development, or the authors' respective organizations.

Contents

List of Figures

List of Tables

Foreword

For all of the well-advertised risks of over-dependence on subsoil assets, they are an important source of government revenues and well-renumerated employment for a number of low- and middle-income countries. But a global economy moving towards low-carbon production is going to dramatically shift demand for subsoil resources, from fossil fuels toward metals and minerals. This paper, by Augustin Kwasi Fosu and Dede Woade Gafa, lays out the evidence on which countries may be winners and losers from the process.

There are new opportunities for extractive industries in a number of low and lower middle-income countries in Africa and beyond. The Democratic Republic of the Congo, for example, is home to considerable reserves of copper, cobalt, zinc and tin. At the same time, at the global scale, it isn't clear that the new revenue opportunities from increased demand for minerals related to the low-carbon economy are as large as the likely lost revenues from lower demand for fossil fuels. The most recent World Bank estimates (for 2018) suggest worldwide fossil fuel wealth is still five times that of metals and minerals wealth. Sub-Saharan Africa has sub-soil assets worth a little over $1 trillion, of which fossil fuels account for about 85 percent. That proportion will surely change considerably as prices and demand adjust toward lower-carbon global economy. But, combined with the forecasts presented in this paper, it suggests that at least in the medium term, revenue losses from lower prices and demand for fossil fuels may considerably outweigh gains from greater demand for metals linked to renewables.

This is a very partial picture: most developing economies are net importers of fossil fuels. And as low-income countries are particularly at risk from the impacts of climate change they will benefit from lower emissions linked to reduced fossil fuel use. But some countries—and the paper points to Angola, Nigeria, and Equatorial Guinea as three African examples—are likely to face particularly challenging adjustment to lower fossil fuel prices.

The paper is part of a broader research project at the Center for Global Development looking at prospects for developing countries over the next thirty years. Other papers in the series suggest that manufacturing may also play less of a role as an engine of prosperity in developing countries, while moving for work will present large new opportunities. Services loom ever larger as the path toward higher incomes for low- and lower-middle-income countries.

Charles Kenny
Senior Fellow
Center for Global Development

1. Introduction

Over the past decades, there has been a paradigm shift from defining development based on the needs of the present generation to a balanced view that accounts for future generations (Lélé, 1991; Redclift and Springett, 2015). This progress led to the adoption of Sustainable Development Goals (SDGs) and the historic adoption of the Paris Agreement on climate change in 2015. To avoid an environmental catastrophe, scholars have urged the global community to reduce the emission of greenhouse gases (GHG)—e.g., carbon dioxides (CO2), methane (CH4), and nitrous oxide (N2O)—and align global and national actions to the goal of limiting the rise of the global average temperature to 1.5°C (below 2°C) above the level before the industrial revolution (United Nations Framework Convention on Climate Change (UNFCC), 2016).

In line with this call for action, the role of extractive industries in achieving a low-carbon future seems to have gradually gained ground in the international discourses on climate change mitigation in recent years (World Bank, 2017; United Nations (UN), 2021). Production and consumption patterns of non-renewable natural resources (fossil fuels, metals, and minerals) are undeniably linked to environmental sustainability and climate change (Addison and Roe, 2018). The nature of resource extraction and processing often has negative implications for the ecosystem and thus diverges from environmental protection goals. Moreover, the combustion of fossil fuels employed in different sectors generates GHG and accelerates global warming. Consequently, environmental preservation and climate change mitigation would require, inter alia, a rapid reduction in the use of fossil fuels and increased adoption of zero-carbon solutions.

Yet, critical metals and minerals continue to play a central role in the development of environmentally friendly technologies, such as renewable energy technologies and low-emission vehicles, which are essential to curb GHG emissions. As the world is expected to progress towards zero-carbon solutions, the change in the energy mix and innovations in low-carbon technologies will alter trends in the demand and supply of fossil fuels as well as the global consumption of critical minerals and metals for zero-emission technologies. Given the critical role of metals, minerals, and fossil fuel extractions in nearly 40% of the world's economies (World Bank, 2017), such anticipated changes would likely have implications for future income streams, policies, and development opportunities globally. The outcomes could be more pronounced in low- and middle-income countries, especially in net exporters of fossil fuels and producers of critical mineral resources.

The aim of the present paper is to, first, discuss the importance of non-renewable resources in the developing world and the expected future trends in the demand and supply of minerals, metals, and hydrocarbon resources. Second, the study examines how these trends would potentially influence growth and development trajectories in low- and middle-income countries. Section 2 reviews key theoretical literature on the link between natural resources and development. Section 3 provides an overview of the global distribution of non-renewable resource production and discusses the importance of such resources across countries. Section 4 examines the expected trends in the demand and prices of non-renewable resources. Section 5 discusses the main implications for development and Section 6 concludes the paper.

2. Natural resources and development: A brief literature review

Non-renewable natural resources are important components of a nation's wealth, and their extraction can generate high rents for exporting countries. For governments, the exploitation of these resources is a source of revenue which could support non-resource wealth creation. According to the 'Big Push' theory, revenue generated from resource exploitation provides an opportunity for poor nations to embark on coordinated investments that would generate demand and profitability spillovers across sectors, drive productivity growth and industrialization, moving the economy from a low-income to a high-income equilibrium (Rosenstein-Rodan, 1943, 1961; Murphy et al., 1989). This suggests commodity booms from natural resources may place producing economies on the path of economic development (Sachs and Warner, 1999).

Yet, existing evidence suggests that natural resource wealth does not always lead to sustainable growth and welfare improvement (Venables, 2016). In the 20th century, the dismal performance of major exporters of raw materials in the developing world led to growing concerns about the adverse economic effects of primary commodity dependence. An early explanation was the potential long-run decline in terms of trade (TOT) for net primary commodity exporters—i.e., the Prebish-Singer hypothesis. The fall in the relative prices of primary commodities was anticipated based, inter alia, on the low price and income elasticities of demand for raw materials, thus resulting in unequal distribution of trade gains favouring manufacturing-based economies to the detriment of primary-product exporters (Prebisch, 1950; Singer, 1950).

So far in the 21st century, however, the upward trend in commodity prices appears to contradict the Prebish-Singer hypothesis but has buoyed an alternate reason for concern with primary-commodity reliance: the 'resource curse' hypothesis (Auty, 2002). This hypothesis suggests that resource wealth constrains development: resource-rich countries tend to perform poorly compared to non-resource-rich economies. Specifically, the exploitation of natural resources tends to be accompanied by economic ailments such as the 'Dutch disease', macroeconomic instability, erosion of institutions, decreasing human capital investment, and increasing inequality (ibid.).

First, Dutch disease manifests through the appreciation of the real exchange rate following a resource boom or discovery, increasing the cost of production and eroding competitiveness in non-resource tradable sectors such as agriculture and manufacturing (Ismail, 2010). Since the manufacturing sector, rather than the extractive sector, is seen as driving economic growth and job creation in developing countries, the structural shift away from the former damages economic growth (Fosu, 1990, 1996). Stunted growth squeezes the tax base, and the economy becomes dependent on extractive sectors and highly vulnerable to commodity price swings, with negative implications for fiscal capacity and future macroeconomic performance (Gylfason, 2001; Bornhorst et al., 2009; Chachu, 2020; Jensen, 2011). Fiscal challenges during the post-boom period are particularly prevalent in countries where the volatility of resource revenues is not well managed. In these countries, governments often tend to overspend during commodity booms and are less able to sustain expenditures during periods of busts (Lundgren et al., 2013; Basdevant et al., 2021). This 'intertemporal syndrome' over the cycle is observed to be growth-inhibiting (Fosu and O'Connell, 2006, Table 7).

Second, resource rent inflows generate unproductive rent-seeking activities (illegal and socially damaging behaviours) with a negative influence on existing institutions (Torvik, 2002). In countries with initially weak institutions, resource abundance often leads to a higher incidence of bribery and corruption, ineffective governance, and mismanagement (Sachs and Warner, 2001). For instance, Salai-i-Martin and Subramanian (2013) showed that oil inflows corroded institutional quality in the context of Nigeria.

Several studies have also found a link between resource abundance and political instability, conflicts, and the erosion of the democratic system (Acemoglu et al., 2004; Arezki and Gylfason, 2013). The latter is attributable to the inefficient redistributive policies (i.e., low taxes and unproductive allocations to political constituencies) that are used by ruling governments to sustain autocratic regimes (Ross, 2001).

Third, natural resource dependence tends to limit human capital investment and increase inequality. As extractive industries are capital-intensive, the transfer of resources to such industries away from labour-intensive manufacturing sectors may decrease human capital investment and the gains from growth would fail to trickle down to workers, resulting in widening income distributions (Gylfason et al., 1999; Gylfason, 2001; Leamer et al., 1999; Hartwell et al., 2019).

Despite the widespread evidence of natural resource curse in low- and middle-income countries, there are a few instances where nations successfully mitigated the adverse effect of resource exploitation and translated their resource wealth into a 'blessing'. Norway is often cited as one of the most important success cases (see, e.g., Cappelen and Mjoset, 2013). In the developing world, Bahrain and Oman are cited (Looney, 2013), while Botswana is the most important example among African countries (Robinson, 2013). Indeed, in the African case, Fosu and Gafa (2019) have presented evidence contrasting Botswana from Nigeria, showing that the former, unlike the latter, has succeeded in sustaining its economic performance thanks to the strength of its institutions. The role of institutions in resolving the resource curse is further buttressed by Sun et al. (2019) and Dou et al. (2022) in the case of China, and by Stevens (2005) in the case of Malaysia and Indonesia.

3. Natural resources in low- and middle-income countries

Non-renewable resource exports and resource dependence

In resource-rich low- and middle-income countries, the extraction of non-renewable resources[1] constitutes a large source of foreign exchange and a major contributor to GDP. Between 1995 and 2021, for instance, the exports of non-renewable resources represented respectively 57.9%, 37.2% and 20.0% of the total merchandise exports of low-income (LICs), lower-middle-income (LMICs) and upper-middle-income countries (UMICs), respectively, while resource rents[2] accounted for 10.9%, 7.2% and 5.0% of GDP (Tables 1 and 2; Figures 1 and 2).

The Middle East and Northern Africa (MENA) region has the highest dependence on non-renewable resources, followed by sub-Saharan Africa (SSA) and Europe and Central Asia (ECA), Latin America and the Caribbean (LAC), East Asia and Pacific (EAP), and then by South Asia (SA) with the least dependence (Tables 1 and 2). On average, resource revenue accounts for 32.2% and 20.5% of total government revenue (excl. grants) in MENA and SSA, respectively (Table 2).

Among extracted resources, fossil fuels (oil, gas, and coal) are the major commodities, accounting for nearly 60% to 70% of the contribution of the mining sector to total merchandise exports. Hydrocarbons dominate not only in MENA (44.2% of total exports) but also in EAC, SSA and LAC (21.4%, 17.0% and 13.9%, respectively).

Since 2010, however, the developing world seems to have become less reliant on natural resource exports. The share of resource rents in GDP and the share of non-renewable exports has fallen, driven by the patterns in the export shares and resource rent contributions in middle-income countries[3] (Appendix Figure A1; Figures 1 and 2). These developments are attributable not only to the decline in the prices of hydrocarbons but also to greater export diversification[4] in middle-income economies over the period (Figures 3 and 5). Meanwhile, there is a growing reliance on non-fuel resources among LICs (Figures 1 and 2).

1 Non-renewable resources include fossil fuels such as coal, natural gas, oil (crude oil and oil obtained from bituminous minerals), precious stones (diamond and other gemstones), metals (base metals and precious metals) and minerals.

2 The indicator captures the gains made from natural resources in excess of the extraction cost. The rent for each of these commodities is calculated as the unit rent multiplied by the quantity of the commodity that is extracted or harvested. The unit rent is estimated by subtracting the average cost of producing that unit from the price of the commodity (World Bank, 2023a).

3 The trend in total natural resource rents (constant 2015 US$) mimics that of its share of GDP, with a decrease by 62.7% over the period 2011–2016 and higher volatility between 2017 and 2021. Meanwhile, the denominator (i.e., GDP) has been increasing over the period. Similarly, the fall in the share of non-renewable exports in total merchandise exports since the early 2010s results from an overall increase in merchandise exports and a decline in the exports of non-renewable commodities over the period (World Bank, 2023a; UNCTAD, 2023).

4 The export product concentration index reported in Figure 3 shows the extent to which a country's exports are concentrated on a few goods or distributed among many products. Higher values indicate that the country's exports are limited to a smaller number of products. Hence, a declining trend in the export product concentration index means increasing export diversification.

The contribution of mineral rents to GDP in LICs has exceeded that of LMICs and UMICs since 2011. Furthermore, the share of exports of minerals, precious stones and metals rose from 22.0% to 57.0% between 2011 and 2021, while the share of the exports of minerals and metals (excluding gold) increased from 11.9% in 2011 to nearly 32.8% by 2021 (Figures 1 and 2).

To shed further light on the patterns of resource dependence in the developing world, Table 1 provides the list of resource-dependent developing countries. Following the World Bank's convention, and as in Lundgren et al. (2013) and Fosu and Gafa (2019), a country is considered resource-dependent if the share of its non-renewable resources in total merchandise exports over the period 1995–2021 (average) exceeded 25%. The extent of resource dependence is evaluated in Table 3 using quintile ranks, with one (1) representing the most dependent and five (5), the least.

Ranked among the top quintile (1st) of non-renewable resource export shares are resource-rich countries such as Angola, Iraq, Algeria, Libya, Nigeria, Yemen, Botswana, Equatorial Guinea, Venezuela, Azerbaijan, Turkmenistan, and Guinea. In this group, the share of resource exports ranges from 84.4% (Guinea) to 98.7% (Angola). These countries are predominantly middle-income oil economies, except Botswana which is an important producer of diamonds, and Guinea which mainly exports bauxite, gold, and minerals. In Algeria, Angola, Azerbaijan, Equatorial Guinea, Iraq, Libya, Nigeria, Turkmenistan, and Yemen, fossil fuel exports generate substantial rents and government revenue. The share of resource revenue in total revenue and the resource rents (% of GDP) range, respectively, from 45.3% (Turkmenistan) to 94.2% (Iraq), and from 13.7% in Nigeria to 44.9% in Iraq. Other high resource-dependent countries (second quintile) include metals and mineral exporters such as the Democratic Republic of Congo (DRC), Zambia, Jamaica, Peru, and Suriname; and hydrocarbon producers such as Bolivia, Republic of Congo, Iran, Mongolia, Papua New Guinea, Gabon, and Kazakhstan.

A large proportion of low-income countries (78.9%) belong to the 3rd, 4th and 5th quintiles and are mostly dependent on the exports of non-oil resources. These countries include Sierra Leone (diamonds and other minerals), Burkina Faso (gold), Mali (gold), Niger (uranium), Rwanda (tin ore), Syria (phosphate and metals), Togo (phosphates), Burundi (gold), CAR (precious stones), and Liberia (iron ore).

TABLE 1. Non-renewable resource exports (% of total merchandise exports) in resource-dependent countries, average

Country	Region	Main Resource	Non-Renewable Resources Produced	Metals, Minerals & Fuels, Avg. 1995–2021	Fossil Fuels, Avg. 1995–2021	Minerals, Precious Stones & Metals, Avg. 1995–2021	Minerals & Metals (excl. gold), Avg. 1995–2021
Low-Income Countries							
Burkina Faso	SSA	Gold	Gold, Phosphates & Manganese	37.5	2.6	34.9	1.6
Burundi	SSA	Gold	Gold	30.9	0.6	30.3	4.6
CAR	SSA	Precious Stones	Precious Stones & Gold	30.3	0.2	30.1	5.8
Chad	SSA	Oil & Gold	Oil & Gold	61.9	61.7	0.2	0.2
Congo, DR	SSA	Minerals, Metals & Oil	Oil, Precious Stones, Gold & other Metals	79.6	11.2	68.4	44.1
Eritrea	SSA	–	Gold & Other Metals	25.2	0.0	25.2	11.6
Guinea	SSA	Bauxite, Gold & Minerals	Precious Stones, Gold & Other Metals	83.4	9.1	74.3	52.0
Korea, DPR	EAP	Coal	Coal, Gold, Other Metals & Minerals	26.3	15.2	11.1	9.7
Liberia	SSA	Iron	Iron	31.5	6.5	25.1	8.9
Mali	SSA	Gold	Gold	46.5	1.1	45.4	0.3
Mozambique	SSA	Gas & Bauxite	Fossil Fuels, Precious Stones, Other Metals	53.0	16.6	36.4	34.3
Niger	SSA	Uranium	Coal & Minerals	47.1	18.6	28.5	20.1
Rwanda	SSA	Tin ore	Precious Stones & Minerals	44.8	9.9	34.8	24.7
Sierra Leone	SSA	Diamonds & Minerals	Oil, Precious Stones, Other Metals & Minerals	47.1	0.7	46.4	23.0
Sudan	SSA	Oil	Oil, Gold, Other Metals & Minerals	63.1	58.2	4.8	0.7
Syria	MENA	–	Phosphates & Other Metals	37.0	35.0	2.0	1.9
Togo	SSA	Phosphates	Phosphates	35.8	15.1	20.7	13.6

TABLE 1. (Continued)

Country	Region	Main Resource	Non-Renewable Resources Produced	Metals, Minerals & Fuels, Avg. 1995–2021	Fossil Fuels, Avg. 1995–2021	Minerals, Precious Stones & Metals, Avg. 1995–2021	Minerals & Metals (excl. gold), Avg. 1995–2021
Yemen	MENA	Oil	Oil, Phosphates & Other Metals	87.7	82.4	5.2	1.3
Zambia	SSA	Copper & Cobalt	Coal, Precious Stones, Gold, Other Metals & Minerals	72.8	0.7	72.1	69.5
Lower Middle-Income Countries							
Algeria	MENA	Oil	Fossil Fuels, Gold and other Metals	96.9	96.6	0.4	0.4
Angola	SSA	Oil	Oil, Precious stones & Gold	98.7	94.6	4.2	1.5
Bolivia	LAC	Gas	Fossil Fuels, Precious Stones, Gold, other Metals, & Minerals	64.0	33.9	30.2	22.5
Cameroon	SSA	Oil	Oil & Precious Stones	49.7	44.1	5.6	3.9
Congo	SSA	Oil	Oil, Precious Stones, Gold & other Metals	83.0	76.4	6.6	5.3
Egypt	MENA	Oil	Oil, Precious Stones, Other Metals & Minerals	41.6	34.3	7.3	4.8
Ghana	SSA	Gold & Oil	Oil, Precious Stones, Gold & other Metals	43.3	12.7	30.6	7.5
India	SA	Multiple	Fossil Fuels, Precious Stones, Metals & Minerals	26.2	10.7	15.5	4.4
Indonesia	EAP	Oil	Fossil Fuels, Precious Stones, Gold, Other Metals & Minerals	29.8	24.1	5.7	5.1
Iran	MENA	Oil	Fossil Fuels, Precious Stones, Gold, Other Metals & Minerals	74.6	70.9	3.7	3.7
Kyrgyzstan	ECA	Gold	Fossil Fuels, Gold, Other Metals & Minerals	40.4	4.0	36.4	9.6

TABLE 1. (Continued)

Country	Region	Main Resource	Non-Renewable Resources Produced	Metals, Minerals & Fuels, Avg. 1995–2021	Fossil Fuels, Avg. 1995–2021	Minerals, Precious Stones & Metals, Avg. 1995–2021	Minerals & Metals (excl. gold), Avg. 1995–2021
Mauritania	SSA	Iron Ore	Oil, Gold & Other Metals	53.5	4.1	49.4	43.6
Mongolia	EAP	Coal	Coal, Precious Stones, Gold, Other Metals & Minerals	74.5	14.2	60.3	48.7
Myanmar	EAP	Petroleum Gas	Fossil Fuels & other metals	30.4	23.3	7.1	2.9
Nigeria	SSA	Oil	Fossil Fuels, Other Metals & Minerals	94.3	93.5	0.8	0.6
Papua New Guinea	EAP	Oil & Gas	Fossil Fuels, Other Metals & Minerals	65.4	23.8	41.6	22.6
Senegal	SSA	Phosphates	Oil & Phosphates	32.5	19.8	12.7	6.5
Tajikistan	ECA	Bauxite	Fossil Fuels, Gold, Other Metals & Minerals	53.0	0.2	52.7	47.8
Tanzania	SSA	Gas & Gold	Fossil Fuels, Precious Stones, Gold, Other Metals & Minerals	35.7	1.9	33.8	8.6
Uzbekistan	ECA	Oil & Gas	Fossil Fuels, Precious Stones, Gold, Other Metals & Minerals	34.9	13.3	21.6	10.5
Zimbabwe	SSA	Precious stones & Minerals	Phosphates, Precious Stones, Other Metals & Minerals	34.4	2.3	32.1	18.1
Upper Middle-Income Countries							
Armenia	ECA	Gold & other Metals	Precious Stones, Gold, other Metals, & Minerals	46.6	0.7	46.0	27.6
Azerbaijan	ECA	Oil	Fossil Fuel, Precious Stones & Metals	84.4	82.5	1.9	1.7
Botswana	SSA	Precious Stones	Coal, Precious Stones, Metals & Minerals	86.4	0.3	86.1	9.5

TABLE 1. (Continued)

Country	Region	Main Resource	Non-Renewable Resources Produced	Metals, Minerals & Fuels, Avg. 1995–2021	Fossil Fuels, Avg. 1995–2021	Minerals, Precious Stones & Metals, Avg. 1995–2021	Minerals & Metals (excl. gold), Avg. 1995–2021
Colombia	LAC	Coal & Oil	Fossil Fuels, Precious Stones, Gold, Other Metals & Minerals	50.8	45.6	5.2	1.2
Ecuador	LAC	Oil	Oil, Gold, Other Metals & Minerals	46.5	44.5	2.1	0.9
Equatorial Guinea	SSA	Oil	Fossil Fuels & Gold	85.6	85.4	0.1	0.1
Gabon	SSA	Oil	Oil, Other Metals & Minerals	79.7	72.9	6.8	6.7
Guyana	LAC	Bauxite and Gold	Precious Stones, Gold, other Metals, & Minerals	49.4	0.0	49.3	13.0
Iraq	MENA	Oil	Oil, Phosphates & Other Metals	98.0	96.4	1.6	0.2
Jamaica	LAC	Bauxite	Other Metals & Minerals	64.7	11.7	53.0	52.8
Kazakhstan	ECA	Oil	Fossil Fuels, Phosphates, Other Metals & Minerals	76.1	60.0	16.2	15.4
Libya	MENA	Oil	Fossil Fuels & Other Metals	95.2	91.1	4.1	0.4
Namibia	SSA	Diamonds	Precious Stones, Gold, Other Metals & Minerals	47.1	1.2	45.9	21.5
Peru	LAC	Copper	Fossil Fuels, Gold, Other Metals & Minerals	64.8	7.6	57.1	39.9
Russian Federation	ECA	Oil	Fossil Fuels, Precious Stones, Gold, Other Metals & Minerals	64.0	55.2	8.8	7.5

TABLE 1. (Continued)

Country	Region	Main Resource	Non-Renewable Resources Produced	Metals, Minerals & Fuels, Avg. 1995–2021	Fossil Fuels, Avg. 1995–2021	Minerals, Precious Stones & Metals, Avg. 1995–2021	Minerals & Metals (excl. gold), Avg. 1995–2021
South Africa	SSA	Coal, Gold & Minerals	Fossil Fuels, Precious Stones, Gold, Other Metals & Minerals	41.8	10.1	31.8	24.2
Suriname	LAC	Bauxite	Oil, Gold, Other Metals & Minerals	69.1	5.7	63.4	30.2
Turkmenistan	ECA	Gas	Fossil Fuels	84.0	83.2	0.8	0.8
Not Classified							
Venezuela	LAC	Oil	Fossil Fuels, Precious Stones, Gold, Other Metals & Minerals	85.3	81.6	3.7	3.3
Low-income Countries (including NRR)				57.9	33.1	24.8	13.8
Lower-middle-income Countries (including NRR)				37.2	29.3	7.9	4.7
Upper-middle-income Countries (including NRR)				20	14.6	5.5	4.2
World				17.6	11.9	5.6	3.6
East Asia & Pacific (excluding high-income; including NRD)				15.4	6.7	8.7	6.1
Europe & Central Asia (excluding high-income; including NRD)				37.5	21.4	16.1	12.0
Latin America & Caribbean (excluding high-income; including NRD)				27.6	13.9	13.7	8.9
Middle East & North Africa (excluding high-income; including NRD)				50.7	44.2	6.5	4.2
South Asia (including NRD)				9.1	3.2	5.9	3.4
Sub-Saharan Africa (excluding high-income; including NRD)				39.6	17	22.5	11.2

Notes: Authors' computation using data from UNCTADStat, UNCTAD (2023). The values are obtained by taking the simple averages of the ratio under each variable for resource-dependent countries unless otherwise specified. The value reported for the income and regional groups are simple averages computed by the author. The following SITC (Revision 3) classification categories are used in the calculations of the variables. The variable 'mineral, metals and fuels' comprises product categories 28, 27, 32, 33, 34, 667, 68, and 971. The variable 'fossil fuels' includes SITC 32, 33 and 34. The values for 'Minerals, Precious stones & Metals' are obtained by subtracting 'fossil fuels' from 'Minerals, Metals & Fuels', while the values for 'Minerals & metals (excl. gold)' exclude data on pearls, precious & semi-precious stones (product category 667). Information on the type of natural resource exported is from Baunsgaard et al. (2012), International Monetary Fund (IMF) (2012), Venables (2016) and the US Geological Survey (2005, 2010). The income groups are based on World Bank (2023b) income classification.

TABLE 2. Natural resource rents (% of GDP) and resource revenue (% of total revenue excl. grants) in resource-dependent countries, average

Country Name	Region	Total Natural Resources Rents (% of GDP), Avg. 1995–2021	Total Resource Revenue (% of total revenue excl grant), Avg. 1996–2020
Low-Income Countries			
Burkina Faso	SSA	9.8	2.0
Burundi	SSA	22.4	
Central African Republic	SSA	10.9	
Chad	SSA	19.4	56.3
Congo, Dem. Rep.	SSA	25.1	13.2
Eritrea	SSA	6.1	
Guinea	SSA	13.9	21.2
Korea, DPR	EAP		
Liberia	SSA	21.3	7.2
Mali	SSA	7.5	10.8
Mozambique	SSA	11.3	
Niger	SSA	8.1	3.9
Rwanda	SSA	6.9	0.0
Sierra Leone	SSA	11.6	4.2
Sudan	SSA	7.6	37.5
Syrian Arab Republic	MENA	6.0	39.8
Togo	SSA	10.2	3.3
Yemen, Rep.	MENA	25.1	68.1
Zambia	SSA	13.0	8.2
Lower Middle-Income Countries			
Algeria	MENA	23.0	60.8
Angola	SSA	34.6	72.8
Bolivia	LAC	7.3	17.7
Cameroon	SSA	6.8	24.9
Congo, Rep.	SSA	39.7	71.9
Egypt, Arab Rep.	MENA	8.5	23.4
Ghana	SSA	11.5	5.8

TABLE 2. (Continued)

Country Name	Region	Total Natural Resources Rents (% of GDP), Avg. 1995–2021	Total Resource Revenue (% of total revenue excl grant), Avg. 1996–2020
India	SA	3.0	0.0
Indonesia	EAP	6.8	22.0
Iran, Islamic Rep.	MENA	24.4	51.7
Kyrgyz Republic	ECA	4.5	
Mauritania	SSA	12.8	25.8
Mongolia	EAP	16.7	21.3
Myanmar	EAP	11.7	48.9
Nigeria	SSA	13.7	65.7
Papua New Guinea	EAP	20.1	19.0
Senegal	SSA	3.0	
Tajikistan	ECA	2.1	0.0
Tanzania	SSA	5.9	0.0
Uzbekistan	ECA	15.1	
Zimbabwe	SSA	7.0	4.1
Upper Middle-Income Countries			
Armenia	ECA	1.0	
Azerbaijan	ECA	26.3	55.9
Botswana	SSA	2.0	42.4
Colombia	LAC	5.2	
Ecuador	LAC	10.2	
Equatorial Guinea	SSA	42.0	82.6
Gabon	SSA	28.9	52.0
Guyana	LAC	16.2	
Iraq	MENA	44.9	94.2
Jamaica	LAC	1.8	4.3
Kazakhstan	ECA	19.4	30.7
Libya	MENA	39.6	78.5
Namibia	SSA	1.7	7.2
Peru	LAC	6.3	

TABLE 2. (Continued)

Country Name	Region	Total Natural Resources Rents (% of GDP), Avg. 1995–2021	Total Resource Revenue (% of total revenue excl grant), Avg. 1996–2020
Russian Federation	ECA	13.7	26.6
South Africa	SSA	4.9	
Suriname	LAC	12.8	20.9
Turkmenistan	ECA	35.3	45.3
Not Classified			
Venezuela, RB	LAC	19.0	12.3
Low-income		10.9	15.4
Lower middle-income		7.2	19.7
Upper middle-income		5.0	13.2
World		2.6	13.2
East Asia & Pacific (excl. high-income)		3.9	18.4
Europe & Central Asia (excl. high-income)		8.8	8.7
Latin America & Caribbean (excl. high-income)		3.5	5.7
Middle East & North Africa (excl. high-income)		18.1	32.2
South Asia		2.6	
Sub-Saharan Africa (excluding high-income)		10.2	20.5

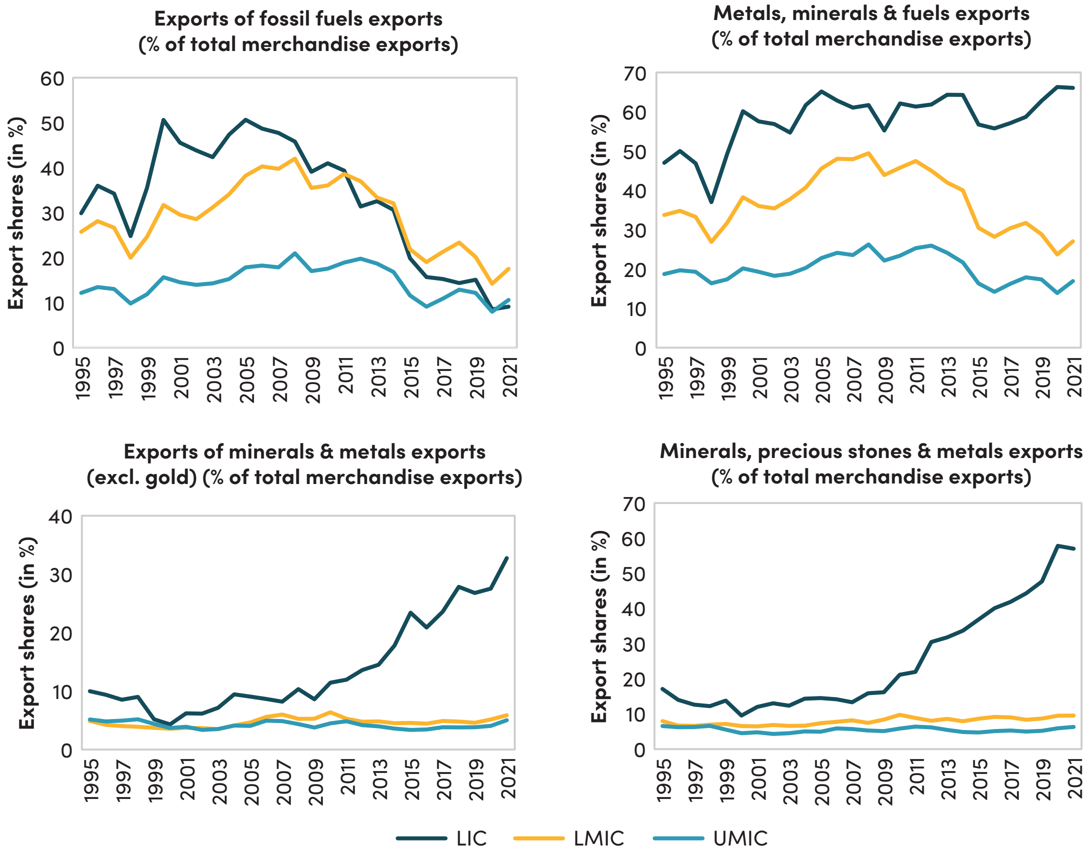
Notes: Authors' computation using data from World Development Indicators (WDI), World Bank (2023a) and the Government Revenue Database (GRD), United Nations University World Institute for Development Economics Research (UNUWIDER) (2023). The income groups are based on World Bank's (2023b) income classification. The regional and income group aggregates for the resource rents-to-GDP ratio are obtained by taking the mean of weighted averages computed by the World Bank (2023a), while the values reported for resource revenue are simple averages taken across countries in each region and income group.

TABLE 3. Metals, minerals and fuels exports (% total merchandise exports) in resource-dependent countries, average 1995–2021 by quintile

Country	Region	Metals, Minerals & Fuels, Quintile Rank	Country	Region	Metals, Minerals & Fuels, Quintile Rank
Algeria	MENA	1	Namibia	SSA	3
Angola	SSA	1	Russian Federation	ECA	3
Azerbaijan	ECA	1	Sierra Leone	SSA	3
Botswana	SSA	1	Sudan	SSA	3
Equatorial Guinea	SSA	1	Tajikistan	ECA	3
Guinea	SSA	1	Armenia	ECA	4
Iraq	MENA	1	Burkina Faso	SSA	4
Libya	MENA	1	Ecuador	LAC	4
Nigeria	SSA	1	Egypt	MENA	4
Turkmenistan	ECA	1	Ghana	SSA	4
Venezuela	LAC	1	Kyrgyzstan	ECA	4
Yemen	MENA	1	Mali	SSA	4
Bolivia	LAC	2	Niger	SSA	4
Congo	SSA	2	Rwanda	SSA	4
Congo, DR	SSA	2	South Africa	SSA	4
Gabon	SSA	2	Syrian	MENA	4
Iran	MENA	2	Togo	SSA	4
Jamaica	LAC	2	Burundi	SSA	5
Kazakhstan	ECA	2	CAR	SSA	5
Mongolia	EAP	2	Eritrea	SSA	5
Papua New Guinea	EAP	2	India	SA	5
Peru	LAC	2	Indonesia	EAP	5
Suriname	LAC	2	Korea, DPR	EAP	5
Zambia	SSA	2	Liberia	SSA	5
Cameroon	SSA	3	Myanmar	EAP	5
Chad	SSA	3	Senegal	SSA	5
Colombia	LAC	3	Tanzania	SSA	5
Guyana	LAC	3	Uzbekistan	ECA	5
Mauritania	SSA	3	Zimbabwe	SSA	5
Mozambique	SSA	3			

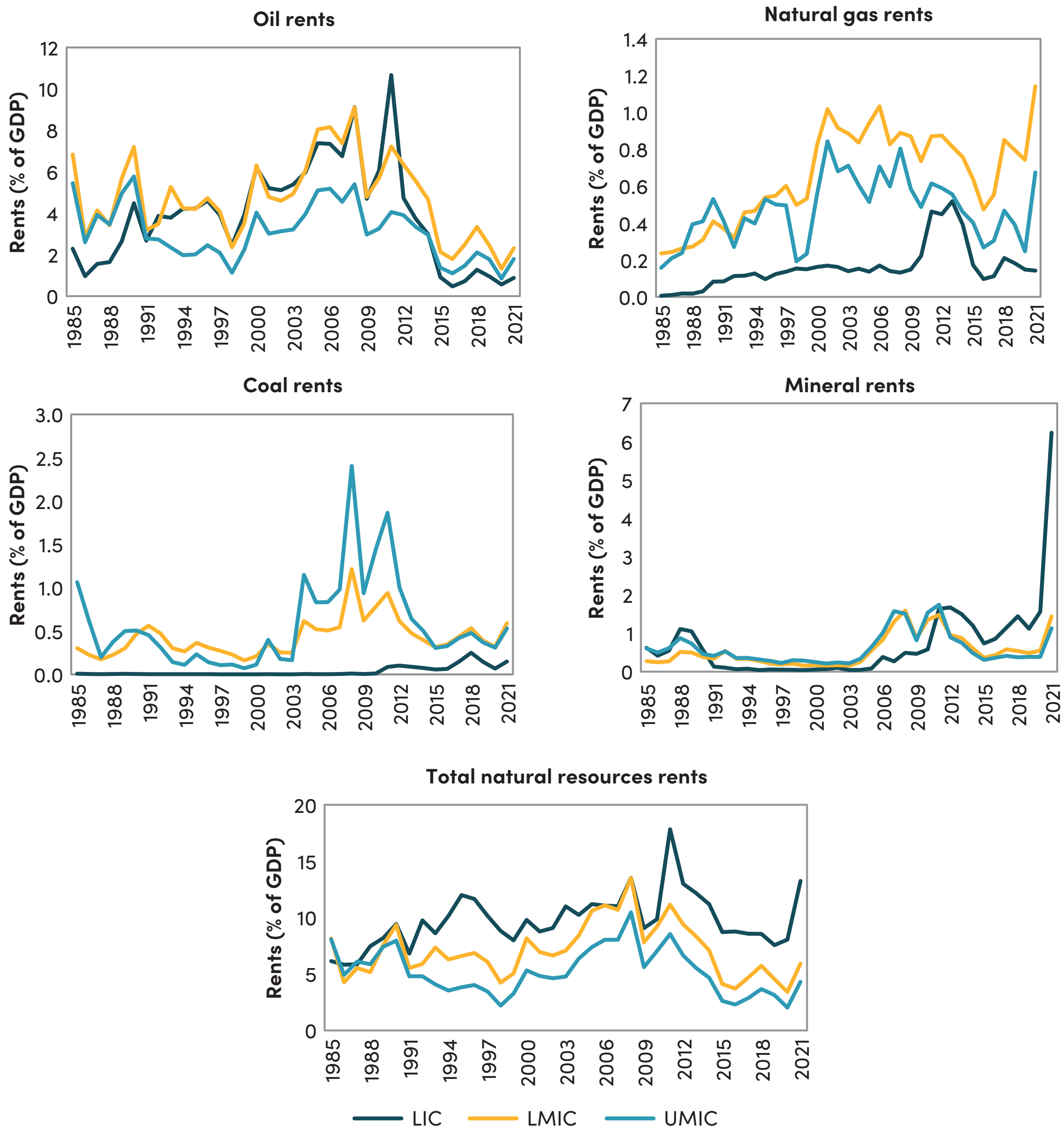
Notes: Authors' computation using data reported in Table 1. The table reports the quintile rank of each country on the share of exports of minerals, metals, and fuels in total merchandise exports (reported in Table 1). The value 1 is assigned to countries with the highest ratio, and 5 to those with the least.

FIGURE 1. Trends in mineral resource exports (% of total merchandise exports) across income groups, 1995–2021



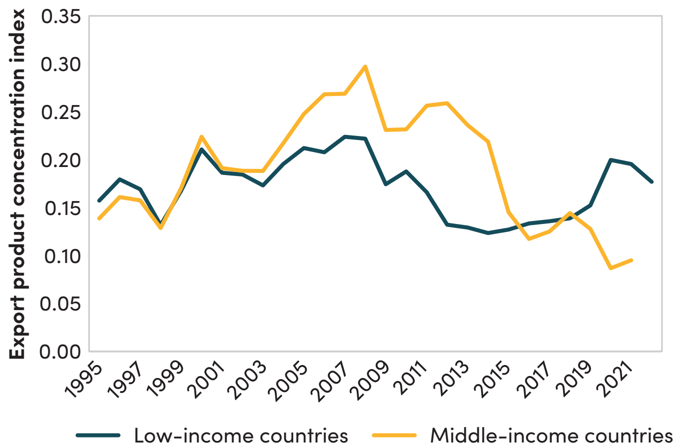
Data source: UNCTADStat, UNCTAD (2023).

FIGURE 2. Trends in natural resource rents across income groups, 1985–2021



Data source: World Development Indicators (WDI), World Bank (2023a).

FIGURE 3. Export concentration across income groups, 1995–2023



Notes: The data on the product concentration index for exports are obtained from UNCTADStat, UNCTAD (2023). The index ranges from zero to 1, with higher values indicating that the country's exports are limited to a smaller number of products.

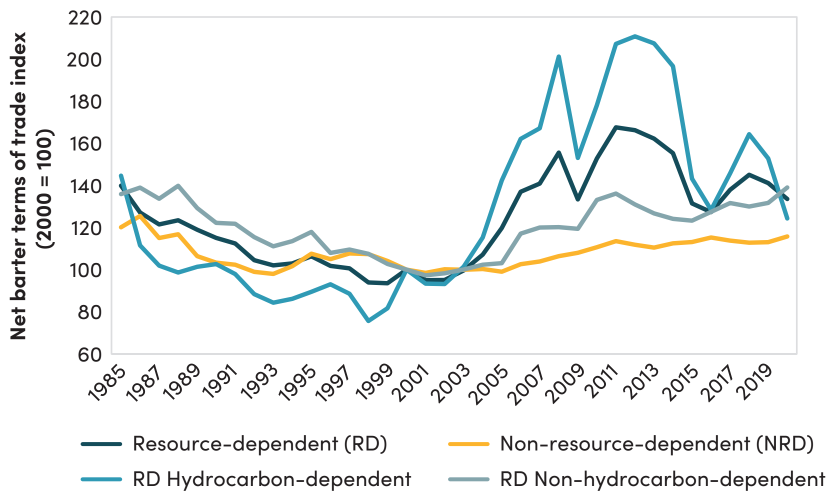
Historical trends and patterns of terms of trade and growth in resource-dependent countries

The TOT of low- and middle-income economies have generally been favourable over the last two decades, ending the downward trend of the preceding decade and a half. The recent positive trend has been mainly driven by commodity prices as the demand for natural resources has increased in the fast-growing Chinese and Indian economies (Figure 4). However, the prices of non-renewable resources have been highly volatile due to successive shocks, such as the 2008–09 economic crisis and the ensuing global recession, the negative 2014–16 oil shocks, the Covid-19 pandemic, and the recent Ukraine-Russia war (Figure 5).

These developments have caused major TOT fluctuations in resource-dependent economies (Figure 4). Furthermore, the boom-and-bust cycles have been more pronounced in fossil-fuel-dependent nations than in their non-hydrocarbon-dependent counterparts, a phenomenon that is explained by the relatively high fossil export concentration in the former (Ross, 2019). Hence, countries that are dependent on other non-renewables (metals, precious stones, and minerals) have generally been less vulnerable in bust periods compared with their carbon-energy-dependent counterparts. Between 2011 and 2015, for example, terms of trade declined by 9.4% in the former compared with 38.0% in the latter (Figure 5).

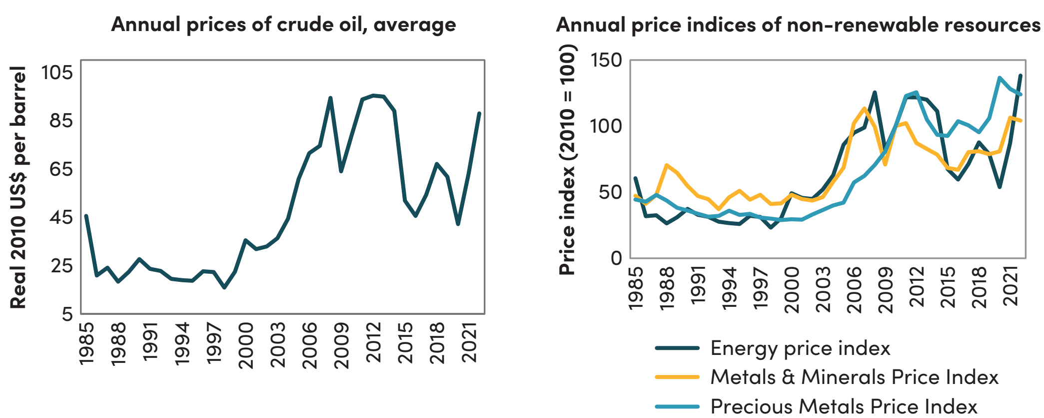
As shown in Figure 6, non-resource-dependent countries generally outperformed resource-dependent countries in the 1980s and early 1990s, due to more volatile and lower commodity prices and TOT leading to sizeable growth collapse in the latter. During the boom period, while growth in resource-dependent nations did not necessarily exceed that of their counterparts, hydrocarbon-dependent countries generally experienced higher growth rates—albeit with sizeable volatilities—than non-fossil-fuel exporters over the period. With the decline in commodity prices since 2013, however, resource-dependent nations were unable to sustain their growth performance, due mainly to the very poor economic performance of fossil-fuel-dependent countries. Overall, non-fossil-fuel-dependent countries seem to have been more resilient than their fossil-dependent counterparts.

FIGURE 4. Net barter terms of trade across sub-groups, 1985–2020



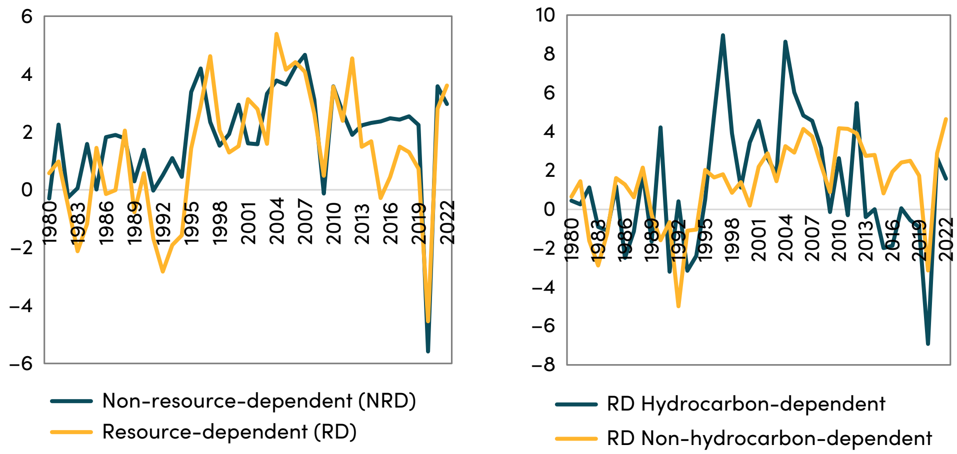
Notes: The values reported are simple averages computed by the authors. The data used are from the World Development Indicators database (WDI), World Bank (2023a). A country is considered resource-dependent and hydrocarbon-dependent if the share of its non-renewable resources in total merchandise exports and the share of fossil fuel exports in total merchandise exports over the period 1995–2021 (average) exceeded 25%, respectively.

FIGURE 5. Prices and price indices of non-renewable resources, 1985–2022



Data source: Commodity Markets, World Bank (2023c).

FIGURE 6. Per Capita GDP growth (%) across sub-groups, 1980–2022



Notes: The data used are from WDI, World Bank (2023a). The values are in percentages. A country is considered hydrocarbon-dependent if the share of fossil fuel exports exceeds 25% of total merchandise exports. The values used are simple averages computed by the authors.

4. The future of mineral resources

Projected trends

In 2015, the Paris Agreement and the global agenda for sustainable development prescribed a development path that is less GHG intensive and supports the replacement of carbon-bearing energy and technologies with renewable energy and climate-friendly innovations. The policy momentum gained since COP21 accelerated the development and use of low-carbon technologies in key sectors such as transport, energy, construction and industry, low-carbon generation consumer electronics, and carbon capture and storage technologies intended for accelerating the decarbonization processes (International Energy Agency (IEA), 2022a). In particular, it generated major technological advances as well as increased investment and demand for nuclear and other clean energy sources: solar photovoltaic (PV), geothermal, bioenergy, and hydropower plants, wind farms, and hydrogen-based energy. In the transportation sector, meanwhile, the prevalence of hybrid and electric vehicles is expected to expand further in the coming years.

Between 2015 and 2022, investment in renewable energy increased by over 50% (from 320 billion US$ in 2015 to 489 billion US$); the highest growth was experienced in emerging nations, particularly in China, where it grew by nearly 85% over the period (IEA, 2022b). Meanwhile, investment in fossil fuels declined, especially prior to the start of the Ukraine-Russia war, with a decline of 35.6% between 2015 and 2020, before increasing by 21.7% over the past three years (IEA, 2022b). Despite growing uncertainties in a tense geopolitical context in the short and medium terms, the declining trends are expected to continue in the long term, in response to the growing calls for decreasing the use of fossil fuels and trending reduction in downstream and upstream investments in the hydrocarbon industry, particularly in advanced economies (Organization of the Petroleum Exporting Countries (OPEC), 2022). Indeed, many developed and emerging nations aim to significantly reduce their shares of non-renewable fossil fuels in total energy demand and substantially change their energy mix by the end of the current decade through growing support for new renewable technologies (IEA, 2022a; OPEC, 2022).

According to IEA (2022a), three main scenarios are distinguishable in the medium and long term: (a) the *stated policies scenario*, (b) the *announced pledges scenario*, and (c) the *Net zero emission scenario*. While the first scenario pertains to continued actions in line with the current policy environment, the second aligns with a situation where all national goals and targets announced as part of efforts towards the achievement of net zero emissions and SDGs are met. The last scenario refers to the case of timely implementation of necessary policies to attain a net zero emission by 2050 in addition to the climate and energy-related SDGs.

Under currently stated policies, it is predicted that increases in the demand for oil and natural gas will slow significantly starting from 2030, with a stagnation in the demand between 2040–50, while the global consumption of coal is expected to consistently decline over the next three decades (IEA, 2022a; Table 4). These predictions are in line with those of OPEC (2022), which forecasts a slowdown in the growing demand for oil and gas between 2030 and 2045, a stagnation between 2035 and 2045, and a significant drop in coal demand starting from 2025.[5] In all cases, the trends are mainly driven by expected changes in policy and consumer preferences, the continuous evolution of technologies, the rise in renewable energy, and the faster adoption of electric energy with growing energy efficiency in sectors such as transport (OPEC, 2022; IEA, 2022a).

To achieve the ambitious target of net zero-emission by 2050, an accelerated decline in the demand for fossil fuels is anticipated from the medium to the long term, especially from the 2030s. The greatest decline is forecasted for the demand for coal at an annual rate of 7.3% in 2030–40 and 10.2% in 2040–50 (IEA, 2022a; Table 4). Natural gas demand is also anticipated to fall by 5.4% and 6.9% in 2030–40 and 2040–50 per annum, respectively, while over both periods, the decline in oil demand is predicted to be roughly 6% (IEA, 2022a; Table 4). The OPEC estimates show a decade decline of 37.8%, 7.9%, and 3.0% in 2030–2040 for coal, gas, and oil demand, respectively (OPEC, 2022).[6]

5 Such predictions are based on key assumptions: increasing global population by 1.6 billion in 2021–2045, more rapid urbanization in the global south, and quick global economic recovery from recent shocks with GDP growth of 3% annually over the period, and continued current changes in policies and technological developments. Also underlined are two extreme scenarios: the 'Advanced Technology Scenario', which aligns with the Paris Agreement and the gradual transition from carbon-bearing energy to renewable sources; and the 'Laissez-Faire Scenario' focusing on minimal changes in policy actions and growing fossil fuels energy demand in the emerging markets (OPEC, 2022).

6 Estimates under the 'Advanced Technology Scenario' (OPEC, 2022). For details see footnote 5.

Overall, coal prices are forecasted to decline the fastest with an expected fall of roughly 47% by 2050 relative to its 2021 level under the *stated policies scenario*, and by 70% under the *Net zero emission scenario* (IEA, 2022a; Figure 7). The anticipated average decline (nearly 60%) is similar to the World Bank's forecast for coal prices by 2035 (World Bank, 2021, 2022; Figure 7). The prices of oil and natural gas would only fall in the medium- and long-term if nations commit to the announced pledges and the world is able to make adequate strides in achieving the targets under the Paris Agreement and SDGs.

An estimated decline of 29.7%–53.1% is forecasted for the average price of natural gas compared with 13.0%–65.2% for crude oil over the period 2021–2050, albeit with a potential stagnation for crude oil between 2021 and 2030 under the *announced pledges scenario*. According to the World Bank (2021, 2022), the nominal prices of gas could fall by 41.5% between 2021 and 2035 while oil prices would potentially stagnate over the period (Figure 8).

The predicted decline in the prices of fossil fuels would lead to significant public sector revenue loss for hydrocarbon-dependent countries if global actions are aligned with announced objectives or become more ambitious for the attainment of net zero emissions by 2050 (Table 5). Under the *Net zero emission scenario,* for instance, Angola and Nigeria could respectively lose nearly 12.9 billion USD, and 15.8 billion USD (constant 2017 prices) in 2030 and over 17 billion USD and 20 billion USD in 2050.[7] In Indonesia, the anticipated resource revenue loss is 14.1 billion USD in 2030 and 17.6 billion USD in 2050, while Equatorial Guinea, Cameroon, and Gabon could experience reductions of 1.3 billion USD, 1.1 billion USD, and 724.9 million USD, respectively, in 2030 under constant production (Table 5).

In Equatorial Guinea, Angola, and Nigeria, such resource revenue loss would weigh heavily on government coffers—e.g., 2030 and 2050 estimates represent nearly 30% and 40% of current government revenue (excl. grants) in Angola, 20.0% and 26.3% in Nigeria, and 36.5% and 47.7% in Equatorial Guinea, respectively (Table 5). Meanwhile, in Indonesia, for example, its incidence on the fiscal budget would be relatively minor, accounting for 3.7–4.6% of current revenue. Under the *Announced policies scenario,* the expected revenue losses are lower, however, ranging from 191.9 million USD (Gabon) to 7.1 billion USD (Indonesia) in 2050 and representing 11.4% of current revenue in Equatorial Guinea, 8.1% in Angola and 5.9% in Nigeria.

7 The calculations are based on the assumption that fuel production remains unchanged between 2021 and 2030 and between 2021 and 2050.

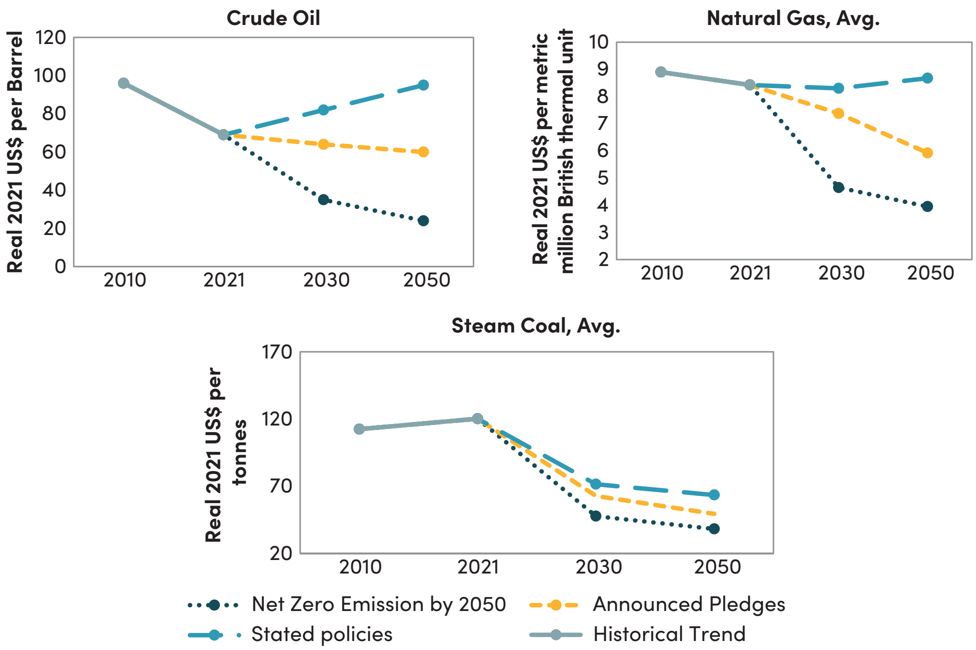
TABLE 4. Growth in total demand for fuels and mineral resources, forecast (2020–50)

	Stated Policies Scenario			Net Zero Emission by 2050 Scenario[8]		
	2020–30	2030–40	2040–50	2020–30	2030–40	2040–50
Annual Growth of Total Final Consumption (%)						
Oil	1.6	0.1	0.0	–1.5	–6.1	–6.3
Natural gas	1.3	0.5	0.0	–2.2	–5.4	–6.9
Coal	–0.1	–0.6	–0.7	–3.9	–7.3	–10.2
Annual Growth of Demand (%)						
Chromium	10.2	–3.0		14.6	–2.2	
Copper	3.4	2.2		6.3	3.5	
Cobalt	16.4	2.2		25.1	5.5	
Graphite	20.0	0.4		28.3	3.8	
Lithium	20.3	5.2		28.6	8.7	
Manganese	9.4	1.6		16.8	4.2	
Molybdenum	9.1	–2.2		13.4	–2.8	
Nickel	16.9	1.8		24.3	5.4	
Platinum group metals	27.9	3.7		38.3	11.8	
Silicon	1.7	4.3		7.6	0.8	
Silver	0.8	0.7		6.4	–3.4	
Zinc	3.9	2.1		8.9	0.8	
REEs	10.9	1.4		16.8	3.1	

Notes: Author's computation using data from IEA (2022a, b).

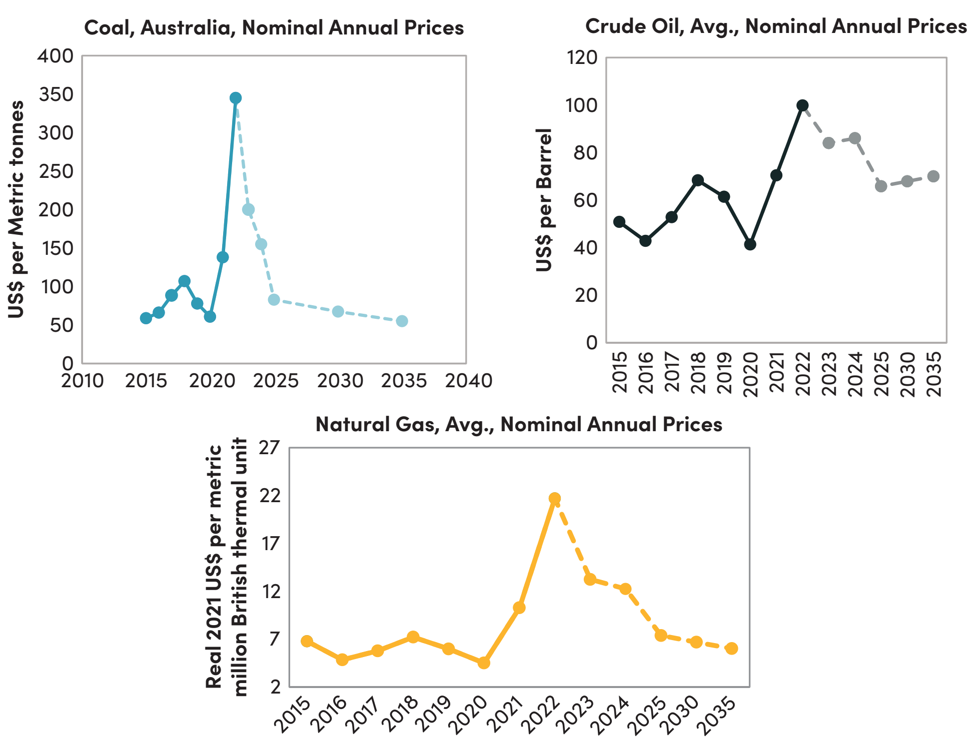
8 In IEA (2022b) this scenario is referred to as the 'Sustainable development scenario'.

FIGURE 7. IEA's historical and forecasted trends in the prices of fossil fuels, 2010–2050



Data source: IEA (2022a).

FIGURE 8. World Bank's historical and forecasted trends in fossil fuel prices, 2015–2035



Data source: World Bank (2021, 2023d).

TABLE 5. Projected resource revenue loss in selected middle-income hydrocarbon-dependent economies in 2030 and 2050

	Net Zero Emission by 2050			Announced Policies			Stated Policies		
	Amount in Millions (constant 2017 USD)	Share of Current GDP (%)	Share of Current Revenue (%)	Amount in Millions (constant 2017 USD)	Share of Current GDP (%)	Share of Current Revenue (%)	Amount in Millions (constant 2017 USD)	Share of Current GDP (%)	Share of Current Revenue (%)
Country					**2030**				
Angola	12888.2	6.3	30.5	1895.3	0.9	4.5	–4927.8	-2.4	-11.7
Cameroon	1067.8	1.1	7.5	157.0	0.2	1.1	–408.3	-0.4	-2.9
Equatorial Guinea	1341.4	5.7	36.5	218.4	0.9	5.9	–445.9	-1.9	-12.1
Gabon	724.9	2.2	14.9	106.6	0.3	2.2	–277.2	-0.9	-5.7
Indonesia	14084.4	0.4	3.7	3954.4	0.1	1.0	–1304.9	0.0	-0.3
Nigeria	15779.4	1.5	20.0	2466.7	0.2	3.1	–5569.8	-0.5	–7.1
Country					**2050**				
Angola	17057.9	8.4	40.4	3411.6	1.7	8.1	–9855.7	-4.8	-23.4
Cameroon	1413.2	1.4	10.0	282.6	0.3	2.0	–816.5	-0.8	-5.8
Equatorial Guinea	1753.1	7.5	47.7	419.2	1.8	11.4	–913.2	-3.9	–24.8
Gabon	959.4	3.0	19.7	191.9	0.6	3.9	–554.3	-1.7	-11.4
Indonesia	17585.5	0.5	4.6	7065.5	0.2	1.8	–4340.1	-0.1	-1.1
Nigeria	20730.4	2.0	26.3	4620.4	0.4	5.9	–11287.4	-1.1	-14.3

Notes: Authors' computations. The table presents the resource revenue loss (amount, percentage of GDP and percentage of total revenue excl. grant) in 2030 and 2050 relative to its 2021 level due to the anticipated decline in the prices of hydrocarbons. The selected countries are primarily dependent on the export of fossil fuels (over 80% of merchandise exports) and have available resource revenue data for the year 2021. The amount in constant prices (purchasing power parity) 2017 international dollars is obtained by multiplying the total resource revenue of each country in 2021 by the price changes (growth rates) for the periods 2021–2030 and 2021–2050. The forecasted prices of oil are used for countries that are heavily dependent on the exports of petroleum and related products such as Angola, Gabon, and Cameroon (94.6%, 90.86%, and 86.2% of merchandise exports, respectively). For Nigeria and Equatorial Guinea, where petroleum products and gas exports represent respectively 91.5% and 7.7% in the former and 86.8% and 13.0% in the latter, the weighted averages of the growth rates of oil and gas prices are used. A similar approach is used in Indonesia where oil, gas and coal account for 40.8%, 31.2% and 8.8%, respectively. The total resource revenue is obtained by using data on resource revenue (% of GDP) obtained from GRD (UNU-WIDER, 2023) and GDP constant prices from the World Economic Outlook Database, IMF (2023). The data on total revenue excluding grants are obtained from GRD (UNU-WIDER, 2023).

Despite the expected fall in demand and the downward trend in the production of fossil fuels, extractive industries are anticipated to remain key contributors to a low-carbon world; a wide range of major minerals and metals are required in the production of the next-generation low-emission vehicles and technologies and low-carbon energy (World Bank, 2017; Deetman et al., 2018; IEA, 2022c). Metals such as copper, lead, manganese, nickel, aluminium, lithium, silver, and zinc are used in the development of renewable energy sources such as solar PV, wind turbines, hydropower, bioenergy, and geothermal energy. Moreover, rare earth elements such as neodymium, dysprosium, and praseodymium are critical in the production of electric vehicles. Other critical minerals and metals include cobalt, graphite, iron ore, chromium, tin, titanium, platinum, indium, molybdenum, magnesium, zirconium, cadmium, tantalum, and silicon (World Bank, 2017; IEA, 2022c). Hence, greater demand for these minerals and metals in the development of climate-friendly innovations and renewable energy is expected to rise and could translate into price increases, particularly for those minerals with highly concentrated supply in specific geographical locations (World Bank, 2017).

As shown by IEA (2022c), under the *stated policies* and the *net zero emission scenarios*, the demand for copper, cobalt, graphite, lithium, manganese, nickel, platinum group metals, silicon, silver, zinc, and rare earth elements would rise over the medium- and long-term, but at a decreasing rate in the 2030s. Furthermore, the demand for chromium and molybdenum is estimated to decrease between 2030 and 2040. The highest growth rates in total demand (over 20% over the period 2020–30) are estimated for cobalt, graphite, lithium, nickel, and platinum group metals (Table 4). Deetman et al. (2018)[9] showed that the large long-term demand increments for cobalt, lithium, nickel, tantalum, neodymium, and copper, are mainly driven by the automobile industry and the growing demand for electric vehicles.

Despite the jump in the prices of most metals and minerals over the past two years—mainly driven by the Ukraine-Russia war[10]—the forecasts of the World Bank (2021) are aligned with the overall future trend estimates of IEA (2022c). According to the former, global prices (in nominal terms) of metals and minerals such as aluminium, zinc, copper, platinum and nickel are expected to increase relative to their pre-crisis levels (World Bank, 2021). The only exception is the price of silver, which is expected to drop over the coming decades, partly driven by potential decreasing demand as its substitution for affordable metals such as copper in the process of scaling up the production of photovoltaics (García-Olivares, 2015). Beyond 2050, Watari et al. (2021) found evidence for a projected rise in the global demand for copper, zinc, and aluminium until the end of the 21st century, and that of nickel between

9 Deetman et al. (2018) derived the estimated trends in the demand for copper, tantalum, neodymium, cobalt and lithium in the production of vehicles, electronics and energy generation systems under three scenarios. The first scenario shared socioeconomic pathway (SSP) 1 considers a sustainable outcome with fast technological advances and climate-friendly policies. The second scenario aligns with the socio-economic status quo with moderate technological progress. Another version of the SSP2 accounts for the implementation of climate actions to alter policies towards achieving the 2-degree policy target, while the third represents the poorest outcome in terms of environmental sustainability.

10 The increase in fuel prices drove the prices of most metals and minerals over the past two years mainly due to the use of hydrocarbons in the extraction and processing of such mineral resources.

2020 and 2060. The demand for lead is projected to decrease after 2050 (Watari et al., 2021). These projections are however subject to considerable uncertainties, as future trends in the prices and demand for hydrocarbons, metals and minerals would depend on several factors, including shifts in supply-side factors and changes in the global geo-political environment.

To provide an overview of the production of *critical* minerals in low- and middle-income countries, Table 6 reports the list of minerals and current producers. The information is obtained by combining the data provided by the US Geological Survey (USGS) (2010)[11] with the mineral production data from the 2005 Global Mineral Resources Data System (USGS, 2005).[12] The data obtained is then complemented by relevant data on mineral production from the Centre for Sustainable Mineral Development (Minerals UK, 2023). Although new discoveries and changes in countries' production capacity for climate-transition metals and minerals are expected over the coming years, the table provides important information on countries that stand to gain from price increases, at least in the short to medium term.

Several low- and middle-income countries are among the top producers of the identified critical minerals for the low-carbon future. Non-resource-dependent middle-income countries such as China, the Philippines, Brazil, Argentina, and Mexico are important producers of resources such as copper, cobalt, silver, cadmium, nickel, zinc, aluminium, manganese, molybdenum, cadmium, and graphite. In addition, China and Brazil are endowed with important reserves of lithium, tin, tantalum, platinum, chromium, and cadmium. Furthermore, China has rich deposits of rare earth elements. Other non-resource-dependent countries with important endowments of critical metals and minerals include Albania, Morocco, Bulgaria, Vietnam, and Costa Rica.

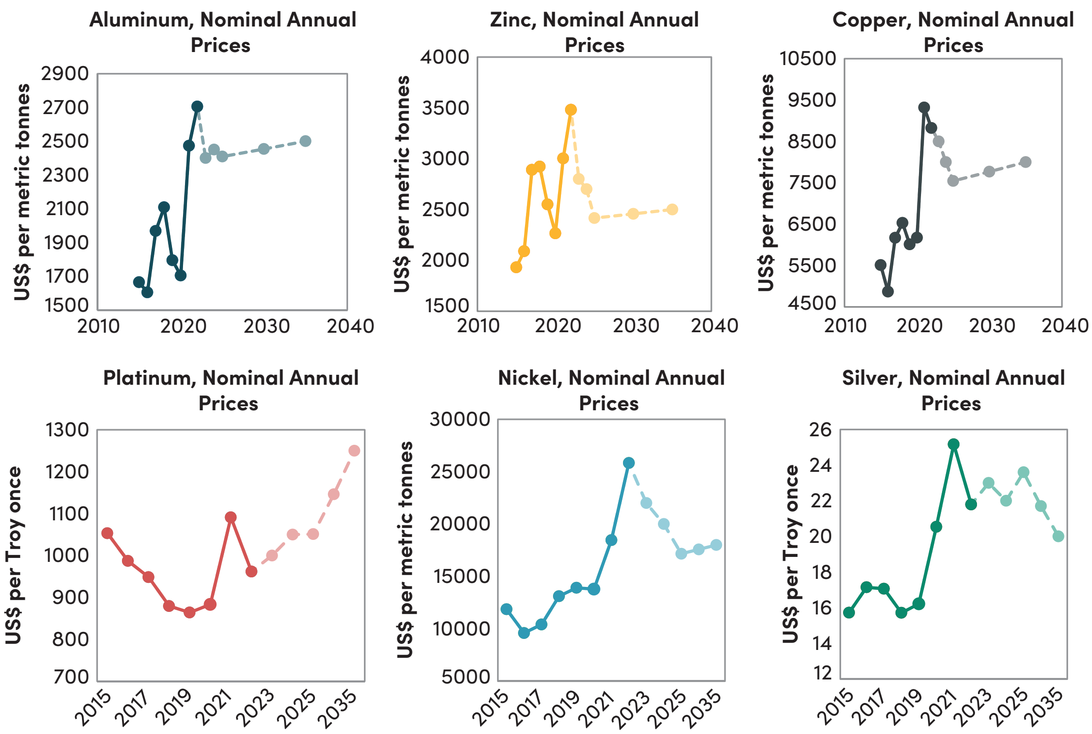
Among non-fuel resource-dependent nations—i.e., countries in which the share of fossil fuels exports in total merchandise export is less than 25%—DRC, Zambia, Mongolia, Papua New Guinea, Eritrea, Kyrgyzstan, Namibia, North Korea, India, and Uzbekistan are copper producers (Table 6). In addition to copper, DRC, Papua New Guinea, and Namibia have cobalt, silver, and zinc reserves. Namibia is a producer of lithium, tin, tantalum and cadmium, while DRC has deposits of molybdenum and cadmium. Deposits of rare earth elements are exploited in countries such as North Korea, Kyrgyzstan, India, and Mongolia. Ghana belongs to the top producers of manganese ores globally (Minerals UK, 2023). In Asia, India is among the richest countries with a variety of important minerals for a carbon-constrained future. The country produces several mineral resources, including manganese, platinum group metals, chromium, titanium, graphite, aluminium, and silicon.

11 Database on mineral operations outside the United States (USGS, 2010).

12 Although the data combines large producers with smaller-scale production, the US Geological Survey (USGS) provides rich information on the type of mineral resources produced across countries.

Hydrocarbon-dependent countries such as Russia, Kazakhstan and Colombia are set to play an important role in the medium and long term in the production of critical non-renewable resources for energy transition and the development of clean technologies. While Russia possesses reserves of most of these resources (e.g., chromium, manganese, indium, cobalt) and is among the top producers globally, Kazakhstan is the second top producer of chromium, fourth top producer of cadmium and among the top ten producers of Manganese ore globally (ibid.). In addition to base metals, Columbia produces molybdenum, silicon, and platinum group metals. Other fuel-dependent countries with endowments in important base metals and other critical minerals include Ecuador, Gabon, Venezuela, Nigeria, Iran, Bolivia, Egypt, and Algeria.

FIGURE 9. World Bank's historical and forecasted trends in the price of selected critical minerals and metals, 2015–2035



Data source: World Bank (2021, 2023d).

TABLE 6. Selected metals and minerals production across countries

	Fossil Fuel Dependent		Non-Fuel Resource Dependent	
	MICs	LICs	MICs	LICs
Copper	Algeria; Bolivia; Congo; Iran; Venezuela; Azerbaijan; Colombia; Ecuador; Gabon; Kazakhstan; Russian Federation		Armenia; Botswana; India; Indonesia; Kyrgyzstan; Mongolia; Namibia; Papua New Guinea; Peru; South Africa; Tajikistan; Tanzania; Uzbekistan; Zimbabwe	Congo, DR; Eritrea; Korea, DPR; Mozambique; Zambia
Cobalt	Algeria; Bolivia; Colombia; Kazakhstan; Russian Federation		Botswana; India; Indonesia; Namibia; Papua New Guinea; Peru; South Africa; Uzbekistan; Zimbabwe	Congo, DR; Zambia
Aluminium	Cameroon; Egypt; Iran; Nigeria; Venezuela; Azerbaijan; Colombia; Gabon; Iraq; Kazakhstan; Russian Federation	Sudan	Armenia; Ghana; Guyana; India; Indonesia; Jamaica; Mongolia; Namibia; Peru; South Africa; Suriname; Tajikistan	Guinea; Mozambique; Sierra Leone
Zinc	Algeria; Bolivia; Congo; Iran; Azerbaijan; Colombia; Ecuador; Russian Federation		Armenia; India; Kyrgyzstan; Mongolia; Namibia; Papua New Guinea; Peru; South Africa; Tajikistan; Uzbekistan; Zimbabwe	Congo, DR; Korea, DPR; Zambia
Iron	Algeria; Bolivia; Egypt; Iran; Nigeria; Venezuela; Azerbaijan; Colombia; Ecuador; Gabon; Kazakhstan; Libya; Russian Federation	Sudan	Armenia; India; Indonesia; Mauritania; Peru; South Africa; Suriname; Uzbekistan; Zimbabwe	Guinea; Korea, DPR; Liberia; Zambia
Tin	Bolivia; Egypt; Nigeria; Kazakhstan; Russian Federation		Indonesia; Kyrgyzstan; Mongolia; Namibia; Peru; South Africa; Tajikistan; Zimbabwe	Burundi; Congo, DR; Niger; Rwanda;
Platinum group elements	Bolivia; Colombia; Ecuador; Kazakhstan; Russian Federation		Botswana; India; Indonesia; Papua New Guinea; Peru; South Africa; Zimbabwe	
Nickel	Bolivia; Venezuela; Colombia; Kazakhstan; Russian Federation		Botswana; India; Indonesia; South Africa	Guinea
Silver	Bolivia; Iran; Nigeria; Colombia; Ecuador; Kazakhstan; Russian Federation		Botswana; Ghana; India; Indonesia; Kyrgyzstan; Namibia; Papua New Guinea; Peru; South Africa; Tajikistan	Congo, DR; Zambia
Manganese	Iran; Venezuela; Colombia; Gabon; Kazakhstan; Russian Federation		Ghana; India; Indonesia; Mongolia; Peru; South Africa; Uzbekistan	Burkina Faso
Titanium	Angola; Venezuela; Kazakhstan; Russian Federation		India; Indonesia; South Africa; Uzbekistan	Sierra Leone
Chromium	Egypt; Iran; Azerbaijan; Colombia; Kazakhstan; Russian Federation		Armenia; India; Indonesia; Papua New Guinea; South Africa; Zimbabwe	

TABLE 6. (Continued)

	Fossil Fuel Dependent		Non-Fuel Resource Dependent	
	MICs	LICs	MICs	LICs
Lithium	Bolivia		India; Namibia; Uzbekistan; Zimbabwe	Mozambique
Platinum group elements	Bolivia; Colombia; Ecuador; Kazakhstan; Russian Federation		Botswana; India; Indonesia; Papua New Guinea; Peru; South Africa; Zimbabwe	
Molybdenum	Bolivia; Iran; Colombia; Kazakhstan; Russian Federation		Armenia; India; Kyrgyzstan; Papua New Guinea; Peru; South Africa; Tajikistan; Uzbekistan	Congo, DR
Indium	Kazakhstan; Russian Federation			
Cadmium	Algeria; Bolivia; Ecuador; Kazakhstan		India; Namibia; Peru; Tajikistan	Congo, DR; Korea, DPR; Zambia
Tantalum	Bolivia; Nigeria; Kazakhstan; Russian Federation		Namibia; Rwanda	Congo, DR; Mozambique
Silicon	Algeria; Angola; Bolivia; Egypt; Iran; Colombia; Gabon; Kazakhstan	Sudan	Guyana; India; Indonesia; Jamaica; Peru; South Africa; Suriname; Tanzania; Zimbabwe	Guinea
Graphite	Russian Federation		India; South Africa; Tanzania; Uzbekistan; Zimbabwe	Korea, DPR
REEs	Cameroon; Egypt; Iran; Nigeria; Venezuela; Azerbaijan; Colombia; Gabon; Iraq; Kazakhstan; Russian Federation	Sudan	India; Kyrgyzstan; Mongolia	Korea, DPR

Notes: Information on the type of natural resource exported are obtained from US Geological Survey (2005, 2010) and Minerals UK (2023).

5. Key Implications for economic development

As the world embarks on a low-carbon generation path, the anticipated changes in prices, global demand, and production of non-renewable resources will have varying effects on developing economies in the medium and long term. The extent of the effect and its nature will depend on several factors, including the level of dependence, the existing reserves and future discoveries, the global geopolitical context and future shocks, the development pattern of the domestic economy, as well as the pattern of innovations and technological progress. For resource-dependent economies, such developments will have implications for economic recovery, GDP growth, foreign exchange inflows and public revenue, with possible long-term repercussions on welfare and income distribution.

As decisive policy actions are taken to limit global warming and ensure environmental preservation, hydrocarbon-dependent countries (net exporters) are anticipated to experience losses in TOT and a decline in exports and tax revenues in the medium and long term. The expected decline in the prices of fossil fuels and the ensuing negative implications for the fiscal balance sheet, macroeconomic stability and economic growth could be significant in highly dependent countries such as Algeria, Iraq, Angola, Nigeria, Libya, Equatorial Guinea, Turkmenistan, Azerbaijan, Yemen, Venezuela, Congo Rep., Gabon, Iran, Russia, Sudan, Kazakhstan and Chad—where fossil fuels represent over 50% of total exports and contribute significantly to public revenue. Given the narrower specialization of these fuel-producing economies, per capita GDP growth would likely mimic trends in TOT and hydrocarbon prices. The adverse effect of downward trending coal prices could also be potentially damaging for more diversified fossil fuel exporters such as Indonesia and South Africa, which are among the top producers of coal.

For the most exposed hydrocarbon economies, the accumulation of significant reserves during high-price episodes would constitute an important buffer against the drop in fossil fuel prices from the short to medium term. Nevertheless, where the 'intertemporal syndrome' holds sway, diversifying away from the sector remains essential for better resilience and growth sustainability.

In oil economies with critical minerals and metals—such as Russia, Algeria, Nigeria, Venezuela, Gabon, Bolivia, Colombia and Iran—scaling up production in key base metals, and/or other minerals such as manganese, silicon and REEs would potentially help mitigate the TOT losses and fiscal pressures. However, in low-income fuel economies bereft of reserves in these critical resources—e.g., Yemen and Chad—diversification away from extractive industries is even more urgent.

Although low-income countries, except North Korea, have generally experienced a growing dependence on relatively few extractive industries, especially metals and minerals (UNCTAD, 2023; USGS, 2010; Figures 1 and 2), current producers of critical metals and minerals stand to derive greater revenue inflows. These countries include DRC, Guinea, Zambia, and Mozambique. Furthermore, middle-income countries such as Tajikistan, Mongolia, Suriname, and Peru, which predominantly export minerals and metals (excl. gold and precious metals) representing over 30% of their merchandise trade, have the potential to supply critical metals and minerals to the new market (Table 6). Other non-fuel resource-dependent countries also stand as major contributors to the market. The list includes Asian countries such as India and Indonesia, and middle-income African economies, such as South Africa, Botswana, and Namibia.

For non-hydrocarbon-dependent countries that are also producers of the required metals and minerals for low-carbon technology development, the expected gains from TOT improvements are considerable. This positive outcome, combined with the decline in fuel prices would offer net fuel importers an opportunity for non-resource wealth creation and economic development.

6. Conclusion

The extraction of non-renewable natural resources and its implications for welfare and development continue to draw attention among development practitioners. Since COP21, the growing call for concrete actions to save the planet from the degradation of the ecosystem is gradually changing the trends in the production and consumption of metals, minerals, and fossil fuels. The growing investment in renewable energy and the penetration of clean innovations are expected to durably reduce the consumption of fossil fuels and increase the demand for critical base metals and minerals over the medium and long term. Even though the high price volatilities of non-renewable resources—particularly in a context of ever-changing global geopolitical and economic outlook with successive and lasting shocks—make accurate predictions of future price trends difficult, recent studies foresee declines and increases in the demand for hydrocarbons and critical resources, respectively.

This paper has shown that resource-dependent economies have historically been linked with both higher TOT and higher TOT volatility as well as relatively poor growth performance generally in the developing world, especially in the recent post-boom period. Furthermore, fossil-fuel-dependent countries have generally performed poorly compared with their non-hydrocarbon-dependent counterparts. Hence, these fossil-fuel-dependent countries have presumably been more exposed to the 'resource curse'. Nonetheless, strong governance and institutional reform will be necessary to ensure maximum benefit to countries home to significant reserves of minerals set to see rising prices. As emphasised by Collier and Hoeffler (2009), the resource curse would not be avoided or resolved by greater democratisation per se, but with stronger constraints on governments and accountability, and good economic governance.

For countries with extreme dependence on oil, gas and coal –predominantly middle-income economies—the outlook does not augur well as the decreasing demand for hydrocarbons in the next decades may mean poorer economic growth and shrinking fiscal revenue. As shown above, substantial resource revenue losses and fiscal pressures are likely to occur in Angola, Nigeria and Equatorial Guinea, if global actions are aligned with the 2050 net zero emission target.

Heterogeneities exist, however, as producers of critical metals and minerals would be less impacted by the adverse impacts of fuel price changes, for the anticipated price surges for these resources could potentially mitigate the negative effects of fuel price declines. For low-income countries with narrow export bases, the overall outlook looks dimmer. Resilience to oil price declines will require urgent diversification away from hydrocarbons. Countries such as Bahrain and Oman stand as recent success stories which could be emulated in the pursuit of diversification away from oil (Looney, 2013).

While the present paper has attempted to delineate the anticipated implications for the economies of low-income and middle-income countries, it is still relatively broad-brushed. Further relatively detailed evidence for specific countries would be valuable. Nevertheless, the paper provides a basis for undertaking such country-specific studies that should be most informative for policymakers going forward.

References

Acemoglu, D., Verdier, T., and Robinson, J. A. (2004). Kleptocracy and Divide-and-Rule: A Model of Personal Rule. *Journal of the European Economic Association*, 2(2–3):162–192.

Addison, T. and Roe, A.R. (Eds.). (2018). *Extractive Industries: The Management of Resources as a Driver of Sustainable Development*. WIDER Studies in Development Economics. Oxford University Press.

Arezki, R. and Gylfason, T. (2013). Resource Rents, Democracy and Corruption: Evidence from Sub-Saharan Africa. *Journal of African Economies*, 22(4):552–569.

Auty, R. (2002). *Sustaining Development in Mineral Economies: The Resource Curse Thesis*. Routledge. Taylor and Francis Group.

Basdevant, O., Hooley, J. and Imamoglu, E. (2021). How to Design a Fiscal Strategy in a Resource-Rich Country. Fiscal Affair Department. How to Notes. Washington, DC: International Monetary Fund, 2021.

Baunsgaard, T., Villafuerte, M., Poplawski-Ribeiro, M. and Richmond, C. (2012). Fiscal Frameworks for Resource Rich Developing Countries. IMF Staff Discussion Note, SDN/12/04, Washington, DC: International Monetary Fund, 2012.

Bornhorst, F., Gupta, S., and Thornton, J. (2009). Natural Resource Endowments and the Domestic Revenue Effort. *European Journal of Political Economy*, 25(4):439–446.

Cappelen, A. and Mjoset, L. (2013). Can Norway Be a Role Model for Natural Resource Abundant Countries? In A. K. Fosu (ed.), *Development Success: Historical Accounts from More Advanced Countries*, Oxford: Oxford University Press.

Chachu, D. O. (2020). Domestic Revenue Displacement in Resource-rich Countries: What's Oil Money Got to Do with It? *Resources Policy*, 66, 101656.

Collier, P. and Hoeffler, A. (2004). Greed and Grievance in Civil War. *Oxford Economic Papers*, 56(4):563–595.

Collier, P. and Hoeffler, A. (2009). Testing the Neocon Agenda: Democracy in Resource-rich Societies. *European Economic Review*, 53(3):293–308.

Deetman, S., Pauliuk, S., Van Vuuren, D. P., Van Der Voet, E., and Tukker, A. (2018). Scenarios for Demand Growth of Metals in Electricity Generation Technologies, Cars, and Electronic Appliances. *Environmental Science & Technology*, 52(8):4950–4959.

Dou, S., Yue, C., Xu, D., Wei, Y., and Li, H. (2022). Rethinking the "Resource Curse": New Evidence from Nighttime Light Data. *Resources Policy*, 76, 102617.

Fosu, A. K. (1990). Export Composition and the Impact of Exports on Economic Growth of Developing Economies." *Economics Letters*, 34, 67–71.

Fosu, A. K. (1996). Primary Exports and Economic Growth in Developing Countries. *World Economy*, 19(4):465–475.

Fosu, A. K. and Gafa, D. W. (2019). Natural Resources, Institutions and Economic Development in Africa. *African Review of Economics and Finance*, 11(1):29–52.

Fosu, A. K. and O'Connell, S. A. (2006). Explaining African Economic Growth: The Role of Antigrowth Syndromes, In F. Bourguignon, B. Pleskovic (eds), *Annual Bank Conference on Development Economics,* World Bank: Washington, DC, 31–66.

García-Olivares, A. (2015). Substituting Silver in Solar Photovoltaics is Feasible and Allows for Decentralization in Smart Regional Grids. *Environmental Innovation and Societal Transitions*, 17, 15–21.

Gylfason, T. (2001). Natural Resources, Education, and Economic Development. *European Economic Review*, 45(4):847–859.

Gylfason, T., Herbertsson, T. T., and Zoega, G. (1999). A Mixed Blessing. *Macroeconomic Dynamics*, 3(2):204–225.

Hartwell, C. A., Horvath, R., Horvathova, E., and Popova, O. (2019). Democratic Institutions, Natural Resources, and Income Inequality. *Comparative Economic Studies*, 61, 531–550.

International Energy Agency. (2022a). World Energy Outlook 2022. Available at https://www.iea.org/reports/world-energy-outlook-2022.

International Energy Agency. (2022b). World Energy Investment 2022. Available at https://www.iea.org/reports/world-energy-investment-2022.

International Energy Agency. (2022c). The Role of Critical Minerals in Clean Energy Transitions. World Energy Outlook Special Report. Available at https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions.

International Monetary Fund. (2012). Macroeconomic Policy Frameworks for Resource-Rich Developing Countries. Washington, DC: International Monetary Fund.

International Monetary Fund. (2023). World Economic Outlook Database. April 2023 Edition. Available at https://www.imf.org/en/Publications/WEO/weo-database/2023/April.

Ismail, K. (2010). The Structural Manifestation of the 'Dutch Disease': The Case of Oil Exporting Countries. Washington, DC: International Monetary Fund.

Jensen, A. D. (2011). State-building in Resource-rich Economies. *Atlantic Economic Journal*, 39, 171–193.

Leamer, E. E., Maul, H., Rodriguez, S., and Schott, P. K. (1999). Does Natural Resource Abundance Increase Latin American Income Inequality? *Journal of Development Economics*, 59(1):3–42.

Lélé, S. M. (1991). Sustainable Development: A Critical Review. *World Development*, 19(6):607–621.

Looney, R. E. (2013). The Omani and Bahraini Paths to Development: Rare and Contrasting Oil-based Economic Success Stories. In A. K. Fosu (ed.), *Achieving Development Success: Strategies and Lessons from the Developing World*, Oxford: Oxford University Press.

Lundgren, C. J., Thomas, M. A. H., and York, M. R. C. (2013). Boom, Bust or Prosperity? Managing Sub-Saharan Africa's Natural Resource Wealth. International Monetary Fund, IMF.

Mehlum, H., Moene, K., and Torvik, R. (2006). Institutions and the Resource Curse. *The Economic Journal*, 116(508):1–20.

Minerals UK Centre for Sustainable Mineral Development. (2023). World Mineral Statistics Data. Available at https://www2.bgs.ac.uk/mineralsuk/statistics/wms.cfc?method=searchWMS.

Murphy, K. M., Shleifer, A., and Vishny, R. W. (1989). Industrialization and the Big Push. *Journal of Political Economy*, 97(5):1003–1026.

Organization of the Petroleum Exporting Countries. (2022). World Oil Outlook 2045. Vienna: OPEC Secretariat.

Prebisch, R. (1950). The Economic Development of Latin America and Its Principal Problems. United Nations, Department of Economic Affairs, Lake Success, NY. Reprinted in *Economic Bulletin for Latin America*, 7(1962):1–22.

Redclift, M. and Springett, D. (Eds.). (2015). *Routledge International Handbook of Sustainable Development.* New York: Routledge.

Robinson, J. (2023). Botswana as a Role Model for Country Success. In A; K. Fosu (ed.), *Achieving Development Success: Strategies and Lessons from the Developing World*, Oxford: Oxford University Press.

Rosenstein-Rodan, P. N. (1943). Problems of Industrialisation of Eastern and South-eastern Europe. *The Economic Journal*, 53(210–211):202–211.

Rosenstein-Rodan, P. N. (1961). Notes on the Theory of the 'Big Push.' In *Economic Development for Latin America*, edited by Howard S. Ellis and Henry C. Wallich. New York: St. Martin's, 1961.

Ross, M. L. (2001). Does Oil hinder Democracy? *World Politics*, 53(3):325–361.

Ross, M. L. (2019). What Do we Know about Export Diversification in Oil-producing Countries? *The Extractive Industries and Society*, 6(3):792–806.

Sachs, J. D. and Warner, A. M. (1999). The Big Push, Natural Resource Booms and Growth. *Journal of Development Economics*, 59(1):43–76.

Sachs, J. D. and Warner, A. M. (2001). The Curse of Natural Resources. *European Economic Review*, 45(4):827–838.

Sala-i Martin, X. and Subramanian, A. (2013). Addressing the Natural Resource Curse: An Illustration from Nigeria. *Journal of African Economies*, 22(4):570–615.

Singer, H. W. (1950). The Distribution of Gains between Investing and Borrowing Countries. *American Economic Review* (40):473–485.

Stevens, P. J. (2005). “Resource Curse” and How to Avoid It. *The Journal of Energy and Development*, 31(1):1–20.

Sun, H. P., Sun, W. F., Geng, Y., Yang, X., and Edziah, B. K. (2019). How does Natural Resource Dependence affect Public Education Spending? *Environmental Science and Pollution Research*, 26, 3666–3674.

Torvik, R. (2002). Natural Resources, Rent Seeking and Welfare. *Journal of Development Economics*, 67(2):455–470.

United Nations. (2021). Transforming Extractive Industries for Sustainable Development. Policy Brief. UN, May 2021.

United Nations Framework Convention on Climate Change. (2016). The Paris Agreement. FCCC/CP/2015/10/Add.1.

United Nations Conference on Trade and Development. (2023). UNCTADstat: Data Centre for Global Trade and Development. Available at https://unctadstat.unctad.org/EN/.

United Nations University World Institute for Development Economics Research. (2023). Government Revenue Dataset, available at https://www.wider.unu.edu/project/grd-government-revenue-dataset.

U.S. Geological Survey. (2010). Mineral Operations outside the United States: Geological Survey (U.S.), Reston, Virginia.

U.S. Geological Survey. (2005). Mineral Resources Data System: U.S. Geological Survey, Reston, Virginia.

Venables, A. J. (2016). Using Natural Resources for Development: Why has it Proven so Difficult? *Journal of Economic Perspectives*, 30(1):161–184.

Watari, T., Nansai, K., and Nakajima, K. (2021). Major Metals Demand, Supply, and Environmental Impacts to 2100: A Critical Review. *Resources, Conservation and Recycling*, 164, 105107.

World Bank. (2017). The Growing Role of Minerals and Metals for a Low Carbon Future. June 2017. Washington, DC: World Bank.

World Bank Group. (2022). Commodity Markets Outlook: The Impact of the War in Ukraine on Commodity Markets, April 2022. Washington, DC: World Bank.

World Bank. (2023a). Word Development Indicators. Washington, DC: World Bank.

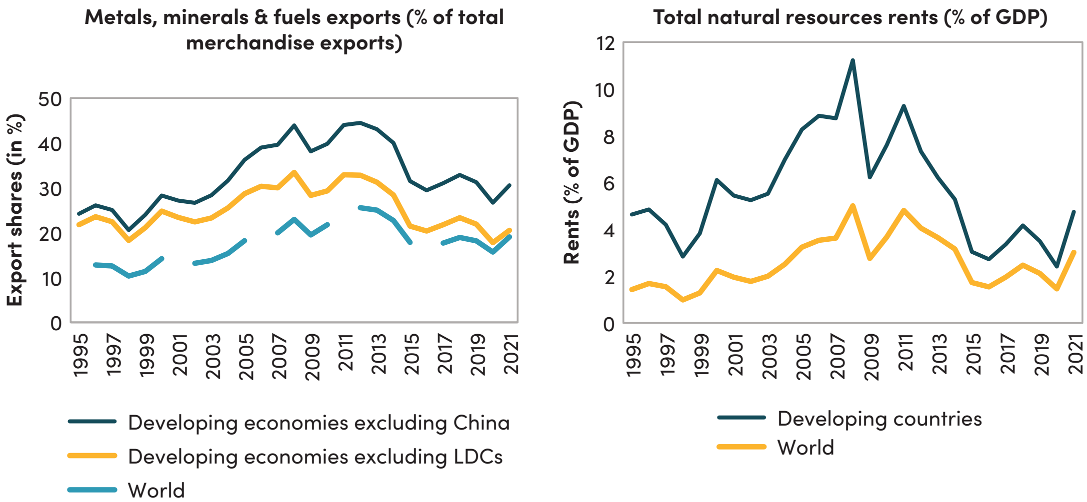
World Bank. (2023b). World Bank Group Country Classifications by Income Level for FY24 (July 1, 2023– June 30, 2024). Available at https://blogs.worldbank.org/opendata/new-world-bank-group-country-classifications-income-level-fy24.

World Bank. (2023c). Commodity Markets. Available at https://www.worldbank.org/en/research/commodity-markets.

World Bank. (2023d). Commodity Markets Outlook: Lower Prices, Little Relief, April 2023. Washington, DC: World Bank.

Appendix

FIGURE A1. Trends in mineral resource exports (% of total merchandise exports) and natural resource rents (% of GDP), Developing countries versus World (1995–2021)



Data sources: UNCTADStat (UNCTAD, 2023) and World Development Indicators (WDI), World Bank (2023a).