FONDATION POUR LES ÉTUDES ET RECHERCHES SUR LE DÉVELOPPEMENT INTERNATIONAL

Working Paper 371 March 2026 Development Policies

On the Politics and Economics of the Shift from Fossil Fuels to Critical Minerals

Rabah Arezki, Michael Ross, Rick van der Ploeg

Rabah Arezki, FERDI, Université Clermont Auvergne, CNRS, IRD, CERDI, F-63000, Clermont-Ferrand, France, and Harvard Kennedy School of Government.

Michael Ross , University of California, Los Angeles.

Rick van der Ploeg, University of Oxford, University of Amsterdam, and CEPR.

Abstract

The global economy is gradually exiting the era of fossil fuels while entering the era of critical minerals. That shift is coming in handy for fossil fuel dependent economies, which have had difficulty diversifying outside the resource sector. It is, indeed, politically and economically expedient for leaders in fossil fuel dependent economies to diversify within the extractive sector instead of moving beyond it. Yet, the massive technological and geopolitical uncertainties associated with the era of critical minerals will make diversification within the extractive sector risky. Adopting fiscal prudence and long-term contracts for critical minerals can partly mitigate the risk but leave open the need to find sustainable engines for economic growth and jobs.

Keywords: natural resources, critical minerals, diversification, politics, uncertainty.

JEL Codes: O1, O4, O5, Q0.

Acknowledgments: We are very grateful for the very constructive comments of two referees and for the comments of the conference participants. We thank Per Magnus Nysveen for helpful comments and suggestions and providing data from UCube from Rystad Energy. Rabah Arezki acknowledges the financial support of the FERDI.

Introduction

The global economy is exiting the era of fossil fuel while entering the era of critical minerals. Indeed, the fossil fuel era is under threat from spectacular reductions in the cost of renewable energy and from the possibility of a shift to more ambitious climate policy. The green transition but also modern industries including related to defence and digitalization require a plentiful and reliable supply of critical minerals. The global shift from oil to critical minerals is thus inevitable in the coming years and of key importance for countries that rely on the production and exports of these natural resources. Here, we explore the consequences of the global shift for resource dependent economies and the policy trade-offs they face.

In the past decade, several countries dependent on fossil fuels have announced ambitious plans to develop the extraction of critical minerals. The Kingdom of Saudi Arabia (KSA), a major oil exporter, is seeking to use the extraction of critical minerals as well as their processing as an anchor for its developmental plan, known as Saudi Arabia's Vision 2030.[1] Other fossil fuel exporters seeking to diversify within the resource sector, and specifically toward critical minerals, include Algeria, Angola, Egypt, Iran, Kazakhstan, Libya, Mexico, Nigeria, Oman, Qatar, Russia, United Arab Emirates, and Venezuela. These countries are either actively investing in the sector through state-owned enterprises or drafted laws with favourable terms aimed at enticing investment to multinational corporations in the sector. Here we explore the political and economic implications of the shift from fossil fuels to critical minerals in economies which have historically depended on the former.

The case of KSA epitomizes the consequences of the emerging shift of the global economy from the oil to mineral era. KSA is home to the world's fourth most valuable rare earths deposit, with significant reserves of heavy rare earths. Jabal Sayid has an estimated 552,000 tons of heavy rare earths, including dysprosium and terbium, and an additional 355,000 tons of light rare earths such as neodymium and praseodymium. The U.S. Department of War, MP Materials, and Saudi Arabia's Maaden have recently launched a joint venture to build a rare earth refinery in the Kingdom. The Department of War will fund the 49% U.S. share, MP Materials will provide technical expertise, and Maaden will hold a 51% majority stake. A new US-Saudi nuclear cooperation agreement is significant given that Saudi Arabia's rare earth deposits occur

[1] See discussion in the link here. Note that KSA also wishes to diversify to areas such as tourism. More importantly, countries such as the KSA and Norway have good access to international capital markets and should therefore aim to separate income and spending decisions, through savings and trade. But if such access is less good and countries have scarcity of funds, such separation is undesirable and it is crucial to invest the resource revenues into diversification and the domestic economy (e.g. Collier et al., 2010).

in tandem with its uranium resources. Jabal Sayid alone has approximately 31,000 tons of uranium. This is the newest chapter in a long-standing relationship between KSA and the U.S. built on offering national security in exchange for natural resources. In 1945, President Franklin D. Roosevelt and King Abdulaziz Ibn Saud met aboard the USS Quincy, forging the landmark "oil-for-security" partnership. Today, it's minerals-for-nuclear-cooperation.[2]

The case of KSA highlights the tensions between two forms of diversification, namely, 'within resource' and 'outside resource' diversifications. The latter form of diversification has proven difficult for fossil fuel exporters leaving them dependent on fossil fuel and hence exposed to the global transition away from fossil fuels. Diversification outside natural resources is made more difficult due to fierce lobbies to safeguard monopolization of imports in the light of the fact that countries with greater commodity export intensity have more concentrated markets for imported goods (Arezki et al., 2025).[3] Outside resource diversification has proven difficult and sometimes nearly impossible, yet in our view it would be the most rewarding path in the long run and for the population as a whole. Within resource diversification is the least resistance path and seems easy but is fraught by a myriad of risks that government should recognize. Within resource diversification seems more prevalent in autocratic than democratic regimes. The choice of within resource diversification is rooted in the ability to continue patronage spending to avoid revolution (led by the poor) but also to avoid conflict with a potential new business elite whom could manipulate the latter.

Lashitew et al. (2020) surveys the evidence and identifies empirical patterns in the economic diversification of resource-rich countries. Interestingly, the authors identify Oman and Indonesia as cases of successful cases of outside resource diversification. However, it also finds that successful diversification is often the result of imminent resource depletion, rather than careful economic planning. That is why the expected bonanza from critical minerals could derail outside resource diversification and limit countries to within resource diversification. In other words, the advent of critical minerals will likely drive the intensive margin as opposed to the extensive margin of diversification.

This paper is closely related to the resource curse literature. That literature describes the often-disappointing track record of developing countries in managing their natural resources,

[2] Many countries including the KSA are setting up date centers, which are intensive in energy. They thus export services (in effect energy) which could qualify as outside resource diversification. Still, this may not be a source of good jobs and sustained growth.

[3] This leads to a new channel for the resource curse stemming from monopolization of imports.

especially fossil fuels. The term 'resource curse' was coined to describe the paradox of countries rich in natural resources that perform worse than similar countries that are resource-poor (e.g., van der Ploeg, 2011; Ross 2012). One common challenge is rent seeking, whereby natural resources increase the return to state capture, potentially leading to inefficient policy choices in the absence of strong political institutions. Furthermore, good institutions are key to exploration and drilling and most likely also for the required shift to international mining investments.[4] The danger is that otherwise illegal mining activities emerge, which do not benefit the country. Tornell and Lane (1999) describe a 'voracity effect' in which a terms-of-trade windfall leads to more aggressive depletion of natural resources and state capture by powerful groups. Robinson et al. (2014) provide a similar model in which incentives for state capture increase with exports of natural resources. Empirical studies by Brollo et al. (2013), Caselli and Michaels (2011), and Arellano-Yanguas (2011) find that resource windfalls tend to increase the incidence of corruption and conflict, while Ross (2001), Tsui (2011), Ramsay (2011), and Prichard et al. (2018) provide evidence that oil wealth helps authoritarian leaders entrench themselves and ward off democratic pressures.[5]

The global shift from fossil fuels to critical minerals might benefit fossil fuel dependent economies that have had difficulty diversifying outside the resource sector. It is, indeed, politically and economically expedient for leaders in fossil fuel dependent economies to diversify within the extractive sector. Yet, the underappreciated technological and geopolitical uncertainties associated with the era of critical minerals will make diversification within the extractive sectors risky. Indeed, the transition from fossil fuel to critical minerals might not be easy.

[4] Cust and Harding (2020) use a global data set on the location of exploration wells and national borders to set up a regression discontinuity design with the identifying assumption that the position of borders was determined independently of geology. They find more than twice as much drilling on the side with better institutional quality. This suggests that institutions shape both exploration companies' incentives to invest in drilling and host countries' supply of drilling opportunities. Ahlvik et al. (2020) also find that higher taxes on oil reduce exploration expenditures and oil discoveries. These taxes thus significantly curb emissions.

[5] Another challenge is the so-called 'Dutch disease', whereby a natural resource discovery or price appreciation is accompanied by an overvalued real exchange rate, which in turn shrinks the non-resource export sector and typically depresses growth prospects. Eastwood and Venables (1982) show how, in the standard neoclassical model, an oil discovery will lead to an appreciation of the real exchange rate, operating through an increase in the relative price of non-tradables. Torvik (2001) shows that the Dutch disease can be avoided in a more sophisticated model by allowing for learning-by doing in the non-tradable sector and knowledge spillovers from the non-tradable to the tradable sector. Arezki and Ismail (2013) present mixed empirical evidence in favour of the Dutch disease. See also Harding et al. (2020) for empirical evidence for real exchange rate appreciations following giant resource discoveries and Harding and Venables (2016) for evidence that non-resource exports fall following natural resource discoveries. In the absence of any market distortions such a restructuring of the economy is optimal. However, in the presence of learning by doing and other cumulative causation effects in the traded sector temporary resource discoveries can permanently harm the traded sector.

At first glance, critical minerals seem much like fossil fuels: both resources may generate rents (super profits), and both are point-source resources. Yet, the two have some important distinguishing features. For one, fossil fuels are consumed and not (at all) recyclable, implying that, in the absence of a rapid global transition to renewable energy, demand will remain high. Critical minerals, in contrast, are reuseable in its raw form or transformed. However, recycling including R&D and innovation make the demand for critical minerals more uncertain. Moreover, critical minerals are unlikely to generate rents – and hence government revenues – at the same scale as oil and gas. While this implies a reduced likelihood of resource curse-like effects on corruption and repression, it also implies reduced fiscal benefits.[6] Finally, mineral resources are significantly more labour-intensive, generating greater local employment in both the formal and informal sectors, which may generate positive local effects on real income (Aragon and Rud, 2013).

Add to that the massive uncertainty around critical minerals due to geopolitical tensions among the economic superpowers. Critical minerals are subject to massive uncertainty due to the risk of rapid obsolescence from aggressive R&D in the global north designed to innovate away from critical mineral dependence.[7] This makes the transition from oil to critical minerals more perilous than it seems for the leaders of fossil fuel dependent economies. We therefore recommend that developing economies adopt fiscal prudence and long-term contracts for critical minerals. These moves will somewhat limit these risks, even while they leave open the need to find sustainable engines for economic growth and jobs in non-extractive sectors. Paying greater attention to the benefits of diversification beyond the resource sector will pave the way for sustainable growth and jobs.

The remainder is organized as follows. Section II explores the rather gradual descent of oil and the ascent of the critical minerals. Section III discusses the political and economic expediency of "within resource" diversification. Section IV argues the risky business of within resource diversification. Section V concludes.

[6] The loss of oil revenue may be less harmful than it appears: Martinez (2025) finds that royalties from oil extraction in Colombia produced significantly fewer public benefits than similar revenues from taxes.

[7] Efforts are also actively being deployed by economic superpowers to foster domestic exploration and extraction of critical minerals to increase self-reliance.

I. The (Gradual) Descent of Oil and Ascent of Critical Minerals

The fossil fuel era has for decades provided many developing countries with major sources of foreign exchange receipt through fossil fuel exports. The prospect of the end of fossil fuel era is however looming: according to the International Energy Agency, China's oil consumption will peak around 2027, and global demand is expected to plateau in the 2030's.

For decades, oil production has risen steadily in Latin America, Africa, and the Middle East. Yet domestic demand has also risen in oil producers, sometimes outstripping domestic supplies (Figures 1-3). Moreover, imminent depletion, weak governance of the oil sector, and the global shift toward renewable energy are eroding export revenues in fossil fuel dependent economies.[8]

Economic diversification may at first look like a straightforward remedy to these problems, but for oil and gas dependent countries it is exceptionally difficult. In the 1950s and 1960s, it was common for low- and middle-income countries – not just oil exporters – to be dependent on a small number of commodity exports. For most of these countries, rising incomes went hand in hand with greater export diversification, as suggested by Imbs and Wacziarg (2003). But fossil fuel exporters have remained highly concentrated, leaving them exceptionally vulnerable to global price shocks (Figure 1). These trends are even more pronounced in Sub-Saharan Africa: from 1960 to 2010, countries without fossil fuels have become slightly more diversified while those with significant oil wealth have become less diversified (Figure 2).

[8] Fossil fuel subsidies for consumption appear almost impossible to reign in, at least before depletion gets to a certain level (Mahdavi et a. 2022).

Figure 1: Export concentration in the oil producers and the rest of the world, 1962-2010

Key: The vertical axis shows export concentration using a Theil index and data from IMF (2014). The red line shows all 38 countries with at least $300 in oil and gas income annually from 1995 to 2014. The grey line excludes eight countries that produced little or no oil before 1990. **Source:** Ross 2019.

Figure 2: Export concentration in Sub-Saharan Africa among oil producers and all other states, 1962-2010

Source: Ross 2019.

The energy transition creates further existential risks for the fossil fuel exporters. First and foremost, the transition risk could lead to existential risks. If we collectively are to meet climate goals, a large fraction of fossil fuel reserves will need to be kept underground. Many developing countries especially in Africa have been growing their reserves of hydrocarbon amidst large discoveries in the past decades (Arezki et al., 2019). McGlade and Ekins (2015) and Welsby et al. (2021) estimate that world reserves of fossil fuels are much larger than the 'carbon budget'. In other words, the billions of barrels of oil and other fossil fuel deposits in developing countries cannot be burned. To keep the increase in temperature below 1.5 °C with 50% probability, Welsby et al. (2021) find that nearly 60 per cent of oil and fossil methane gas, and 90 per cent of coal must remain unextracted.

In addition to stranded oil and gas reserves, the structures and capital used in extraction and in exploitation of fossil fuel are also at risk of becoming stranded. Furthermore, the capital used in carbon-intensive industries such as steel, cement or aluminium is also at risk of becoming stranded. Having said that, the energy transition has somewhat been derailed also on account of the fragmentation of the international community. That is likely to lengthen the lifespan of the fossil fuel era and hence cushion the impact on fossil fuel rich countries.

Energy consumption in fossil fuel rich countries is rising rapidly and eroding their revenue sources. The problem is worsened by the frequent use of large consumption subsidies for fossil fuels. These subsidies introduce a range of distortions, including wasteful consumption, misallocation, and harmful effects on the environment from local air pollution and traffic congestion (Coady et al., 2019). They also slow the adoption of renewable technologies.

But these subsidies are difficult to abolish. Between 2016 and 2023, over 90 percent of all attempts to reform gasoline subsidies ended in failure (Mahdavi, Ross, and Simoni, 2025). Because most developing countries have weak social welfare systems, subsidized energy prices are an important part of a second-best – and deeply inadequate – social safety net.[9] From 2016 to 2023, none of the 21 largest gasoline subsidizers were able to sustain reforms. For oil and gas exporting countries in the Global South, low domestic energy prices have also historically formed an important element of the social contract, in which political elites capture riches from the extraction of hydrocarbons and purchase the acquiescence of citizens through a variety of direct and indirect channels, including energy subsidies.

[9] See https://social-assistance.africa.undp.org/data

Consequently, it is not uncommon for subsidy reform efforts to be abandoned when governments are faced with street protests or if tensions build up when domestic energy prices increase (Natalini, Bravo and Newman, 2020). In 2025, subsidy reform efforts in Angola led to the most significant civil unrest since the end of the civil war in 2003. Evidence from Indonesia and Nigeria indicates that the perception of corruption in the implementation of targeted transfer programmes increases public resistance to fuel subsidy reform among the poor citizens who consume the least fuel and who stand to lose the most from any reductions in targeted programmes (Kyle, 2018, McCulloch et al., 2021b). These challenges to remove subsidies raise important questions about the political feasibility of the next step to address climate ambition toward carbon pricing (Klenert et al., 2018).

These constraints raise the question of macroeconomic adjustment. The permanent income hypothesis (PIH) offers a useful framework to address issue of sustainability for oil rich economies: the depletion of natural resources, because anticipated, should first lead a country to borrow in advance of the resource windfall. Since these windfalls are typically temporary, they then require saving during the windfall to smooth consumption and particularly maintain consumption when the windfall has ceased. Thus, if the optimal path of consumption was followed, nearing depletion should not give rise to any further fiscal adjustment. However, if the history of consumption has exceeded the level required by the PIH, a fiscal adjustment beyond what would have been required by the PIH early on becomes necessary to ensure fiscal sustainability. In the latter scenario of deviation from PIH, the existence of another source of rent, such as from that from critical minerals, can potentially limit the need for a major fiscal adjustment to restore fiscal sustainability.

The advent of an alternative source of rent, such as critical minerals, can help to curb the lack of fiscal sustainability, and even more so with erroneous peak oil expectations. The need for an adjustment of the non-resource deficit decreases in this new "regime" where the depletion of fossil fuel wealth is "compensated" by the increase in mineral wealth. However, given the significant uncertainty about future critical mineral demand (and revenues) due to technology (rapid obsolescence) and geopolitical tensions (economic insecurity), and the likelihood that mineral mining will generate fewer rents than fossil fuels, countries need to exercise caution and make more precautionary savings.

That said, the energy transition at the global level seems to be derailed. The United States has now twice pulled out of the Paris climate agreement. As a result, many corporations seem to bother less or no longer at all about transitioning to net zero. This also seems to be the case in

Europe where many countries seem to have less appetite for the Green Deal and for an ambitious climate policy. Many developed countries have reneged on promises to transfer funds. Peak oil has thus been postponed.

Still, critical minerals are in high and growing demand not just for the batteries and other products needed for the transition towards green energy, but also for the growing demand of the defence and arms industries and the exploding demand for the digital and artificial intelligence industries. Notwithstanding the international context, at the local level many traditional fossil fuel-exporting countries are experiencing depletion and rapid domestic consumption of fossil fuel, which is eroding their fossil fuel exports. This and the advent of renewable substitutes makes the end of the fossil fuel era inevitable (cf. van der Ploeg, 2016; Helm, 2017) and is the reason why countries are searching for new sources of rents.

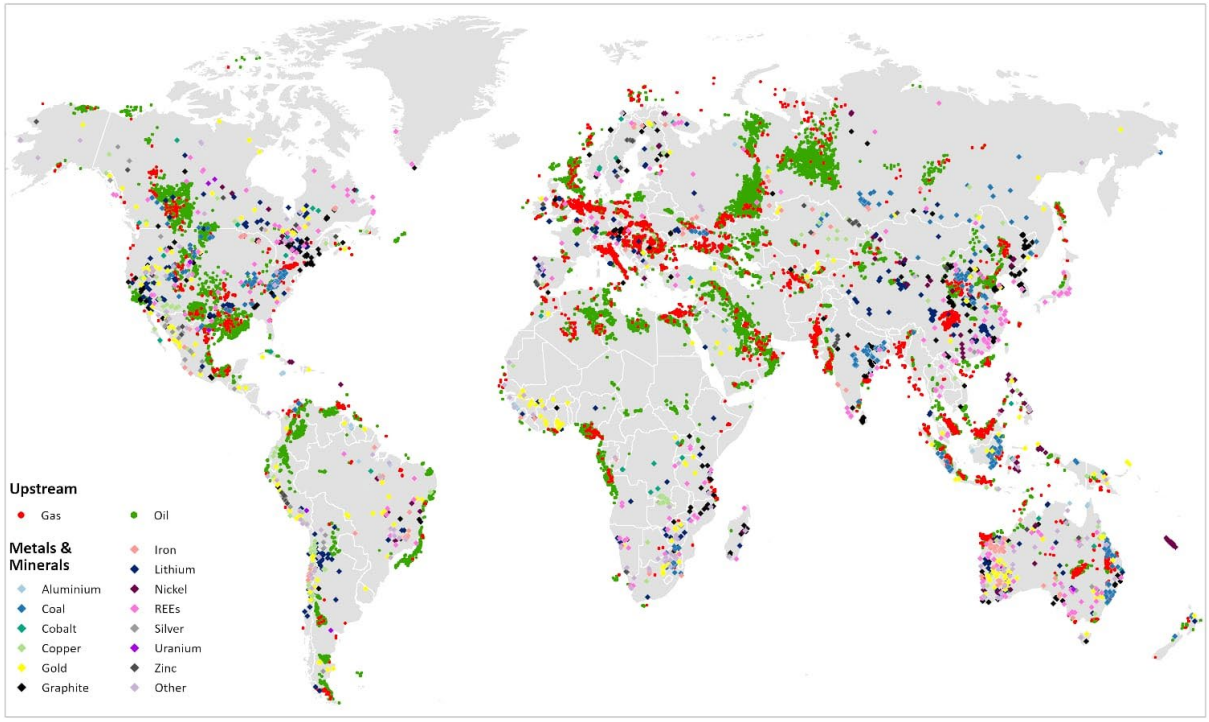
Just at the same time when fossil fuels are gradually disappearing from the global economic scene, demand for critical minerals has begun to soar. The energy and digital transitions both rely on technologies that both require critical minerals with some with intensive use of these minerals. Technologies including wind turbines, solar PVs, electricity networks, electric vehicles, and nuclear power require minerals such as copper, lithium, nickel, silicon, cobalt, rare earth elements, and uranium. Demand for these minerals is expected to grow quickly as the energy transition as well as defence and artificial intelligence gathers pace. In the face of this growth in demand, the limited supply of critical minerals has put upward pressure on their prices (although the increase in prices has receded for certain minerals, especially energy minerals).

Forecasts suggest that demand for minerals for clean energy technologies will rise at least four-fold by 2040 to meet climate goals, with particularly high growth for minerals needed for electric vehicles (IEA, 2021). Graphite, nickel, lithium, and rare earth minerals could witness explosive demand resulting from policy changes to meet climate goals. However, recent setbacks to the global climate consensus cast uncertainty over future demand for energy-related critical minerals. That said, in their most recent update, the IEA (2025) estimates that demand for critical minerals continued to grow strongly in 2024.

At the same time, major supply increases – led by China, Indonesia, and the Democratic Republic of Congo (DRC) – have caused a glut that pushed prices down, especially for battery metals. Current investment decisions will likely take account of significant market and economic uncertainties, even though future demand growth is expected to be strong. Supply is expected to catch up to demand through 2035, but concerns remain, especially for copper. There is an overlap between fossil fuels and critical minerals deposits, which helps to make within

resource diversification feasible (see Figure 3). This overlap is also important given extraction (ore from rocks) and transformation (bauxite to aluminium) are intensive in energy.

Figure 3: Overlap between Hydrocarbon Fields and Critical Mineral Mining



Source: UCube from Rystad Energy. **Notes:** All mines or oil & gas fields shown are active or under development.

The growing significance of critical minerals is paving the way for a new source of extractive revenues in developing countries. In many fossil fuel exporting countries, the failure to achieve economic diversification has fostered a turn to critical minerals. Many have facilitated exploration for critical minerals, which they hope will generate new revenue streams. Yet uncertainty regarding future demand for critical minerals and growing geopolitical risks make the move from fossil fuel to critical mineral wealth uneasy.

II. Political and Economic Expediency of "Within Resource" Diversification

Fossil fuel dependent economies have always found it difficult to diversify into other industries and are therefore notoriously vulnerable to fluctuation in prices of their commodities. Many of these economies also have potential reserves of critical minerals. The key question is why

political leaders in fossil fuel-rich economies want to transition to critical minerals rather than to non-resource related industries or services. Such economies face the choice between 'within resource' and 'outside resource' diversification. The short answer is that 'within resource' diversification is both economically and politically easier. Critical minerals may serve as a viable sector for diversification: they are sufficiently attractive for autocrats to move into, while still representing a departure from hydrocarbons by generating smaller and more diffuse rents.

For example, in Russia and Kazakhstan roughly one-third of federal government revenue comes from oil and gas taxes, whereas revenues from non-hydrocarbon mining are an order of magnitude smaller. Uranium production in both countries is economically important, especially in Kazakhstan, but fiscally insignificant relative to oil and gas. Oligarchs associated with oil and gas are typically much closer to the power of the head of state. This fiscal asymmetry might explain why hydrocarbons, rather than minerals, have historically been at the core of rent concentration and political control.

Economically, a specialization in fossil fuels combined with specialization in non-tradables and financial market imperfections can make it difficult for states to attract non-resource capital: by heightening economic volatility as the non-resource tradable sector disappears, it may deter investment in other types of tradable goods (e.g., Hausmann and Rigobon, 2003). Oil and gas production also depends on highly specific infrastructure and labour force, whose attributes are hard to transfer outside the resource sector. Of the nearly 800 products in the SITC4 classification evaluated by Hausmann et al. (2014), crude oil was the single most difficult to diversify away from because it shares the fewest characteristics with other products, placing it in the most isolated sector of the "product space." The only sector that shares crude oil's characteristics is minerals, making it the easiest sector for oil producers to diversify towards.[10] Both oil and minerals are not only economically remote, but typically also geographically remote.

Hence, it is politically expedient for ruling politicians and the elites that support them to look for alternative sources of natural resource rents instead of fostering an industrial policy that might create opportunities for new entrepreneurs in new economic sectors. At the root of such entrenched behaviour are rent seeking behaviour and the rapacity effect combined with the desire to avoid the rise of new economic elites that may threaten current leaders politically.

[10] Furthermore, there is a U-shaped relationship between sectoral measures of concentration and income per capital (Imbs and Warciag, 2003). This suggests that countries early on in the development process diversify and then later on specialize again.

Mining of critical minerals might preserve the bond between political leaders in resource-rich countries and multinationals at the expense of the larger population. In the distributional conflict literature, there is an emphasis on the importance on tangible capital such as land and natural resources (e.g., Acemoglu and Robinson, 2012; Boix, 2015; Rohner, 2024; Couttenier, and Rohner, 2016). Within resource diversifications allow autocrats to keep a tangible source of wealth as the economy shifts from oil and gas production to mining; unfortunately, this raises the probability of conflict.

There is ample evidence that mining tends to generate violent conflict (Berman et al., 2017; Morelli and Rohner, 2024). Furthermore, rent-seeking and conflict has been identified in the context of mineral extraction (e.g. Asher and Novosad, 2023). However, Dube and Vargas (2013) show that resource price increases in capital-intensive resource industries such as the oil industries depress wages and lead to more conflict while in labour-industries the opposite holds. This suggests that such price increases might lead to more conflict in industrial than in informal and artisanal critical mining.[11]

It is then the case that industrial critical mining leads much less employment than informal and artisanal mining as has been shown for cobalt mining in the Democratic Republic of Congo by Kara (2023). Hence, in contrast to an oil or gas boom, a critical mineral boom can in principle lead to substantial additional employment provided the right policies are in place such as local-contents policies (e.g. Aragon and Rud, 2013). On the other hand, if no such policies are in place, local populations benefit hardly from industrial mining as Bazzillier and Girard (2018) show in their comparison of artisanal and gold extraction. It follows that contracts between resource-rich economies and mining companies should insist on local-contents requirements for otherwise the rents from mining will not reach local citizens.

On the political front, fossil fuel dependence tends to undermine democratic institutions (Brollo et al., 2013) and strengthen autocratic rule (Tsui, 2011; Ross, 2016). In many cases, a collusion between leaders and multinationals in the extractive sectors have favoured the status quo at the expense of the population. Foreign aid has also been used for advanced economies to secure access to resources including fossil fuel in many developing countries.

Historically, governments have become more democratic after the emergence of new economic sectors, which create new economic and social classes that seek a voice in government (Ansell

[11] It is then the case that industrial critical mining leads much less employment than informal and artisanal mining as has been shown for cobalt mining in the Democratic Republic of Congo by Kara (2023).

and Samuels, 2014). Today economic diversification – especially outside the extractive sector, which governments overwhelmingly dominate – tends to produce pressures for greater government accountability and the redistribution of political power.

The parallel between the early development of oil and the early development of so-called critical minerals is telling. Indeed, a race is underway among the superpowers over critical minerals in developing countries to power the simultaneous energy and digital transitions as well as technological military race that the world is experiencing. The extraordinary growth in demand for critical minerals is putting upward pressure on prices and stimulating new critical mineral discoveries around the world. Just like with fossil fuel, in developing countries, the new bonanza from critical minerals presents opportunities but also important risks. Absent governance system shifts, developing countries risk facing a 'critical minerals curse'.

A key difference of context perhaps between the fossil fuel era is the (bi-)polarization of world power between the US and China, which in turn is fragmenting the global economy; the polarization has become much sharper since January 2025, due to the deepened US commitment to fossil fuels. Unlike the Soviet Union during the Cold War, China is both a strategic and an economic rival to the US. China's growing trade and financial ties with the Global South help to explain the shift in many poorer countries' allegiances vis-à-vis America. The decision by many developing countries to abstain from voting on United Nations General Assembly resolutions condemning Russia's invasion of Ukraine surprised US and European officials.

The growing geopolitical and economic split between the superpowers is key difference between the advent of the oil and critical mineral eras. Both the petroleum sector and the global economy flourished amid the relative stability of the post-World War II era. Today, critical minerals are likely to grow on account of growing geopolitical risks and despite economic fragmentation of the global economy. Geopolitical risk is fuelling the race for critical materials for military and other technological purposes.

The Bretton Woods institutions and the World Trade Organisation, with the West and specifically the US providing an implicit backstop, have helped support the global economy's expansion. Since 1960, global GDP has increased about eightfold. And resulting from the Chinese economy's formidable rise in recent decades, China's GDP, measured at market exchange rates, could surpass that of the US by 2030.

But today's geopolitical polarization risks fragmenting the global economy in multiple ways. There are strong indications that this is already happening. US President Donald Trump's

'America First' approach and instigation of a tariff war with China dealt a sharp blow to free markets and free trade. Former US Treasury Secretary Janet Yellen advocated "friend-shoring" supply chains to trusted allies as part of America's strategic response to the growing Chinese challenge. But deciding who counts as a 'friend' may be difficult; using criteria such as a country's commitment to democracy could result in a rather small group. And the demand for critical minerals in the US has become closely tied to partisan politics, with the two parties holding diametrically opposing views on the energy transition.

In this new environment where security of supply has become paramount, the design of value chains will have to minimize the risk of weaponization. And while free markets define efficient pricing better than any other mechanism, fragments of the global economy will likely function independently with autonomous pricing and sourcing. All in all, securing critical minerals is thus fuelled by the self-reliance motive in that new polarized global context. Yet, that security motive is likely to be accompanied by major sources of uncertainty closer to so-called Knightian uncertainty. That is especially the case for the suppliers of these minerals. Shifting from fossil fuel wealth to mineral wealth is unlikely to be easy.

III. The risky business of within resource diversification

Critical minerals create both opportunities but also carry important risks, especially for the developing countries, due in part to technological uncertainty and geopolitical tensions affecting demand. A telling example is lithium, which is used to make batteries. While lithium-ion batteries remain the norm, a myriad of potential alternatives technologies is being developed, including sodium-based batteries (Vu, 2025). This rapid technological evolution is driven by the usual market size effect but also importantly by concerns about economic security. From the perspective of the economic superpowers, there are concerns about the security of supply from politically unstable countries such as the DRC. In addition, there are geopolitical tensions between economic superpowers that could disrupt supply chains. China controls the supply of lithium iron phosphate cells, which essentially makes other economic superpowers dependent on it. Such technological uncertainty, coupled with geopolitical tensions, affects critical minerals and their potential obsolescence in important ways. This situation stands in sharp contrast with conventional minerals – for example, the risk of obsolescence might lead to more rapid depletion of reserves.

The potential for reduced lithium demand has far-reaching implications for many countries: Chile, Bolivia, Argentina, and Afghanistan have all been touted as "the Saudi Arabia of lithium" and may need to revisit their expectations.

From the perspective of developing economies, potential obsolescence could have major economic consequences, from the drying up of exports of critical minerals to the disruption of investments, leading to sunk costs. This calls for more fiscal prudence and the design of extraction and sale contracts to ensure adequate risk-sharing between multinational corporations and governments in developing economies. To do so, developing economies should consider longer-term contracts similar to the 'take-or-pay' contracts for natural gas, which require purchasers to pay for a contractually specified minimum quantity of output, even if delivery is not taken.

Long-term contracting alone will not suffice to deal with the inflexibility stemming from fluctuations in supply and demand. Contingent claim contracts exist, but they are difficult to administer. To mitigate these hazards, parties will therefore wish to choose contract terms that minimise the need for costly adjudication while maintaining incentives for appropriate adaptation (Crocker and Masten, 1988). Masten and Crocker (1985) examine the incidence of take-or-pay provisions in contracts between natural gas producers and pipelines from this perspective. The main reason for such provisions is to avoid repeated bargaining in transactions by specifying the future terms of trade in a long-term contract at the outset of the relationship. The authors also provide theoretical and empirical evidence that obligations contained in contracts written in unregulated environments allow efficient adaptation to changing circumstances in long-term contractual relationships.

In the context of critical minerals, longer-term contracts help reduce the uncertainty stemming from perceived political instability and geopolitical tensions. In a nutshell, the contract reduces the incentive to engage in costly and hazardous outcome-linked R&D to innovate away from, say, existing lithium battery technology. This is because without such longer-term contracts, a higher bidder (say, China) could sway the supplier of critical minerals such as the DRC away from, say, Europe. Long-term access to lithium would also allow Europe to catch up with China in existing processing technology. In other words, the proposal is to steer away from runway R&D spending and industrial policy that might turn out to be inefficient. Longer-term contracts reduce 'inefficient' R&D by reducing uncertainty vis-a-vis suppliers of critical minerals and the dominance of processing powers such as China. Still, fixed-price oil contracts between Angola

and China have been subject to criticism but the merits of long-term versus short-term contracts need to be taken account of.

Failure to ensure appropriate risk-sharing could lead developing economies to speed up extraction. This would lower prices of critical minerals and potentially also erode fiscal discipline and degrade the environment. These unintended consequences stemming from demand uncertainty are akin to the so-called 'green paradox', whereby the announcement of a future carbon tax or a sufficiently fast-rising carbon tax encourages fossil fuel owners to extract reserves more aggressively, thus exacerbating global warming.

While we emphasize long-term contracts and risk-sharing arrangements as tools to mitigate uncertainty in critical mineral extraction, the issue of weak contract enforcement deserve also close attention. The effectiveness of any contract depends not only on its design but also on the ability of both parties to enforce the contract, which may be questionable in geopolitically fragile environments and/or weak judicial institutions, as is often the case in developing countries. In environments with weak enforcement, firms may delay investment and backload production by relying on self-enforcing agreements that maximize profits while minimizing the risk of expropriation at each point in time during the extraction process.[12]

IV. Conclusion

The global economy is gradually exiting the era of fossil fuels while entering the era of critical minerals. That shift is coming in handy for fossil fuel dependent economies which have had difficulty diversifying outside the resource sector. It is, indeed, in our view politically and economically expedient for leaders in fossil fuel dependent economies to diversify within the extractive sector. Yet, the massive technological and geopolitical uncertainties associated with the era of critical minerals will make diversification within the extractive sector risky. Adopting fiscal prudence and long-term contracts for critical minerals will somewhat limit the risk but leave open the need to find sustainable engines for economic growth and jobs.

[12] An alternative argument is that contracts might instead be front-loaded in anticipation of future expropriation, following a Hotelling-type logic. However, such front-loading would require very large transfers to the government to reduce its incentive to expropriate today. From the multinational's perspective, these payments would generally not be profit-maximizing. As a result, firms tend to opt for backloading (see Thomas and Worrall, 1994, for the theoretical argument, and Paltseva et al., 2025, for empirical evidence). While backloading may be optimal under weak enforcement, it is inefficient and highly costly for both firms and host countries relative to the first-best. There are several ways to address these inefficiencies. In this context, two policy options appear particularly relevant, and they are not mutually exclusive.

References

Acemoglu, D., S. Johnson and J.A. Robinson (2001). The colonial origins of comparative development: An empirical investigation, *American Economic Review*, 91(5): 1369–1401.

Acemoglu, D. and J. Robinson (2012), *Why Nations Fail: The Origins of Power, Prosperity, and Poverty*, Random House, New York.

Ahlvik, L., J. Andersen, J. Hveding-Hamang and T. Harding (2026). Quantifying supply-side climate policies, *Review of Economic Studies*, forthcoming.

Ansell, B. W., & Samuels, D. J. (2014). *Inequality and democratization: An elite-competition approach*. Cambridge University Press.

Aragón, F. M., and J.P. Rud (2013). Natural resources and local communities: evidence from a Peruvian gold mine. *American Economic Journal: Economic Policy*, *5*(2), 1-25.

Arellano-Yanguas, J. (2011). Aggravating the resource curse: decentralisation, mining and conflict in Peru. *The Journal of Development Studies*, *47*(4), 617-638.

Arezki, R and K. Ismail (2013). Boom–bust cycle, asymmetrical fiscal response and the Dutch Disease, *Journal of Development Economics*, 101: 256-267.

Arezki, R., V.A. Ramey and L. Sheng (2017). News shocks in open economies: Evidence from giant oil discoveries, *Quarterly Journal of Economics*, 132(1):103–155.

Arezki, R., R. Bouccekine, J. Frankel, M. Laksaci and F. van der Ploeg (2018). Rethinking the macroeconomics of resource rich countries, VoxEU.org, April.

Arezki, R., F. van der Ploeg, and F. Toscani (2019). The shifting natural wealth of nations: The role of market orientation, *Journal of Development Economics*, 138(C): 228-245.

Arezki, R., A. Fernandes, F. Merchan, H. Nguyen and T. Reed (2025). *Review of Economics and Statistics*, July, 1-36.

Asher, S. and P. Novosad (2023). Rent-seeking and criminal politicians: evidence from mining booms, *Review of Economics and Statistics*, 105, 1, 20-39.

Bazillier, R. and V. Girard (2020). The gold digger and the machine. Evidence on the distributive effect of artisanal and industrial gold rushes in Burkino Faso, *Journal of Development Economics*, 143, 102411.

Berman, N., Couttenier, M., Rohner, D., & Thoenig, M. (2017). This mine is mine! How minerals fuel conflicts in Africa. *American Economic Review*, *107*(6), 1564-1610.

Boix, C. (2015). *Democracy and Redistribution*, Cambridge University Press, Cambridge, U.K.

Brollo, F., T. Nannicini, R. Perotti and G. Tabellini (2013). The political resource curse, *American Economic Review*, *103*(5), 1759-1796.

Caselli, F., & Michaels, G. (2013). Do oil windfalls improve living standards? Evidence from Brazil. *American Economic Journal: Applied Economics*, *5*(1), 208-238.

Collier, P., R. van der Ploeg, M. Spence and A.J. Venables (2010). Managing resource revenues in developing economies, *IMF Staff Papers*, 57, 1, 84-118.

Crocker, K.J. and S.E. Masten (1988). Mitigating contractual hazards: Unilateral options and contract length, *RAND Journal of Economics*, 19(3): 327–43.

Couttenier, M. and D. Rohner (2016). Critical minerals and conflict: a policy roadmap, *Oxford Review of Economic Policy*, special issue.

Cust, J. and T. Harding (2020). Institutions and the location of oil exploration, *Journal of the European Economic Association*, 18, 3, 1321-1350.

Dube, O. and J.F. Vargas (2013). Commodity price shocks and civil conflict: evidence from Columbia, *Review of Economic Studies*, 80, 4, 1384-1421.

Eastwood, R.K. and A.J. Venables (1982). The macroeconomic implications of a resource discovery in an open economy, *Economic Journal*, 92(366): 285-299.

Halvor, M., K. Moene and R. Torvik (2006). Institutions and the resource curse, *Economic Journal*, 116(508), 1-20.

Harding, T. and A.J, Venables (2016). The implications of natural resource exports for non-resource trade, *IMF Economic Review*, 64, 2, 268-302.

Harding, T., R. Stefanski and G. Toews (2020). Boom goes the price: giant resource discoveries, *Economic Journal*, 130, 630, 1715-1728.

Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., & Simoes, A. (2014). *The Atlas of Economic Complexity: Mapping Paths to Prosperity*. MIT Press, Cambridge, Mass.

Hausmann, R. and R. Rigobon (2003). An alternative interpretation of the 'resource curse': theory and policy implications, Working Paper 9424, NBER, Cambridge, Mass.

Helm, D. (2017). *Burn Out: The Endgame for Fossil fuels*, Yale University Press, New Haven, Connecticut.

IEA – International Energy Agency (2021). *The Role of Critical Minerals in Clean Energy Transitions*, Paris.

IEA (2022). *The Role of Critical Minerals in Clean Energy Transitions*, Paris.

IEA (2025). *Global Critical Minerals Outlook*, Paris.

IEA (2025). *Oil 2025,* Paris.

Imbs, J. and R. Wacziarg. (2003). Stages of diversification, *American Economic Review*, 93(1), 63-86.

IMF (2014). Long-run growth and macroeconomic stability in low-income countries - The role of structural transformation and diversification. *Policy Paper*.

Kara, S. (2023). *Cobalt Red: How the Blood of the Congo Powers Our Lives*, St. Martin's Press, London.

Leruth, L., A. Mazarei, P. Régibeau and L. Renneboog (2022). Green energy depends on critical minerals. Who controls the supply chains?, PIIE Working Paper 22-12.

Labay, K., M.H. Burger, J.D. Bellora et al. (2017). Global distribution of selected mines, deposits, and districts of critical minerals, U.S. Geological Survey data release.

Lashitew, A. A., M.L. Ross and E. Werker (2021). What drives successful economic diversification in resource-rich countries?, *The World Bank Research Observer*, *36*(2), 164-196.

Leruth, L., A. Mazarei, P. Régibeau and L. Renneboog (2022). Green energy depends on critical minerals. Who controls the supply chains?, PIIE Working Paper No. 22-12.

Mahdavi, P., Martinez-Alvarez, C. B., & Ross, M. L. (2022). Why do governments tax or subsidize fossil fuels?. *The Journal of Politics*, *84*(4), 2123-2139.

Mahdavi, P., M.L. Ross and E. Simoni (2025). Fossil fuel subsidy reforms have become more fragile, *Nature Climate Change*, 1-6.

Martínez, L. R. (2025). Natural resource rents, local taxes, and government performance: Evidence from Colombia. *Review of Economics and Statistics*, *107*(5), 1460-1469.

Masten, S.E., and K.J. Crocker (1985). Efficient adaptation in long-term contracts: take-or-pay provisions for natural gas, *American Economic Review*, 75(5): 1083–93.

Morelli, M. and D. Rohner (2024). Natural resources and conflict: The crucial role of power mismatch and geographic asymmetries. In *Handbook of the Economics of Conflict* (Vol. 1, pp. 307-323). North-Holland.

Natalini, D., G. Bravo and E. Newman (2020). Fuel riots: definition, evidence and policy implications for a new type of energy-related conflict, *Energy Policy*, 147, 111885.

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems, *Science*, 325(5939): 419-422.

Paltseva, Elena, Gerhard Toews, and Marta Troya-Martínez. 2025. The Geoeconomics of Contract Enforcement. Working Paper.

Prichard, W., P. Salardi and P. Segal (2018). Taxation, non-tax revenue and democracy: New evidence using new cross-country data, *World Development*, 109, 295-312.

Ramsay, K. W. (2011). Revisiting the resource curse: natural disasters, the price of oil, and democracy, *International Organization*, 65(3), 507-529.

Robinson, J.A., R. Torvik and T. Verdier (2014). Political foundations of the resource curse: A simplification and a comment, *Journal of Development Economics*, 106: 194-198.

Rohner, D. (2024). *The Peace Formula: Voice, Work and Warranties, not Violence*, Cambridge University Press, Cambridge, U.K.

Ross, M. L. (2001). Does oil hinder democracy?, *World Politics*, 53(3), 325-361.

Ross, M. L. (2012), *The Oil Curse: How Petroleum Wealth Shapes the Development of Nations,* Princeton University Press.

Ross, M. L. (2015). What have we learned about the resource curse?, *Annual Review of Political Science*, *18*(1), 239-259.

Ross, M. L. (2019). What do we know about export diversification in oil-producing countries?, *The Extractive Industries and Society*, *6*(3), 792-806.

Thomas, Jonathan, and Tim Worrall. "Foreign direct investment and the risk of expropriation." *The Review of Economic Studies* 61, no. 1 (1994): 81-108.

Tornell, A. and P.R. Lane (1999. The voracity effect, *American Economic Review,* 89(1): 22-46.

Torvik, R. (2001). Learning by doing and the Dutch disease, *European Economic Review*, 45(2): 285-306.

Tsui, K. K. (2010). Resource curse, political entry, and deadweight costs, *Economics & Politics*, *22*(3), 471-497.

van der Ploeg, F. (2010). Why do many resource-rich countries have negative genuine saving? Anticipation of better times or rapacious rent seeking, *Resource and Energy Economics*, 32(1): 28-44.

van der Ploeg, F. (2011). Natural resources: Curse or blessing?, *Journal of Economic Literature*, 49(2): 366-420.

van der Ploeg, F. (2016). Fossil fuel producers under threat, *Oxford Review of Economic Policy*, 32, 2, 206-222.

van der Ploeg, F. and C Withagen (2015). Global warming and the green paradox: A review of adverse effects of climate policies, *Review of Environmental Economics and Policy*, 9(2): 285-303.

Vu, A. (2025). Beyond lithium? Why alternative battery chemistries are promising—but not ready", *Energy Storage News*, 7 May.

Welsby, D., J. Pryce, S. Pye and P. Ekins (2021). Unextractable fossil fuels in a 1.5ºC world, *Nature*, 597, 7875, 230-234.

"Sur quoi la fondera-t-il l'économie du monde qu'il veut gouverner ? Sera-ce sur le caprice de chaque particulier ? Quelle confusion ! Sera-ce sur la justice ? Il l'ignore."

Pascal

FERDI

Created in 2003 , the **Fondation pour les études et recherches sur le développement international** aims to promote a fuller understanding of international economic development and the factors that influence it.

Contact
www.ferdi.fr
contact@ferdi.fr
+33 (0)4 43 97 64 60