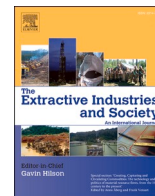




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Original article

## Strategic minerals: Global challenges post-COVID-19

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## ABSTRACT

In 2020, many countries endorsed lockdown measures, closed their borders, and practiced social distancing in a bid to contain COVID-19. These moves, however, disrupted global production and supply chains; no economic sector remained fully intact. The pandemic has exposed the vulnerability of supply chains in a globalized world, perhaps none more so than those linked to the distribution of essential raw materials. Minerals are considered raw materials, the extraction of which has important implications for a country's sovereignty and economic autonomy. They are found in abundance in consumer goods such as smartphones, cell phone batteries, computer monitors, cards, and other electrical and electronic products whose useful life has ended. In response to the health and economic problems arising from the current crisis, several countries have moved ahead and outlined post-COVID-19 strategies for the supply of critical metals, over the medium and long term, to reduce their dependence on other states for these commodities. This paper reflects critically on the positioning of the world's large economies, in the face of the COVID-19 crisis, on strategic minerals.

## 1. Introduction

Access to mineral resources contributes is critical to the sovereignty and autonomy of any country. Today, in addition to relying on an energy matrix based on fossil fuels, especially oil, most countries depend on essential minerals, which make technological development possible. The growing scarcity of minerals is owed to increased population growth and rising consumption patterns, which impact high-tech industrial sectors. Moreover, the low supply of some metallic elements is a global problem arising from the simple fact that primary raw minerals are not renewable (Kiddee et al., 2013). However, many can be recycled and recovered through urban mining of various electronic waste components (Xavier et al., 2021; Giese, 2021; Giese, 2022).

Raw materials that are of great economic importance but which are at high-risk of depletion are referred to as "critical minerals". The list includes antimony (Sb), cobalt (Co), phosphorus (P), niobium (Nb), and rare earth elements. Critical minerals are fundamental to both the production of a wide range of everyday products in contemporary life and the development of "clean" (or green) technologies, namely wind turbines and electric vehicles (Grndell et al., 2016). Mine production and supply in certain countries rich in subsoil resources have been influenced by international geopolitics linked to critical raw materials, and the commercial and industrial strategies of other countries and economic blocs.

The COVID-19 pandemic has revealed how quickly and extensively global supply chains can be disrupted by unpredictable factors. In the first half of 2020, all economic sectors were impacted by the pandemic,

creating uncertainty in the global economy. The mining sector, and in particular, the demands for critical metals, did not go unscathed. Changes in behavior and consumption, caused by social isolation policies, which fueled an increase in the use of digital technologies, and spawned both telework and remote learning, on the one hand, seemed to drive the economic recovery of some segments of the mining sector due to heightened societal demands for essential raw materials. On the other hand, since it is not yet known when the pandemic will end and what its geopolitical and economic impacts will be in the medium and long term, moves were made by the world's largest economies to regain lost autonomy over their productive sectors while simultaneously reducing dependence on critical metals.

This paper reflects critically on the positioning of the world's large economies, in the face of the COVID-19 crisis, on strategic minerals.

## 2. Surveying the impacts of COVID-19 on the global mining sector

In December 2019, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) was first reported in Wuhan, Hubei Province, China; it spread rapidly here and eventually, worldwide. On 12 February 2020, the World Health Organization (WHO) officially named the disease "Coronavirus 2019" or "COVID-19" (Zu et al., 2020), and by 11 March 2020, more than 118,000 cases had been documented in 114 countries. Officials at WHO declared, at around this time, that the COVID-19 outbreak had become a "global pandemic". From this point onward, mitigation measures and strategies aimed at curbing the spread of

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COVID-19 were rapidly adopted: restrictions on international travel; the closing of schools and non-essential businesses such as parks, theaters, cinemas, and museums; requirements for people to work from home; the mandating of masks in public places; and social distancing (Baker et al., 2020).

As the first country impacted by COVID-19, China adopted strict restrictive policies, from as early as January 2020, circumscribing the problem in some regions of its territory. They made considerable progress in limiting the spread of the virus in the country (Zhang et al., 2020). In an increasingly globalized world, such action has reverberated on international trade. This first blockade caused interruptions in the global supply chain. It exposed the dependence on the world economy, which faced a shortage of supplies related to metals, textiles, plastics, auto parts, electronics, medicines, and other goods for which China is the leading world exporter (Dente and Hashimoto, 2020).

China started to reopen its economy in March 2020, a time when other countries around the world were beginning to implement restrictive measures in a bid to mitigate against the spread of COVID-19 (Zhang et al., 2020). It led to a decrease in the production of goods in these countries and a consequent decline in the demand for parts produced in the Asian region (Dente and Hashimoto, 2020). Furthermore, due to the exponential rate at which the virus began to spread in the first quarter of 2020 and the increasing uncertainty about how bad the situation could get, the global population decreased its consumption patterns. In addition, many countries had their economies disrupted due to investors and international trade partners (Ozili and Arun, 2020).

The economic impacts of the outbreak are still unclear. No previous infectious disease outbreak, including the Spanish flu, the severe acute respiratory syndrome (SARS) of 2003 or the H1N1 of 2009, has affected the stock market as significantly as the COVID-19 pandemic. Past pandemics have left only limited soft streaks in the stock market (Baker et al., 2020). The COVID-19 pandemic is an exceptional and extraordinary event that has impacted global supply chains.

The impact of measures implemented to enforce social distancing has affected the way in which supply chains have been managed across the world throughout the pandemic. According to the United Nations Conference on Trade and Development (UNCTAD, 2020), the pandemic cost the global economy a minimum of US\$2 trillion in 2020 alone. The United Nations forecasted a dip in global GDP of at least 2% (Maliszewska et al., 2020), and decline in global economic growth of 2.4%, in 2020, compared to the increase (in global economic growth) of 2.9% achieved in 2019 (Sheam et al., 2020). Should the pandemic continue, long term, the GDP of some countries could fall between 10% and 15%. According to Fernandes, 2020, on average, each additional month of crisis would cost between 2.5 and 3% of global GDP.

In April 2020, at the height of the global crisis, production at more than 1600 mines worldwide had been suspended. The countries with some of the most significant restrictions included Mexico, Namibia and Peru. In the former two countries, policymakers had established set periods of total closure of mining activities; in the latter, the government mandated that the mining workforce reduce by 75% (Jowitt, 2020).

The President of Peru declared, on 15 March 2020, a national state of emergency, culminating in implementation of restrictions on most economic activities in a bid to combat COVID-19. One exception was authorized large-scale mining, the rationale being that the government believed that production should be maintained. Restrictions were imposed, however, on the operations of artisanal and small-scale miners for an extended period. In early-May 2020, eight Peruvian mining companies permitted to continue production had employees or collaborators infected with COVID-19. In total, there were 264 cases, 216 of which were linked to the activities of the Antamina Mining Company, which was forced to suspend operations (Benites and Bebbington, 2020).

Globally, artisanal and small-scale mining (ASM) was also impacted by COVID-19 restrictions. Perks and Schneck, 2021 confirmed this through surveys conducted in 3400 ASM communities across 22 countries. The data reveal that in 20 of these countries, respondents reported

having endured difficulties associated with restrictions imposed to curb the COVID-19 pandemic in the first half of 2020 (the two exceptions were Ghana and Myanmar). Reports on how COVID-19 has affected ASM in sub-Saharan Africa have also been shared in the literature, the key conclusions drawn being that it has cut off peoples' main sources of income, and has increased food insecurity, as it is earnings from the sector that are used to sustain agriculture (Hilson et al., 2021).

Most countries across the globe, including Brazil, permitted mining activity to continue during the pandemic, albeit in most cases, with some restrictions (imposed to mitigate the spread of COVID-19). However, many of the corrective measures implemented to contain the pandemic would interfere with mining activities, key examples being physical distancing and mandates to reduce the number of employees per shift. Even actions which, at first glance, it was believed would not compromise mining activity, such as international and national travel restrictions, would end up impacting workforces across the industry, including the significant number of employees who are in transit and who rotate seasons (Jowitt, 2020). For example, Teck Resources was forced to halt the construction of a copper mine in Chile and reduced coal production, and Yamana Gold reduced gold production (Au) and demobilized workers at its operations in Canada and Argentina (Laing, 2020).

As noted, the COVID-19 pandemic has exposed fully the vulnerabilities of global value chains, characterized by high interdependencies between leading global companies and suppliers, on several continents (Seric and Winkler, 2020). Countries across the globe would implement stringent measures, such as national blockades and border closures, move which exposed the fragility of the global economy, and the complex supply chains at its core. Interventionist measures were indeed needed to flatten the COVID-19 curve and prevent national health systems from becoming completely overloaded; however, they ended up triggering cross-border economic crises because of the highly-interconnected and interdependent world in which we live (Ibn-Mohammed et al., 2021). Among the most significant impacts induced by COVID-19 in the mining sector, therefore, corresponded to persistent interruptions in the supply chain, logistics and the temporary closure of smelting and refineries industries (Jowitt, 2020). These interruptions affected both exporters, due to the decline in and lack of local production, and importers, which were impacted by the temporary unavailability of essential raw materials (Fernandes, 2020).

The crisis has also exposed the fragility of logistics so crucial to the transport of mine inputs and outputs. One example is the cobalt metal concentrates (Co) produced within the Democratic Republic of Congo (DRC). Typically, the concentrates of this critical raw material are shipped for processing to China via the South African port of Durban. However, with the closure of ports and transport restrictions in South Africa, ships had to be diverted to Mozambique or Tanzania, causing delays and decreased exports (Luk, 2020). The pandemic was accompanied by an unprecedented shock that ruptured the demand-supply relationship for mining commodities. At first, the restricted supply of mineral goods may have triggered a temporary rise in prices. However, the metals and minerals, and oil and gas markets experienced sharp declines in the first quarter of 2020. With the reduction in demand for oil, the energy sector was the hardest hit, with an average monthly drop of 15% on energy indices, between December 2019 and April 2020. After energy, base metals were the most affected sector, experiencing average monthly negative variations of 3.49% over the same period. Aluminum was less affected than copper, as demand for the metal declined, a result of major auto and appliance manufacturing centers being hit. The values of the primary non-ferrous metals, however, began to increase at the end of April 2020. By August, iron ore had surpassed the US\$120/t mark, and gold exceeded US\$2000/oz (Ezeaku and Asongu, 2020; Şenol and Zeren, 2020; Tesfaye et al., 2020).

### 3. The lack of essential raw materials, post-COVID-19

The COVID-19 epidemic has fueled a rethinking of supply chain organization, particularly in terms of material sourcing. This is particularly the case for raw material value chains in particular, the vulnerability of which affects all industrial ecosystems. For raw material sourcing, we must take a more strategic approach to planning.

Numerous developed countries lack the capacity to extract, refine, and separate critical metals; they rely on supplies from other parts of the world. Acquiring refining and extractive metallurgy technologies, skills, and abilities is important but geopolitical alliances with countries that have natural mineral resources and has traditionally been relied upon for a large proportion of this. A brief overview of the history of, and recent trends in, the global production of key mineral resources captures these dynamics.

Geopolitically, closer examination of metals as primary raw materials began during the World War I and World War II (1914–18 and 1939–45, respectively), when industrialized Western countries' reliance on strategic minerals needed to fabricate war machinery and implements was revealed. It fueled, for European countries and the United States, a growing dependence on imports and production of critical minerals sourced from a group of underdeveloped countries, mostly on the African continent. Similar concerns emerged during the oil crises of the 1970s and 1980s, when timely and consistent availability of metals and other mineral resources proved challenging.

Concerns about mineral supply have once again resurfaced, brought about by China's demand-related problems, which first become visible in the first decade of the twenty-first century (Sykes et al., 2016). Following the onset of the global financial crisis in 2008, officials United Nations Environment Program (UNEP) reported that certain metals were critical for the electronics industry, including Ta, In, and Ru. They also drew attention to how these metals were also important for photovoltaic technologies, batteries, platinum group metals, and rare earth elements in general (Rhodes, 2019).

In June 2011, the European Union (EU) published a report which identified 14 critical raw materials vital to countries comprising the zone. It included detailed information about essential supply and demand, sharing statistics, as well as insights on how to obtain these resources through the circular economy (i.e., through electronic waste recycling) (Rhodes, 2019). Senior EU officials expressed concern from possible supply restrictions for environmental reasons. The EU proceeded to publish new reports, updating its list of critical raw materials in 2014, 2017, and 2020, in which 20, 27, and 30 critical raw materials were identified, respectively (Table 1). This is what the US Geological Survey (USGS) proposed to do by November 2021, in anticipation of the world being better positioned to navigate COVID-19. The objective is to elicit public feedback on a list of 50 minerals that have been determined to be crucial the US economy and national security (Nassar and Fortier, 2021).

### 4. National/Regional mineral strategies

#### 4.1. United States

On 30 September 2020, former US President Donald Trump signed Executive Order 13,953, stating unequivocally that the country will no longer rely on foreign imports of critical minerals. These minerals will become increasingly necessary to sustain the United States' economic and military strength in the twenty-first century. But despite the executive order, the government cannot produce and process enough to meet the needs of its businesses right now.

Broadly, North America's mining sector is reliant on Chinese imports. In the US, for 31 of the 35 critical minerals identified, over half of what is consumed is imported. For instance, the United States imported 80% of rare earth elements and 50% of barium sulfate directly from a single supplier country in 2020 (i.e., China). Additionally, there is a

**Table 1**

Frequency of critical metals and minerals in EU, US and Brazil lists.

Critical Raw Material	EU				US		Brazil
	2011	2008	2011	2020	2008	2021	2021
Aluminum						X	
Antimony	X	X	X	X			
Arsenic						X	
Barite			X	X		X	
Bauxite				X			
Beryllium	X	X	X	X		X	
Bismuth			X	X		X	
Borate		X	X	X			
Cesium						X	
Chromium		X	X			X	
Cobalt	X	X	X	X		X	X
Coking coal		X	X	X			
Copper					X		X
Fluorspar	X	X	X	X		X	
Gallium	X	X		X	X		
Germanium	X	X		X			
Graphite	X		X	X		X	X
Hafnium			X	X		X	
Helium			X				
Indium	X	X	X	X	X		
Lithium				X	X		X
Magnesite		X				X	
Magnesium	X	X	X	X		X	
Manganese					X		
Molibdenium							X
Natural rubber			X	X			
Nickel						X	X
Niobium	X	X		X	X		X
Phosphate rock		X		X			X
Phosphorus			X	X			
Potassium							X
Platinum group metals	X	X	X	X	X	X	X
Rare earths	X	X	X	X	X	X	X
Rubidium						X	
Silicium		X	X	X			X
Strontium				X			
Sulfur							X
Thallium							X
Tantalum	X		X		X	X	X
Tellurium						X	
Titanium				X	X	X	X
Tin						X	
Tungsten	X	X	X	X		X	
Uranium							X
Vanadium			X	X	X		X
Zinc						X	
Zirconium						X	

reliance on the importation of all gallium, a critical component of cell phones, blue and violet light-emitting diodes (LEDs), diode lasers, and fifth-generation (5G) communication technologies. China is thus the world's largest producer and exporter of rare earth elements. These important metals will be produced up to 168,000 tons in 2021, up 20% from 148,000 tons in 2020. This is the highest amount ever recorded (Daly, 2021).

President Trump also pledged to reduce the mining sector's vulnerability to unanticipated moves made by foreign governments, natural disasters, and other supply chain disruptions, notably those brought about by the COVID-19 pandemic. As a result, the fates of critical minerals became a centerpiece of national security, foreign policy, and economics.

By expanding and strengthening the country's mining and processing capacity, United States officials aim to safeguard against future supply chain disruptions, to neutralize attempts made by strategic competitors to undermine the national economy, and to ensure military readiness.

#### 4.2. Japan

The Japanese Government's response to the epidemic was informed by the United Nations 2030 Agenda for Sustainable Development, the Paris Agreement's Sustainable Development Goals (SDGs), and the Sendai Framework for Disaster Risk Reduction (SFDRR). The COVID-19 pandemic spawned policies complementary to those already in place to protect the archipelago from natural disasters.

The mining sector's growth, post-COVID-19, will be facilitated by the efficient use of resources and diversified access to critical raw materials such as cobalt, lithium, rare earth, and copper (Dewit, 2020). Japan, which has had economic disputes with China, has succeeded in reducing its dependence on imports. Most of the rare earth materials Japan acquired in 2010 were sourced from China. This reliance was reduced to 58% in 2019, and it has set a goal reducing this further to 50% by 2025. The Japanese Government announced a new plan in March 2020 to increase the country's stock of rare earth elements, despite being preoccupied at the time with managing the pandemic (Duchateau, 2020).

#### 4.3. European Union

On 3 September 2020, in response to the COVID-19 pandemic, EU officials published a report (European Commission, 2020) in which they identified 30 critical minerals for the region. The list includes bauxite, Li, Sr and Ti. Ni is likely to be added to this list in the near future due to the high demand for it for use in next-generation batteries (Haschke, 2022).

#### 4.4. United Kingdom

On 10 March 2020, at the start of the COVID-19 pandemic, Nadhim Zahawi, the UK Minister of Business and Industry, announced the establishment of the "APPG Critical Minerals" program with support from the Critical Minerals Association (CMA), an organization formed to address the supply chain and mineral needs critical to the national economies of England, Wales, Northern Ireland, and Scotland. Minister Zahawi had previously identified critical minerals as critical for the United Kingdom's Green Growth Agenda, which aims to make the island nation self-sufficient by 2050. The UK must find supplies of critical minerals, invest in extraction technology, and ensure that the government increases support for recycling programs.

#### 4.5. India

On 12 May 2020, Prime Minister Narendra Modi expressed grave concern about COVID-19's devastating impact on his country and its relationship with the rest of the world. Among the measures being considered at the time, modernizing the country's industrial park stands out, as do incentives for the manufacture of photovoltaic solar energy panels and advanced batteries. To this end, India must expeditiously explore critical minerals on its own soil, with a view to adding value along the production chain in order to facilitate the processing of extracted metals in the region. Defense, aviation, and space industries will also benefit from this plan, as will the domestic mining and energy sectors.

On 1 August 2019, a specialized committee was established to monitor national reserves of critical minerals and to assess the feasibility of establishing agreements with other countries, particularly Australia, Argentina, and Bolivia, to secure supplies of cobalt and lithium. The Indian Government has also demonstrated its commitment to ensuring a steady supply of critical metals as raw materials for the defense, aviation, and space research sectors through this initiative. When India and Australia signed a Memorandum of Understanding on 4 June 2020, the latter agreed to supply the former with important minerals such as lithium, cobalt, antimony, tantalum, and rare earths, as well as other important minerals.

#### 4.6. Brazil

Brazil entered a state of alert on 11 March 2020, when the WHO director-general declared the COVID-19 pandemic. State governments quickly adopted social distancing measures and implemented border restrictions as countermeasures to contain the new coronavirus outbreak. Through Executive Power decrees (No. 10,282 of 3/20/2020 and No. 10,329 of 4/28/2020), the country's mining sector was minimally impacted as it was declared an "important activity" and therefore permitted to continue functioning during the pandemic. Despite widespread concern about the pandemic, stopping ASM in the Brazilian Amazonia was ruled out. In general, ASM sites in Brazil have long been the locations of intense socio-environmental conflicts that predate the pandemic, in which workers have historically been vulnerable due to their lack of formal employment contracts (Calvimontes et al., 2020).

The country's mining sector generated US\$7.2 billion in revenue during the first quarter of 2020. The second quarter saw an increase of 9% over the previous quarter, generating revenue in the range of US\$7.8 billion. Mineral exports, on the other hand, amounted to US\$7.3 billion, equivalent to 50% of the Brazilian trade surplus recorded in the second quarter of the year, a large proportion of which was iron ore. Revenue from mining helped to buffer against shocks and stresses brought on by the pandemic.

Recent economic indicators point to the mining sector having already played a critical role in the country's economic recovery. Mineração Serra Verde, for example, is making progress on its project to develop infrastructure for rare earth element extraction in Minaçu (GO). With a projected useful life of 24 years, the future mine is expected to begin operations in early 2022 producing 7000 tons of rare earth concentrate per year (Conexao Mineral, 2020). In January 2021, Mineração Caraba S/A in Curaçá (BA) reopened its Surubim mine. The project is expected to create approximately 250 direct jobs and increase copper production in the state of Bahia by up to 10%. (Correio, 2020).

The Ministry of Mines and Energy launched the Mining and Development Program (Programa Mineração, 2020) in September 2020, with a target date of 2020–2023. Expanding geological knowledge of the country, increasing mineral activity, increasing production, bolstering revenue, and making mining more sustainable are some of the goals of the PMD. It also seeks to transform mining into an engine of socio-economic and environmental development, especially in municipalities where operations are located and

The Brazilian Government established the "Política de apoio ao licenciamento ambiental de projetos de investimentos para a produção de minerais estratégicos" (Policy to Support Environmental Licensing of Investment Projects for the Production of Strategic Minerals) (Decree No. 10.657 of March 24, 2021). The initiative is the result of a coordinated effort by government agencies to explain and prioritize actions related to the environmental licensing process, with the aim of moving forward with important mineral projects that will help the country grow.

To qualify as a mineral that is important for the country's growth, it must fall into one of the following categories:

- Sulfur, phosphate, potassium, and molybdenum are minerals on which Brazil relies heavily on imports of to supply critical sectors of the economy. This is also the case with potash and phosphate, which are required for fertilizer production.
- For high-tech products and processes that use rare earth and lithium elements, these minerals are important: cobalt and copper; tin; graphite; Platinum Group Metals; lithium; niobium; nickel; silicon; thallium; tantalum; rare earth minerals; titanium; uranium; and vanadium.
- Minerals with critical comparative advantages for the economy, such as iron ore and niobium, such as aluminum, copper, iron, graphite, gold, manganese, niobium, and uranium, are likely to include aluminum, copper, iron, graphite, gold, manganese, niobium and uranium.

Brazil's geological potential is excellent for a variety of critical minerals, including rare earth elements, lithium, tantalum, niobium and cobalt. While exploration and extraction of critical minerals are necessary, they can only be commercialized if the entire value chain is developed concurrently, from prospecting to extraction, processing, and final product development. Although Brazil has developed technologies for the extraction and processing of some critical minerals and is encouraging research, development, and innovation in the sector through its centers of excellence, such as the Center for Mineral Technology (CETEM), the country has not yet advanced in the developing value chains to spur product manufacturing.

In Brazil, a plan for the mining of strategic minerals and development of cutting-edge extraction technologies like bio-hydrometallurgy (Xavier et al., 2021; Giese, 2021, Giese, 2022) that can be used to make solar panels, lithium batteries, and other advanced technologies locally, is desperately needed. In a post-COVID-19 scenario, the mining sector can jumpstart the economy and fortify national production chains, in turn, boosting GDP and creating jobs not only in mining-related activities, but also in numerous downstream sectors, such as manufacturing and service provision. There is an unmistakable and pressing need to develop national value chains that encompass the processing and production of goods on national territory. There should be changes made to the mining industry so that the country can meet its goal of having clean and sustainable energy in the future.

To become a globally competitive and self-sufficient sustainable mining hub post-COVID-19, Brazil must elevate the strategic importance of this economic sector to a level consistent with the twenty-first century. Major players have already done this, by valuing their mineral reserves, developing and utilizing cutting-edge technology, creating qualified jobs, and, finally, by ensuring environmental sustainability and sustaining society's consumption. As a result, the mining industry in Brazil is well-positioned to stimulate growth and to improve.

## 5. Conclusion

During COVID-19, most mining companies were permitted to continue operating. However, the supply chains they were severely disrupted. Given the impending shortage of critical metals and the need for them to operate various productive sectors, many countries have become aware of the issue, even in the pandemic environment of COVID-19. They have devised bold plans to strengthen the resilience and autonomy of advanced productive sectors in order to fend off threats to their national sovereignty. As a result, the US, EU, UK, Japan, and India, among other locations, intends on making every effort in the coming years to upgrade their capacity to produce mining and mineral processing technologies, while also pursuing international diplomatic and trade agreements to facilitate strategic investment in mines located throughout the world.

Many uncertainties remain in terms of the pandemic's positive and negative effects on the various production chains linked to the mining sector. Brazil, the world's eighth-largest economy, has significant natural mineral reserves and could play a major role in the supply of critical metals, post COVID-19. However, this potential can only be realized if an industrial and scientific strategy is implemented. The country will, therefore, need to take steps to value its mineral resources and encourage the development of value chains in order to become an industrial hub rather than simply a raw material supplier.

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