LONDON POLITICA

Powering the future: Cobalt in the EV battery value chain

11th May 2023

A series by London Politica's Global Commodities Watch

Research Director: Noah Trowbridge

Research Analysts: Nathan Alan-Lee, Sharif Fatourehchi and Ojus Sharma

Table of Contents

Executive summary

This research paper sheds light on the key risks associated with the supply of cobalt, a critical mineral for the production of electric vehicle (EV) batteries. With demand for EVs projected to grow steadily in the coming decade, it is crucial that companies mitigate these risks. The concentration of finite cobalt reserves in the Democratic Republic of the Congo (DRC) and the concentration of refining capacities in China create a delicate balance of supply that is highly risk prone.

London Politica has highlighted crucial medium-term risks including political instability in the DRC, environmental degradation, human rights violations, and geopolitical tensions. While efforts are being made to address these risks through responsible sourcing initiatives and the development of cobalt-free batteries, there are still challenges that need to be addressed. In addition to these supply-side risks, EV battery manufacturers should also be concerned by demand-side risks. These may notably include a slowdown in the expected EV adoption rate and competition from other renewable technology solutions such as hydrogen fuel.

Furthermore, this research paper identifies a series of long-term risks that would have a highly damaging impact on the EV battery industry upon materialisation. De-globalisation, and geo-economic confrontation between the United States and China would undoubtedly spur drastic increases in the price of cobalt and hence hamper the development and deployment of affordable EVs. The development of cobalt-free batteries may be an appealing way of mitigating risks associated with cobalt extraction, yet there is no guarantee these risks will not simply be transposed to other materials required for cobalt-free batteries, such as nickel and manganese. Finally, climate change will likely increase the operational risks for mining facilities, as well as strain food security in the already politically unstable DRC.

Overview

By Sharif Fatourehchi

Cobalt is a transition metal and is commonly used as a cathode material in the production of lithium-ion batteries, which are used in electric vehicles. Cobalt is used in the form of lithium cobalt oxide (LiCoO2), which is a popular cathode material due to its high energy density and long lifespan.

Technical characteristics

In electric vehicle (EV) batteries, cobalt plays a crucial role in helping to increase the energy density and stability of the batteries. The high energy density of cobalt-based batteries allows electric vehicles to travel longer distances on a single charge, making them more practical for daily use. The stability of cobalt-based batteries also ensures that they have a long lifespan, which is essential for the sustainability of electric vehicles.

However, there are concerns about the use of cobalt in EV batteries due to its potential negative environmental and ethical impacts. The demand for cobalt has been increasing due to the growing popularity of electric vehicles, which has led to an increase in the demand for lithium-ion batteries. However, cobalt is a finite resource, with the majority of the world's cobalt reserves located in the Democratic Republic of Congo (DRC), a country known for its unstable political situation and human rights abuses.

The mining of cobalt in the DRC has been linked to environmental damage, as well as the use of child labour and other labour rights abuses. To address these concerns, efforts are being made to reduce the reliance on cobalt in EV batteries or to find alternative sources of cobalt.

Some companies are exploring the use of cobalt-free cathode materials, such as lithium iron phosphate (LiFePO4), which are less energy-dense but more stable and safer than cobalt-based batteries. Other companies are investing in the development of recycling technologies to recover cobalt and other valuable metals from used batteries, reducing the reliance on new mining.

Overall, cobalt and its use in EV battery production are complex and involve balancing the environmental and ethical concerns with the economic realities of producing and selling electric vehicles. As the demand for electric vehicles continues to grow, it is likely that companies will continue to explore new materials and technologies to reduce the reliance on cobalt.

Cobalt in the EV battery value chain

By Sharif Fatourehchi

The lifecycle of cobalt in electric vehicle (EV) battery manufacturing can be broken down into several stages, including mining, refining, battery cell manufacturing.

1. *Extraction*

Cobalt is typically mined from deposits of copper and nickel ores that also contain cobalt. Cobalt mining is a complex issue that involves multiple stakeholders, including mining companies, governments, local communities, and civil society in the form of environmental and human rights organisations. The majority of the world's cobalt reserves are located in the DRC, where cobalt is often mined using both industrial and artisanal methods.

Industrial mining involves large-scale mining operations that use heavy machinery and advanced technologies to extract cobalt from the ground. This type of mining is typically conducted by large mining companies that have the resources and infrastructure to operate at scale. The mining process involves drilling and blasting to remove the overburden, followed by the extraction of ore through underground or open-pit mining methods. Once the ore is extracted, it is transported to processing facilities for further refining.

The largest companies in industrial cobalt mining are Glencore and ERG (Eurasian Resources Group). With an estimated total production of 25,320 metric tons (MT) in 2021, Glencore is the dominant player in cobalt mining, far outpacing its competitors. The company is poised for further growth in the near term, particularly at its mining sites in the DRC. Plans for increased cobalt production include the restart of the Mutanda mine and expansion of their operations in Katanga.

In 2021, ERG is estimated to have produced a total of 20,700 MT of cobalt. The company's Metalkol RTR recycling project in the DRC is focused on reprocessing mine tailings from other mining operations in the area. The project currently has the capacity to produce up to 21,000 MT of cobalt annually, which the company suggests is enough for the production of 3 million EV batteries.

Artisanal mining, on the other hand, involves small-scale mining operations that are often carried out by individual or small groups of miners using hand tools and simple equipment. Artisanal mining is prevalent in the DRC, where an estimated 18% to 30% of cobalt is mined through these informal methods and injected into formal networks through purchases from refining companies such as Zhejiang Huayou Cobalt. Action is being taken against such practices as artisanal mining is often associated with poor working conditions, including the use of child labour, and can have negative environmental impacts.

2. *Refining*

The refining stage of cobalt processing is a critical step in producing a high-purity cobalt product that meets the stringent specifications required for use in EV batteries. Cobalt refining largely takes place in China through companies such as Zhejiang Huayou Cobalt in Tongxiang that supply cobalt to large buyers such as Apple and Tesla. The refining process typically involves multiple stages of chemical and physical treatment to remove impurities such as copper, nickel, and iron.

One common method for refining cobalt is solvent extraction, which involves mixing the cobalt-containing material with a liquid solvent that selectively extracts the cobalt. The solvent is then separated from the rest of the material, and the cobalt is further purified using a series of chemical treatments and precipitation steps.

Another refining method is electrowinning, which uses an electrical current to selectively deposit the cobalt onto an electrode, leaving behind other impurities. This method is typically used for refining cobalt from solutions that have already been treated using solvent extraction.

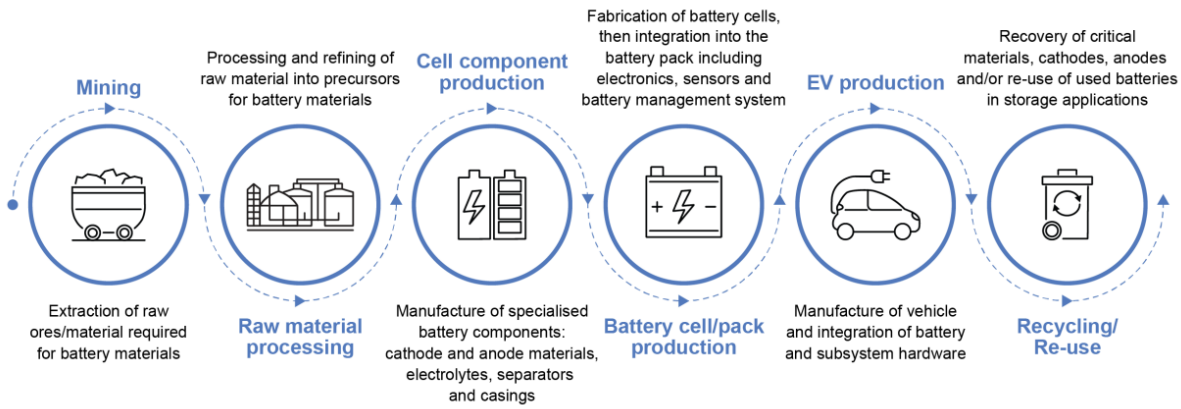
Cobalt is also produced as a by-product of nickel refining. The largest nickel refinery in Europe is Glencore's Nikkelverk, located in Kristiansand (Norway), producing large quantities of refined cobalt as well.

After the refining process is complete, the resulting high-purity cobalt product is typically in the form of cobalt hydroxide. This material is then shipped to chemical processing facilities, where it is further treated to produce cobalt sulphate, which is the form of cobalt used in the cathodes of lithium-ion batteries for EVs.

3. *EV battery cell manufacturing*

Cobalt is a critical component of the cathode material used in most lithium-ion batteries, which are the most common type of battery used in EVs. The cathode material is typically made by mixing cobalt with other metals, such as nickel and manganese, to create a high-performance material that can store and release energy efficiently. The cathode material is then assembled into battery cells, which are used to build the battery packs used in EVs.

Figure 1: EV battery life cycle



Source: International Energy Agency, *Global Supply Chains of EV Batteries*, 19 (Paris: IEA Publications, 2022).

In the EV battery manufacturing industry, there are several major players who use cobalt in their batteries. These include Tesla, CATL, and LG Chem. Tesla, one of the largest EV manufacturers in the world, has been working to reduce its reliance on cobalt in recent years and plans to shift to cobalt-free batteries in the near future. Similarly, CATL, a Chinese company and one of the world's largest producers of EV batteries, has also been reducing its use of cobalt and increasing the use of alternative materials. LG Chem, a South Korean company and major battery producer for the EV market, uses cobalt in its batteries but has been working to reduce its reliance on the metal and increase the use of nickel and other materials.

Projected risks and trends

By Ojus Sharma

Medium-term risks

As the demand for cobalt continues to rise, there are growing concerns about the supply chain risks associated with its production and distribution. This section explores the cobalt supply chain risks, including the impact of political instability, human rights violations, environmental concerns, and ethical considerations.

1. *The Democratic Republic of Congo: a hotspot of political risk*

The Democratic Republic of Congo (DRC) is the country with the world's largest cobalt reserves, accounting for approximately 70% of global cobalt production. However, the mining of cobalt in the country is associated with several risks, both social and environmental.

One of the biggest risks associated with cobalt mining in the DRC is child labour. According to a report by Amnesty International, approximately 20% of cobalt mined in the country is

done by hand, and it is estimated that around 40,000 children work in cobalt mines in the DRC. These children are often forced to work in dangerous conditions, and they are at risk of developing serious health problems, including lung damage and injuries from accidents.

Another risk associated with cobalt mining in the DRC is the use of artisanal and small-scale mining (ASM) techniques, which are often informal and unregulated. ASM can lead to environmental degradation, including deforestation, soil erosion, and water pollution. Moreover, ASM can also result in safety risks for the workers, including exposure to hazardous chemicals and accidents in the mines.

The DRC is also prone to political instability, with a long history of conflict and violence. The mining of cobalt in the country is associated with several human rights abuses, including forced labour, child labour, and unsafe working conditions. Moreover, there is a risk of corruption and exploitation of resources, which can lead to further social and economic instability in the region.

2. *Supply-side risks*

Political instability in the DRC
Likelihood: High
The majority of the world's cobalt is produced in the DRC, which has a long history of political instability and conflict. The DRC's cobalt industry has faced significant challenges, including corruption, weak governance, and a lack of regulatory oversight. The political instability in the region has also resulted in significant social and economic challenges, including poverty, displacement, and violence. This will be discussed in detail in the following points. The resurgence of rebel activity in the DRC's eastern region of North Kivu and the capture of key cities threatens the supply of other critical minerals such as coltan. Whilst the extraction of cobalt is concentrated in the region of Katanga, with facilities such as the Kolwezi mine dominating production, political instability remains a serious concern in the country.

Human Rights Violations
Likelihood: Medium
Cobalt production in the DRC is often associated with human rights violations, including the use of child labour, forced labour, and unsafe working conditions. Many of the cobalt mines in the region are artisanal and small-scale mines, which are often unregulated and lack proper safety measures. This puts the miners at risk of accidents and illnesses, leading to significant social and ethical concerns.

Environmental Concerns
Likelihood: Medium
Cobalt production also poses significant environmental concerns, including soil erosion, deforestation, and water pollution. The production process involves the use of toxic chemicals, which can pollute local waterways and have long-term environmental impacts. Additionally, the unregulated mining practices in the DRC can result in environmental degradation, which can affect the local communities' health and livelihoods.

3. *Demand-side risks*

Electric Vehicle Adoption Risks: Likelihood – Low
The cobalt industry is dependent on the growth of the electric vehicle market, and there is a risk that the adoption of EVs may not meet current expectations. Factors that could impact the growth of the EV market include the availability of charging infrastructure, the cost and range of EVs, and consumer preferences.

Hydrogen as a Risk to Lithium-ion Batteries: Likelihood – High
While the demand for EVs is expected to continue to grow, the use of cobalt in these batteries may decline in the medium term due to competition from alternative energy sources. Hydrogen fuel cell vehicles are emerging as a potential alternative to EVs. These vehicles use hydrogen as fuel, which is converted into electricity through a fuel cell, producing only water as a by-product. Hydrogen fuel cells have a higher energy density than lithium-ion batteries, and they can be refuelled much faster than EVs can be recharged.

The growth of hydrogen fuel cell vehicles poses a risk to the demand for cobalt in the long term, as these vehicles do not require cobalt in their production. While fuel cells do contain small amounts of precious metals such as platinum and palladium, the quantities used are significantly lower than the amounts of cobalt used in lithium-ion batteries.

The increasing competition from alternative energy sources is expected to put downward pressure on cobalt prices in the long term. If the demand for cobalt declines due to competition from alternative energy sources, the oversupply of cobalt could lead to lower prices, which could have a significant impact on the cobalt industry.

Conclusion

In conclusion, the shift towards alternative energy sources and the adoption of new technologies comes with both opportunities and risks. The demand for cobalt, a key component in batteries for electric vehicles and renewable energy storage, has led to a surge in mining activities in countries such as the DRC, resulting in environmental degradation, human rights violations, and geopolitical tensions. While efforts are being made to address these risks through responsible sourcing initiatives and the development of cobalt-free batteries, there are still challenges that need to be addressed. It is important for all stakeholders, including governments, the private sector, and civil society, to work together to ensure the sustainable and responsible development of the sector through promoting ethical sourcing practices, investing in research and development of new technologies, and supporting local communities in mining areas.

Long-term risks

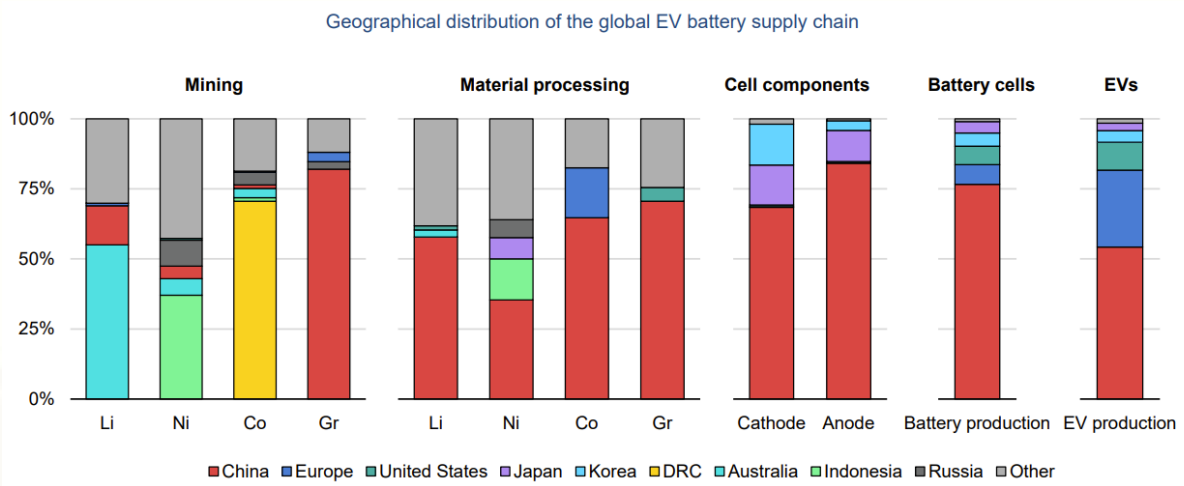
By Nathan Alan-Lee

Looking beyond the more concrete medium-term risks associated with the cobalt economy, there are tangible macro-concerns that could radically alter the role and significance of cobalt in the long-term (5+ years).

1. *Geopolitical risks*

In the short-term the risks to cobalt are more obvious as both primary extraction and secondary processing capacities are highly concentrated in the DRC and China. This leads to a situation where the cobalt market is highly sensitive to the policies and positions of these two countries. Moving forward into the longer term, this inherent risk will be the primary factor in cobalt instability. In terms of geopolitical risks there are several scenarios which could evolve and present risk to cobalt.

Figure 2: Geographical distribution of the EV battery supply chain



Source: International Energy Agency, *Global Supply Chains of EV Batteries*, 5 (Paris: IEA Publications, 2022).

De-globalisation

Likelihood: High

De-globalisation, which roughly defined as "a movement towards a less connected world, characterised by powerful nation states, local solutions, and border controls rather than global institutions, treaties, and free movement," is increasingly a reality. Brexit and Trump's "America First" policy already hinted at a shift away from the pursuit of global interconnectedness. The COVID-19 pandemic, which kickstarted a global supply crunch, has further demonstrated the fragility of globalised supply lines. Since then, the notion of de-globalization has only gained traction with Russia's renewed invasion of Ukraine and the increasingly tense, "bi-polar," relationship between the US and China.

Given the highly concentrated nature of cobalt production capacity, the global cobalt market will be very sensitive to the general wellbeing of global trade and supply. The raising of tariffs, sanctions and trade barriers, and the resulting breakdown of free trade may have an inordinate impact on cobalt pricing and access.

Sino-American confrontation
Likelihood: Medium
Building on the scenario of further de-globalization, the risk of heightened conflict between great powers, namely China and the US, would have a profound impact on the cobalt market. This conflict could come in several forms, from a more unlikely open conflict to a renewed "cold war."

With current cobalt processing being dominated by China, this could greatly impact the US led market's access to refined cobalt. This would necessitate either investment in domestic capacity, or the pursuit of cobalt alternatives. The technologies outlined in the previous section may be a significant factor if Chinese and US markets were separated.

With regard to the DRC and primary extraction, the increased competition between geopolitical blocs may very well influence future stability in the region. Examples of the destabilising influence of competing power blocs was made clear during the Cold War between the US and the Soviet Union, particularly in the African context. In the DRC itself this was seen during the regime of Mobutu Sese Seko which was supported by the US to counter "communist" influence in the country.

More recently the conflict between French expeditionary forces and the Russia backed Wagner Group clearly demonstrates what this kind of competition would look like in a contemporary context.

While this is a potential risk, based on previous experience with great power competition in volatile regions, it is not destined to repeat itself. Countries such as Zimbabwe and Indonesia have already taken steps to control their markets, and force outside interests to play by their rules. A key discriminator here may be in the relative strength of state institutions and their ability to resist external pressure.

2. *Technological risks*

Cobalt-free batteries
Likelihood: High
The short to mid-term risks of cobalt have already begun a longer process of diversification and reducing dependence on cobalt. As a result, there has been increasing interest in the development of cobalt-free batteries, which use alternative materials such as nickel or manganese in place of cobalt. While this development is a positive step towards ethical and sustainable battery production, it is not without its risks and challenges.

One of the main risks associated with cobalt-free batteries is the potential for decreased performance and durability. Cobalt is an important component of the battery cathode, where it

helps to improve stability, energy density, and cycle life. Without cobalt, it can be more difficult to achieve these properties, which could impact the overall performance of the battery and its suitability for use in EVs and other high-demand applications.

Additionally, the demand for cobalt-free batteries could lead to increased demand for alternative materials such as nickel and manganese. This could result in environmental damage in regions where these materials are mined, and potentially lead to other ethical issues such as child labour and exploitation.

While the development of cobalt-free batteries is an important step towards more ethical and sustainable battery production, it is important to carefully consider the potential risks and challenges associated with this shift. It will be important to continue to invest in research and development to improve the performance of cobalt-free batteries, while also ensuring that ethical and sustainable mining practices are used for the alternative materials that are used.

There are multiple initiatives to create reliable and realistic cobalt-free batteries but these remain in the early stage of development. As cobalt-free batteries are relatively new technology, there are limited case studies available. However, some companies have started to explore the use of cobalt-free batteries in their products. In the US the start-up SPARKZ looks to set up production of cobalt-free lithium-ion batteries, and in Europe and China SVOLT looks to set-up a similar production.

Another example is Tesla, which has been working on developing cobalt-free batteries for its electric vehicles. In September 2020, Tesla announced plans to manufacture its own batteries in-house, including cobalt-free batteries. This move is intended to reduce the company's dependence on external suppliers and improve the performance and affordability of its batteries.

3. *Climatic risks*

Likelihood: Medium
In the long term the effects of climate change are predicted to impact the DRC and the region, with increased rainfall and extreme weather events.

The risk impact of climate change on cobalt production is two-fold. In the first case, climate change in the region is likely to exacerbate an already tenuous food supply, which depends on individual and subsistence farming. The collapse of agriculture in the DRC would directly impact the ability to extract cobalt as both the workforce and political stability would be highly impacted. The second point would be that mining operations themselves may be adversely impacted by more extreme weather.

In terms of a mitigation strategy, companies would likely have to explore more diverse cobalt reserves to ensure security of supply. Alternatively, heavier investment in infrastructure may also ameliorate natural events.

Conclusion

The overarching theme in cobalt risks is a lack of sourcing diversity. Many of the downsides and challenges to cobalt use, could be mitigated by both finding more easily accessible reserves and by developing refining capacity outside of China. This would also disincentive the development of cobalt free alternatives, which represents a risk to cobalt even without geopolitical and environmental factors. ■