Driving Demand:

Assessing the impacts and opportunities of the electric vehicle revolution on cobalt and lithium raw material production and trade

IISD REPORT

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1.0 Introduction

The electric vehicle (EV) industry has grown significantly in the last few years. Analysis from McKinsey of sales of plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) reports an average annual growth rate of 45% between 2015 and 2019 (Gersdorf et al., 2020) and selling 2.3 million units in 2019 (Woodward et al., 2020). In 2020, COVID-19 brought some uncertainty to the market, especially on the demand side, with a decline of 25% in new EV sales during the first quarter of 2020.

Nevertheless, the current pandemic does not seem to have affected the EV industry as significantly as the market for internal combustion engines vehicles (ICE), particularly in Europe. Despite the overall drop in sales, global EV market penetration still increased in both 2018 and 2019, with a current market penetration rate of 2.8% (Gersdorf et al., 2020). EV growth forecasts remain encouraging despite the current uncertainty. Given several indicators such as Norway's high EV registration share as well as bans on sales of new gasoline and diesel cars scheduled for 2030, some scenarios expect EV sales growth of 29% per year until 2030, possibly reaching annual new sales of 31.1 million new cars and securing a market share of 32% of all new car sales (Woodward et al., 2020). This incredible growth forecast is partially explained by several regulatory developments, such as stricter emission regulations in the European Union and further advances in the Chinese EV market due to the extension of the country's subsidy scheme in the wake of COVID-19 that runs to 2022 (Lichun & Wei, 2020).

Strong EV growth and strong supply chains depend on a secure and sustainable supply of raw materials. The main EV component is the battery, which encompasses between one third and one quarter of total cost of production, and a significant amount of the car's weight (Bills et al., n.d.). Although battery costs have decreased significantly in the last few years, from ~USD 1,000/kilowatt hour (kWh) in 2010 to USD 150/kWh by 2019 (Azevedo et al., 2018; Yeon et al., 2019), EVs still have a higher sales price than their ICE counterparts. Technological improvements together with growing demand for EVs with greater range are expected to further reduce costs and drive demand for raw materials. One projection from Bloomberg New Energy Finance (BNEF) estimates that by 2030 battery pack prices will be down to USD 58 per kWh (BNEF, 2021)

In 2018, raw materials accounted for about 10% of total EV production costs (Azevedo et al., 2018), indicating their importance in EV supply and value chains. Many of the raw materials used in battery production are sourced in developing countries. Two of the key minerals for battery production are lithium and cobalt, along with other minerals, including manganese and nickel.

The growing interest and projected increase in manufacturing EVs and the subsequent rising demand for specific minerals needed for EV components present a key opportunity for developing countries that are some of the main producers and suppliers of these minerals. However, the adoption of new battery chemistries could also lead to falls in demand for some minerals. Developing countries' ability to take advantage of this opportunity is dependent on their economic and political readiness to manage sustainable investment as well as the trade policies in place that shape the growth of their mining and manufacturing sectors.

This policy brief considers the impact of the EV raw materials boom on developing countries and how trade policy could play an important role in helping them capture value from this expansion while managing the risks of overinvestment so as to provide a reliable source of revenue and improve development and economic outcomes. The brief is structured as follows: First, it discusses demand for lithium-ion batteries of various chemical compositions to highlight the impact that changing technology could have on mineral demand and on producers; Second, it uses case studies of two major producer countries of related minerals—Chile, a major producer of lithium, and the Democratic Republic of the Congo (DRC), a major producer of cobalt—to identify trade-related risks and opportunities and illustrate how policy settings can support or obstruct engagement in evolving value chains. The brief concludes by presenting a summary of trade issues raised in the case studies that may be relevant for other producer countries of minerals used in the production of EV batteries.

2.0 The Global Market for Lithium-Ion Batteries and Associated Raw Materials

Lithium-ion batteries, containing the element lithium, power almost all the large EVs currently in production (Gersdorf et al., 2020). Lithium has a number of other uses, but the EV industry has changed the lithium market significantly. In 2010, global demand was at 123 kilotons (kt) of lithium carbonate equivalent of which 42% was used for ceramics and glass, 14% for batteries (mainly rechargeable and non-rechargeable batteries for portable electronics), and 11% for lubricating greases (Azevedo et al., 2018). In one decade, the market had changed significantly. Global demand was up to 290 kt of LCE in 2019, of which 65% is now going to battery development (the majority of which to EV batteries), 18% to ceramics and glass, 5% to lubricating greases (U.S. Geological Survey, 2020b).

Increasing demand for EVs is expected to continue: a study from BNEF estimates that EVs' share of car sales will increase from 2% in 2018 to 35% by 2030. Such an increase would lead to an even higher increase in demand for lithium-ion batteries, and as production increases to meet demand, the economies of scale involved are expected to further reduce battery costs, and thus make additional uses more viable. The falling price of lithium-ion batteries has already started creating financially viable options for grid energy storage. Other sectors that will experience further growth include consumer electronics (BNEF, 2019).

Much of this demand comes from highly industrialized economies. China was the world's largest consumer of lithium in 2019, accounting for 39% of global lithium consumption. South Korea and Japan followed as the second and third largest consumers of the metal, at a 20% and 18% share of global lithium consumption, respectively. All three countries are major manufacturers of batteries and electronics, which explains their high share of lithium consumption (Statista, n.d.).

This growth has not been smooth, however. In the last few years, the lithium industry has been plagued by price volatility in response to changing demand projections and external shocks. During the first phase of EV expansion between 2015 and 2017, lithium prices increased significantly. This encouraged the development of new projects around the globe. Australia invested in new capacity and developed five new lithium extraction projects (Nesfircroft, 2017). Argentina also started heavily promoting lithium investments, with two projects under construction and several others in different stages of development (Marchegiani et al., 2019). Between 2015 and 2018, lithium production increased threefold, achieving a 44% average annual growth in those years (U.S. Geological Survey, 2020b).

After 2017, however, the anticipated Chinese slowdown in EV subsidies, the COVID-19 crisis, and the added capacity of several new lithium projects around the world created a lithium oversupply, which has resulted in prices falling to historic lows (U.S. Geological Survey, 2020b). Lithium production decreased almost 20% between 2018 and 2019 (U.S. Geological Survey, 2020b), and its price decreased by 80% between November 2017 and 2019 (Trading Economics, 2020b).

Despite a reduction in the price of lithium, lithium extraction projects have experienced relatively few difficulties during 2020, and production has continued as usual, especially in Chile and Australia (Lynch, 2019). This is mainly because the market expects a return to previous growth trends in the medium and long terms due to the expected increase in battery demand for EVs, electronics, and grid stabilization. While forecasts need to be taken with a grain of salt since grid stabilization batteries do not require energy densities as high as EV batteries, market participants agree that more investment in the international lithium industry is needed to avoid a supply crunch in the medium term.

Lithium is not the only element that is used for the production of EV batteries. The most commonly used lithium-ion batteries use cobalt to stabilize the cathode, which allows batteries to recharge faster while maintaining safety from overheating, melting, or fire. Besides having higher conductivity and offering more structural stability, cobalt-based lithium-ion batteries are also lighter than alternative chemistries (Li & Lu, 2020). Given these characteristics, based on current technologies, the current performance of cobalt-based lithium-ion batteries is generally superior compared to other, non-cobalt batteries. However, there are also several concerns regarding the use of cobalt, including the concentration of the resource in a single country, the DRC (see subsequent sections), and the toxicity of cobalt. Despite the concerns, however, the absence of effective alternatives to cobalt has meant that as the EV industry has grown, so has the demand for lithium-ion batteries and for cobalt. In 2020, 62% of the end market of cobalt was in lithium-ion batteries, compared to 20% in 2006 (Global Energy Metals Corp, 2020).

Deetman et al. (2018) estimated that cobalt demand will increase tenfold to twentyfold by 2050 as a result of the growing demand for EVs. More conservative scenarios still foresee a fourfold increase by 2050 (Tisserant & Pauliuk 2016). However, there is a possible alternative scenario in which the cobalt-free battery announcements and goals of some notable players (e.g., Tesla) result in a peak and decline in demand for cobalt. Given the importance of lithium and cobalt to the EV industry, this brief will focus on the two developing countries with pivotal roles in the global supply chain: Chile, for lithium, and the DRC, for cobalt.

Box 1. Battery Reuse and Recycling

A key factor in the future demand for batteries and the raw materials associated with them is the potential for battery reuse and recycling to replace demand for virgin materials. One estimate from battery industry observer CES suggests that by 2030 there will be more than 820 metric kilotons of lithium ion batteries to recycle and that 799 metric kilotons will be reused (Circular Energy Storage [CES], 2021). The value of materials contained in the batteries is estimated to amount to around USD 8 per kilo for NMC batteries, creating a substantial incentive to recycle and creating a multibillion dollar business opportunity (CES, 2021).

Battery recycling processes tend to be designed to cope with heterogeneous cell or pack designs due to the fragmentation of the market. Batteries are disassembled through shredding in low oxygen environments and materials are then separated via a combination of physical, thermal, or chemical processes. Standardization of battery design and improvements in disassembly technologies could reduce costs and increase purity of recovered materials. There is a need for greater research in this area (Harper et al., 2019).

As battery packs age and decline in capacity, vehicles may not be scrapped but could find new lives as vehicles used for short-distance driving: battery packs and cells may also be remanufactured for stationary storage applications. Vehicles that are uneconomical to operate in one country are often exported to countries with lower labour costs. This trend has already been observed in early-generation EVs; around one third of first-generation Nissan Leafs sold in the United Kingdom and Germany have now been exported (CES, 2020, 2021)

The impact on demand for new materials from reuse and recycling is unclear. More than 100 companies are engaged in the recycling of lithium-ion batteries—but demand is still increasing dramatically. In the short term, much of the material required for batteries is likely to come from virgin sources. As electric vehicle penetration increases and these vehicles reach the end of their lives over the next two decades, the potential for increasing shares of recycled batteries will steadily grow.

Table 1 illustrates how important these two countries are to the production of lithium and cobalt. Chile produced around 23% of the world's lithium (excluding the United States) in 2019, while Australia produced 54%, and China, the next largest producer after Chile, accounted for 9%. Chile also holds around 50% of the world's reserves of lithium. Australia's lithium resources are mineral based, which means the lithium is found in solid form combined with other minerals, mainly in the form of spodumene (Li2O.Al2O3.4SiO2). Chile's lithium resources are mainly in the form of brines found in salt lakes. Lithium extraction from brine requires evaporation. Natural evaporation using sunlight is the primarily used in Chile. This process is slow and influences the ability to scale up production (Geoscience Australia, 2019). The DRC produces over 70% of the world's cobalt, and no other producer comes close to these levels, though several countries including Russia, the Philippines, Cuba and Canada produce cobalt (U.S. Geological Survey, 2021). The DRC also holds around 50% of the world's known reserves, followed by Australia at 17%. It is possible that better geological survey data in the future may identify additional resources of these minerals.

Table 1. Share of global production and estimated reserves of lithium and cobalt

Mineral	Top producers	Share of global production in 2019	Share of known global reserves
Lithium	Australia	54%	16%
	Chile	23%	50%
	China	9%	6%
	Argentina	8%	10%
Cobalt	DRC	71%	51%
	Russia	4%	3%
	Australia	4%	17%

Source: U.S. Geological Survey, 2020b.

2.1 Lithium-Ion Battery Chemistries

To make good policy decisions, policy-makers in developing countries that produce the raw materials used in EV batteries must have access to accurate projections for the development of the market for different kinds of EV batteries, each of which involves a different combination of raw materials depending on the performance characteristics required. These different battery types, their applications, and likely demand direction, are set out next.

There are different kinds of lithium-ion batteries. All have metallic lithium for their anode material, but the use of different minerals for the batteries' cathode produces batteries with varying properties. The most common commercially available types of batteries are lithium cobalt oxide (LCO), lithium manganese oxide (LMO), lithium iron phosphate (LFP), lithium nickel manganese cobalt (or NMC) and lithium nickel cobalt aluminum oxide (or NCA). Table 2 provides an overview of types of the main lithium-ion battery chemistries and their uses.

Table 2. Types of lithium-ion batteries chemistries

Name	Abbreviation	Chemical formula	Cobalt content	Properties and applications
Lithium cobalt oxide	LCO	$LiCoO_2$	60%	High capacity: mobile phones, tablets, laptops, cameras
Lithium manganese oxide	LMO	$LiMn_2O_4$	0	Safest: lower capacity than LCO but high specific power and long life. Power tools, e-bikes, medical devices
Lithium iron phosphate	LFP	$LiFeO_4$	0	
Lithium nickel manganese cobalt oxide	NMC	$LiNiMnCoO_2$	10 - 30%	
Lithium nickel cobalt aluminum oxide	NCA	$LiNiCoAlO_2$	1 - 15%	High capacity: gaining importance in electric power train and grid storage; industrial applications, medical devices

Source: United Nations Conference on Trade and Development (UNCTAD), 2020.

2.2 Lithium-Ion Battery Market Forecast

NMC batteries' dominance of the market is likely to change in the coming years, as companies are working toward deploying batteries containing less cobalt due to spiking prices and toxicity concerns. China's growing role in the sector over the next decade is also likely to influence the global levels of use of different kinds of batteries. Today, LFP batteries dominate the Chinese market, with over 44% of the total battery demand (Wood Mackenzie, 2020). One reason for this is that China has domestic reserves of phosphate, a key component of LFP batteries. As China's role as an EV producer grows, so may global levels of use of LFP batteries, with clear implications for levels of demand for cobalt and phosphate.

Other factors may lead to a shift toward LFP batteries at a global level, not just in China. According to research from Wood Mackenzie, NMC batteries are projected to become the first to dominate the EV sector in the early 2020s but will be overtaken by LFP batteries if a new rise in cobalt prices coincides with a boost of LFP's energy density achieved through research and development (Wood Mackenzie, 2020). Rises in the cost of cobalt also will also shift the economics and increase the price of cobalt-containing NMC cells compared to LFP cells, potentially accelerating a transition to LFP cells and a corresponding reduction in demand for cobalt.

Even if not all the predictions above come to pass, the likely evolution in the market for EV batteries over the next 15 years highlights a risk that mineral producer countries face. They need to monitor and manage risks associated with how technological change will influence the global market for their minerals: this will help them avoid the pitfalls of missing an opportunity to export or possibly overinvesting in capacity before technological change reduces demand.

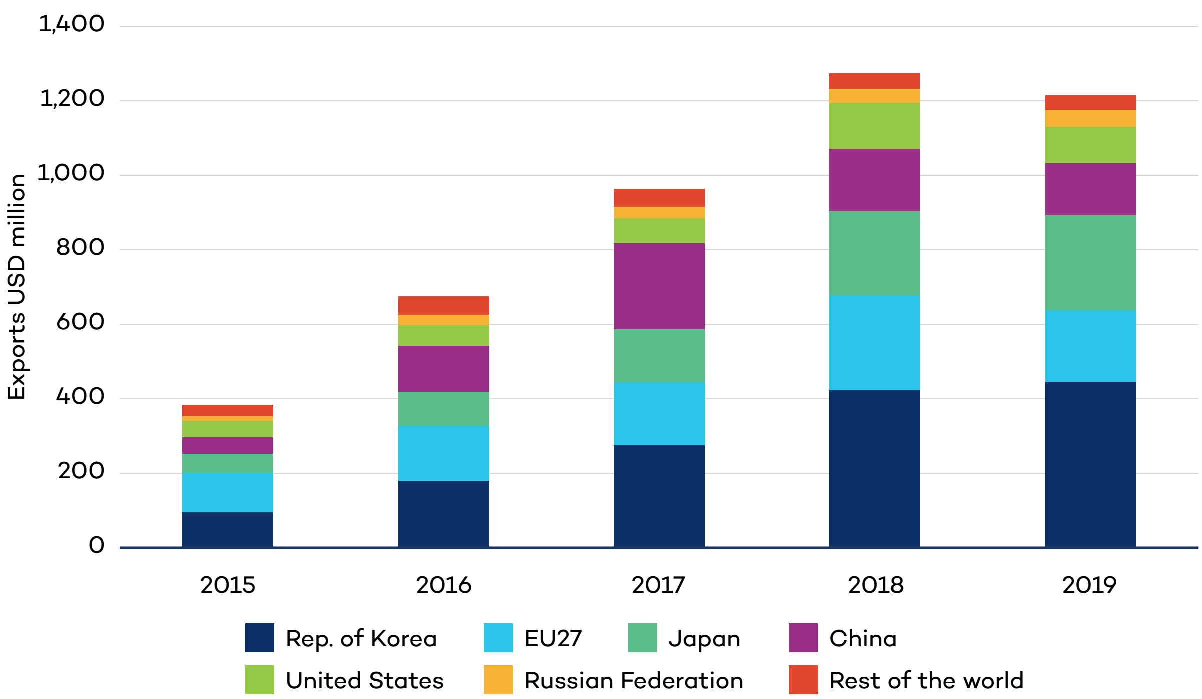
3.0 Lithium Supply From Chile

While current lithium production is dominated by Australia, Chile, and China, the largest reserves are located in what is called the Latin American triangle formed by Chile and the Northern parts of Argentina and Southern Bolivia. Chile's Atacama Salt Lake is located in this area and provides more than 95% of Chilean lithium production: it holds about half of global reserves (U.S. Geological Survey, 2020b).

3.1 Exports

Chile exports lithium to many countries. The total value of exports increased from around USD 300 million in 2015 to over USD 1.2 billion in 2019. While there is no single export market that is overwhelmingly important, there are a number of key markets, including South Korea, Japan, China, Belgium, and the United States. Over time, South Korea has accounted for an increasing proportion of exports. Currently, the main export destinations for Chilean lithium are South Korea (68% of lithium oxide and hydroxide, and 36% of lithium carbonate), the European Union (EU), and Japan (13% of lithium oxide and hydroxide and 26% of lithium carbonate) (International Trade Center, 2020).

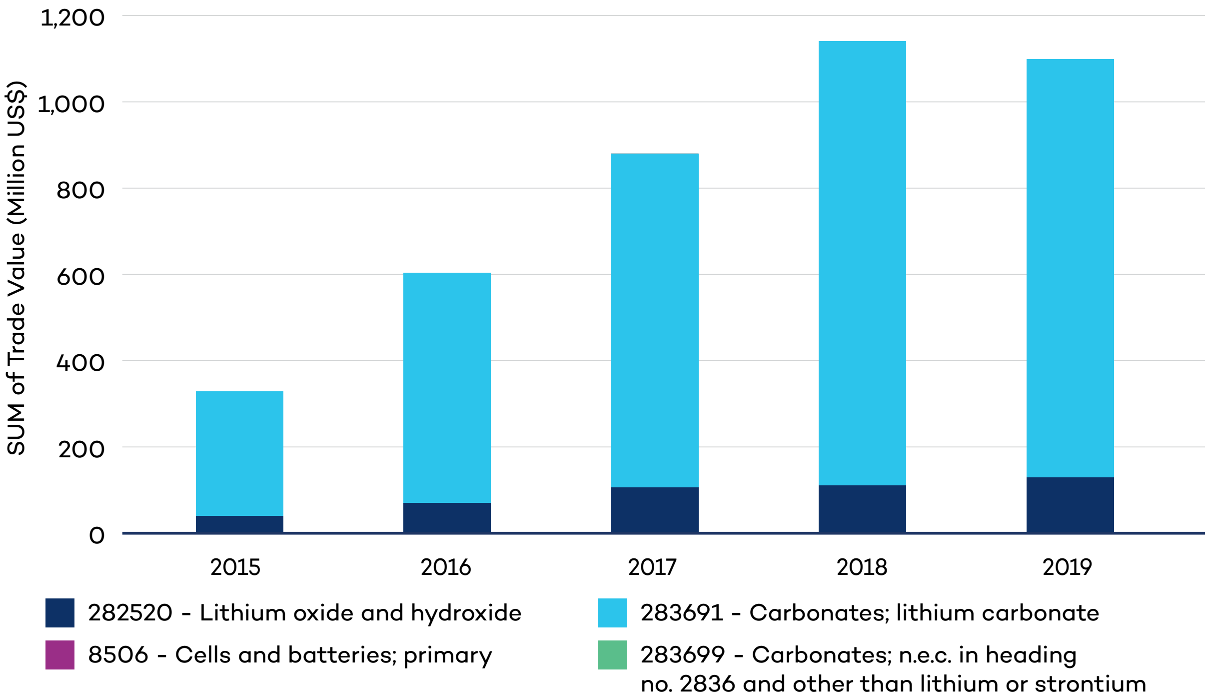
Figure 1. Chilean lithium exports by destination country



Source: Authors' analysis based on Comtrade data.

The form in which Chile exports lithium is also important. Chile exports two main lithium-related products—carbonates (which are relatively unrefined) and oxides and hydroxides, which are relatively refined products. The data in Figure 2 shows that recent increases in exports have predominantly been associated with less-refined products.

Figure 2. Chile lithium exports by World Customs Organization Harmonized Item Description and Coding System (HS) codes 8506, 283699. 283691, 282520



Source: Authors' analysis based on Comtrade data..

3.2 Lithium Industry Structure and Regulation in Chile

Mining is a critically important sector for Chile's economy and such has gone through a number of fundamental regulatory shifts since the 1980s. Before 1979, private companies would receive concessions allowing them to extract lithium like any other mineral (i.e., subject to royalty payments and environmental requirements). After 1979, however, Chile defined lithium as a strategic "non-concessionable" mineral, restricting its extraction and production to the state, its public companies, and private companies that agree to develop special operation contracts and administrative concessions with the state (Chile Ministry of Mining, 1983). The only special operation contract ever concluded was developed in 2018 with a subsidiary of the state-owned copper production company (Gerencia de Comunicaciones, Coldeco, 2018).

The only other lithium production is undertaken by two companies: Albemarle, an international company, and SQM, a Chilean company privatized in the late 1980s. These two companies hold administrative concession contracts under Corfo (Corporacion de Fomento a la Produccion) an agency of Chile's Ministry of Economics which, for historical reasons, holds the pre-1979 Atacama Salt Lake lithium concession where both SQM and Albemarle operate today. Through the contracts agreed with Corfo, the government regulates SQM's and Albemarle's production quotas, minimum refining levels, environmental compliance, engagement with local communities, and future expansion.

By law, any intention to explore or extract lithium must be communicated to the government so it can develop the appropriate legal agreement for extraction. The Ministry of Mining is another particularly important public stakeholder for the development of new lithium projects because it has the competence to define the exact procedures and extraction agreements with possible lithium developers. However, there does not appear to be a clear delineation of responsibilities within the government to conclude an extraction agreement.

Other public agencies also have particular roles in overseeing lithium companies' operations but are less relevant for the industry's development. The Water General Direction is an agency of the Ministry of Public Infrastructure, which oversees water management and is involved in all major industrial developments. The Chilean Copper Corporation (Cochilco) advises the government on matters concerning the production of copper, its by-products, and other industrial mining—it thus has an influential role in the whole mining sector.

Finally, the Atacama communities' council (Consejo de pueblos Atacameños) represents the local Indigenous communities who populate the Atacama Salt Lake area and is an important stakeholder to be considered for the development of any new project.

3.3 Chile's Strategic Objectives for Lithium Production

Chile's developmental goals for its lithium industry are twofold. On the one hand, the government wants to make sure that production can be increased to meet growing global demand. It would also like to help businesses to add more value by moving from mere extraction to more downstream operations in refining and even the battery value chain.

First, in an effort to benefit from the expected increase in battery demand and in the context of increasing lithium prices before 2019, the government started the process of updating the contracts in place with Albemarle and SQM. This negotiation process was long and difficult, marred by scandals regarding public auctions of licences, challenges in court on the basis of the mines' environmental impacts, and even SQM's involvement in a campaign finance scandal ("Chile's SQM fires," 2015). This all somewhat undermined the legitimacy of the process in the eyes of the public (Mineria Chilena, 2012).

In an effort to address the controversy while improving lithium mining and its regulation, the administration created the National Lithium Commission in 2014. This Commission consisted of more than 20 professionals and included mining and environmental specialists, politicians, and Indigenous community leaders. It developed several proposals and suggestions to improve sustainable production and expand capacity while including local communities' development goals and environmental protection (Williams et al., 2014). It appears that many of these proposals were not implemented when governmental priorities changed.

The government did manage to reach new production agreements with both Albemarle and SQM in 2016 and 2018, respectively. These new contracts were agreed with Corfo and were much more detailed than their predecessors, specifying new production quotas, refining levels, stronger environmental standards, and ambitious expansion plans (Albemarle, 2017; Roskill, 2018). As of 2020, Chilean producers extract around 80,000 tons of LCE, and the expansions plans should allow the doubling of production within the next 5 years. Albemarle and SQM are currently seeking to secure contracts with international customers.

A second key objective of the government (and a proposal of the Chilean National Lithium Commission), is to improve the value added of Chilean lithium products. Extraction of lithium uses brine from the Atacama Salt Lake, in the northern part of Chile, and the first, relatively simple, stage of refining produces lithium carbonate (60% of 2017 SQM production) and hydroxide (23% of 2017 SQM production), both precursors to lithium used in battery production. Currently, there are no Chilean or international companies devoted to developing any part of the battery manufacturing value chain. However, the Chilean government aspires to change that and develop the first stages of battery manufacturing in the country.

Through its agreement with Corfo, SQM agreed to sell up to 25% of its production at special prices to companies devoted to developing lithium and battery products within Chile. After a failed public auction process in 2018, the government awarded the contract to Nanotec, a Chilean company dedicated to developing nanoparticles, in 2020. The auction revealed, however, that there was some international interest in developing battery-related technologies in Chile. Companies who participated in the first auction process included TVEL Fuel Company of ROSATOM (Russia), Sichuan Fulin Industrial Group Co. Ltd. (China), Jiangmen KanHoo Industry Co. Ltd. (China), Molymet (Chile), Gansu Daxiang Energy Technology Co Ltd. (China), UMICORE (Belgium), and Samsung SDI Co. Ltd. (South Korea). This broad participation suggests there may, in fact, be international interest in producing batteries in Chile, to respond to local content requirements, and in developing value-added activities in the lithium sector.

This tentative policy progress may be vulnerable, however, as Chile started experiencing considerable political uncertainty in October 2019. After many protests and riots in all major cities demanding better public management, the government agreed to call for a referendum to reform Chile's current constitution, which eventually took place on October 25, 2020. The whole process to develop a new constitution is expected to last almost 2 years and may have impacts on the regulation of economically—and politically—sensitive sectors like mining. In addition, the COVID-19 crisis has struck the country hard (Roser et al., 2020).

These two events have hurt the Chilean economy, and current forecasts estimate a 6% decrease in the country's GDP for 2020 (IMF, 2020). The current government, many companies, and almost all productive associations are engaged in the development of stimulus measures to promote economic growth (CEPAL, 2018). These short-term shocks, combined with the medium-term challenge of somewhat opaque regulatory processes around lithium mining, create uncertainty about the role of lithium mining in the country's economic development.

3.4 Trade and Investment Risks

The Chilean lithium industry has significant comparative advantages for lithium extraction and its first refining stages. The country holds most of the proven international reserves, and its extraction processes consume less fresh water and energy than in other countries, though it is also difficult to increase production as it uses natural evaporation driven by the sun's energy. However, the preceding sections point to several challenges that have hampered the development and expansion of the industry in the last years, and that will continue to constrain investments and operations if not carefully managed.

As indicated, the most significant challenge to achieving a more sustainable and reliable industry is the regulatory uncertainty related to developing new lithium extraction projects. Without well-defined procedures, informed compliance standards, and clear responsibilities within the government, effectively assessing and granting transparent authorizations for new lithium extraction projects will continue to be difficult. Consequently, the country's production is likely to continue to depend on the operations of SQM and Albemarle and the agreements they can negotiate with Corfo, at least in the short term. This opens the lithium business to risks related to the definition of Corfo's role and its capacity to design and agree contracts.

Environmental protection, sustainable water management, and local communities' engagement will also continue to be important challenges that will need to be taken into account in the sustainable development of Chile's lithium industry. Considering the public's concerns related to lithium and other extractive industries, companies may find their ability to expand constrained. Part of this opposition may be alleviated by guaranteeing the protection of the environment in other areas and ensuring responsible management of water use so communities and ecosystems can flourish, and the sharing of benefits with the communities through well-paying jobs and development projects.

The world's lithium supply is another challenge to keep in mind. Even though an increase in lithium demand is expected in the medium term, lithium prices are volatile, creating the risk of price reductions due to oversupply. Other factors affecting the potential future supply of lithium include the potential for development of new sources of lithium, since it is not as geographically concentrated as other minerals and the increase in supply of recycled lithium as recycling technology improves and increasing quantities of products such as lithium batteries reach the end of their lives.

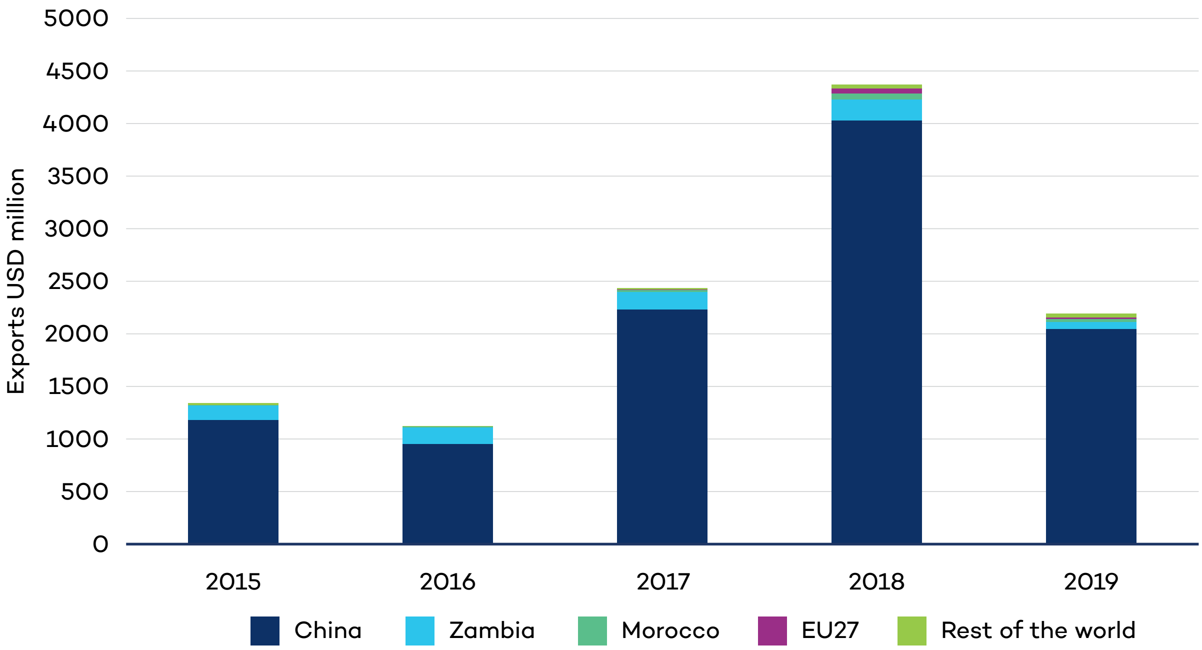
Finally, there are always challenges resulting from battery producers constantly working to develop safer batteries, with higher energy densities, at lower costs. At the present time, it appears that lithium-ion batteries will play a dominant role in the years ahead, but technological advancements are always possible. Furthermore, changes in the global perception of the lithium industry could increase pressure to diversify. Lithium producers and governments in lithium-rich countries should be aware of this risk and plan its long-run development accordingly.

4.0 Cobalt Production in the DRC

The DRC is the world's key source of cobalt. The United States Geological Survey estimates that the DRC represented about 71% of global cobalt production in 2019 and holds just over 50% of global reserves (U.S. Geological Survey, 2020a). No other country comes close to its production and reserves. The main reason for this is that cobalt is a metal generally found as an alloy, i.e., joined with another metal. As a result, cobalt is rarely mined on its own but is rather a by-product of copper and nickel. In many places, there is an insufficient concentration of cobalt alongside either of these two metals to make extraction economical. In the African Copper Belt, however, cobalt quantities occur in higher concentrations. Most of it is located in the DRC, which is also responsible for 88% of global cobalt exports (compared to 4% for Zambia, the next highest exporter) (van den Brink et al., 2020).

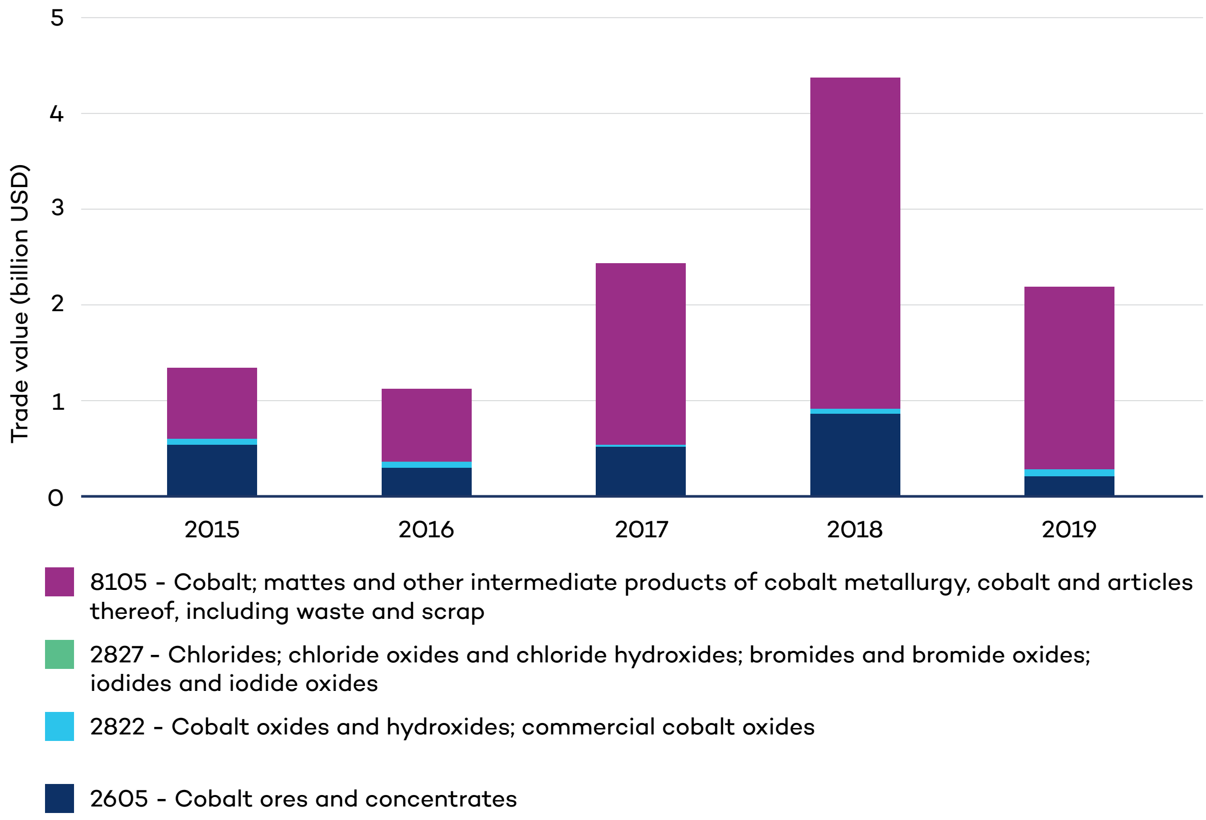
The refining of cobalt is as concentrated as its production: China is responsible for refining almost half of all mined cobalt (van den Brink et al., 2020). Of the top 10 refineries worldwide, six are in China (with the rest in Finland, Belgium, Zambia, and Japan). This means that China is also the key global importer since the country does not have sizable cobalt mines. In total, China accounted for 97% of world imports of cobalt (van den Brink et al., 2020). Not surprisingly, then, most DRC cobalt exports go to China, in quantities that rose steadily until 2018 before falling back (see Figure 3).

Figure 3. Cobalt exports from the DRC by destination country



Authors' analysis based on Comtrade data.

Figure 4. DRC cobalt exports by HS codes 2605, 2822, 2827, and 8105



Source: Authors' analysis based on Comtrade data.

Trade data also shows clearly that the DRC's cobalt exports have changed over the years. As recently as 2015, nearly half of cobalt exports (by value) were ores and concentrates. By 2018 this proportion had fallen to less than a quarter (see Figure 4). This is partly due to the threat of export restrictions on ores and concentrates designed to promote local processing (Organization for Economic Co-operation and Development [OECD], 2021a). On several occasions since 2007, the government of the DRC has taken steps to ban the export of ores and concentrates, but these bans have always been later cancelled or overturned. Increases in export taxes on these products have been introduced and upheld over this period. However, the threat of an impending ban has certainly created a signal to the market that seems to have had an impact (Roskill, 2021). This indicates that the country has taken steps to move up the value chain through greater domestic refining and that these had succeeded, at least by this measure.

4.1 Cobalt Industry Structure in the DRC

Mining is a key sector for the economy of the DRC, representing about 18% of its GDP and 98% of exports (Extractive Industries Transparency Initiative [EITI], 2020). In 2018 alone, metals and mineral exports accounted for USD 9.7 billion, more than half of which went to China. Of that USD 10 billion, USD 4.3 billion was in the form of cobalt exports, most of which going, again, to China (Chatham House, 2020). Besides cobalt, copper is also exported in large quantities, accounting for USD 5.3 billion in 2018, most of which goes to China, Zambia, Gulf states (the United Arab Emirates and Saudi Arabia) and South Korea.

There are two large types of cobalt mining in the DRC: industrial or large-scale mining (LSM) and artisanal and small-scale mining (ASM). While often considered distinct practices, there is extensive interaction between LSM and ASM across the entire upstream supply chain, with LSM operations sourcing cobalt from ASM and blending it with their own production (OECD, 2019).

Large-scale or industrial mining is responsible for over two thirds of cobalt production in the DRC. The key players fall into three broad groups (Sanderson, 2019a). First, there is the Swiss mining conglomerate Glencore, which operates two of the largest mines in the country (Mutanda and Katanga). Second, there are Chinese-owned companies that occupy 7 out of the top 12 cobalt mines in the DRC. In total, these mines account for about half of total cobalt output from the DRC. Third, there are several other companies from the Gulf and elsewhere that operate Congolese subsidiaries.

Artisanal mining is responsible for about a quarter to a third of total cobalt output in the DRC and between 140,000 and 200,000 jobs (OECD, 2019). Some of this artisanal mining is formal and registered. Most artisanally mined cobalt, however, is informal and outside of the legal code. This type of mining takes place on active or inactive parts of privately owned mining concessions, many of which were granted to LSM companies. Even if it falls outside of the legal framework, such informal artisanal mining still involves local and state authorities that verify ASM output (OECD, 2019).

Besides LSM and ASM, a key player is the state-owned mining company Générale des Carrières et des Mines (Gécamines). Until the 2000s, Gécamines had a monopoly on cobalt mining, but that changed when the DRC opened up to private investment as a result of a strong drop in mining output. Today, Gécamines is still involved in some mining, though they are now more important in terms of granting mining concessions outside of the licensing system set up by the Mining Code and setting up joint ventures with international companies (OECD, 2019).

4.2 The Political Context

One of the largest impediments to a trustworthy, ethical, and efficient cobalt industry in the DRC is its history and colonial legacy of fragile governance (Crawford & Church, 2018). To put this into today's context, the DRC is 161st out of 198 countries on Transparency International's Corruption Perception Index (Transparency International, 2020) and 5th out of 178 countries on the Fragile States Index (Fund for Peace, 2020). In terms of resource governance, the Natural Resource Governance Institute (2020) gives the DRC a mining sector value realization score of 69 points out of 100, which is relatively good. However, it highlights a revenue management score of 30 out of 100 and an enabling environment score of 12 out of 100.

This macro-level picture can be substantiated by practical experience in the DRC's cobalt sector. In principle, cobalt mining is governed by the DRC Mining Code, which was last updated in 2018. This update increased taxes and royalty rates for strategic minerals, which includes cobalt. It also sets out requirements related to the transparency and allocation of licences and contracts (EITI, 2020). That being said, Gécamines also holds a large number of mining concessions that are not covered by the DRC Mining Code. The granting of such concessions to LSM has been marred by a lack of transparency and corruption allegations (OECD, 2019). This dual system of licence and concession allocations continues today.

The DRC's cobalt industry has also been rocked by two large scandals in recent years. The first one related to corrupt mining deals, which were estimated to have deprived the Congolese state of over USD 1.3 billion in revenues (U.S. Department of the Treasury, 2017). The second corruption scandal involved the largest cobalt producing company, Glencore. In July 2020, the Swiss government opened a criminal investigation into Glencore over its alleged corrupt practices in the DRC (Hume & Jones, 2020). This investigation comes on top of several other corruption allegations and investigations, including the 2018 investigation by the U.S. Department of Justice (Hume, 2020) and the 2019 corruption investigation by the U.S. Commodity Futures Trading Commission (Farchy & Mazneva, 2019). These corruption scandals show how some governments are tightening their oversight of the activities of their multinational companies, intermediaries, and even state-owned mining companies, bringing (in addition to labour-related concerns) a spotlight on fraud and corruption associated with cobalt production and trade.

International efforts to reduce human rights violations, negative social impacts, and environmental damage such as the Responsible Minerals Initiative or the OECD Guidelines on Responsible Mineral supply chains have pushed international consumers of cobalt to seek sources of cobalt outside of the DRC and contract directly with producers they believe to be responsible (OECD, 2021b). This trend may create a risk for DRC-based producers if other competitive sources of cobalt become available.

4.3 Strategic Goals for Cobalt in the DRC

The DRC has two strategic and specific goals besides the general objective of improving the overall sustainability of all producers within the country (addressed below). First, the country wants to tighten its control of global cobalt markets. Most recently, it has aimed at doing so by establishing the government as the monopoly buyer of artisanally mined cobalt. By controlling around 25% of exports, the government hopes to get more control over international market prices. The system would require artisanal miners to sell to one single company that is a subsidiary of Gécamines (reported to be called "Entreprise Générale du Cobalt"). That company would then be the conduit that sells to downstream refiners. Despite having been confirmed in a governmental order in November 2019, it is unclear exactly how the system will work and when it will be implemented (Clowes & Kavanagh, 2020; Holland & Bujakera, 2020).

Second, the DRC seeks to keep part of cobalt processing within its borders. After extraction, cobalt goes through a first stage or “crude” refining process, which already adds value to the extracted raw cobalt. One challenge with some of these processes is that the processing of cobalt concentrates relies on the introduction of oxide to produce cobalt hydroxide. These oxide deposits are gradually depleting, and this will require companies to make capital investments to keep up refining capacity in the next decade (OECD, 2019). In the recent past, during the price slump, the DRC tried to implement export restrictions on cobalt and copper concentrate to encourage both price recovery and domestic crude refining (Hunter & Luk, 2019).

4.4 Trade and Investment Measures Regarding Cobalt in the DRC

There are two main types of private sector trade and investment concerns at play in the DRC: those related to supply chain responsibility and those related to supply chain reliability. The first deals with problems associated with cobalt production and their increased visibility worldwide. It is now well-known that various large-scale miners source material and cobalt from artisanal miners without adequate reporting. Since there are no clear regulations to recognize and register ASM, this LSM–ASM interaction is often reported as sourcing minerals from open markets rather than their actual ASM origin (OECD, 2019). Unethical practices such as inhumane salaries and child labour, which are not exclusive to the ASM sector but are considered to be more common in ASM operations, are severely under-reported because of a lack of due diligence rules and practices across the DRC, as well as a general lack of transparency in local supply chains (Bayer & Cooper 2019; Federal Institute for Geosciences and Natural Resources [BGR], 2019; World Economic Forum, 2020).

This means that the final cobalt used in batteries is difficult to trace and may be linked to irresponsible practices in the cobalt supply chain—which leads to increased pressure on consumers, companies, governments, and civil society to track the supply chain and hold actors accountable. The most noteworthy example of the pressure imposed on downstream manufacturers is the class-action lawsuit brought by a human rights group on behalf of victims injured or killed in ASM against Apple, Google, Microsoft, Dell, and Tesla in December 2019. The lawsuit identified both producers and intermediaries, including some of the largest cobalt producers, such as Glencore and Huayou (Dempsey, 2019).

These reputational risks can weigh heavily on producers and incentivize two reactions. On the one hand, they can engage in ensuring better traceability and performance of existing supply chains in the DRC. Because of supply chain concerns, several companies have decided to cut out intermediaries (see below). This type of vertical integration can open new possibilities for supply chain management. There has also been a rise in several company initiatives that engage explicitly or implicitly with the OECD Due Diligence Guidance. Companies such as Tesla, BMW, Volkswagen, and Ford also committed to the Responsible Minerals Initiative (RMI), which seeks to ensure that cobalt that finds its end purpose in EV batteries was mined responsibly. Another example is various downstream companies such as Volkswagen, BASF, BMW, and Samsung supporting the Cobalt for Development Initiative, which seeks to train artisanal miners on environmental, social, and governance aspects of responsible mining (BASF, 2020). Another example of directly engaging with supply chains is the teaming up of Ford, Huayou Cobalt, IBM, LG Chem, and RCS Global to use blockchain technology to trace where cobalt comes from (Lewis, 2019). More examples include the "Fair Cobalt Initiative" and the "Responsible Cobalt Initiative" that include Chinese refiners and top cobalt producers such as Glencore and others. A lot of these initiatives are new, and their ability to influence unethical practices remains to be proven.

On the other hand, downstream companies can try to reduce their dependence on cobalt from the DRC. They may do this because of supply chain reliability concerns since the results of the efforts described above will be under increasing scrutiny. The lack of supply chain reliability is linked to several factors. First, most of the production is centred around the DRC, which poses a supply risk in and of itself, even without taking into account ethical considerations. While it could help to alleviate some unethical practices in artisanal mining, the new plan to have Gécamines be the monopoly buyer of artisanally mined cobalt can also increase supply chain risks because there will be less diversification. Second, since cobalt is mined as a by-product of nickel and copper, the economics of cobalt mining is fundamentally tied to not only the cobalt market, but also the market of the host metal (van den Brink et al., 2020). And third, trade tensions with China have pushed countries to consider finding new cobalt supply chains, which could create cracks in the de facto DRC–China monopoly over cobalt-based battery production.

Public sector trade and investment measures imposed by the government of the DRC have tended to focus on encouraging domestic refining of cobalt. In 2013 the government of the DRC imposed an export ban on unrefined cobalt, as well as copper and tin, but the absence of local refining capacity reportedly forced it to waive the ban repeatedly; the latest indefinite waiver was issued in August 2020 (Reuters, 2020). According to domestic business associations, the lack of reliable energy supply in the country was one of the main barriers to the domestic refining of minerals (Radford et al., 2019).

The quasi-monopoly of cobalt from the DRC will remain a reality over the next decade. The pressure for major consumers to secure access to cobalt from the DRC is evidenced by increasing numbers of direct purchasing agreements between Glencore and key players such as China's refiner GEM Company (Sanderson, 2019b), Europe's largest battery manufacturer Umicore (Sanderson, 2019c) and the world's largest EV manufacturer, Tesla (Sanderson, 2020). However, there are also changes that may weaken this monopoly and the prospects of cobalt mining in the DRC in the longer term. The best example is Tesla, which, besides its direct cobalt trade deal with Glencore, has also announced its intention to eventually cut cobalt from its batteries altogether (AP News, 2020). Even in the medium term, though, uncertainty around policy settings could encourage players to consider alternative cobalt sources and to increase efforts to recover cobalt through recycling batteries that have reached the end of their economic life. There are possible alternatives in Ontario, for example. If battery producers can lower the amount of cobalt used, such other supply sources might offer possibilities for more significant substitution in the medium term.

5.0 Possible Trade Policy Considerations

The rise in demand for EVs, lithium-ion batteries, and the raw materials used to produce them will continue to create rising demand for the production of lithium and cobalt. As discussed in this paper, a significant quantity of these materials is produced in developing countries. This boom in global demand creates a number of trade-related issues for producer and consumer countries. Based on the global analysis and the case studies presented here, the following considerations could be relevant for policy-makers.

5.1 Addressing Social and Environmental Risks Associated With Mineral Booms

In a context of mineral booms and high prices, combined with weak states, where few opportunities for income generation exist beyond mining, there is a high risk of uncontrolled increases in artisanal mining and illegal or unethical labour practices, with significant environmental impacts. On the one hand, these concerns may lead to increased government regulation or control of multinationals by their countries of origin (as seen above), including potentially regulation, in addition to the many private initiatives in place, requiring certain raw materials to be ethically sourced. On the other hand, the increased demand for minerals that can be shown not to be associated with illegal or unethical labour practices could create a dual market, whereby a formalized and regulated part of the market serves the part of the market subject to effective regulation and, outside of this, unethical practices continue unabated.

In practice, many of the sustainable production initiatives are driven by the private sector in this area. Trade rules under the World Trade Organization (WTO) or regional trade agreements do not restrict the ability of the industry to adopt such voluntary standards, and their design and implementation remain largely unregulated. Nonetheless, the voluntary nature and the proliferation of these schemes raise several challenges. The predominance of industry-led responsible cobalt initiatives, for example, suggests that companies may be trying to demonstrate that regulation in this area is not required. The plethora of initiatives could also generate consumer (and regulator) confusion if the coverage and veracity of different standards are not clear. Enhanced transparency, combined with an independent review of such schemes, may help address part of the problem.

Beyond private sector initiatives, however, the primary responsibility to regulate mining practices rests with the host country, which has sovereignty over the resources. Evidence highlighted in this brief suggests, however, that not all host countries have the capacity to design, implement, and effectively monitor regulations or contracts. In light of this reality, the question arises as to whether home countries of the mining companies or simply importing countries should also assume responsibilities in this area to ensure sustainable extractive practices or the respect of human rights (Cottier, 2016). As demand rises, pressure to secure vital minerals while demonstrating that supply chains conform to ethical norms, end users of minerals may get more directly involved down the supply chain. This could be achieved through different instruments such as quantitative restrictions, labelling requirements, certificates of origin, or potentially "blockchain" distributed ledger technologies. To be credible, such measures should be supported by effective mechanisms to trace the origin of the resources and ensure compliance. A possible approach in this area could consist of establishing an international index or reference list of responsible miners, traders, investors, and/or shippers (Bellmann, 2016).

To avoid the extraterritorial nature of such measures and ensure that they do not undermine standards and regulations of the host state, they should be based on a set of internationally agreed uniform standards, as illustrated by initiatives in conflict diamonds. International standards, however, risk convergence around the lowest common denominator—a situation that may lead to less stringent labour or environmental standards than those required in more advanced countries. In the absence of harmonized standards at the international level, large importing and exporting countries could put emphasis on mutual recognition agreements or equivalences. Regional trade agreements may offer avenues to incorporate such efforts at promoting enhanced cooperation, as is already the case in a range of other areas.[1] Alternatively, this could be reflected in plurilateral sectoral initiatives following the model of the WTO Information Technology Agreement (ITA) or, many years ago, the EU coal and steel agreements. Such efforts could be supplemented with technical assistance and capacity building, including transfer of technologies to enable host countries and companies to comply with relevant standards.

5.2 Balancing Trade and Investment Policy for Investment and Value Addition

There is a delicate balance to be struck between allowing sufficient flexibility in business operations to attract investment for export and creating domestic employment opportunities for value addition or industrial development. In practice, most developing countries find it difficult to mobilize domestically the long-term investments needed to exploit their mineral resources and usually rely on foreign direct investment. This is often facilitated by providing an enabling environment including an open and predictable trade regime, effective border clearance mechanisms, good connectivity, including transport, logistics services, and information and communications technology. From an investor's perspective, lack of transparency and accountability (including complex and opaque licensing regimes), difficulties for investment due to corruption, complexity, or simply a slow-moving bureaucracy can create significant barriers to investment and trade.[2] The reluctance or inability of new entrants to enter a market or expand operations can, in turn, stymie value-added processing and exports more generally.

[1] See for, example, the sectoral Annex on Energy Performance Standards in the United States–Mexico–Canada Agreement (USMCA) or the chapter chapters on trade in renewable energy in the EU–Singapore or the EU–Vietnam agreement including disciplines on local content requirements, standards, regulations, and mutual recognition of conformity assessment procedures.

[2] This is arguably less the case for critical raw materials, where none of those issues seem to be stopping requests for licences for mining.

From the host state perspective, there are legitimate expectations that investments should create jobs, enable the country to move up the value chain, and diversify its economies. However, while the mining sector has significant potential to foster sustainable development, many of the benefits do not materialize automatically. In this respect, one approach consists of promoting forward linkages by undertaking the first stages of processing domestically and adding value to the raw material. Another strategy consists of fostering backward linkages by encouraging the use of domestic factors of production or encourage the development of local input providers for the extractive industry (Korinek, 2020).

Tariff barriers affecting minerals at a more advanced stage of transformation are relatively limited. While some countries like China or Korea still maintain some level of tariff escalation for lithium and cobalt products (i.e., higher tariffs on processed products compared to raw material) large exporters such as Chile or the DRC benefit from duty-free and quota-free market access on all large importing markets, be it through bilateral free trade agreements or trade preferences benefiting least developed countries.[3] As a result, most of the regulating efforts by host countries have focused on local content requirements, pricing regulation, export restrictions, the establishment of government-regulated monopolies, and licensing restrictions.

5.2.1 Local Content Requirements

To capture more of the potential benefits associated with mineral resources, governments often use local content policies. In practice, local content requirements (LCRs) may either be implemented through demand-side policies to encourage mining companies to procure goods and services from local suppliers or through supply-side policies to support local suppliers to compete with international suppliers (Ramdoo & Cosbey, 2019). They often impose a combination of binding quantitative requirements (e.g., number of contracts awarded to local suppliers or share of spending on local procurements) and non-binding qualitative targets (e.g., training or technology transfer). In many cases, LCRs are also complemented by other types of incentives in the form of tariff exemptions on imports of equipment for local suppliers, subsidies, access to finances, training, etc.

At the international level, LCRs are subject to WTO disciplines as defined under the General Agreement on Tariffs and Trade (GATT), the Agreement on Trade-Related Investment Measures (TRIMs), the General Agreement on Trade in Services (GATS), the Agreement on Subsidies and Countervailing Measures (ASCM), and the Agreement on Government Procurement (GPA). Overall, these disciplines impose strict conditions in terms of national treatment and non-discrimination and prohibit LCRs affecting the use of foreign inputs or the granting of subsidies contingent on the use of domestic over imported goods. Exceptions to these rules are relatively limited and mostly relate to public procurement or services if the member has not undertaken any commitment in this area. With many LCRs being primarily investment related, international and bilateral investment agreements also discipline the use of LCRs and impose additional limitations on top of WTO disciplines.

[3] Beyond tariff protection, however, it should be noted that countries manufacturing high tech and green tech products have provided subsidies or other incentives to their domestic companies.

In practice, however, these strict disciplines have not stopped the proliferation of LCRs—a situation that points to the inadequacy of existing rules and how they are enforced. According to earlier research by McKinsey (2013), 90% of resource-rich countries have at least one form of LCR in place, and half of these are of a quantitative nature. This, in spite of the fact that many LCRs have a net negative impact on the productivity of the sector and ultimately reduce investment incentives (Korinek & Ramdoo, 2017). LCR policies also often fail to achieve their stated objectives due to a lack of capacity to implement, manage, and monitor them. This reality suggests governments could consider whether agreeing a more pragmatic approach to existing disciplines, including for example a clarification of when and how they can be legally applied, might help make the rules more effective. This could take the form of an annex to the TRIMs Agreement. At the national level, lessons learned from successful practices point to the need to establish strong partnerships bringing together companies, government agencies, research institutions, and relevant stakeholders. Ramdoo and Cosbey (2019) also highlight the need to base policies on reliable data and evidence; use a combination of mutually support measures, including on the supply and demand side; and design adaptable and flexible policies to reflect the evolution of the situation.

5.2.2 Export Restrictions

Export restrictions are another tool used by governments to regulate the production and processing of mineral products. Many are introduced for environmental purposes, to reduce negative externalities associated with extraction, or slow down the pace of extraction. In other cases, government imposes them to encourage local processing and capture domestically a higher share of the value flowing from extraction (Korinek & Kim, 2010). By restraining exports, governments hope to divert these materials to the domestic market and give local industries access to cheap raw materials, thereby creating opportunities for employment and industrial development. From an importing country perspective, however, export restrictions have been firmly contested as unjustifiable restrictions on trade, particularly when imposed by suppliers controlling a large share of the world market.

In practice, export restrictions can take the form of export bans, quotas, duties and taxes, or mandatory minimum export prices. In the WTO, quantitative export restrictions are generally prohibited under GATT Article XI except for balance of payment or national security reasons, or under the general exceptions provided in GATT Article XX (for example for the conservation of exhaustible natural resources if they are applied in conjunction with domestic restrictions on production or consumption). Export bans or quantitative restrictions may, however, be applied temporarily to prevent or relieve critical shortages of essential products. By contrast, WTO disciplines contain no binding limitations on the extent to which members may impose export taxes.[4] As a result, most resource-rich countries have tended to privilege this form of export restriction on mineral products, and the use of such instruments has proliferated in recent years.

[4] Some newly acceded WTO members have nonetheless accepted to bind their export taxes at a certain ceiling level. Similar provisions also exist in some bilateral or regional trade agreements. For a full discussion of this topic see Korinek and Bartos (2012).

Export restrictions also entail a cost for countries applying them, by lowering returns on material, creating inefficiencies, and discouraging investment in the extractive sector. Empirical evidence by the OECD also suggests that in most instances they have failed to promote downward processing industries or generate employment. In some cases, they have even led to negative effects on the primary sector (Fliess et al., 2017). Avoiding disruptions in international market may require enhanced transparency and predictability in the use of allowable export restrictions, this could be achieved through notification requirements on export taxes and duties and by providing incentives to resource-rich countries to bind their level of export taxes to a maximum (Espa, 2015).

5.3 Avoiding the Boom and Bust in Lithium and Cobalt: The role of mining-related activities.

A key risk in the fast-evolving EV industry is that technology will bypass problematic or expensive materials, leaving countries that have grown dependent on mining them with stranded assets and the loss of mining-related jobs. While lithium appears to have a relatively certain market for the foreseeable future, the market for cobalt in lithium-ion batteries seems much less certain. This may be achieved by diversifying away from mining, and use revenue from mining to invest in other industries—but this is much more easily said than done. In practice, a more pressing question for producing countries will rather be how to avoid excessive dependence on certain minerals. This may be achieved by promoting the development of services, capital goods, or intermediate goods industries that support mining activities. In the case of the DRC, cobalt is primarily mined as a by-product of nickel and copper mining. The development of mining-related activities could support the extraction of other minerals should the demand for cobalt decrease in the near future.

In practice, this approach tends to offer wide opportunities with lower capital requirements and greater multiplier effects than investing in mineral processing and transformation (Korinek, 2013).[5] Over time, international mining firms have increasingly focused on their core business, with remaining activities being outsourced. Sustainability and resource-efficiency requirements in areas such as water and energy use, emission reduction, or waste treatment have created a significant potential for specialized goods and services. Chile has already undertaken steps in this direction by taking advantage of its concentration of mining operations. Other countries have successfully developed mining-related goods and services: these include mining equipment in Canada, metallurgy and technology services in Finland, and the development of mining software in Australia (Korinek, 2013). In turn, these activities offer important trade opportunities as the country becomes competitive in international markets. For countries that do not have a comparative advantage in developing a competitive downstream industry, focusing on the processing of minerals, policies fostering the development of mining-related goods and services (e.g., through specialized education programs or public–private partnerships) may provide opportunities for diversification and employment creation while reducing the country's dependence on mineral extraction in the face of market uncertainty.

[5] It should be noted, however, that new technologies in the mining sector are evolving rapidly and fundamentally changing the face of mining and the demand for mining-related products (e.g., software development). This evolution may affect local procurement if such trends are not well understood.

Box 2. Fostering a Regional Approach

One critical challenge encountered by mining companies considering new investment is the absence of existing infrastructures in areas such as transport, energy, or logistics. Such infrastructure can, in turn, serve other economic sectors and ultimately help foster economic diversification. For example, Ramdoo shows that in countries with important agriculture potential, connecting last-mile mineral infrastructure to farms, storage facilities, or markets can play a critical role in supporting agri-business supply chains as illustrated by the case of the Northern Corridor in Brazil (Ramdoo, 2015b). In many developing countries, however, the limited size of domestic markets requires a coordinated approach with regional partners to establish cost-effective transnational projects. This, in turn, can foster regional integration, link markets, and enable the movement of goods and people within the region. Connecting infrastructure across borders can also lead to improved accessibility and economies of scale, potentially unlocking other economic benefits. In a similar vein, resource-rich countries might want to promote the development of regional value chains focusing on backward or forward linkages. Regional integration schemes in particular can play a critical role in removing intra-regional barriers to trade and complement efforts at creating national clusters around extractive industries. Extending local content requirements to a regional market, for example, can constitute (together with other coordinated measures), a first step in incentivizing such regional value chains.

6.0 Conclusion

This policy brief considered the impact of the EV raw materials boom, with a specific focus on lithium and cobalt as components of EV batteries, and how trade policy could play an important role in helping developing countries capture value from this expansion while managing the risks of overinvestment, so as to provide a reliable source of revenue and improve development and economic outcomes.

Broadly, current forecasts suggest that demand for EVs will continue to rise in the coming decades, and with it will demand for lithium as a component of lithium-ion batteries. Recent volatility caused by surging demand, and then surging supply, does not appear to have discouraged investment in lithium production, and demand is projected to keep growing. By contrast, the market for cobalt is likely to tighten in coming decades as demand for battery chemistries changes, because of the mineral's toxicity and the environmental, social, and governance problems associated with its mining.

The case study of Chile, which accounts for 23% of global lithium production but which holds 50% of global reserves, illustrates the opportunities for revenue generation and value addition that the EV boom presents, but also the challenges of developing transparent and efficient regulatory processes to facilitate investment in the sector while balancing domestic political pressures. Reasonable expectations of continuing demand growth suggest the risk of overinvestment in lithium production is limited. Requiring some lithium to be sold to domestic players or on regional markets appears to be a useful way of attracting foreign investment in battery manufacturing and other value-adding activities (judging by the interest already expressed), but ensuring investment contributes to development objectives will require coordination across several areas of policy and engagement with local stakeholders. Such a process would be greatly facilitated by ensuring transparency in institutional structures and processes. Part of the revenue from lithium mining could be reinvested in local communities. This would help reduce the environmental impact of the activity and support education and training, thus enabling local employment in mining-related services and refining services and battery manufacturing, should this be pursued.

The case study of the DRC, which holds a virtual monopoly on the world's supply of cobalt with 71% of production and 50% of global reserves, is a useful contrast because it illustrates, conversely, a situation where there is a real risk of overinvestment in production and refining of cobalt, demand for which appears likely to fall in the coming decades. Previous attempts to impose export bans on cobalt have been abandoned because of a lack of domestic refining capacity; had they been successful, they may even have increased the risk of stranded assets if demand falls as projected. Instead, the DRC's virtual monopoly position for cobalt, combined with the importance of mining other compounds (copper, tin) for which demand may be more stable, suggests that if cobalt revenues could be maximized in the short term, they could then be reinvested in the basic infrastructure, governance, and education required to build local capacity to provide mining-related services to other local extractive industries. However, without basic governance and labour and environmental standards, these may not render such development sustainable either.

Developing country governments have a range of trade and investment policy options available to them to maximize the development outcomes they can achieve from the EV boom. Policies should obviously be chosen to fit particular political and economic contexts, but with a clear view of the long-term development of this fast-changing industry. Where demand for key raw materials looks stable in the medium term, policies that leverage domestically sourced inputs to attract investment in value-adding activities would appear to be a good long-term option as long as the "created" industries are economically viable. Where demand for a key material is volatile, and in particular where it is likely to fall, trade measures to encourage domestic refining of those minerals run the risk of stranding assets, and revenue might be better applied to supporting diversification of economic activity in the extractives sector.

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Appendix 1. Lithium and Cobalt Production

Table A1. Lithium global production per country (metric tons)

Country	2015	2016	2017	2018	2019*	Reserves
United States**	W	W	W	W	W	630,000
Argentina	3,600	5,800	5,700	6,400	6,400	1,700,000
Australia	14,100	14,000	40,000	58,800	42,000	2,800,000
Brazil	200	200	200	300	300	95,000
Canada				2,400	200	370,000
Chile	10,500	14,300	14,200	17,000	18,000	8,600,000
China	2,000	2,300	6,800	7,100	7,500	1,000,000
Namibia				500		NA
Portugal	200	400	800	800	1,200	60,000
Zimbabwe	900	1,000	800	1,600	1,600	230,000
Other						1,100,000
World total (rounded)* **	**31,500**	**38,000**	**69,000**	**95,000**	**77,000**	**17,000,000**

Source: U.S. Geological Survey, 2020b.
*Forecasted data
**Withheld to avoid disclosing company proprietary data
****Does not include the United States.

Table A2. Cobalt global production and reserves per country (metric tons)

Country	2015	2016	2017	2018	2019*	Known reserves
United States	760	690	640	490	500	55,000
Australia	6,000	5,500	5,030	4,880	5,100	1,200,000
Canada	6,900	4,250	3,870	3,520	3,000	230,000
China	7,700	NA	3,100	2,000	2,000	80,000
Congo (Kinshasa)	**63,000**	**64,000**	**73,000**	**104,000**	**100,000**	**3,600,000**
Cuba	4,300	4,200	5,000	3,500	3,500	500,000
Madagascar	3,700	3,800	3,500	3,300	3,300	120,000
Morocco	NA	NA	2,200	2,100	2,100	18,000
New Caledonia	3,680	3,390	NA	2,100	1,600	NA
Papua New Guinea	NA	2,190	3,310	3,280	3,100	56,000
Philippines	4,300	4,100	4,600	4,600	4,600	260,000
Russia	6,200	5,500	5,900	6,100	6,100	250,000
South Africa	3,000	2,300	2,300	2,300	2,400	50,000
Other	16,200	10,600	7,650	5,540	5,700	1,100,000
World total (rounded)* **	**126,000**	**111,000**	**120,000**	**148,000**	**140,000**	**7,000,000**

Source: U.S. Geological Survey, 2020b.
*Forecasted data

Annex 2. Global Trade Data on Lithium and Cobalt Products

To understand how trade in minerals related to electric vehicles is affecting developing countries, an analysis of trade data for two key minerals, lithium and cobalt, was conducted in the leading developing country producers, Chile and the Democratic Republic of Congo respectively.

Key product (HS) codes were identified and used to extract data from the UN's Comtrade database to assess a) changes in overall values of exports b) changes in the destination country for exports and c) changes in the types of products being exported, for example from unrefined ores to refined products such as oxides and unwrought metals. A list of codes is presented in Table A2 below, and trade data is presented in the country case studies.

Table A3. Cobalt and lithium HS codes

	HS Code Level 1	HS Code Level 2	HS Code Level 3	Commodity Description
Cobalt	26	2605	260500	Cobalt ores and concentrates
	28	2822	282200	Cobalt oxides and hydroxides; commercial cobalt oxides
	28	2827	282734	Chlorides; of cobalt
	81	8105	810520	Cobalt; mattes and other intermediate products of cobalt metallurgy, unwrought cobalt, powders
	81	8105	810590	Cobalt; articles n.e.c. in heading no. 8105
Lithium	28	2825	282520	Lithium oxide and hydroxide
	28	2836	283691	Carbonates; lithium carbonate
	28	2836	283699	Carbonates; n.e.c. in heading no. 2836 and other than lithium or strontium
	85	8506	850650	Cells and batteries; primary, lithium

Source: Authors' analysis.

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