

Connection Between Chinese Refineries and DRC Cobalt Mines, 2015-2020

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ABSTRACT

With increasing demand in electric cars and consumer electronics devices, the lithium batteries market has rapidly grown. This correspondingly increased cobalt demands, however cobalt production is not able to match up the demand rate due to limited resource availability. Democratic Republic of Congo produces the world's most amount of cobalt, however the country's political instability and unprogressive financial and social infrastructures make resource development projects difficult. As demand for cobalt increases globally, it is essential for everyone in the cobalt industry to take responsibility in improving identified socio-environmental risks. The first step is to identify who has the most immediate direct influence in DRC mines - through this research, I've identified that Chinese refineries dominated the cobalt market, with engagement trends shifting from owning mine shares and exercising purchasing powers to direct ownership. There haven't been any notable improvement projects initiated by Chinese refineries to address social conditions in Democratic Republic of Congo.

KEYWORDS

minerals supply chain, responsible minerals sourcing, supply chain traceability, social compliance.

INTRODUCTION

Electronic devices are integrated into our everyday life, connecting global communities. The minerals used in electronic devices and their sourcing conditions, on the other side, remained fairly unconnected and distant between producers and customers until recent decades. The main raw materials used to build semiconductors and circuit boards were collectively called 3TG and had been watched by international communities through the Dodd-Frank Act established in the 2010. Meanwhile, cobalt, the main material of lithium-ion batteries essential for consumer electronic devices and vehicles, has only recently gained attention in the past couple of years and not yet has a regulation to be controlled and monitored throughout the electronics supply chain.

Cobalt demand has been steadily increasing with the rise of electric vehicles and is expected to grow at 7 to 13 percent annually from 2017 to 2030 (Alves 2018). The cobalt market struggled to meet this rising demand, as cobalt production is heavily reliant on a single supply country. Approximately two-thirds of the global cobalt supplies are mined in DRC, Democratic Republic of Congo (WMD 2021), while the rest of the combined production outputs from countries outside of the DRC - Australia, Russia, and Zambia - declined, producing 28% lower than a decade ago (BMO, 2017). This trend is concerning, as more concentrated demand on DRC cobalt would mean more exploitation and fights for their cobalt resources. DRC mines historically had signs of financing armed rebel groups that smuggled and sold various minerals, including more than \$400 million in diamonds and gold (Kaplan 2007) alone into the international market. Because of the huge profit minerals bring to the DRC's economy, its community also started relying on mining sales as the major source of living. Roughly 8 to 10 million people (or 16 percent of DRC population) made a livelihood by direct employment in the Artisanal and Small-scale Mining (ASM) sector alone (World Bank, 2008), including many children from poor families working at mine sites. Despite the prevalence of child labor and forced labor from these conflicted armed groups, the DRC government took a passive stance on regulating cobalt mines conditions.

More cases of these child labor and forced labor as well as poor living conditions in DRC mining were reported globally. Instead of helping to address these conditions, many developed countries' businesses and other cobalt supply chain stakeholders decided to take the easy route -

disengaging from DRC cobalt, especially those sourced from ASM mines. China was an economically emerging nation at the time, and they took this opportunity to accumulate a dominant share of ownership across the cobalt supply chain by making direct foreign investments through their state-owned enterprises. Between 2006 and 2017, China invested \$33B in mining across Africa (Tim De Chant, 2020) leveraging their government state capitals, with China's M&A activity in metals hitting a record high in 2018 (MassifCapital, 2019). As a result, China's government grew ownership and influence over half of the DRC cobalt extraction. (Foreign Policy, 2019) Then, when extracted from mine sites, cobalt is often bought and refined within the DRC by Chinese international traders. From there, cobalt is mostly shipped to mainland China for processing. Through this process, China is responsible for more than 80 percent of the world's refined cobalt (BMO) with three Chinese firms responsible for 46 percent of the world total (Darton Commodities, 2018). Tracing cobalt chains this way demonstrates how the global communities heavily rely on China for cobalt supplies.

With such evident Chinese dominant influence on the cobalt supply chain, understanding Chinese refineries' relationship with DRC cobalt mines was critical for stakeholders in the cobalt supply chain to collectively promote more responsible cobalt procurement practices. Thus, my meta-analysis review examined how Chinese refineries gained their influence over DRC cobalt mines over time. First, I presented collected data demonstrating why the connection of DRC and Chinese Refineries is an area of study. I anticipated obtaining study results indicating that most of the major DRC cobalt products will have some sort of linkage with Chinese refineries. Second, Of those mines with identified connections to Chinese refineries, I examined how the engagement methods of Chinese refiners with DRC cobalt mines changed over time. I hypothesize that the majority of the influence Chinese refineries held on DRC cobalt mines grew, with engagement methods shifted from mining project partnerships and purchasers to direct owners of cobalt mines over time.

Lastly, I examined and analyzed whether Chinese companies' impacts have expedited or mitigated socio-environmental risks in DRC mining conditions. This question was inspired by an IMF case study (Landry, 2017) suggesting potential DRC economic disruption with Chinese investment, especially from DRC obtaining commercial loans from China that will increase DRC's debt. In contrast, the DRC government believed that with Chinese funds, DRC will be able to construct fundamental societal infrastructures. I examined whether this DRC

government's expectation is valid. I expected to see both positive results of a decrease in illegal smuggling and forced labor, as well as the negative side effects of some residents unwillingly losing jobs as Chinese refineries take over mine operations. I concluded this paper with recommendations on what direction the industry stakeholders should head to help foster positive collaborations between Chinese refineries and DRC communities.

BACKGROUND OF DRC SOCIAL RISKS

Health Risks

There were two parts of health risks cobalt poses to the DRC community: direct health risks from participating in mining practices, and indirect health risks from polluted environments coming from mining activities. DRC communities residing near the mines also suffered from a lack of sanitary infrastructures, clean and drinkable water, and occupational diseases caused by mercury used to dig minerals in mine sites. Mercury often polluted the water resources around the mining communities and insufficient water filtering infrastructure posed notable health threats. Direct health risks were more concerning, as miners are exposed to working long hours without breaks, spending several weeks underground digging minerals where the underground mines are not well ventilated (Amnesty International 2016). Many studies confirmed chronic exposure to cobalt dust can lead to fatal lung disease, including respiratory sensitization, asthma, and shortness of breath. (NIEHS, 2002). Thus, United States Centers for Disease Control and Prevention (CDC) advised all cobalt miners working to wear respirators, impervious clothes, gloves, and face shields (NIOSH, 2015). However, the 2002 DRC Mining Code (and its 2018 revision) did not include specific guidelines to examine miners' health, no protocols on how to safely handle cobalt substances, nor any enforcement to provide safety equipment to miners. With the absent enforcement on workers' health monitoring, there was no evident linkage between discussed health issues and cobalt mining conditions. On top of that, miners were exposed to fatal accidents. Many accidents were not recorded, as many were unlicensed workers working in unauthorized mining areas. Thus, despite these unsafe situations, miners chose to continue working at mines without reporting their grievances.

DRC Children

Many children participated in DRC cobalt mining activities, and yet there were no defined regulations to protect children. With the 2005 and 2008 Trafficking Victims Protection Reauthorization Acts, DRC cobalt was reported as goods produced by child labor by the US Department of Labor since at least a decade ago in 2009. DRC is also a party of the International Labour Organization (ILO) Worst Forms of Child Labour Convention (ILO No. 182), where ILO requires governments of each party to take immediate and effective measures to secure the prohibition and elimination of the worst form of child labor (ILO 2017). However, there is no evidence of the DRC government taking an active stance to follow ILO's guidelines.

Oftentimes, family poverty is the primary reason children work at mine sites. In 2018, more than 70 percent of DRC communities lived below the international poverty rate a day (World Bank). Although the 2009 DRC Child Protection Code mandates free and obligatory primary education for all children, schools pressured parents with education costs such as school uniforms and books. As poor families were not able to afford those costs, many children instead worked. Of these children, 23% worked in mines. (Benjamin et al, 2017). Due to excessive mining activities, children suffered from health disruptions. Children were also taken financially advantage of by traders, as children were not able to verify on their own the weight of the minerals they mined. As a result, children often accepted what traders offered to pay.

Stakeholder Limitations

DRC Government

In 1999, DRC established SAESSCAM, the government agency regulating artisanal mining and improving conditions for artisanal miners. The 2002 Mining Code required artisanal mining to take place only in authorized Zones (ZEAs). With this code, SAESSCAM officers were required to be present at ZEAs providing safety training. However, there were not enough ZEAs to accommodate all workers that wanted to mine in DRC, with only 40 ZEAs opening up in the entire copper and cobalt mining region of Kolwezi, DRC (World Economic Forum, 2020). Because SAESSCAM officers only operated and controlled conditions in ZEAs, the majority of artisanal miners operated in unauthorized and uncontrolled mining areas, where the government was not able to actively regulate miners' safety and labor conditions. Additionally, DRC Labour Code included inspecting worksites for child labor and ensuring that they abide by health and

safety rules. The Labour Code prevented employment under 16, but child labor was still prevalent in DRC mining with ongoing media articles reporting this issue. This was criticized by UN human rights monitoring bodies and many other NGOs for the DRC government's failure to put adequate resources on taking ownership and responsibility of improving mining conditions.

Companies in Cobalt Supply Chain

Stakeholders in the cobalt supply chain included upstream companies and downstream companies (OECD 2019). Upstream companies are categorized as mines, traders, and smelters and refiners. Under the 2016 OECD guidance, the smelters and refiners were annually expected to trace the source of minerals back to the point of extraction, abiding by the chain of custody rule of keeping all the documentation on their traced cobalt sourcing information and providing requested data by downstream companies. Downstream companies included component producers, contract manufacturers, and electronics and automobile companies. They were not expected under OECD Guidance to trace the cobalt in their products back to the mine level. Instead, downstream companies were asked to collect and report smelters and refiners listed in their supply chain and make proper business decisions to work with smelters and refiners with proper due diligence in alignment with OECD Guidelines.

Because the majority of downstream companies only report a list of conformant smelters and have not allocated more resources to evaluate suppliers based on responsible mineral practices, no practical influences were made. Meanwhile, upstream companies also have not focused on procuring human rights risk-free minerals, because taking that action has not incentivized winning their business with downstream companies. Even when downstream companies mandated conflict-free sourcing, upstream companies chose to simply disengage with mines with allegations, most of which were small-scale minings. Despite knowing this disengagement norm, many downstream companies stayed silent, as long as their goal of a conflict-free supply chain was achieved. As a result, many livelihoods in small-scale mines were impacted.

Industry Coalitions

Several industry coalitions worked with companies to promote responsible mineral sourcing and tracing programs. The most influential industry coalition was Responsible Business Alliance (RBA)'s Responsible Minerals Initiative (RMI), providing Conflict Minerals Reporting

Template (CMRT) for downstream companies to collect Smelters and Refiners (SOR) in their supply chain and to publicly disclose their SOR lists following Dodd-Frank Section 1502 compliance requirement. In December 2018, RMI released Cobalt Reporting Template (CRT) to help downstream companies additionally collect cobalt refiners in their supply chain and practice due diligence following OECD Due Diligence Guidance. Based on the collected information, RMI's Smelter Engagement Team (SET) continued ongoing efforts to contact identified 3TG and cobalt smelters to validate their standing business operation. Further, RMI conducted Responsible Minerals Assurance Process (RMAP) assessment to certify that examined SORs have responsible minerals management and sourcing practices by reviewing minerals inventory SORs received from mines in the record. Ideally based on the assessment result, downstream companies were able to influence their component producers to purchase minerals from RMAP or equivalent certified SORs.

International Minerals Guidance

OECD Due Diligence Guidance

The UN Guiding Principles on Business and Human Rights outlined the responsibility of companies to respect international human rights in their global operations, including their minerals supply chains. It required companies to carry out human rights due diligence. Guidance for how such due diligence should be carried out was provided by OECD, through its Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas (CAHRA). However, because there has been no evidence to indicate that cobalt revenues financed armed groups in the DRC, cobalt was excluded from the regulation.

CCCMC and Chinese Regulations

In 2014, OECD signed a Memorandum of Understanding with the Chinese Chamber of Commerce of Metals Minerals & Chemicals Importers & Exporters (CCCMC), to promote the OECD Guidance in China. The CCCMC has since published its own Chinese Due Diligence Guideline for Responsible Mineral Supply Chain. CCCMC complements other Chinese regulatory measures that can be used for cobalt trading. For instance, the Ministry of Commerce for the Government of the People's Republic of China (MOFCOM) and its provincial departments are

responsible for regulating the foreign investment by Chinese companies, which majority of Chinese refineries' investments in cobalt are done this way.

United State's Dodd-Frank Act

As fundamentals of minerals supply chain risk mitigation efforts, Dodd-Frank Act Section 1502 states that publicly listed companies in the United States are obligated to publicly disclose their investigation efforts in how the minerals were traded and used in their supplychain, ensuring that no significant human rights violations are involved in their value chain. However, there was a hidden consequence of the Dodd-Frank Act. After their investigations, corporations have chosen to rather immediately boycott minerals coming from DRC, instead of extensive but expensive due diligence to trace the exact origins of minerals. As a result, rather than cutting financial funding for armed groups, this threatened many ASM miners' job securities.

Research Limitation

On ground data collection was challenging, firstly due to restricted circumstances on safely traveling DRC, but also collaborating with NGO to obtain data was challenging since research work done in DRC has significantly dropped since COVID-19. For the period of 2020to the first half of 2021 when this meta-analysis was conducted, we have been fighting the COVID-19 crisis, with global traveling restrictions. Thus, instead of conducting an on-time data analysis, I decided to sum up all spreaded research done on the cobalt mine sector, and provide a concise overview for readers. I plan to move forward with my research as I continue my career inthe responsible sourcing sector, and examine ways to bring industry collaboration in the electronics sector.

METHODS

Annual Cobalt Production by Country

Data on annual cobalt production by each country was collected to validate why studying cobalt mines in DRC would represent the norm of cobalt supply trends. I examined USGS (accessed annual publication from 2017 to 2021) and World Mining Data (reviewed bi-annual data of 2016, 2018, and 2020) to identify the top 5 countries by production, china's production yield, and the total production output globally on the most recently available data in 2019. To Analyze

this data, I graphed the top 5 countries' change in production in the past 5 years and used Herfindahl-Hirschman Index (HHI) calculated from the World Mining Data. The HHI measures concentration in commodity markets used to determine competitiveness in the examined market sector, calculated by summing the squares of the market share of each firm in the market (U.S Dept. of Justice). The U.S. The Department of Justice defined HHI ranges as following: HHI value between 100 and 1000, indicates examined data is not concentrated. HHI between 1500 and 2500 signals a moderate concentration, and HHI above 2500 indicates a highly concentrated market. Based on this definition, I will confirm the visual trend I observed from my graph.

Top Operating Cobalt Mines in DRC

A list of top operating cobalt mines in DRC was collected by each mine's production amount to ensure conclusions made from this study represent the majority of DRC cobalt mine conditions. To obtain a list of all existing cobalt mines I reviewed IPIS Cobalt Mine Data in DRC which provides an overview of all reported cobalt mines in DRC. On Figure 1, Grey (26.2%) indicated a pure cobalt site, while brown (73.8%) indicated copper mines that produce cobalt as a by-product. Additionally, to obtain a list of top cobalt producing DRC mines, I used 2018 publicly released data sources from Darton Commodities, Inc. I added up productions from identified top mines and compared them with USGS and World Mining Data's total DRC cobalt production by metric tons to ensure these top mines accurately represent DRC cobalt mines by production yield percentage.



Figure 1: IPIS interactive Map. International Peace Information Service (IPIS) collected data on DRC ASM from 2009 to 2018 and published publicly available data where users can filter out mines based on sourced minerals.

Chinese Refineries Engaged with DRC Cobalt Mines

Chinese refineries linked with identified top operating cobalt mines were identified to analyze their connection and engagement methods in the cobalt supply chain. I reviewed media articles and NGO data using each identified cobalt mine as keywords to find any owners and shareholders of each DRC mine that are linked to Chinese refineries or state-owned mining enterprises. Then, I reviewed annual investor documents and financial statements published in each Chinese refiner's public websites to collect engagement methods and level of engagement with each DRC mine (Table 2). Additionally, I conducted another desktop research on media articles and NGO reports to understand the conditions of each DRC mine, and whether Chinese refiners took action to improve DRC mines' socio-environmental conditions.

RESULTS

Annual Cobalt Production by Country

The total production of cobalt ranged from 120–148 kt on an annual basis in USGS cobalt Database. The total production was from 125-158kt on World Mining Data. Based on the

two datasets, I identified the top 5 countries: DRC, Russia, Australia, Cuba, and Canada, in the order of production yield (Figure 2). Although other countries take a noticeable portion in cobalt production, examining HHI Values in (Figure 3) indicates how the rest of the countries bring no competitiveness in the market, while DRC exceeds 2500, indicating its high competitiveness. These top 5 countries represented a total cobalt production between 95-136kt (Table 1). Of Those, 69-111 kt was produced in DRC, representing 60-70 percent of global cobalt supply.

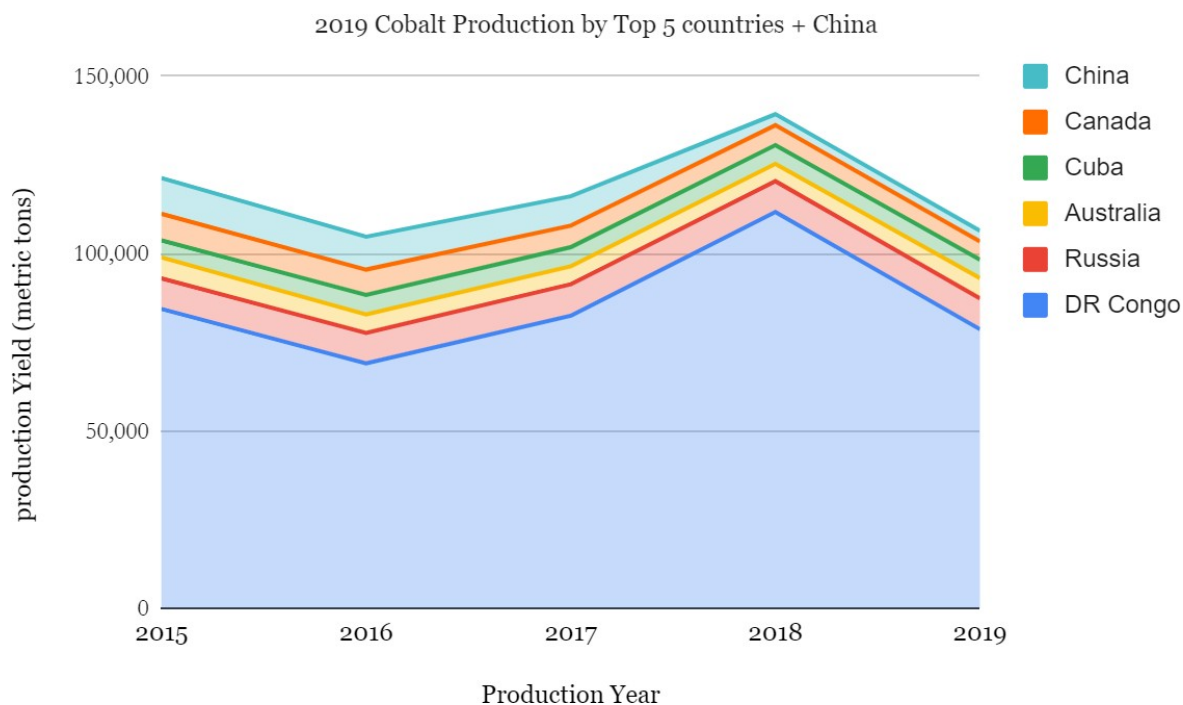


Figure 2: Cobalt Production Yield of Top 5 Countries and China. This figure visually indicates DRC accounts for the majority of cobalt production. China's cobalt production decreases overtime, initially part of the Top 5 countries but losing that status by 2018.

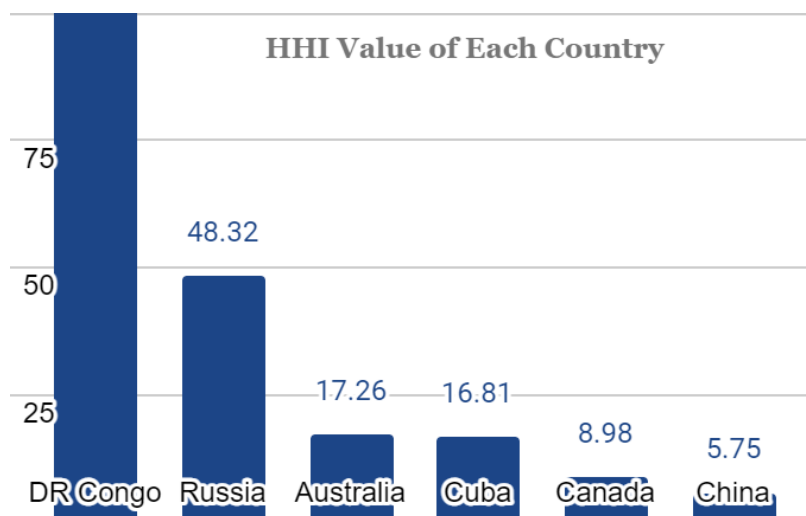


Figure 3: HHI Value of Top 5 Countries and China. Only DRC's HHI Value (off the chart; HHI Value 3950.34) indicates that cobalt resources are highly concentrated in DRC. Note that there is no unit for HHI value.

World Mining Data 2021					
	2015	2016	2017	2018	2019
Top 5 sum production	111,212	95,483	108,035	136,199	103,442
Top 5 output % globally	75.64%	73.03%	78.02%	86.01%	82.65%
USGS Cobalt Production 2021					
	2015	2016	2017	2018	2019
Top 5 sum production	86,400	88,800	92,800	122,000	118,540
Top 5 output % globally	68.57%	72.20%	77.33%	82.4%	82.32%

Table 1: Top 5 Countries with Cobalt Production in Global Market. Top 5 sum production refers to the summed output from top 5 cobalt production countries from figure 2. Top 5 output % globally indicates how much out of global production do Top 5 countries account for each year.

Top Operating Cobalt Mines in DRC

I identified 42 DRC cobalt mines from the IPIS Cobalt Mine Data (available in Appendix C). Two trends are evident: (1) All DRC cobalt mines were located in Haut-Katanga or Lualaba province, and (2) the majority of cobalt mines also produced copper. Of the DRC cobalt mine list, I have identified the 14 largest cobalt mines in DRC based on the 2018 Data from Darton

Commodities. Production yields for 4 cobalt mines were not publicly available. When I summed up production yield (available in Appendix D) for the rest of the 10 cobalt mines in the most recently available data of 2019 to 2020, the outcome of 78,246 tons, or 82% of total DRC-produced cobalt of 95,000 tons. Based on this number, I concluded that analyzing identified top cobalt mines can fairly demonstrate the norm of DRC cobalt mines.

Chinese Refineries Engaged with DRC Cobalt Mines

Of identified 14 largest DRC cobalt mines, 10 mines showed direct and/or obvious signs of engagements from Chinese refinery businesses. Through desktop research on reviewing institutional publications and trading databases, I found all engagements to fall under three engagement categories (Table 2): (1) direct ownership through subsidiary operations, (2) purchasing agreements with owner of DRC mine, or (3) mines were constructed by Chinese companies as pilot mining project, through investments from the Chinese government or state-owned enterprises.

Unfortunately, the evidence on Chinese refineries driving more responsible minerals mining practice, or investment on improving DRC mining condition were mostly unavailable. Of 10 DRC mines that had connection with Chinese refineries, 6 mines had no signs of positive and/or negative influences done by Chinese refineries. Of the remaining 4 mines, the investment amount or specific corrective action plans and evidence to improve DRC mine conditions were unknown. Some of the major Chinese refineries demonstrated efforts in working with industry coalitions. For instance, Huayou collaborated with UK supply chain audit firm RCS Global to develop a mobile app that would enable miners to report accidents and death directly to Huayou. However, the effectiveness of this program is unknown, as the smartphone coverage among miners is unavailable. Meanwhile, continuous death reports from both COVID-19 and occupational incidents were reported by the media, such as Amnesty International and the Reuters. China Molybdenum (CMOC) was also called out by African NGO crisis group that they hired a minimal local labor force. This worsened during COVID19, as CMOC terminated a few lasting contracts that supported the area's economy. Lastly, Wanbao Mining that owns DRC's Kamoya and Lamikal project committed to invest 683,000 USD to help build educational and health service infrastructure near its owned mines. They ambitiously stated to construct 4 underground wells and

20 water intake points, though the actual progress is unknown especially from the COVID-19 impacts.

Table 2: Top 10 DRC Cobalt Mines with Chinese Refinery Business Engagement.

Cobalt Mine	Chinese Stakeholder	Current Engagement
Congo Dongfang Mining	Zhejiang Huayou Cobalt	Ownership as subsidiary
Ruashi Mining	JinChuan Group	Ownership as subsidiary: 75%
Mutanda DRC	Shenzhen GEM Co.	Purchasing Agreement through Glencore with 70% Ownership to mine. Purchases 1/3 of mine's output
Kamoto Copper	Shenzhen GEM Co.	Purchasing Agreement through Glencore with 55% Ownership to mine. Purchases 1/3 of mine's output
Tenke Fungurume Mine	Chinese Molybdenum (CMOC)	Ownership, 80% Partial ownership to Chinese government
Metal Mines	Nanjing Janrui Cobalt	Ownership as a subsidiary, invested by China's Ministry of Commerce
Kamoya	Wanbao Mining Ltd.	Mining project initiated by Wanbao Engineering Co.
MJM	Guangdong Jiana Energy Technology Co., Ltd.	Ownership as subsidiary
MKM	China Railway Engineering Corp.	Mining project; CREC owns 80% of mine shares and invested 39M USD

DISCUSSION

DRC as Critical Cobalt Producer

I observed some misaligned data between USGS and World Mining Data. This is because the traceability between trading companies do not always keep accurate records of procured cobalts. Also, there is misalignment between the amount of cobalt produced at mine site, and the amount of cobalts reaching international trading centers in documented ways, as some are lost from smuggling and illegal transporting activities. Additionally, cobalt is not a primary supply, but mostly a byproduct of nickel and copper production. In fact, nickel mines account for roughly 55% of the world's cobalt production (Cobalt Institute). Thus, we see that the majority of the DRC cobalt mines are focused around the Katanga Copperbelt in Lualaba province, eastern DRC where nickel and copper mines are concentrated.

Chinese Mining Engagement Strategy

Traditionally, DRC's mine projects faced resource development risks from lack of infrastructure and political instability. Thus, many mines initiated their operation by distributing shares to the investors. Chinese took opportunities to put early investments in growing DRC cobalt mines, and increased their shares throughout past decades. Example of this is China's JinChuan group safely mining cobalts by co-investing with Gecamine, the DRC state-owned enterprise. Strategy on expanding their engagement worked well. Now, to safely expand their control in cobalt mines on ground, Chinese refineries need to improve networks with local governments to respond to sudden governmental changes regarding mining policies. This can be partially done by revisiting the Infrastructure-For-Minerals Deal with DRC in 2008, where China agreed to help build social infrastructures in DRC communities in exchange for owning mine shares. This agreement can help Chinese Refiners to give a friendly impression to the DRC local community, bringing two parties close together to discuss the next step on fostering the local miner hiring process.

Cobalt Phase-Out Option

There are several options to phase out from heavily relying on cobalt. Purchasers can procure DRC cobalts in more responsible sourcing methods by only buying responsible minerals from Chinese refineries, reduce the amount of cobalts used in lithium-ion batteries and other critical components of electric devices, or phase out from the cobalt supply chain. Most effective option is to examine the possibility of phasing out cobalt in lithium-ion batteries. This option is appealing, as it significantly reduces cost of electronic devices and vehicles. Batteries account for about one-third of electric vehicle cost, of which China manufactures nearly 80 percent of the world's battery. Cobalt-free battery means not only localizing cathode supply chain and production and reducing miles traveled by all the materials that end up in the cathode by 90 percent to reduce the overall cost, but also to decentralize the weight China has on the cobalt market. However, to date, no commercial lithium ion batteries without cobalt can match the performance of those with it.

Recommendations

In the short term, all in the cobalt industry should follow OECD guidance and chain of custody rule to increase traceability. In the next 5 years, downstream companies should start collecting SOR lists in product-level CMRT, instead of company-level CMRT, meaning companies are requesting their suppliers to take extra due diligence to reporting SORs relevant to minerals going into their product only. The DRC government should promote more formalization of ASM sites, bringing unregistered ASM sites under properly licensed ZEA to be monitored by SAESSCAM officers. Additionally, more capital will have to flow back into mining to improve the situation. If the DRC government's financial capacity is fragile to take this role, potential solutions can come from more of the major refineries and battery companies owning shares and assets of DRC mines.

Concurrently, industry business coalitions should take a more active stance on examining cobalt supply chain. Traditionally, influence downstream industry coalitions can make was limited. The limitations RMI face is that their RMAP assessment is not legally required. Often, RMI needed to reach out to smelters multiple times to convince them to go through RMAP assessment, which assessment cost and employee resources dedicated to support the assessment process had been costly to smaller-scaled smelters and refiners. Because RMI operates from the company's membership fee and donations, RMI was financially constrained from providing more support. No cost-and-benefit analysis was done on why the RMAP process could bring them long-term financial returns. Especially since COVID, some SORs have dropped out of their RMAP participation. The solution to this would be for downstream companies to take a firm stance on only doing business with suppliers buying from RMAP certified SORs, so suppliers would put financial pressure on SORs to conduct a minimal human rights risk assessment.

Lastly, for a long term strategy, cobalt substitution in batteries and improved cobalt recycling infrastructure will be the key to mitigate risks, while reducing cost. Cobalt resources are limited. The global community does not have accurate data on when reservoirs will run out of cobalt, but examining ways to replace cobalt with more sustainably mined, more available minerals would be a key future step. If alternatives could not be found, every stakeholder should bring up cobalt recycling discussion to re-use extracted cobalt, instead of exploiting more natural resources through methods like deep sea mining.

Broader Implications

The significance of this study lies in identifying the stakeholders and operators of DRC mines to understand what improvements stakeholders can make to improve DRC's socio-environmental conditions. The findings prove the clear connection between DRC mines and Chinese refiners as major purchasers and owners. Outlining these engagements and connections would be the primary step, before discussing potential improvement Chinese refiners can make, such as enforcing business contracts with mines only with safety gear present on site. This study shows further implications for addressing the passive behavior among other stakeholders in the mining industry. For the consumer electronics industry, material sourcing price was the core factor determining purchase decisions. Considering the rising human rights issue awareness and sufficient demands for cruelty-free products globally, the possibility of promoting responsible minerals purchasing behavior will depend on companies putting more resources to build traceability in their supply chain and make this information available to the public for consumers to make responsible purchasing choices.

ACKNOWLEDGEMENTS

I want to thank my family for all the warm support throughout my academic career at UC Berkeley. Another huge thank you to professor Patina Mendez from ESPM 175 for not only the technical support on the research paper, but more importantly the encouragement and kind guidance on this project. I would also like to thank all the peers I met at UC Berkeley who inspired me to never give up on my path on a sustainable business career. Lastly, I thank my sustainability team for providing non-stop inspiration for me to find passion in designing responsible business programs and to look into human rights risks in the supply chain.

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APPENDIX

Appendix A: World Mining Data Cobalt Production: Top 5 Country & China

Country	2015	2016	2017	2018	2019	Share in 2019	Share HHI
DR Congo	84,400	69,038	82,461	111,713	78,664	62.85%	3950.34
Russia	8,600	8,600	8,900	8,700	8,700	6.95%	48.32
Australia	5,930	5,183	5,034	4,878	5,746	4.59%	17.26
Cuba	4,793	5,514	5,407	5,300	5,200	4.15%	16.81
Canada	7,489	7,148	6,058	5,608	5,132	4.10%	8.98
China	10,093	9,293	8,300	3,100	3,000	2.40%	5.75
Total Production	147,032	130,739	138,472	158,358	125,158	Note: Annual global production change: -14.88%	

Appendix B: US Geological Survey Mining Data: World Mine Production and Reserves

Country	2015	2016	2017	2018	2019	2020	Reserves
DR Congo	63,000	66,000	73,000	104,000	100,000	95,000	3,600,000
Russia	6,200	6,200	5,900	6,100	6,300	6,300	250,000
Australia	6,000	5,100	5,030	4,880	5,100	5,700	1,400,000
Cuba	4,300	4,200	5,000	3,500	3,800	3,600	500,000
Canada	6,900	7,300	3,870	3,520	3,340	3,200	220,000
China	7,700	7,700	N/A	2,000	2,500	2,300	80,000
Total	126,000	123,000	120,000	148,000	144,000	140,000	7,000,000

Appendix C: IPIS Identified DRC Cobalt Mines Visited May 19th, 2019.

	Cobalt Mine	DRC Province	Minerals	
1	Bridon	Lualaba	Cobalt	NA
2	Carriere 52	Lualaba	Cuivre (Copper)	Cobalt
3	Chabara Kansunki	Lualaba	Cuivre (Copper)	Cobalt
4	Chache	Lualaba	Cuivre (Copper)	Cobalt
5	Chipuki	Lualaba	Cuivre (Copper)	Cobalt
6	Drain UCK	Lualaba	Cuivre (Copper)	Cobalt
7	EMAK-C	Lualaba	Cuivre (Copper)	Cobalt
8	Goma1	Lualaba	Cuivre (Copper)	Cobalt
9	Goma2	Lualaba	Cuivre (Copper)	Cobalt
10	Kabushona	Haut-Katanga	Cobalt	NA
11	Kafwaya	Lualaba	Cuivre (Copper)	Cobalt
12	Kaki3	Lualaba	Cuivre (Copper)	Cobalt
13	Kamilombe rouge	Lualaba	Cobalt	NA
14	Kamilombe2	Lualaba	Cuivre (Copper)	Cobalt
15	Kaminafitshi	Haut-Katanga	Cuivre (Copper)	Cobalt
16	Kampemba	Haut-Katanga	Cuivre (Copper)	Cobalt
17	Kanina	Lualaba	Cuivre (Copper)	Cobalt
18	Kansuki Kimbalasani	Lualaba	Cuivre (Copper)	Cobalt
19	Karaji popo	Haut-Katanga	Cuivre (Copper)	Cobalt
20	Kasulo CDM	Lualaba	Cobalt	NA
21	Kayebala	Lualaba	Cuivre (Copper)	Cobalt
22	Kimbalasani	Lualaba	Cuivre (Copper)	Cobalt
23	Kimbeja	Lualaba	Cuivre (Copper)	Cobalt
24	Kimono	Haut-Katanga	Cobalt	NA
25	Kimpese	Haut-Katanga	Cobalt	Or (Gold)
26	Menda	Lualaba	Cuivre (Copper)	Cobalt
27	Menuiserie	Lualaba	Cuivre (Copper)	Cobalt
28	Midingi	Haut-Katanga	Cuivre (Copper)	Cobalt
29	Milele	Haut-Katanga	Cuivre (Copper)	Cobalt
30	Mukwanto	Haut-Katanga	Cobalt	NA
31	Mulondo 1	Lualaba	Cuivre (Copper)	Cobalt
32	Mulondo 2	Lualaba	Cuivre (Copper)	Cobalt

33	Mutoshi Mining	Lualaba	Cuivre (Copper)	Cobalt
34	Mwilu	Lualaba	Cobalt	NA
35	Ndjukumabwe	Lualaba	Cobalt	NA
36	Remblais 55	Lualaba	Cuivre (Copper)	Cobalt
37	Remblais 612	Lualaba	Cobalt	NA
38	Ruwe	Lualaba	Cuivre (Copper)	Cobalt
39	Shikiya Bintu	Lualaba	Cobalt	Fer
40	Tilwizembe intermediaire	Lualaba	Cuivre (Copper)	Cobalt
41	Tulizembe	Lualaba	Cuivre (Copper)	Cobalt
42	Twilizembe intermediaire	Lualaba	Cuivre (Copper)	Cobalt

Appendix D: Top 10 DRC Cobalt Mines with Publicly Available Annual Production

CDM	Ruashi Mining	Mutanda DRC	Kamoto Copper	Tenke Fugurume
21,400 tons in 2019 22,253 tons in 2018 19,777 tons in 2017 20,685 tons in 2016	5070 tons in 2019 4752 tons in 2018 4638 tons in 2017	27400 tons in 2020 katanga (23,900), Mutanda shut down 2020 42200 tons in 2019 Katanga (17,100), Mutanda (25,100) 38400 tons in 2018 Katanga (11,112), Mutanda (27,300) 23900 tons in 2017 Mutanda (23,900) Katanga (N/A)		8614 tons in 2019 9029 tons in 2018 7364 tons in 2017
Chemaf Etoile / Usoke	Metal Mines	Big Hill	MKM	Sicomines
6200 tons: Usoke (2400 +Etoile (3800)) ~7000 tons in 2018. ~5000 tons in 2017.	4000 tons cobalt concentrate + 5000 tons cobalt metal	Max 5500 tons, year unknown	0.35 tons in 2020	61.65 tons in 2020