COBALT SUPPLY CHAINS: GLOBAL RESPONSIBILITY FOR CHILDREN'S RIGHTS IN THE DEMOCRATIC REPUBLIC OF CONGO 2018-2022

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ABSTRACT
This study examines child labour practices within the cobalt supply chain of the Democratic Republic of Congo (DRC) through the lens of the Global Production Network (GPN) framework. The findings indicate that, between 2018 and 2022, the DRC supplied over two-thirds of the world's cobalt, with national reserves reaching 4 million metric tonnes, approximately 48% of global reserves. The Artisanal and Small-Scale Mining (ASM) sector contributes 15–30% of national production, yet operates with minimal regulation, rendering it highly vulnerable to exploitation. UNICEF (2014) estimates that around 40,000 children are engaged in cobalt mining, while the CLMRS recorded 5,346 child workers in two key provinces. External interventions such as the COTECCO project have enhanced monitoring capacity (+38%), but regulatory implementation and certification remain largely administrative, lacking substantive transformation in governance. The GPN analysis highlights that disparities in value distributions and risks within the cobalt supply chain stem from the dominance of global actors, weak local governance, and fragmented cross-sectoral collaborations. This study underscores the necessity of global governance reform, local capacity strengthening, and genuine commitment from consumer countries and multinational corporations to ensure the protection of children's rights and the creation of an equitable and sustainable cobalt supply chain.
Keywords: cobalt, child labour, Global Production Network, supply chain, governance, DR Congo

ABSTRAK
Penelitian ini mengkaji praktik buruh anak dalam rantai pasok kobalt Republik Demokratik Kongo (RDK) melalui perspektif Global Production Network (GPN). Temuan menunjukkan bahwa RDK memasok lebih dari dua pertiga kobalt dunia pada 2018–2022, dengan cadangan nasional mencapai 4 juta metrik ton atau sekitar 48% cadangan global. Sektor Artisanal and Small-Scale Mining (ASM) berkontribusi 15–30% dari produksi nasional, namun minim regulasi sehingga rawan eksploitasi. Data CLMRS mencatat 5.346 anak pekerja di dua provinsi utama. Dari intervensi eksternal seperti proyek COTECCO tersebut, kapasitas monitoring telah mengalami

peningkatan sebanyak +38%, namun implementasi regulasi dan sertifikasi masih terbatas pada kepatuhan administratif tanpa transformasi substantif dalam tata kelola. Analisis GPN menegaskan bahwa ketimpangan distribusi nilai dan risiko dalam rantai pasok kobalt merupakan konsekuensi dari dominasi aktor global, lemahnya tata kelola lokal, serta fragmentasi kolaborasi lintas sektor. Studi ini menegaskan pentingnya reformasi tata kelola global, penguatan kapasitas lokal, serta komitmen nyata dari negara konsumen dan perusahaan multinasional untuk memastikan perlindungan hak anak dan terciptanya rantai pasok kobalt yang adil dan berkelanjutan.
Kata kunci: kobalt, buruh anak, Global Production Network, rantai pasok, tata Kelola, RD Kongo

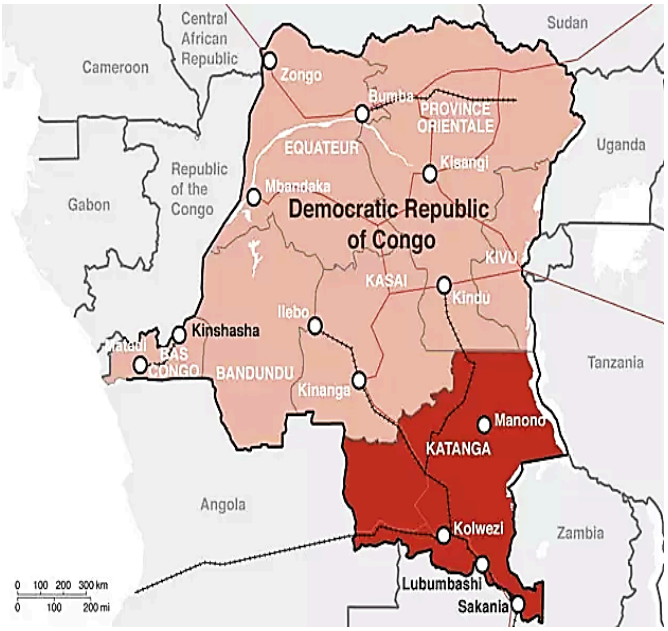
INTRODUCTION

As a key material in lithium-ion batteries for electric vehicles (EVs) and modern electronic devices, cobalt is a strategically important mineral in the global industry. Demand for cobalt is increasing with the global transition to clean energy and the rapid growth of the EV and other electronic technology industry in general with multinational companies such as Apple, Tesla, and CATL relying heavily on cobalt supplies from major producers (Brink et al., 2020; Sovacool, 2019; U.S. Geological Survey, 2023). In this regard, the Democratic Republic of Congo (DRC) plays a central role in the global cobalt supply chain by supplying more than two-thirds of the world's production in the 2018-2022 period (EITI, 2019), with almost half of the world's total reserves (Zegers, 2023; World Economic Forum, 2020). The cobalt mining sector is a major pillar of national exports and a source of foreign exchange, although it only contributed around 3.94% of total hard mineral production in 2017 (Crundwell et al., 2020; U.S. Geological Survey, 2023).

The significance of DRC in the strategic-mineral supply chain is further amplified by its position as the leading country of coltan (columbite-tantalite) production, accounted for about 40% of global production in 2019 with estimated 80% of the world's tantalum reserves (Ojewale, 2022). This mineral is also critical for electronic industries, with approximately 60% of global coltan consumption is used in capacitors for smartphones, computes, and medical devices (Taka, 2011). Similar to cobalt, coltan is extracted predominantly through artisanal and small-scale mining (ASM), an unregulated sector which faces governance, environmental, and human right issues, with estimated 40% of its workforce is child labour and many women exposed to gender based violences (Ojewale, 2022; Wakenge et al., 2018). These challenges highlight the systemic failures within the mineral production in the DRC, since many artisanal miners (80%) do not have access to formal health care; 40-50% of children of school-going age living in mining areas do not go to school, which indicates a lack of social or economic welfare since children are forced to work (Taka, 2011; Wakenge et al., 2018; Ojewale, 2022). Child labour exploitation happens alongside ongoing challenges of child welfare. For example, net primary school attendance data taken between 2018 and 2021 was below 78% and for secondary school only 32% with almost six million children aged 6-17 out of school nationally (UNICEF, nd; UNICEF, 2018). Approximately 40% of children under the age of five are stunted due to chronic malnutrition and almost half of under five deaths are attributable to malnutrition

(UNICEF, 2018). The under-five mortality rate is estimated at 73 per 1000 live births while the basic health service coverage is only 42 in the WHO Coverage Index (WHO, 2021). The DRC also has one of the highest rates of adolescent births in the world at approximately 109 births for every 1000 girls aged 15-19 (World Bank, 2022). These vulnerabilities or deprivations such as limited education, poor health, and high fertility rates intersect with the attraction of small-scale mining creating an ongoing cycle of children uniquely subjected to the labour exploitation in mineral-rich areas.

Figure 1. Map of Cobalt Mining Distribution in the Democratic Republic of Congo



Source: BatteryIndustry.net (2021, April 7). https://batteryindustry.net/congo-launches-state-artisanal-cobalt-buyer-to-meet-booming-demand/

Figure 1 shows the colour-coded territory of the Democratic Republic of Congo (DRC), the colour pink representing areas with few cobalt mining operations, and dark red where cobalt mining operations are prevalent. The types of mining operations are fragmented between ASM (*Artisanal and Small-Scale Mining*) which is informal and located near settlements with minimal supervision, and LSM (*Large-Scale Mining*) which is managed by large corporations with stricter operational standards (Amnesty International & Afrewatch, 2016; Sovacool, 2019). ASM are critical nodes in global supply chains due to its informality and weak state oversight (Maiotti & Katz, 2019), while LSM face social and environmental challenges despite operating with better standards (Crundwell et al., 2020; Sovacool, 2021; Campbell, 2020).

This phenomenon is able to be explained by the prevalence of child labour, especially in ASM that lack regulations. According to UNICEF in 2014, around 40,000 children were estimated to be involved in mining, including cobalt mining, where they work in hazardous conditions without adequate protection and access to education (Kadek et al., 2024). CLMRS 2024 data recorded 5,346 child labourers in the two main provinces, Haut-Katanga and Lualaba, showing that the problem has not improved

(USDOL, 2024) Family economic pressures, weak state protection, and economic incentives from global demand reinforce the cycle of poverty and social vulnerability in cobalt mining areas (AfDB, 2022). Ideally, the protection of children's rights has been guaranteed by various international conventions such as ILO No. 138 and 182, as well as national regulations (Neal, 2019). However, the implementation is far from expectations. The gap between norms and reality is exacerbated by weak supervision, limited institutional capacity, and global demand pressures that often ignore ethical aspects (Campbell, 2020; Zegers, 2023). Government efforts such as illegal mining bans and law enforcement have not been effective in curbing child labour (Human Rights Watch, 2022; Opakas, 2023). Thus, despite its strategic role, DRC faces a harsh reality in the protection of children's rights.

Meanwhile, global cobalt supply chain studies have been growing, highlighting the DRC's strategic position and social issues in ASM (Brink et al., 2020; Crundwell et al., 2020; Amnesty International & Afrewatch, 2016; Sovacool, 2021). Most of the studies have discussed on the technical aspects of supply chains, such as the risk of supply disruptions and local structural issues, but the social dimensions and accountability of global distribution have not been explored deeply (Coe & Yeung, 2015; Gereffi, 2018; Grabs & Ponte, 2019; Kim et al., 2017). The framework that suitable to provides an important perspective for understanding the dimensions that are rarely touched upon, like how global actors engage with each other in the distribution of value, power, and risk in the mineral supply chains is the Global Production Network (GPN) (Coe & Yeung, 2015; Gereffi, 2018). However, in the context of cobalt supply chain and child labour issue, the application of GPN is still limited, resulting in a significant research gap.

Radebe & Chipangamate (2024) have explained that the centralisation of the cobalt trade networks can cause serious vulnerabilities because a disruption in supply at one point may spread globally. In line with this, Li & Zobel (2020) and Mishra & Singh (2021) emphasised that building resilience in supply networks and developing cleaner production designs are impotant steps to reduce these risks. By contrast, Schuh et al. (2013) have highlighted the high complexcity of global production network design, although their research does not link this complexity to social dimensions. In the other hand, supply chain fragmentation and weak monitoring have been identified as loopholes that informal actors exploit for child labour practices (ILO, 2019; Amnesty International & Afrewatch, 2016; Sovacool, 2021). Not only that, global pressure on strategic mineral supply chains without strong governance increases grey spaces for exploitative practices (Radebe & Chipangamate, 2024; Brink et al., 2020; Opakas, 2023). Here, the unequal distribution of added value is also a concern. Most of the economic value of cobalt goes to consumer countries and multinational corporations, while local communities in the DRC bear the brunt of social and environmental externalities (Campbell, 2020). Industrialised countries such as China, the United States and Europe are the main destinations for cobalt exports, with China accounting for around 80% of total exports (OEC, 2025). Cobalt refined abroad is processed into high-value batteries and components, reinforcing global inequalities in the distribution of economic benefits (Brink et al., 2020; Zegers, 2023; Campbell, 2020; Crundwell et al., 2020).

In the context of the *Global Production Network* (GPN), every actor in the supply chain, from local miners, exporters, technology companies, to end-consumers, has a responsibility: moral, legal and economic to ensure that the cobalt supply chain is free from child exploitation practices (Pease, 2016; Bellamy, 2023; Opakas, 2023). However, GPN-related stakeholders are often dominated by multinational corporations, while social risks and negative externalities are pushed upstream the supply chain in producing countries, (Kim et al., 2017; Coe & Yeung, 2015). Ethical certifications and audits implemented by consumer countries are also often not accompanied by equitable redistribution of economic value (Deberdt & Le Billon, 2022; Ford & Nolan, 2020). For example, The Tenke Fungurume mine owned by China Molybdenum (CMOC) in the Democratic Republic of Congo (China Molybdenum, 2022), is one of the world's largest producers of cobalt and copper, with a production capacity of over 200,000 tonnes of copper and 17,000 tonnes of cobalt per year (Daly, 2021). Reports indicate unsafe working conditions, violence against workers who report safety violations, and the forced expulsion of traditional workers by the army in 2019 (Searcey et al., 2021). Local communities are affected by environmental pollution, while the Congolese government has repeatedly questioned CMOC's compliance with the contract, leading to legal disputes and temporary changes in mine management (Anderson, 2023). These operations take place amid weak governance and local power struggles, leading to tensions between small-scale miners and company management (Searcey et al., 2021). The research of Anderson (2023) added another relevant study case such as Glencore's involvement through Mutanda Mining and Kamoto Copper Company which also demonstrate the power imbalance in the cobalt supply chain, where the company prioritise profit while local communities bear the social and environmental risks, including child labour, unsafe mines and displacement of local communities. These dynamics underscore the need for stronger regulation, transparency, and a more equitable economic distribution in GPN.

Therefore, this research offers an academic contribution by integrating the GPN framework in the analysis of child labour issues in cobalt supply chains, filling a gap in research that has often separated *supply chain* analysis from social dimensions (Coe & Yeung, 2015; Gereffi, 2018; Grabs & Ponte, 2019; Kim et al., 2017). By combining analyses of the position and power of global actors, supply chain dynamics, and local stakeholder challenges, this research presents a more comprehensive understanding of how cross-actor interactions and technological innovation can strengthen supply chain resilience, transparency and risk management, including for cobalt minerals (Zhao et al., 2023; Wieland, 2020; Aldrighetti et al., 2021; Fan et al., 2015). Not only that, this research also draws on recent findings of digitalisation in the supply chain, the development of adaptive network designs, and the role of multinational corporations in setting sustainability standards while shifting social risks to the upstream level of the supply chains.

Therefore, this study argues that the protection f children’s right in cobalt mining cannot be achieved without the fair distribution of global responsibility along the supply chain (Pease, 2016; Bellamy, 2023; Opakas, 2023). Child exploitation in the Democratic Republic of Congo is not only the result of weak local governance, but is also driven by global demand pressures, consumer country policies, and the dominance of multinational companies in the cobalt market (Brink et al., 2020; Sovacool, 2019).

Hence, the analysis of this research aims to examine the interconnectedness between the structure of the global supply chain, child rights violations in the DRC, and the effectiveness of external interventions such as COTECCO project initiated by the US in collaboration with ILO and local partners. Furthermore, this reseach recommendations empasise the importance of supply chain transparency policies, ethical ceticication, and multi-stakeholder collaboration involving producer countries, concumer countries, companies, and civil society to strengthen child protection that is fair and based on human rights-oriented supply chain monitoring and certification mechanism (Sovacool, 2019; Brink et al., 2020).

LITERATURE REVIEW

The issue of child labour in the Democratic Republic of Congo's (DRC) cobalt mines portraits the paradoxes of globalization. By supplying more than two-thirds of the world's cobalt needs for the high-tech industries and supporting the clean energy transition, DRC has become the heart of the global cobalt supply chain and a symbol of international dependence (Brink et al., 2020; Crundwell et al., 2020; USGS, 2023). However, behind the narrative of clean energy transition and digital revolution that is often-glorified, lies a bitter reality: thousands of children are trapped in a dangerous labour environment of artisanal mines. Amnesty international & Afrewatch (2016) described how they lose their childhood by carrying heavy materials among rocks and mud, while facing serious health risk to help their family's economy. An ILO report (2019) asserts that this practice is not an anomaly, but part of a fragile economic structure that is perpetuated by global demand. Sovacool (2019) even characterises this phenomenon as one of the most brutal forms of exploitation in the history of the modern mineral industry.

The massive cobalt's global demand for technology and renewable energy industries has affected the expansion of the scale of artisanal and small-scale mining (ASM) in the DRC. Yet, as noted by Brink et al. (2020) and Sovacool (2019), ASM in the DRC is prone to human rights violations due to lack of supervision and regulations that are pro-worker rights. This situation makes ASM a fertile ground for child labour practices, driven by family economic pressures and the absence of state protection (ILO, 2019; Human Rights Watch, 2022). Meanwhile, on the upstream landscape, major costumer nations and multinational corporations are competing to secure supplies for electric vehicles (EV) and smart devices (Kallitsis et al., 2020). This global reliance creating supply chain that are not only vulnerable to disruptions but also reinforce economic incentives for child exploitation in the informal sector.

The vulnerability of the DRC cobalt supply chains to global disruption has been widely addressed in several studies. Li and Zobel (2020) introduced the concept of "ripple effects", which explains how disruptions at one point of supply chain, whether due to conflict, the change of policy, or social disasters, can destabilise the global industries systemically. Sun et al. (2022) emphasise that the cobalt supply chain crisis is likely to be extended to other sectors, highlighting the DRC's strategic yet fragile position in the global mineral production network. This risk is exacerbated by supply chain fragmentation, inadequate monitoring system, and insufficient local government capacity (Zegers, 2023). In this context, supply chain digitalization and technology innovation come forefront in solving these problems. Wieland (2020) emphasised the

need for future-oriented and resilient supply chain management through transparency and early detection of disruption. Zhao et al. (2023) found that digitalization enhances resilience and performance by improving visibility, while Aldrighetti et al. (2021) emphasise the importance of integrating resilience cost into network design. A reconfigurable supply chain approach (Dolgui et al., 2020) and the use of big data in risk management (Peng et al., 2021) also strengthen the industry's capability of responding more effectively to trends in the markets and social pressures.

However, the existing literature also suggests that the solution to child labour in the cobalt sector is not sufficient with local interventions alone. The involvement of external actors, especially major consumer countries such as the United States, is crucial in building more ethical and sustainable supply chain governance. Through that, the United States initiated the COTECCO project with the ILO and Pact, which focuses on strengthening national capacity, developing a Child Labour Monitoring and Remediation System (CLMRS), and cross-sector collaboration between governments, mining companies and civil society (Zegers, 2023).

On the other hand, the Global Production Network (GPN) approach provides an important theoretical foundation for understanding the dynamics of actors and the distribution of power in strategic mineral supply chains. Coe and Yeung (2015) emphasise that GPN not only explains the physical flow of goods production, but also maps the social, political, and economic relationships among the actors involved. Gereffi (2018) has explained that large companies often set production and sustainability standards in their counties as costumer without considering their impact on communities upstream in the supply chain. Grabs and Ponte (2019) ague that this pattern creates value and risk imbalances, whereby economic gains accumulate in the developed countries while social burdens are borne by the producing countries. Kim et al. (2017) add that the global production network (GPN) approach can be used to trace points of vulnerability to human rights violations, including child labour practices. In the context of cobalt mining industry in the DRC, the GPN framework helps explain how global inequality combine with weak local regulations perpetuates such exploitative practices.

By reviewing literature on child labour, supply chain risks, supply chain digitalisation, humanitarianism, and GPN theory as outlined above, a thinking framework can be developed based on four main pillars:

1. Global demand and the structure of strategic minerals market, are the main drivers of cobalt production expansion in the DRC, making the country an important hub in the global supply chain. Within the framework of GPN, the DRC's position as a weak producer highlights the imbalance in value and power distribution in the global economy (Coe & Yeung, 205; Gereffi, 2018) The high demand from the high-tech and energy industries has increased pressure on the producer countries without being balanced by improvements in local-governance or social protection (Brink et al., 2020; Kallitsis et al., 2020; USGS, 2023).
2. Local government and social vulnerability, for instance, the exploitation of child labour in the ASM sector of DRC, are the demonstration of how risk in the GPN is often to be transferred to upstream actors. Structural inequalities prevent local actors bargaining power to set standards or secure social rights (Grabs &

Ponte, 2019; Kim et al., 2017; Coe & Yeung, 2015). This phenomenon is even exacerbated by systemic poverty and legal protections that doesn't protect vulnerable groups (ILO, 2019; UNICEF, 2014; Amnesty International & Afrewatch, 2016; Sovacool, 2019).

3. The involvement of external actors through humanitarian approaches and global certification mechanisms reflects reactive efforts to improve supply chain governance. However, GPN literature indicates that these initiatives are often more administrative than transformative, and tend to reinforce the dominance of global actors through symbolic regulation (Grabs & Ponte, 2019; Ford & Nolan, 2020; Deberdt & Le Billon, 2022). For example, the COTECCO project by the US, together with the ILO and Pact, seeks to establish a child labour monitoring system, but its long-term effectiveness still faces structural challenges (Zegers, 2023).
4. Supply chain transformation through digitalisation and innovative governance is a strategy to improve transparency and accountability. In the context of GPN, technological innovation is seen as a form of upgrading that can strengthen the visibility and bargaining power of local actors, although it does not automatically alter the structure of inequality (Wieland, 2020; Zhao et al., 2023; Dolgui et al., 2020). Supply chain digitalisation is seen as crucial method for enhancing resilience while enabling faster and more efficient social risk (Fan et al., 2015; Aldrighetti et al., 2021; Urzedo et al., 2020).

The framework built on the four pillars above underlines the need for a multi-level and cross-actor engagement, with humanity as strategic tool to drive a more ethical, sustainable, and human-rights oriented governance of the global mineral supply chain.

METHODS

This research uses a descriptive qualitative method with a case study approach to analyse the distribution of global responsibility in cobalt supply chains and child labour practices in the Democratic Republic of Congo (DRC). This method was chosen because it can provide an in-depth understanding of the complex socio-political-economic dynamics in strategic mineral supply chains (Kim et al., 2017; Denzin & Lincoln, 2018). The data analysed are secondary data obtained through a systematic search of various sources, including books, scientific journals, international organisation reports, policy documents, and company reports related to cobalt production, exports and supply chains (Snyder, 2019; Fink, 2019).

The analysis was conducted qualitatively with a focus on the *Global Production Network* (GPN) literature that examines actors, power relations and political economy dynamics in strategic mineral industries (Coe & Yeung, 2015; Gereffi, 2018). Through thematic analysis, patterns and important linkages between child labour issues, cobalt supply chains and distribution of responsibility were analysed (Castleberry & Nolen 2018). Data validity was maintained by triangulating sources from various documents and scientific publications to ensure consistency (Bowen, 2009). The limitation of the research lies in focusing on the period 2018-2022 and the issue of child labour in the cobalt mining sector in the DRC.

RESULTS

This research analyses the dynamics of the cobalt *Global Production Network* (GPN), with a focus on the distribution of risk and responsibility for child labour issues in the Democratic Republic of Congo (DRC). Findings are presented under three broad themes: global production and consumption structures, social vulnerabilities and local governance, and supply chain monitoring and certification efforts.

Global Structure of Cobalt Production and Consumption

Despite accounting for only 3.94% of the DRC's total national mineral production in 2017, cobalt is a strategic commodity that supports exports and foreign exchange, particularly in the context of renewable energy and digital technology (EITI, 2019). This role is illustrated in **Table 1.**

Table 1. Mineral Production of the Democratic Republic of Congo 2017

Mineral Name	Total Production (Tonnes)	Percentage of Total (%)
Wolframite	1,996,248.00	95.42%
Copper	1,094,638.00	52.32%
Cobalt	82,461.00	3.94%
Cassiterite	17,682.00	0.85%
Zinc	12,337.00	0.59%
Diamond	3,778.20	0.18%
Fine Gold	29.50	14%

Source: EITI. (2019). *Democratic Republic of the Congo 2017 & 2018 EITI report*. https://eiti.org/sites/default/files/attachments/rapport_contextuel_itie-rdc_2017_2018_version_adopte_par_le_gtt_et_ce2.pdf

The DRC's contribution to global cobalt production is also reflected in the annual data in **Table 2** below. In 2018, the DRC accounted for 72.57% of global production, increasing to 75.23% in 2022 (U.S. Geological Survey, 2023). Production rose from 97,900 tonnes (2020) to 130,000 tonnes (2022), reflecting increased extraction capacity (Brink et al., 2020).

Table 2. Global Cobalt Production 2018-2022

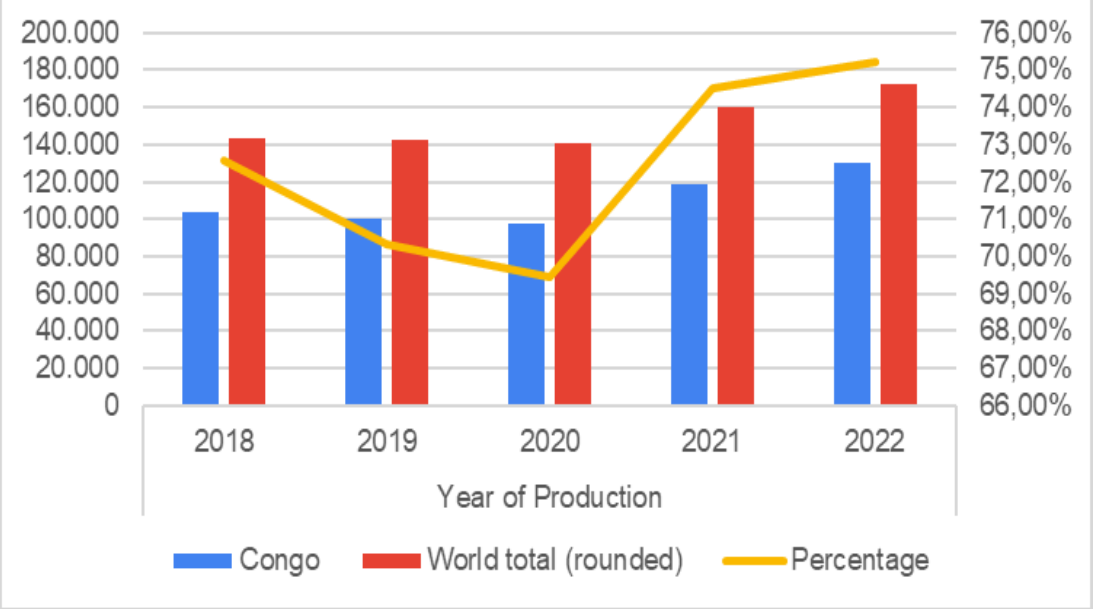
Cobalt Production Source	Year of Production (Tons)				
	2018	2019	2020	2021	2022
United States	490	500	600	650	800
Australia	4.880	5.740	5.630	5.295	5.900
Canada	3.520	3.340	3.690	4.361	3.900
China	2.000	2.500	2.200	2.200	2.200
Cuba	3.500	3.800	3.800	4.000	3.800
Madagascar	3.300	3.400	850	2.800	3.000
Morocco	2.100	2.300	2.300	2.300	2.300

Papua New Guinea	3.280	2.910	2.940	2.953	3.000
Philippines	4.600	5.100	4.500	3.600	3.800
Russia	6.100	6.300	9.000	8.000	8.900
Other countries	5.540	6.320	7.640	4.567	5.200
Democratic Republic of Congo	104.000	100.000	98.000	119.000	130.000
World total (rounded)	143.310	142.210	141150	159.726	172.800
Percentage	72,57%	70,32%	69,43%	74,50%	75,23%

Source: U.S. Geological Survey. (2023). *Cobalt statistics and information [Data set]. U.S. Department of the Interior.* https://www.usgs.gov/centers/national-minerals-information-center/cobalt-statistics-and-information

In addition, the trend of DRC versus world cobalt production is visualised in **Graph 1** below. This graph makes it clear that while world production is increasing, the DRC's share remains consistently above 69% and peaks in 2022 (USGS, 2023).

Graph 1. Cobalt Production Trend of DRC vs World Total from 2018-2022



Source: U.S. Geological Survey. (2023). *Cobalt statistics and information [Data set]. U.S. Department of the Interior.* https://www.usgs.gov/centers/national-minerals-information-center/cobalt-statistics-and-information

In **Table 3**, the DRC's export pattern specifically shows the dominance of China as the main destination, with export value reaching USD 5.74 billion in 2022, an increase of 68.95% from 2018. South Korea and Singapore also show significant growth

in demand for cobalt from the DRC (OEC, 2025). On the downstream side, global companies such as CATL (27,000 tonnes/year), LG Energy Solution (20,000 tonnes/year), and Tesla (10,000 tonnes/year) are the largest consumers of cobalt (The Cobalt Institute, 2023).

Table 3. DRC Cobalt Exports per Destination Country (2018-2022)

Country	2018 (USD)	2022 (USD)	Growth (%)
China	3,398,035,941	5,741,000,312	+68.95
Singapore	43	151,027,036	+351,225,565
South Korea	5,557,502	82,375,016	+1,382.23
UAE	11,549,666	11,959,743	+3.55
Belgium	11,151,618	0	-100
Zambia	5,714,069	0	-100
Brazil	2,575,149	0	-100
South Africa	2,382,315	0	-100
India	2,143,462	0	-100

Source: OEC. (2025). *Democratic Republic of the Congo: Cobalt exports by destination (2018-2022) [Data set].* https://oec.world/en/profile/bilateral-product/cobalt/reporter/cod

In addition, **Graph 2** shows the high volatility of global cobalt prices in 2018-2022. Prices reached an average of USD 81,358 per tonne (2018), dropped dramatically to USD 34,651 (2019), and remained relatively stable in 2020. However, the price jumped again to USD 52,359 (2021) and USD 70,208 (2022) (The Cobalt Institute, 2023).

Graph 2. World Cobalt Aveage Price 2018-2022 (USD/ton)

Source: The Cobalt Institute. (2023). *Cobalt market report 2022 [Market report].* https://www.cobaltinstitute.org/wp-content/uploads/2023/05/Cobalt-Market-Report-2022_final-1.pdf

Social Vulnerability and Governance Fragmentation in GPN

This research identifies governance fragmentation between the ASM and LSM sectors as a key cause of social vulnerability, particularly child labour exploitation in the *Global Production Network* (GPN) cobalt supply chain. While ASM accounts for 15-30% of national production, the sector is a critical point where labour protection norms and children's rights are often violated (Amnesty International & Afrewatch, 2016). In **Table 4**, UNICEF (2014) estimates that around 40,000 children are involved in cobalt mining, but in 2024 CLMRS only identified 5,346 child labourers in two provinces, signalling the limited scope of monitoring.

Table 4. Child Labour in the DRC Cobalt Sector

Year	Source	Estimated Number of Child Labourers	Geographical Coverage	Data Collection Method	Notes/Limitations
2014	UNICEF (2014)	± 40,000 children	National (all DRC)	Macro survey & national estimates	Estimation-based data, possible under/over-reporting, but broad national coverage
2024	COTECCO/CLMRS (USDOL, 2024)	5,346 children	2 main provinces (Kolwezi & Lualaba)	Community monitoring (CLMRS)	Micro data, only 2 out of 26 provinces, very limited coverage, reporting dependent

Source: UNICEF. (2014). *An estimated 40,000 children worked in artisanal cobalt mines in the Democratic Republic of Congo in 2014* (cited in Kadek, Pratama, Dewi, & Resen, 2024). https://ojs.unud.ac.id/index.php/hi/article/download/104042/56033 and U.S. Department of Labor. (2024*). Combatting child labour in the Democratic Republic of the Congo's cobalt industry (COTECCO).* https://www.dol.gov/agencies/ilab/combatting-child-labor-democratic-republic-congos-cobalt-industry-cotecco

Monitoring, Certification, and Digital Innovation Efforts

Several efforts have been made to improve accountability of the cobalt supply chain, including through initiatives such as the COTECCO project and the CLMRS system, whose achievements and key challenges can be seen in **Table 5.**

Table 5. COTECCO & CLMRS Project Achievements

Indicator	Data/Scores	Description/Key Challenges
Training/socialisation workshops	>40	Only in Kolwezi & Lualaba
Workshop participants	>1,200 people	Limited to local stakeholders
Increased knowledge of participants	38%	Not evenly distributed across the ASM community
Child labourers identified by CLMRS	5,346 children	Only in 2 provinces; national data not yet available
Adoption of CLMRS as national policy	-	Government support & funding challenges

Source: U.S. Department of Labour. (2024*). Combatting child* labour *in the Democratic Republic of the Congo's cobalt industry (COTECCO).* https://www.dol.gov/agencies/ilab/combatting-child-labor-democratic-republic-congos-cobalt-industry-cotecco and International Labour Organization. (2024, November 20). *ILO launches GALAB project in Democratic Republic of the Congo to address child labour in cobalt mining sector.* https://www.ilo.org/resource/news/ilo-launches-galab-project-democratic-republic-congo-address-child-labour

Meanwhile, RMAP (Responsible Minerals Assurance Process) certification covers ±100 out of ±200 global smelters/refiners, yet very few African facilities are certified (<10%) (RMI, 2022). The biggest gap remains in the ASM sector which is difficult to audit and lacks transparency.

DISCUSSION

This study analyses child labour issue in the Democratic Republic of Congo's (DRC) cobalt supply chain using the Global Production Network (GPN) framework, focusing on four analytical pillars: (1) global demand and mineral market structure, (2) local governance and social vulnerabilities, (3) humanitarian engagement of external actors, and (4) supply chain transformation through integration, digitalisation, and governance innovations. These pillars were selected because they directly reflect GPN's core dimensions, such as market structure, territorial embeddedness, and multi-scalar governance, providing a lens to connect global market pressures with local socio-political realities (Coe & Yeung, 2015; Gereffi, 2018). Previous research on strategic minerals shows that demand shifts, governance capacity, external

interventions, and technological innovation are interlinked drivers of both value distribution and human rights outcomes (Grabs & Ponte, 2019; Ford & Nolan, 2020; Zhao et al., 2023). Analysing these pillars together allows the study to contextualise findings within structural inequalities that sustain child labour in cobalt mining (Sovacool, 2019; Deberdt & Le Billon, 2022). Following the discussion of these four pillars, this section will also present reflections and policy implications to provide a broader understanding of how the findings can inform governance, industry practice, and future research.

Global Demand, Market Structure, and Supply Chain Dependencies

The DRC holds around half of the world's cobalt reserves and supplies more than two-thirds of global demand (USGS, 2023; Zegers, 2023). Although cobalt represented only 3.94% of total national hard mineral output in 2017, it generated USD 1.68 billion in export revenue—about 55% of government income and over 99% of total exports (World Bank, 2021; EITI, 2019). The literature and results confirm that this production is almost entirely exported, driven by surging demand from electric vehicle and consumer electronics industries (Brink et al., 2020; Sovacool, 2019). Furthermore, national cobalt production increased from 69,000 tonnes in 2018 to 95,000 tonnes in 2022. Large-scale mining (LSM) operations rose from 15 to 20 sites, with output growing from 70,000 to 80,000 tonnes, while artisanal and small-scale mining (ASM) employment increased from 150,000 miners in 2019 to 200,000 in 2022. Although not all ASM workers are children, ASM remains the primary site of child labour due to minimal oversight and weak regulation.

In GPN terms, the cobalt chain is vertically fragmented: the DRC exports raw cobalt, while value-added refining, manufacturing, and innovation occur abroad, where most profits are captured (Gereffi, 2018; Campbell, 2020). This dependency means that disruptions in DRC mining can trigger a "ripple effect" (Li & Zobel, 2020), where the supply disruptions could provoke a systemic crisis in the global technology industry, demonstrating how important yet fragile the country's position is in the global economic network.

Local Governance, Social Vulnerability, and Child Labour Issues

ASM contributes 15–30% of national cobalt output but largely operates outside formal regulation, creating conditions for exploitation, including child labour (Amnesty International, 2016; Sovacool, 2019). While LSM sites typically meet higher operational standards, they often source ore from ASM, enabling cobalt mined by children to enter global supply chains indirectly (Brink et al., 2020).

This vulnerability is exacerbated by the price volatility as a key driver. Data from Graphs 1 and 2 indicate that increases in global cobalt prices are accompanied by significant production growth, suggesting a likely rise in child labour involvement, although precise figures remain unavailable due to the absence of an established tracking system. This pattern underscores the link between market incentives and household decisions to involve children in mining, particularly within highly informal ASM (Sovacool, 2019). Bashwira and Haar (2022) note that "push" factors such as poverty, loss of land, or armed conflict initially play a dominant role, but over time these combine with "pull" factors such as the pursuit of income, perceived safety, and aspirations for a better life, reinforcing the integration of children into household economic strategies.

This intertwined push and pull dynamics shape the scale and persistence of child labour in cobalt mining, reinforcing its entrenchment within ASM communities. This vulnerability is also reflected in education sector, where around 40-50% school-age children in mining areas are not able to attend school because they have to work in the mines. Nationally, the DRC net primary school attendance rate is only 78%, while for secondary school is 32%, with nearly 6 million children aged 6-17 out of school (UNICEF, 2018). The extent of the problem is reflected in national and project-level data, which reveal both the magnitude of child participation and the persistent gaps in law enforcement and policy implementation. Child labour in the DRC cobalt sector reflects a complex and persistent challenge. In 2014, an estimated 40,000 children were involved in cobalt mining, predominantly in ASM under hazardous conditions (UNICEF, 2014; Kadek et al., 2024). These children face long working hours, accident risks, respiratory diseases, and gender-based violence (Amnesty International & Afrewatch, 2016; Human Rights Watch, 2021). Moreover, child health issues in DC are very serious where more than 40% of toddlers suffers from stunting due to chronic malnutrition, nearly half of toddler deaths are related to poor nutrition, with the under-five mortality rate reaching 73 per 1.000 live births. The situation is aggravated by the fact that approximately 2 million informal works in ASM are women, 40% of whom play dual roles as breadwinners and caregivers, so that mothers' involvement in mining often reduces attention to children's nutrition and health (World Bank, 2017; Lukamba, 2023). Furthermore, it gets worsen as the basic health service coverage stands at only 42 in the WHO Coverage Index (UNICEF, 2018; WHO, 2021).

The ILO (2018) classifies such work as among the Worst Forms of Child Labour (WFCL). Recent CLMRS data from the COTECCO project which ended in 2022 recorded 5,346 child labourers in two provinces, Lualaba and Haut-Katanga, though this is likely an undercount due to limited monitoring and high mobility (USDOL, 2024). Enforcement is hampered by informality, corruption, and intimidation of inspectors (Sovacool, 2019). The inspection capacity is also insufficient as there are only 200 active labour inspectors for a population of over 100 million and thousands of mining sites (Zegers, 2023). Although the DRC has ratified ILO Conventions No. 138 and No. 182 and enacted child protection regulations, implementation remains weak due to limited political will, inadequate resources, and poor inter-ministry coordination (Zegers, 2023). Low awareness of child rights among communities further reduces detection (Amnesty International & Afrewatch, 2016). This gap between international commitments and ground realities highlights the urgent need for sustained NGO and humanitarian engagement to strengthen monitoring, advocacy, and law enforcement in the cobalt sector.

Humanitarian Approach and External Actor Engagement

Humanitarianism has emerged as a strategic response to the persistence of child labour in the DRC's cobalt sector, driven by weak state capacity and mounting global pressure to ensure ethical supply chains for strategic minerals (Pease, 2016; Bogatyreva, 2022; ILO, 2020). The United States, through the U.S. Department of Labor (USDOL), launched the Combating Child Labor in the Democratic Republic of the Congo's Cobalt Industry (COTECCO) project in partnership with the International Labour Organization (ILO) and Pact. The initiative focuses on strengthening national

capacity, developing a Child Labour Monitoring and Remediation System (CLMRS), and engaging the private sector via the Fédération des Entreprises du Congo (FEC) working group (USDOL, 2024; Amnesty International & Afrewatch, 2016). This multilateral model integrates policy advocacy, technical assistance, and cross-actor collaboration, aligning with a broader humanitarian trend that calls for consumer countries to uphold human rights standards in mineral supply chains (Pease, 2016; Responsible Minerals Initiative, 2023; ILO, 2020; OHCHR, 2014).

The CLMRS under COTECCO has enhanced local supervisory capacity by 38% (USDOL, 2024; Zegers, 2023). However, challenges remain, including limited monitoring coverage, reluctance among some businesses to embrace transparency, and the absence of national policy adoption (Zegers, 2023). Broader systemic barriers such as limited resources, high informality in ASM, and weak political will continue to hinder the expansion of monitoring systems and the enforcement of child protection standards (Sovacool, 2019).

Cross-sector collaboration through COTECCO has strengthened cooperation between government, the private sector, and civil society, while promoting the uptake of ethical standards and certification schemes such as the Responsible Minerals Assurance Process (RMAP) (Responsible Minerals Initiative, 2023). Internationally, pressure from major consuming countries including the United States, European Union, and China has intensified through regulatory measures, transparency requirements, and support for independent audits and certification (U.S. Congress, 2023; White House, 2023; European Commission, 2025; China2West, 2024; QIMA, 2024). Frameworks such as the Dodd-Frank Act and the OECD Due Diligence Guidance for Responsible Supply Chains have become key benchmarks, compelling multinational corporations to address social impacts at the upstream stages of their supply chains (OECD, 2025; Responsible Minerals Initiative, 2021).

Supply Chain Transformation: Digitalisation, Certification, and Governance Innovation

The global cobalt supply chain is increasingly shaped by demands for transparency, accountability, and multi-actor collaboration, driven by growing international pressure to address child labour in the Democratic Republic of Congo (DRC). A key initiative is the Responsible Minerals Assurance Process (RMAP) certification by the Responsible Minerals Initiative (RMI), which aims to ensure smelters and refiners meet human rights standards and are free from child and forced labour (Responsible Minerals Initiative, 2021). However, certification coverage remains concentrated in formal supply chains and large companies, while the ASM sector, which is most vulnerable to rights violations, is rarely included (Deberdt & le Billon, 2022; O'Faircheallaigh & Corbett, 2016; Opakas, 2023).

Digitalisation and technology-based auditing offer new tools for tracing and monitoring strategic mineral supply chains. Blockchain, big data, and CLMRS have been adopted to improve transparency and enable early detection of child labour (USDOL, 2024). Blockchain allows real-time, tamper-proof records of cobalt transactions and origins, while CLMRS uses community-based reporting to capture field-level violations (USDOL, 2024; Zegers, 2023). These technologies can reduce audit costs, speed up responses, and strengthen consumer confidence (Zhao et al., 2023; Wieland, 2020).

Expansion, however, remains constrained by fragmented supply chains, resistance to transparency, and limited local government capacity (Ford & Nolan, 2020; Zhao, Hong, & Lau, 2023). For example, RMAP covers about 100 of 200 global smelters/refiners, yet fewer than 10% of African facilities are certified (RMI, 2022). Many consumer countries and multinational corporations also pursue minimum compliance rather than systemic reform, with short-term economic and political interests undermining collaboration (OECD, 2016; Dolgui et al., 2020). Strengthening governance therefore requires a shared, sustained commitment by states, companies, and civil society to extend certification and digital monitoring into ASM and integrate social justice into strategic mineral supply chains.

Global Value, Responsibility Distribution, and Policy Implications

The distribution of economic value and social risk in the cobalt GPN is highly unequal. The DRC supplies over two-thirds of global demand, yet most value added accrues to technology and automotive companies in developed economies (EITI, 2019; Zegers, 2023; World Economic Forum, 2020; Brink et al., 2020; Kallitsis et al., 2020). Artisanal mining communities, particularly children in ASM, bear the greatest social burdens (Amnesty International & Afrewatch, 2016; Sovacool, 2019; ILO, 2019). Power asymmetries enable large companies to set standards and prices, while producer countries remain politically and economically weak (OECD, 2016; Urzedo et al., 2020).

Although certification and auditing have increased moral pressure, they have not altered the structural imbalance in value and risk sharing (OECD, 2016). Mechanisms for equitable redistribution are lacking; local communities continue to receive low wages and face significant social costs, while multinational corporations and consumer nations capture the largest economic gains (Brink et al., 2020; Coe & Yeung, 2015). The prevalence of unskilled labour, including in ASM, further threatens the DRC's long-term economic productivity (World Bank, 2025). Without structural reforms that demand proportionate redistribution of benefits and responsibilities, child labour will remain a persistent undercurrent of the global technology and energy transition (Sovacool, 2019; World Economic Forum, 2020; Brink et al., 2020).

These structural dynamics frame the urgency of the policy priorities identified in this study, which combine governance reform, economic empowerment, and strengthened protection mechanisms. Certification and auditing tools such as RMAP contribute to compliance but cannot, on their own, dismantle structural inequalities or fully eliminate child labour (European Parliament, 2023; Le Billon, 2024). Without integrating ASM into formal certification systems and providing viable alternative livelihoods, these mechanisms risk reinforcing exclusion (Sovacool, 2019).

At the national level, the Mining Code (Law No. 007/2002, amended 2018) and Child Protection Code (Law No. 09/001, 2009) prohibit child labour but lack operational integration. Enforcement remains largely provincial, with poor cross-sectoral coordination. Aligning mining governance with child protection systems could strengthen prevention and remediation. Local NGOs such as Afrewatch and CAJJ have important advocacy and awareness roles (Amnesty International & Afrewatch, 2016), but their reach is limited by funding and political constraints. Embedding their work into state-led initiatives could improve sustainability.

The policy priorities suggested from this study include:

1. Institutionalise CLMRS within national law, supported by sustained international technical and financial assistance (ILO, 2021; Zegers, 2022).
2. Expand ASM formalisation and create diversified livelihood programmes to reduce reliance on child labour income (Hilson, 2022; O'Faircheallaigh & Corbett, 2016).
3. Strengthen multi-actor coordination, ensuring the inclusion of local communities and civil society in decision-making (Le Billon, 2024; Sovacool, 2021).
4. Reform certification schemes to include ASM and make child rights protection a core compliance requirement (Bainton et al., 2021; Hilson, 2022).

Thus, the child rights protection agenda in the cobalt sector requires bolder, more inclusive, and social justice–oriented global governance reforms, not just formal compliance with international standards.

CONCLUSION

The issue of child labour in the DRC's cobalt supply chain confirms the paradox of strategic mineral globalisation, where the DRC's central role as a major global supplier of cobalt is not accompanied by equity in value distribution and social risk management. *The Global Production Network* (GPN) approach is effective in mapping power relations and value flows, but needs to be further developed with explicit integration of child rights and social justice dimensions. Findings show that while external interventions and supply chain certification have improved monitoring capacity, they are still limited to administrative compliance and have not achieved substantive transformation in governance and distribution of economic benefits. Future research is recommended to explore more participatory, collaborative governance models and examine the impact of supply chain digitalisation innovations on child rights protection. Thus, global governance reforms and the distribution of responsibilities across actors are key to realising a fair cobalt supply chain free from child exploitation.

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