Responsible Sourcing via Blockchain in Mineral Supply Chains

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ABSTRACT
Manufacturers and suppliers in the tech industry, trading and utilizing minerals, are often unable to conduct substantial supply chain due diligence, due to reasons such as lack of competence, the scattered spread of information and fluid nature of their supply chains. Declaring whether a product has been responsibly sourced, or whether it contains conflict minerals or not, is almost impossible.

This study is an exploration of the potential role of blockchain in mineral supply chain management, as a supplementary tool for carrying out due diligence. Well-performed supply chain due diligence should demand continuous status records of various measures of social sustainability, identifying impacts on human well-being. So, how may a blockchain solution for traceability in a mineral supply chain contribute towards ensuring responsible sourcing?

Blockchain provides traceability of transactions through its immutable chain structure, and knowing an asset’s origin is vital in order to carry out supply chain due diligence. While the blockchain network has the potential to provide information on the digitally registered flow of an asset, the validity of the information of the physical and social qualities of the asset remains dependent on the actor adding it to the blockchain, leading to an inherent problem regarding the interface between the digital and the physical world, in application of blockchain in supply chains.

Through a background study and interviews with researchers and professionals, this study proposes a set of requirements to take into account while addressing responsible sourcing via a blockchain solution.

The study finds that a blockchain alone cannot ensure responsible sourcing, and further provides insight into the challenges and opportunities present in the industry and discusses the suitability of potential solutions.

SAMMANFATTNING
Tillverkare och leverantörer inom technindustrin, som handlar med och drar nytta utav mineraler, är ofta oförmöga att genomföra djupgående företagsgranskningar i sina logistikkedjor, på grund av exempelvis kompetensbrist, vida utspridd information och kedjornas flytande natur. Att säkerställa ifall en produkt har utvunnits på ett hållbart sätt eller huruvida den innehåller konfliktnmineraler är i det närmaste omöjligt.

Denna studie utforskar blockkedjeknikens potentiella roll i leverantörskedjor för mineraler, som ett kompletterande verktyg för att genomföra företagsgranskningar. Välgenomförda granskningar bör inkludera fortlöpande statusprotokoll för olika åtgärder gällande social hållbarhet, som identifierar utvinningens påverkan på mänskligt välmående. Så, hur kan en blockkedjelösning för spårbarhet i en leverantörskedja för mineraler bidra till att säkerställa hållbar utvinning?

En blockkedja möjliggör spårbarhet av transaktioner genom sin oföränderliga kedjestruktur; samtidigt är känt om ursprunget hos en resurs avgörande för att genomföra företagsgranskningar i logistikkedjor. Ett blockkedjenättverk har potential att tillhandahålla information gällande det digitalt registrerade flödet hos en resurs, men informationens validitet gällande dess fysiska och sociala kvaliteter är fortsatt beroende av aktören som registrerar resursen på blockkedjan, vilket leder till ett ofrånkomligt problem gällande gränssnittet mellan den digitala och fysiska världen vid applicering av blockkedjor i leverantörskedjor.

Util från en litteraturgenomgång och intervjuer med forskare och professionella, så föreslås i denna studie en kravlista att ta hänsyn till ifall blockkedjelösningar ska användas för att understödja hållbar utvinning.

Studien visar att en blockkedja på egen hand ej kan säkerställa hållbar utvinning och ger vidare insikt i utmaningar och möjligheter inom industrin, samt diskutera lämpenheten för potentiella blockkedjelösningar i dessa sammanhang.

Keywords  
Blockchain; data quality; supply chain traceability; minerals; responsible sourcing; sustainability; supply chain due diligence

1. INTRODUCTION
The number of modern electronic devices used globally, such as smartphones or laptops, is continuously increasing [4, 10]. To manufacture these devices, materials from several parts of the world are shipped to assembly facilities where they are put together to make the final product. Reaching this stage requires the raw materials to go through refinement processes like sorting and smelting. First, however, they need to be extracted from their point of origin. Tracing raw materials, especially minerals such as cobalt or gold, back to their source often proves to be a futile undertaking.

While legislations and transnational initiatives, such as the Dodd-Frank Act [33], the EU regulation 2017/821 [12] and the Responsible Mining Initiative [27] establish due diligence obligations, a number of components are still manufactured using minerals sourced under uncertain conditions, sometimes conflict
minerals [20], and companies often lack the required in-house competence to conduct exhaustive due diligence [32, 1].

Transparency and traceability are key features of the emerging blockchain technology, which was introduced by Satoshi Nakamoto through the Bitcoin white paper in 2008 [21]. Although the technology is still in its infancy and cryptocurrencies remain the most widespread application, the potential for broader application of blockchain is widely discussed both in research and in popular media [29, 6]. The use of blockchain for enhanced traceability of raw materials in particular is also being investigated by numerous startup companies, such as Everledger, Cobalt Blockchain Inc., Circular, Peer Ledger and Minespider. While several researchers are identifying blockchain as a tool to enhance supply chain traceability [29, 6], discussions around the technology’s role in the intersection of the digital world and the physical world and in addressing fraudulent activities are limited [17, 36].

Looking at the emerging blockchain technology, whose key features include the impossibility of altering previous entries of a shared ledger, we ask the following question: how may a blockchain solution for traceability in a mineral supply chain contribute towards ensuring responsible sourcing?

Following the background, this study uses interviews as a method for qualitative research. Interviews are carried out with researchers and professionals within the fields of blockchain and social sustainability. Then, we qualitatively analyze the possible limitations of blockchain technology in mineral supply chains and its contribution towards responsible sourcing. Finally, we propose a set of requirements for a blockchain solution intended to contribute towards responsible sourcing of minerals, and discuss the challenges at hand.

1.1 Definitions

1.1.1 Artisanal and small-scale mines (ASMs)

Labor-intensive artisanal and small-scale mines (ASMs) are typically located in rural, inaccessible and economically disadvantaged areas, and carry a higher risk of being tied to ongoing conflicts than large-scale industrial mines, characterized by higher investments and lower levels of employment [30, 31].

1.1.2 Due diligence

The ongoing, proactive and reactive measures a company carries out to ensure that human rights and other legalities are respected in all aspects of their activities [22], through the identification, managing and reporting of risks throughout their supply chains [11].

1.1.3 Human well-being

The state in which “people in a sustainable society are not subject to structural obstacles to health, influence, competence, impartiality or meaning-making” [19].

2. BACKGROUND

2.1 Blockchain technology

A blockchain is a decentralized network, where all participants, or nodes, have a replicated version of a shared blockchain ledger, keeping a log of all transactions taking place. When new transactions are added to the blockchain, the nodes run a consensus protocol authenticating or denying the added transaction, and their replica of the ledger is updated accordingly. Besides the node’s consensus protocol, a blockchain network can also deploy smart contracts for additional functionalities to the network. A smart contract is a sort of autonomous contract which runs a script of policies and rules that apply to the network [15, 29], such as not delivering an asset before a receipt is received or various types of reports.

The blockchain is an append-only log, where each new transaction, or block, added to the ledger is linked and secured to the previous block through cryptographic hash functions (see Figure 1). This practically prevents any altering of the chain and provides all nodes with information about the digital provenance of any block, as well as additional information about a block’s properties depending on the area of application (for example owner and transfer location) [29].

2.1.1 Variations of blockchain

General categorization of different types of blockchain networks can represent varying levels of decentralization (see Figure 2). It should be noted that the following variations do not necessarily represent the entire span of possible blockchain designs, since the technology is evolving rapidly.

Wüst and Gervais define a writer as an entity which participates in the extension of the blockchain, either via its own additions or by verifying those of others [36]. Conversely, a reader reads, analyzes and audits these activities without extending the blockchain.

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**Figure 1. A recreation of “Steps in a blockchain information and transactions” by Saberi et al. [28]**
A permissioned blockchain is one where any joining entity needs a central identity manager to grant them access and provide them with an identity. A permissionless blockchain is open for anyone with certain software tools to join using an anonymous identity, and gives both writing and reading access to the system, without need for approval. A public blockchain is one where anyone can join, either because it demands no approval for joining (public permissionless) or because anyone who demands to join is granted access (public permissioned), involving central identity management, but providing reading access to all. Central management in a permissioned setup can also be distributed amongst several leader nodes, resulting in what is known as a federated blockchain. In a private blockchain, a central manager allows access to participants, hence such a blockchain can only be permissioned [7, 37, 24, 2].

<table>
<thead>
<tr>
<th>Centralized (traditional) database</th>
<th>Private permissioned blockchain</th>
<th>Public permissioned blockchain</th>
<th>Public federated blockchain</th>
<th>Public permissionless blockchain</th>
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<tr>
<td>low</td>
<td>LEVEL OF DECENTRALIZATION</td>
<td>high</td>
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Figure 2. Spectrum of blockchain variations

Within the varieties of blockchain networks, there are also significant differences in e.g. immutability, consensus mechanisms, data protection, efficiency and power consumption [7, 37]. These all make up a variety of traits that are of importance for the application area, such as a business that might benefit from transparency in some areas, while at the same time requiring some level of confidentiality in others in order to maintain a competitive advantage.

2.1.2 Consensus protocols

In a blockchain, the different nodes are required to agree on and validate whether a proposed new block has a rightful place in the chain. Algorithms for consensus in distributed computing have been studied for years and provide a solid basis for application in blockchain networks [5]. Consensus protocols are needed to avoid any faulty behavior in a network, such as in the case of a crash due to nodes going offline, or in cases of unreliable, misbehaving nodes, in a network where the different parties do not necessarily trust each other.

Different blockchains are in need of, and use different consensus protocols. Proof-of-Work (PoW) protocols are among the most common consensus protocols for blockchain application. If the identities of the nodes in the network are unknown, as in a permissionless blockchain, the nodes perform a task, typically solving a difficult cryptographic problem, to prove their reliability. This process, demands heavy use of computational power by the nodes and not participating would undermine a node’s own stakes in the network, since no commitment is registered [9].

In a network with identifiable parties, permissioned blockchains, the need for consensus protocol takes a different form. If one already knows the other parties involved in the network, even while not trusting them, if a node misbehaves, one can trace their moves and swiftly identify them, and thus hold them accountable. However, the network is still required to handle cases of corrupted nodes who might operate against a common agreement and validation [5]. Byzantine fault tolerance (BFT) protocols are one way of handling this, and are widely used in permissioned blockchains, as they require identifiable nodes [36]. BFT is an iterative voting process between all the nodes [37].

These are only a few of many different consensus mechanisms that are being used in blockchain, and key properties are energy consumption, node identity management (permissioned or permissionless blockchain) and tolerated power of adversary (fault tolerance) [37, 34].

2.1.3 Blockchain in the physical world

Despite its technological and automated nature, blockchain creation and advancement remain products of human input. The connection between the digital and the physical world serves challenges, and demands consideration of the fact that blockchain applications are sociotechnical systems.

If there is no trust in the writer registering the properties of the initial block, then the entire continuation of the blockchain is imperiled. As an example, if the writer in a mine, where human well-being conditions are good, registers a new block with data saying that “this batch of a mineral is responsibly sourced from this mine”, while in reality the mineral was brought there from another mine where human well-being conditions are poor, then this registration of false data cannot be identified by the blockchain alone. On the contrary, if all writers are trusted, there is no need for a blockchain [36].

One solution which is being explored to address this problem is the use of sensors addressing data quality, to include more subjective metrics of quantifiable qualities of the assets at hand. However, these are also subjected to manipulation [36, 15].

2.2 Blockchain and supply chain management

Robust supply chain management (SCM) demands the ability to confirm and verify the movement of assets, as well as to uphold expected measures of social, environmental and financial sustainability, the latter being especially important in competitive businesses and when aiming for financial gain and stability [29].

Applications of blockchain in supply chains have been studied and described by several researchers and professionals [13, 17], and is often pointed out as a field with great potential [29, 17, 13], despite the inherent problems with the connection between the digital and the physical world.

Blockchain allows for new possibilities in SCM through e.g. enhanced efficiency, partly brought along by smart contracts, and traceability, the latter being the main focus of this study.

Examples of operations are given in a variety of industries, such as the agricultural and food industry, the diamond industry [13] and the pharmaceutical industry [29, 17, 36].

Flow charts for deciding whether blockchain is the right choice for a given application are brought forth by e.g. Peck (see Figure 3) and Wüst and Gervais [36].

As companies often have little to no insight into their complete supply chains [32, 1], trust becomes a concern. Based on the assumption of lack of trust, a blockchain-driven supply chain would hold the following properties [36, 2]:

1. Input by multiple, known writers (supply chain actors), given that an online trusted third party (TTP) is not available. In the case of a single trusted writer or mutual trust between the writers, a regular database would be sufficient.
The possibility of storing private data, as commercial entities at times desire to keep their data secret as a means of competitive advantage.

Reading access might vary. Either anyone can read the state of the system, or only the ones allowed access are able to do so.

Therefore, in the case of SCM, Peck and Wüst and Gervais argue for the use of either a permissioned blockchain or no blockchain at all [36, 23].

### 2.3 Responsible sourcing of minerals

A conflict mineral is a mineral extracted and traded in a zone of ongoing conflict, contributing to prolonging the conflict and catalyzing violations of human rights [14, 22, 30, 33, 12, 11]. The four most common of these, the so-called 3TG metals tin, tungsten, tantalum, and gold, are standard components in IT products [30].

The United States and the European Union have passed legislations on conflict minerals. The US Dodd-Frank Act, section 1502, demands all commercial entities to disclose whether their products contain conflict minerals sourced in the Democratic Republic of the Congo (DRC) or adjoining countries, as well as details on their process of due diligence [33]. However, commercial entities do not meet any consequences in forms of penalization or labeling if they disclose the possible use of conflict minerals [3]. Apple, as an example, having identified all its supply chain’s smelters from the year 2015 and onward, acknowledge the possibility of their products containing conflict minerals [1], but the company does not undergo any penalization as an effect of the Dodd-Frank Act.

The EU regulation 2017/821 aims to prevent the import of conflict tied 3TGs into the EU, and will take effect in 2021. The regulation requires all EU-based importers to meet the standards of a given a supply chain due diligence scheme [12].

The Organisation for Economic Co-operation and Development (OECD) has developed a Due Diligence Guide for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas [22], which forms the basis for the due diligence scheme required by the EU regulation.

It should be noted that even while conflict minerals and certain countries in particular are seeing regulations developing, similar issues regarding responsible sourcing exist with various other minerals as well. One such mineral is cobalt, which is a key part of lithium-ion batteries and sometimes also included in the definition of conflict minerals [30]. The majority of cobalt sourced in the world originates in the DRC [4], where an estimate of more than one million people are employed in labour intensive ASM's [31].

Other notable actors are the Responsible Minerals Initiative (RMI) and the Responsible Cobalt Initiative (RCI). The RMI works with the industry, offering services such as due diligence guidance. The RCI, founded by the Chinese Chamber of Commerce of Metals, Minerals & Chemicals, is another multi-stakeholder initiative addressing risks in the cobalt supply chain. The Chinese Government is heavily invested in several African countries, and wrote an 8.5 billion dollar agreement with the DRC in 2007, ensuring access to the country’s minerals [18].

A 2018 article suggests that measures, such as the responsible sourcing scheme iTSCi [32], taken to improve traceability, have had a de facto low practical impact on the ground, with workers unaware of them, problems known but not spoken of and bureaucratic issues addressed over conflict-mending ones [16].

### 2.4 Blockchain and mineral supply chain traceability

As the traceability of mineral supply chains is known to be lacking overall, and often goes no further than the smelters [1], several start-ups, companies and organizations are addressing responsible sourcing of minerals through solutions claiming improved traceability through blockchain-driven SCM.

Minerspider is a start-up company developing a blockchain protocol aimed at raw material SCM. The company has developed a blockchain agnostic protocol, meaning that the underlying functionalities provided via Ethereum may be replaced with another blockchain platform if desired. The protocol aims to, under some circumstances, provide access to both anonymous and identifiable writers, while still keeping parts of a stakeholders supply chain information secret, and can therefore be classified as a public permissioned blockchain. Minerspider is currently working on pilot projects, and is not yet working with a protocol which is fully decentralized. In the long run, Minerspider aims to be able to provide information about a given batch of mineral’s degree of responsible sourcing, similar to the systems for tracking green energy [35].

Another start-up, Everledger started their work on implementing blockchain to diamond supply chains in 2016 and are currently expanding into various other goods, including gemstones and critical minerals and metals [13]. Despite it being a mineral, the diamond supply chain has some vital differences from the supply chains of the minerals mentioned in subsection 2.3. The diamond
remains more or less in its initial form from extraction to end user compared to minerals such as 3TGs and cobalt used in the digital industry. The technology behind the Everledger blockchain is not openly accessible, but the start-up has declared to be using some sort of a public permissioned blockchain [36].

Cobalt Blockchain Inc. (COBC) holds mineral assets in the DRC and uses a Hyperledger framework (private blockchain), the Mintrax blockchain platform, claiming that the platform ensures that their cobalt is conflict free [8]. The Resource Consulting Services Global Group (RCS Global) provides services for responsible sourcing, among others a “Responsible Sourcing Blockchain Network” using a Hyperledger framework in combination with what they describe as “on-the-ground expertise from the RCS Global Group” [26]. Neither COBS nor RCS Global leave open access to their platforms, but their blockchains, being based on Hyperledger, are presumably private.

In response to the growing interest of applying blockchain to mineral supply chains, and the numerous startups addressing the area, RMI released their “Blockchain Guidelines” at the end of 2018 [27]. This initial release focuses on the very first part of the mineral supply chain, from extraction to smelter.

The guidelines aim to promote the use of shared definitions of terms and concepts, as well as fundamental attributes identifying all actors and events occurring on the supply chain. The RMI accordingly establishes a set of core principles for the design and implementation of blockchain-driven mineral SCM [27]. Among these principles, the guidelines encourage blockchain solutions to be decentralized, giving no sole place or actor the means to control or create data, interoperable, enabling collaboration across platforms, resistant to potential attacks, as well as to adhere to global standards and legal requirements [27].

The guidelines emphasize that any application of blockchain does not replace the need to carry out due diligence, and also point out the importance of the blockchain solution to focus on creating “a positive impact for supply chain actors and local communities in mineral producing countries” [27].

3. METHOD

In this study, the background (see Section 2) stands as the basis for the formation of a draft set of requirements for blockchain solutions for traceability in mineral supply chains aiming to contribute towards responsible sourcing. The literature consists of mostly academic sources retrieved via Primo (the KTH Library search portal), where the focus areas while searching for material were blockchain and its limitations and opportunities in SCM, as well as responsible sourcing schemes and regulations regarding minerals. The literature also involves some cases of investigative journalism and business reports, which were included to provide more insight into the evolving industry as a whole.

The requirements derived from the background were evaluated through semistructured interviews with experts within the fields of blockchain and social sustainability (see subsection 3.1). The semistructured interviews allowed for both open and closed questions, as well as adaptability towards the order in which the questions are asked [28]. Following a transcription process, the contents of the interviews were qualitatively analyzed in relation to the study’s research question. Through an inductive approach, recurring themes in the transcripts were coded, and the three central themes, challenges regarding mineral supply chains, blockchain technology and incentives, provided an outline for the overall content. The remaining themes were assorted as sub-themes which functioned as tools for connecting the links between the three central themes. The analysis was used to further revise the requirements.

At the beginning of the study, before having drafted the requirements or carried out any interviews, unstructured preparatory interviews were also conducted with four subjects (Bahri, Ekener, Fuller and Meilgaard), which provided us with various perspectives on the field as a whole, and an understanding of the professional desires, possibilities and limitations, as well as suggested reading material. A test interview was conducted with an EdTech entrepreneur, resulting in insight into how the questions may be received.

3.1 Interviews

The following people were interviewed for the study:

- Leila Bahri, postdoc researcher on Blockchain technology at the School of Electrical Engineering and Computer Science at the Royal Institute of Technology (KTH).
- Elisabeth Ekener, researcher at the Department of Sustainable Development, Environmental Science and Engineering at KTH, with the focus area of social life cycle assessment. This interview was conducted in Swedish, with the quotes used herein being translated into English.
- Stephen Fuller, criteria development and compliance manager at TCO Development, an organization certifying sustainable IT products.
- Kasper Meilgaard, freelance front-end and blockchain developer who previously worked with the start-up Mineral Track, which aimed to provide traceability in mineral SCM via blockchain.
- Nathan Williams, CEO and founder of Minespider.

The interviewees were approached due to their expertise in either blockchain technology or social sustainability. They could also be a professional working simultaneously in both of these fields, as is the case with Meilgaard and Williams. Both academics and industry experts were interviewed, however the interviews with Meilgaard and Williams were carried out via Skype calls since they are not based in Stockholm. Prior to the interviews, the interviewees were provided a brief of the study thus far, including the requirements draft as seen in subsection 4.1. Due to the variations in expertise, some of the interview questions varied between participants.

4. RESULT

Due to the inherent challenge arising from the interface between the digital and the physical world, where one cannot guarantee the validity of an input through a blockchain alone, there is need for additional measures to address and ensure responsible sourcing.

Through the use of social sustainability metrics addressing human well-being, violations of human rights can be identified, potentially contributing towards ensuring responsible sourcing.

4.1 Requirements draft

After reviewing and discussing the background material (see Section 2), the following draft set of sociotechnical requirements was formulated. Regardless of implementation method, these were deemed necessary for a blockchain solution for traceability in mineral supply chains aiming to contribute towards responsible sourcing:
A. (technical requirements): The technical structure, while not the main focus of this study, ought to rely on a permissioned blockchain for participating stakeholders to maintain some desired level of secrecy [36, 23]. This entails the following:

**Requirement A.1:** The system is decentralized, i.e. data is spread across the various nodes and not aggregated at a single place, which brings about accountability [27, 15].

**Requirement A.2:** A distributed network will always require voluntary collaboration between all actors in the supply chain. In an environment familiar with illegal activities such as corruption and human rights violations [20, 18, 25, 13, 35], multiple actors might actively be hiding aspects of their activities. As a result, there is need for incentives for all actors to join [29], so that they can partake and share data out of their own volition.

**Requirement A.3:** The system must be protected against attacks so that no permissioned data is compromised [27].

**Requirement A.4:** There must be a level of interoperability, allowing for data transfer between different blockchain applications [27].

**Requirement A.5:** Adherence to laws and applicable global standards [27].

B. (social requirements): The main focus of this study regards the implications of the interface between the digital and the physical world, and how the technology handles social sustainability metrics. Specifically the validation process of the input into the blockchain and how the mineral in question is declared as conflict-free. This entails the following:

**Requirement B.1:** Supply chain due diligence is needed for stakeholders to be held accountable for the impact of their business on the local environment and population. A blockchain network is not to replace a company carrying out supply chain due diligence [27].

**Requirement B.2:** Including local mining communities. Working towards creating incentives for miners to participate, the system should:

**Requirement B.2.1:** Contribute to improved working conditions, through providing social sustainability metrics.

**Requirement B.2.2:** Contribute to a positive impact on the entire community [27].

**Requirement B.2.3:** Provide grievance mechanisms, for anonymously reporting mismanagement and other malpractices, and work towards a system providing inherent protection of “whistleblowers”.

**Requirement B.3:** Multiple sources of truth are required in order to objectively register the initial data input onto the blockchain [36, 23].

4.2 Interviews

4.2.1 Challenges regarding mineral supply chains

Regarding mineral supply chains and the challenges arising throughout them, there was an overall agreement among the interviewees of what these challenges entail, pointing to human rights abuses, negative environmental impact, the lack of transparency and the complexity of supply chains. Williams recapitulates the challenges as follows: “forced labor and all of these human rights abuses ... these issues happen at companies that are possibly 10 or 20 steps behind them in the supply chain, and no one knows who’s there ... you don’t even have any proof that material from these mines [where abuse occurs] is in your articles.” (Williams)

As the poor conditions of human well-being in the mines prompt some to induce change, challenges are likely to arise when an outside party, such as a supply chain actor who is several steps removed from the mines, seeks to impact local conditions. Cases of abuse being exposed may lead to stakeholders leaving the area of operation, whereupon the effects on the local community could be detrimental: “if you were to crush the entire [informal] system [where abuse takes place], what’s there to replace it? ... These systems are a source of income for many people and not something that you can shut down just like that.” (Ekener). An outside party’s expectation might be for the local government to take over in such a situation, but Ekener notes: “the state needs to have plenty of muscle and capital to establish a fair system, which is rarely the case.” Hence, in cases where there is no apparent alternative solution and the expectations from outside parties are not in line with the reality on site, abandonment can lead to increased vulnerability of workers and their communities.

Fuller describes TCO’s process upon discovering abuse taking place in a factory later on in the supply chain, as evaluating the establishment’s history and willingness to work towards improvement, which may result in a process of phasing it out from the certification list, typically taking around 12 months. Additional conditions are imposed on the factory during this period, as well as continued monitoring of its operations. He also stresses that the requirements should ensure the presence of democratically elected union representatives, who are appointed independently of management involvement. On having these representatives, Fuller notes: “it’s like having an on-site surveillance and monitoring program working you, compared to factories that restrict free worker representation and unions, these factories can require fewer resources to continually monitor improvement. Brand owners have grown to see the benefits of including local representatives in their social responsibility programs.”

4.2.2 Blockchain types, data quality and SCM

Blockchain has the potential to contribute with provenance data of digital assets (see Section 2), providing a possibility for an increased level of traceability. Williams clarifies that Minespider has built a blockchain protocol which aims to function as a tool for improved due diligence: “the whole [Minespider] system is geared toward provenance, to traceability ... it’s to enable on the ground initiatives.” (Williams)

Furthermore, in the case of Minespider, the data quality, which implies whether a mineral was responsibly sourced or not, is determined by already existing certification schemes: “as a six-person start-up based in Berlin, I wouldn’t tell [the] industry [that they have] to use my certification scheme, but rather I would provide an infrastructure and an incentive model so that the industry can decide [which certification scheme they prefer]” (Williams). In such a solution, a certain level of reliability is demanded from the certification schemes, and in the case of stakeholders not having the necessary in-house competence to follow up on due diligence, there is a risk for excessive reliance on these certification schemes. Fuller notes: “there are international certification standards that exist to identify areas of social and environmental impact and independently verify levels
set by stakeholders ... There's a big reliance on these established certifications, since the standard in fact takes over the verification responsibility of buyers that don’t have the resources or necessary level of competence to follow-up on suppliers themselves”...

Another potential risk arises from this, where a blockchain solution alone might become a way for stakeholders to assert conduction of due diligence, which in reality is inadequate as a proof of responsible sourcing.

Challenges regarding data quality and the underlying problematics of the interface between the physical and the digital world are recurring: “a mere blockchain will help with transparency issues, but first people need to put credible information in there, and then we can infer its transparency. ... Technology assists to the best, but then there is this human-technology interaction that introduces vulnerability in the link.” (Bahri). Williams’ suggestion to deal with these risks include standard anti-corruption measures (such as two parties not overseeing each transaction) and establishing a trust score, allowing for a group to rate the different entities according to e.g. governance model and prevalence of corruption or incidents.

According to Bahri, the solution relevant to the study could lie anywhere on the spectrum between a public permissionless and a public permissioned blockchain, offering properties of a decentralized system.

Key differences between the two, and other networks, arise in terms of:

• computational power demanded
• scalability
• immutability & resistance towards censorship
• reading and writing access

For any application in SCM, there is a need for managing identities, Bahri points out that: “we need to make sure that it’s people who are participating in the supply chain who actually make changes ... There needs to be a point of control in which we make sure at least that whoever is making some changes to the state of the system, or is participating in the system, is initially eligible to participate and to be there.”

A public permissionless blockchain has no central management, and with reading and writing access being open to anyone, it provides high resistance to censorship, as well as a secure way for anonymous participants to contribute, creating a functionality which has the potential to manifest itself as a grievance mechanism. However, the reliability of reports from anonymous sources is questionable. At the same time, the network might be deemed too transparent for an industry with information to hide, and attracting commercial entities could be difficult, if they see joining as a loss in competitive advantage. Furthermore, the technical aspects of a public permissionless blockchain include the demand for heavy computational power, leading to time consuming transactions and reduced scalability, which is incompatible with the use of “light devices”, such as mobile phones.

With the above properties in mind, a public permissionless blockchain would be more suitable for a global cooperation, where stakeholders operate under various regulations and with no common interest: “if all these [actors in a supply chain] share one common interest, then they can collude and again [behave as a central network manager]. If ... they have some common interest to collude, then they become equal to a central entity. But if there is conflict of interest that is not technical and they don’t have any interest in colluding, then everyone wants to just unveil the others, attack them and show that the others are bad. So it will be very difficult in such a conflict of interest setup to make the majority of these nodes agree to go and destroy a piece of data, for example” (Bahri). However, in regional cooperation, where supply chain actors operating under the same regulations (e.g. Dodd-Frank) share interests in following up on these, there is a possibility of them colluding, and thus a need for central management, suggesting that a public permissionless blockchain is less suitable.

A public permissioned blockchain serves the option of providing identities, where in the case of SCM, some actors on the supply chain can be identified while others would want to remain anonymous. This provides central identity management, and a more suitable alternative for regional cooperation. Anyone demanding to join is let in and provided with an identity. Then, in the case of anonymous reporting, the participant can choose to use a ‘fake ID’ for their account, while a commercial stakeholder such as a mining company would want to vouch for their identity, (this is similar to what user identities look like in networks like Facebook or Google). However, anyone still has access to read the data in the network, which puts a certain pressure on the central manager. Bahri provided the given scenario: “outside observers can see that ‘oh, this is a permissioned blockchain, but I see that there are [no miners] participating in there, they are all companies at a certain level in the supply chain’”. Furthermore, such a network would not inherently provide the same possibilities for an anonymous reporting system, with functionalities like a grievance mechanism.

While public (both permissioned and permissionless) blockchains demand heavy computational power, Bahri pointed to work in progress addressing lighter solutions, involving e.g. light nodes, which may only keep hashes of the blockchain.

The different properties of a public permissionless and a public permissioned blockchain for an SCM application are illustrated in the diagram below (see Figure 4).

Figure 4. Public permissioned/permissionless comparison
In terms of what is desired in an application for a mineral supply chain, the level of the various qualities of a blockchain network is evaluated as high (3), medium (2) or low (1). For instance, a
public permissioned blockchain provides a high level of open writing access, thus it is evaluated as high (3), and a public permissionless blockchain as almost immutable (3) while a public permissioned carries a higher risk of collusion attacks and works under somewhat centralized management (2).

A private permissioned blockchain is considered inapplicable, due to the centralization that comes with a network having a central manager, as well as restrained reading and writing access.

Williams mentions several of Minespider’s competitors using private permissioned blockchains: “there is nothing wrong with that, it just means that there is some third party or consortium that has to be somewhat trusted in order to transact that and this may or may not be good enough.” (Williams)

The decentralization added by the blockchain technology serves no purpose in this setup, according to Bahri, since the permitting aspect of a private blockchain adds a centralizing attribute to the structure where the provider is trusted by participants, thereby foregoing the intended transparency of a blockchain (see Figure 5). Instead, she argues, a regular database design would serve the same purpose: “a blockchain with a small ‘b’ (referring to a private blockchain) is just the data structure, the database, how the database is being constructed and this construction of blocks that are tied to each other with this hash lock, with this cryptographic lock. It’s tamper-proof and all of these things. That’s the little ‘b’ and that you can have in a normal, classical centralized system”... “we can still say, ok, if the purpose is just for some few entities that are well-defined, to vote before making a change, we can still make that in a classical setup over a centralized server that computes and counts the votes.” (Bahri)

Figure 5. Database comparison

Bahri and Meilgaard personally believe that the private blockchains used by companies to provide information, are blockchains only in name and not in their underlying structures, thus they argue that the term is being used for marketing purposes: “it’s a buzzword that everyone is following so they get onto the hype and they want to get something by saying “we are using blockchain” (Bahri). Noting the failure of projects using private blockchains, Meilgaard summarizes the network provider’s approach as: “hey, you want to do something with blockchain but aren’t comfortable with the permissionless side of it - we can essentially build you ... something like a distributed database ... which allows you to use the word ‘blockchain’ for marketing purposes, but it doesn’t give you the dirty side of actually having to do something on an open permissionless system.”

### 4.2.3 Varying incentives for different stakeholders

The importance of incentives for stakeholders to join a system was brought up by all interviewees. Incentives in a supply chain may be rooted in various aspects such as financial or moral ones, which at times may be addressed by the technological capabilities of a system. Financial incentives were mentioned by several interviewees as crucial to the state and development of systems.

One aspect directly linked to the technology, which was briefly mentioned in the background (see subsection 2.2), is commercial entities wanting to hide information from the public in order to gain competitive advantage: “to make profit, you need to hide something. If you leave everything open and anyone can do it or replicate it, then why are you in business? Your existence is no more justified. That’s the biggest problem with blockchains - blockchain in its raw definition and construction, in general, goes against the mainstream business model that operates in the world today. Because it decentralizes power and it opens everything to everyone and then no one can claim profit.” (Bahri)

Fuller noted the importance of financial incentives in a setting where commercial entities often choose not to carry out thorough due diligence and follow up on responsible sourcing due to the cost that comes with it: “unfortunately, many companies are only reactive and not proactive towards mapping their supply chains and improving the social and environmental impacts of their businesses. This is a problem, since it demands much time and resources to drive companies to make improvements ... If companies don’t see the financial benefit or there is no legislated demand then they will do very little or nothing about a situation until there’s a win for them ... If [commercial entities] work together with [TCO Development], the economic incentive is that they’re able to be a part of instead of excluded from very large public and private procurements.” (Fuller)

A financial incentive might arise from laws and regulations, as a commercial entity risks losing money through penalization if they are not up to par with regulations. Regulation or formalized pressure could also come from interest organizations or others. Fuller describes the industry’s behavior regarding responsible sourcing of minerals as follows: “we found that when we launched our first criteria for conflict minerals that a lot of [commercial entities] didn’t even have a conflict mineral policy. So you won’t get any kind of development in [the area of responsible sourcing] without pressure.”

Williams also points to the importance of regulations regarding financial incentives: “human rights abuses are essentially an externality that don’t have a cost. It costs society.”. He further develops that as long as this remains an externality, and it does not affect people’s everyday lives and their economy, the issues risk being ignored “until regulations come in, and this is the role of the regulator.” (Williams).

Additionally Fuller, Meilgaard, Ekener and Williams point to commercial entities’ incentive to gain capital as an important reason for the exploitation of people and the environment along complex and opaque supply chains: “if [commercial entities] are losing profits by taking more responsibility, they know that this will be a gain to their competitors, which perhaps isn’t driving the same level of responsibility and so can keep retail prices lower. So there has to be a levelled playing field where the whole branch
moves together, simultaneously driving a minimum level of development toward the same goal.” (Fuller)

“Unfortunately it can be economically valuable to have children work for you. As soon as somebody can make more money by having children work for them than adults, somebody will do it... It’s very unprofitable to be a good company. Because it reduces your chances and opportunities... And it is in the best interest of companies that are making more money by sourcing conflict minerals or by sourcing in irresponsible ways, to keep [information about the supply chain] obscure, so you have a natural adversary if you’re trying to map supply chains, which is the companies that are abusing people in the supply chain.” (Meilgaard)

Ekener and Meilgaard also point to poverty as the root cause of the exploitation of people and noted ways to address that, through for example education, especially for children, and through higher salaries: “the only road out of poverty for poor children in poor countries is through education. That’s the only thing that really helps.” (Ekener)

“It really comes down to trying and see if you can, somehow, raise the price that artisanal scale miners are getting for the product that they’re getting out of the ground.” (Meilgaard)

Moral incentives might also induce measures for responsible sourcing. Whereas a commercial entity striving to source their material responsibly also are likely to carry less of a moral burden and perhaps gain some financial stability through eliminating risks: “it may initially cost brand owner suppliers more to have a certification system, but it will give brand owner’s peace of mind, which instead of continuously needing to drive and spend resources on identify and improving the impact of their business on suppliers, they can have an independent body to certify the factories. A certification can work in the factories benefit also, since continued compliance helps them to retain business and build a lasting relationship with the brand owner that will validate factory improvement investments.” (Fuller)

Incentives carry noticeable differences between different stakeholders, and while financial gain is a more purebred incentive for some, it might be more of a combination of both financial and moral incentives for others. These mechanisms appear to be of great importance for anyone aiming to work in a competitive industry.

Regarding incentivising miners (see subsection 4.1.B) via an anonymous grievance mechanism, Bahri stated that: “with a [permissionless] blockchain, enabling people that normally don’t have a say or wouldn’t have a say in a classical system would be quite easy, because no one can deny them access” (Bahri). Fuller commended the emphasis on involving workers, but also expressed concern over their willingness to trust an external system which they are unfamiliar with, stressing that they must see results from using it, while also bringing up the credibility issue that comes with anonymous whistleblowing. Ekener pointed out that the need for trust also extends to the organization responsible for handling such information, which likely would be an NGO, especially in societies where governments tend to be weaker institutions. Regarding the design of such a system, Williams describes one created by his team, which uses a smart contract to report on the presence, or absence, of child labor in the mines visited by the users. Each entry contributes to fund a non-profit which is tasked with following up on the reports.

Williams also elaborates on Minespider’s own work towards ending the stigma of artisanally mined minerals by providing formal buying stations through which these can be sold. These stations require a license for the miners to operate them; a process overseen by local law enforcement. Together with electronic payments and four eyes on every transaction, this is to ensure that the miners’ inputs are accurately documented, which also serves to protect them from illegitimate claims. The pilot projects are currently being implemented in non-conflict areas, “where there’s some semblance of institutions that can support this” (Williams), to demonstrate their feasibility, before moving on to less stable regions. Williams describes the role of blockchain in these scenarios as being: “about the secure transactions [and] probably about identification as well - is this person who they say they are, can they receive payments on their smartphone, is their license also linked to that? Then that can give [purchasers further down the supply chain] the confidence of buying from an artisanal source.”

4.3 Revised requirements

Following the thematic analysis of the interview responses, the requirements draft was revised to optimize the premise for an application of a blockchain solution for traceability in mineral supply chains with the aim of contributing towards responsible sourcing.

Parts of the technical requirements were incorporated into A.2. The requirement regarding blockchain network type was expanded, as a result of analyzing the suitability of a given network, with respect to a variety of implementations. The demand for interoperability was discarded as it was found to be too particular and considered a low priority feature regarding the scope of the study.

The social requirements were revised with the limitations of the technology in mind, with a main focus on the implications of data quality and how a mineral is declared to be responsibly sourced. Also here, some of the requirements were found to be too specific for the proposal in this study, and were thus incorporated into other, more broadcast scale ones.

As a result, the following sociotechnical requirements are considered as necessary, regardless of implementation method, in a blockchain solution for traceability in mineral supply chains aiming to contribute towards responsible sourcing:

A. (technical requirements):

Requirement A.1: The technical structure ought to rely on a blockchain network within the spectrum of varieties of a public permissionless and a public permissioned blockchain, effectively providing a decentralized system. This spreads data across the various nodes and does not aggregate it at a single source, which brings about accountability.

Requirement A.2: A distributed network will always require voluntary collaboration between all actors in the supply chain. In an environment familiar with illegal activities such as corruption and human rights violations [20, 18, 25, 13, 35], multiple actors
might actively be hiding aspects of their activities. Thus, there is need for incentives for all actors to join [29], so that they can partake and share data out of their own volition. Additionally, the system shall be protected against attacks so that no confidential data is compromised, as well as adhere to laws and applicable global standards.

B. (social requirements):

Requirement B.1: Supply chain due diligence is needed for stakeholders to be held accountable for the impact of their business on the local environment and population. A blockchain network is not to replace supply chain due diligence, but rather to facilitate it.

Requirement B.2: Local mining communities should be included, and the system should contribute towards a positive impact on the entire community. Working towards creating incentives for miners to participate, the system should:

Requirement B.2.1: Provide the ability to anonymously report on the conditions of human well-being in the mines, incorporating social sustainability metrics into the system.

Requirement B.2.2: Provide a mechanism for corrective actions when reports expose malpractices and abuse.

5. DISCUSSION

The purpose of this study has been to investigate the role of a blockchain in mineral supply chains for IT products to ensure that these assets are responsibly sourced, with a goal of establishing a set of sociotechnical requirements for how such a system ought to be designed. Our findings suggest that the choice of blockchain ledger should be restricted to a public blockchain (permissioned or permissionless), otherwise the decentralization of the network is compromised and the additional value of using a blockchain is unsubstantiated. Additionally, the blockchain should serve some option of anonymous reporting from those working in the mines, which in the case of a permissionless blockchain is a built-in feature, while in a permissioned blockchain it must be solved in other ways, i.e. through the use of smart contracts for anonymous reporting.

Both a public permissioned and a public permissionless blockchain carry their pros and cons, where the demand for heavy computational power is perhaps the biggest obstacle as of now. The implementation of such a system would require all users to have access to certain computing machinery, which is not necessarily the case in many mines around the world.

The requirements brought forth by this study address transparency issues in mineral supply chains, through the effective use of a public blockchain. A blockchain solution in line with the requirements could aggregate information regarding a supply chain, i.e. transfer information, comments from workers, NGOs, etc., to make up a comprehensive collection of data that can give a clear picture of the situation. While primary data in some cases might be more valuable, the issue of its validity remains, and it should be noted that such a system is not a unique solution, but it would provide great convenience to those wanting to investigate mineral supply chains and carry out due diligence.

Thus, there ought to be a sustained focus on improving the conditions of human well-being for those being subjected to abuse in the mineral supply chain, regardless of how entities wish to trace the minerals. It should again be emphasized that a blockchain for traceability alone, cannot ensure whether a mineral is responsibly sourced, and that the challenges of a sociotechnical system must be taken into consideration.

Previous research by Kshetri and Wüst and Gervais are pointing to the issue of data quality with blockchain application in SCM. However, in the case of blockchain for responsible sourcing in mineral supply chains, the frameworks proposed by some (Wüst and Wüst and Gervais), designed to guide determination of whether a blockchain is an appropriate technical solution, passes a blockchain application without further noting the challenges at hand. Thus, the requirements proposed in this study can serve as a supplementary tool when evaluating the suitability of a blockchain for responsible sourcing.

The study also opens up for discussions around other potential solutions, and sheds light on the technical needs that must be addressed for a system to be improved, or for it to even function to serve its purpose at all. Discussions around public blockchains using light nodes, as well as alternative incentive models to the ones described in requirements A.2 and B.2, are needed and will be of great value for potential future solutions.

As of now, incentives are likely to play an important role in attracting supply chain actors to a decentralized blockchain network. Among the possible financial incentives is the marketing value of corporate social responsibility (CSR), which a commercial entity can use to attract customers. In the case where CSR is substantiated, the long-term effect could be improved work towards responsible sourcing, through a sort of collective push in the industry.

Any given system is likely to involve multiple actors on a single network with a variety of incentives, some being financial and others being moral. A blockchain system would ideally contribute towards balancing out these different incentives across all stakeholders in the supply chain.

Another potential effect of a solution derived from subsection 4.3, could be the reduction of opportunistic behavior, where supply chain actors act according to their own self-interests. Saberi et al. provide an example of opportunistic behavior in SCM, of when one supply chain actor induces dependency with their suppliers, leading to a power imbalance [29]. Another example of such behavior has been seen in Chinese investments in the mining industry in the DRC [18]. With the transparency provided by a blockchain solution in line with subsection 4.3, these practices are likely to decrease, as any misdemeanor or power imbalance would be open and accessible for other actors to learn about, presenting the opportunity to put pressure on those involved.

The conditions of human well-being in certain mines are poor, sometimes destructive. Details and information about this are already known, so a system gathering primary data, such as the one described in subsection 4.3, will perhaps contribute to improved data and information of the situation, but it may be seen as redundant by some. Either way, it could be used to facilitate due diligence. However, in an economic system driven by profit, a system providing more information about human well-being throughout the supply chain is perhaps not sufficient to prompt change in the behavior of the commercial entities.

While some regions’ regulations and policies demand due diligence, at times as a measure to improve consumer rights [33], the incentives for stakeholders to invest in improving their competence for conducting due diligence are perhaps inadequate in terms of financial profit.
A more pragmatic solution would be one that makes it profitable for stakeholders along the supply chain to source responsibly and thus level out the moral and financial incentives, instead of turning them against each other. A proposal for such a system, where financial profit arises from sharing data along a supply chain, was elaborated by Meilgaard during the interview. The system would involve three main actors. First, there are certifiers, such as an NGO gathering social sustainability metrics from the supply chain and assessing the development and the state of human well-being in the mines. Then, there are financial institutions, aiming to improve the price or reduce the risk on their financial products, such as insurances on mineral ore. This would be done via supply chain data shared by supply chain actors (i.e. information about mineral buyer and mineral price), making market predictions easier and more secure for the bank, hence they can offer lower prices, creating a financial incentive for supply chain actors to share their data. The supply chain data is in turn shared with the certifiers and a fingerprint of the data is added to the blockchain, for notary purposes, if the parties can agree on validating the data. The third main actor would be an institution for government-cooperation, approving compliance with due diligence regulations. When the social sustainability metrics and other supply chain data are provided by the financial institutions and the certifiers, and in case of compliance with regulations, the data is approved. In consequence, enforcing regulations of responsible sourcing can be done through such a network, where all data is stored in a blockchain-backed network under distributed management, made up by a federation of the three main actors, with permissionless writing access to state public claims about fingerprints of data, such that not only the certifiers, but everyone, has access to read and control the data.

As the root cause for the exploitation and mistreatment of workers is poverty, a blockchain system should work to find ways to directly address low salaries and secure direct payment to workers in the mines. Supply chain actors connected to the system also ought to provide higher salaries than those who are not, which again brings about the need for on-site presence.

5.1 Method critique

A thematic analysis like the one used to study the interviewees’ answers should have been used more explicitly when drafting the initial set of requirements as seen in subsection 4.1. Instead, the requirements draft emerged primarily from unstructured discussions between the authors following the background research, which led to a consensus on which themes we considered essential. Although the revised requirements followed from a thematic analysis of the interviewees’ answers, these were most likely influenced by those in the draft, with many of the revised requirements being combinations or rephrasings of the draft. This approach might have influenced the result by author’s bias. Even in the case of a proper thematic analysis yielding the same, or similar, requirements draft, it would nevertheless have provided a better foundation for the remainder of the study.

Our research question and approach were based around the altruist idea that people and commercial entities work around moral incentives. Several interviewees pointed out the improbability of a move towards responsible sourcing if this requires a change in commercial entities’ behavior leading to financial loss, or without the undertakings eventually being profitable. Even if there are many altruist actors driven by moral incentives working with these issues, they are typically not those with the most resources and ability to affect the system. Having this perspective while shaping our research could have altered the course of the study to focus on more pragmatic solutions.

While the interviews gave us extensive argumentations from various experts, transcription was an arduous process and the answers were difficult to categorize. We could have opted to send out an email questionnaire to even more interviewees, which likely would have yielded less exhaustive, albeit more easily assembled, answers. Talking to additional stakeholders, e.g. representatives from multiple commercial entities in the supply chains and preferably mine workers themselves, would also have helped to further diversify the perspectives. A larger participation body is also desirable to assess the general consensus on the requirements.

As blockchain is a rapidly evolving technology, much of what is being written on the subject is posted on blogs, forums and other non-academic sources. The latter property led us to practically disregard most of these sources, which are certain to contain the most up-to-date information on the technology. Preferably, these should have been approached methodologically and assessed individually.

Some interviewees pointed out the possible negative impacts of introducing an outside solution to e.g. a mining community. Besides the trust issue, there may be intricate local systems in place that, although harmful to the workers in several aspects, could destabilize the communities if disrupted. This study does not contain a risk assessment of implementation of the requirements, which ought to be carried out prior to taking such actions. It is also worth mentioning that we still have quite limited insight into the actual organization of work in the mines, so our knowledge for anticipation of a blockchain system’s contribution towards responsible sourcing is restricted.

Approaching both academic and industry professionals was partly necessary due to the limited number of people working with blockchain technology in the academic field in Stockholm, where we are based, but this also provided us with different perspectives on the technology. Interviewees gave varying answers, some based on their personal opinions, but some variation also stems from the technology not being well-established yet.

5.2 Future work

Future work should evaluate the available blockchain networks in practice, i.e. how they operate when implemented and their impact on the supply chains and the respective mining, smelter and manufacturing communities.

Further research on the use of light nodes in public blockchain are also needed to better address applications in SCM.

Thoroughly inspecting the incentives of the various stakeholders will also add to a more comprehensive understanding of the vast networks supply chains make up. A key concern will be how to best address these incentives at all stages, where, ideally, the incentives line up throughout the supply chain. Theories on e.g. nudging and human well-being could be applied to investigate how to optimize the incentives for all parties involved.

As the blockchain technology evolves rapidly and the initial draft of requirements was influenced by author’s bias, it would likely be necessary to review the field ahead of conducting the aforementioned research.
6. CONCLUSION

A blockchain solution has the potential to provide enhanced traceability in a supply chain, and with a decentralized network, somewhere between a public permissionless and a public permissioned blockchain, there are possibilities for these networks to provide mechanisms contributing to responsible sourcing. As of today, such blockchains require a lot of computing power and that all participants have access to heavy-duty servers, which is not necessarily the case in a mineral supply chain. It should also be noted that the less decentralized the network (such as those of private permissioned blockchains) the argument for the use of blockchain over a regular database becomes weaker, due to the lack of additional value the blockchain brings to the network.

However, it is not sufficient for actors to solely rely on this digital solution as a means to claim their products are responsibly sourced, and the technology does not replace on-site due diligence obligations. This study has focused on the need for a sociotechnical solution in order for a blockchain network to effectively handle responsible sourcing, as illustrated by the requirements (see subsection 4.3).

A major challenge remains how to make commercial entities, aiming to make profit, risk their competitive advantage through increased transparency. One proposal on how to address this challenge was brought up by one of the interviewees, Meilgaard, and has the potential to impact responsible sourcing, by making it profitable for supply chain actors to share their supply chain data.

To our knowledge, there are still no up and running applications of actual decentralized blockchain networks (i.e. not private) in the mining industry.

The study demonstrates how recognizing the technology’s limitations can lead to new doors opening regarding other potential solutions.

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8. REFERENCES


