The Practice and Potential of Blockchain Technologies for Extractive Sector Governance

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Contents

Key messages

- Blockchain technology could potentially reduce transparency challenges and information asymmetries in certain parts of the extractives value chain. However, stakeholders considering blockchain technologies need a more nuanced **understanding of problem definition, value proposition and blockchain attributes** to ensure that such interventions could positively impact extractive sector governance.
- The blockchain field currently lacks **design principles, governance best practices, and open data standards** that could ensure that the technology helps advance transparency and good governance in the extractive sector.
- Most blockchain projects are preliminary concepts or pilots, with **little demonstration of how to effectively scale up** successful experiments, especially in countries with limited resources.
- Meaningful impact evaluations or peer-reviewed publications that assess impact, including on the **implications of blockchain's emissions footprint**, are still lacking. More broadly, a **shared research agenda around blockchain** could help address questions that are particularly ripe for future research.
- Transition to a blockchain-enabled system is likely to be **smoother and faster in cases when digital records are already available** than when a government of company attempts to move from an analog system to one leveraging blockchain.
- Companies or governments using blockchain are more likely to implement it successfully when they have a firm grasp of the technology, its strengths, its weaknesses, and how it fits into the broader governance landscape. But often these **actors are often overly reliant on and empowering of blockchain technology vendors and startups**, which can lead to "lock-in, whereby the market gets stuck with an approach even though market participants may be better off with an alternative."
- The **role played by intermediaries** like financial institutions or registrars can determine the success or failure of blockchain applications.

INTRODUCTION

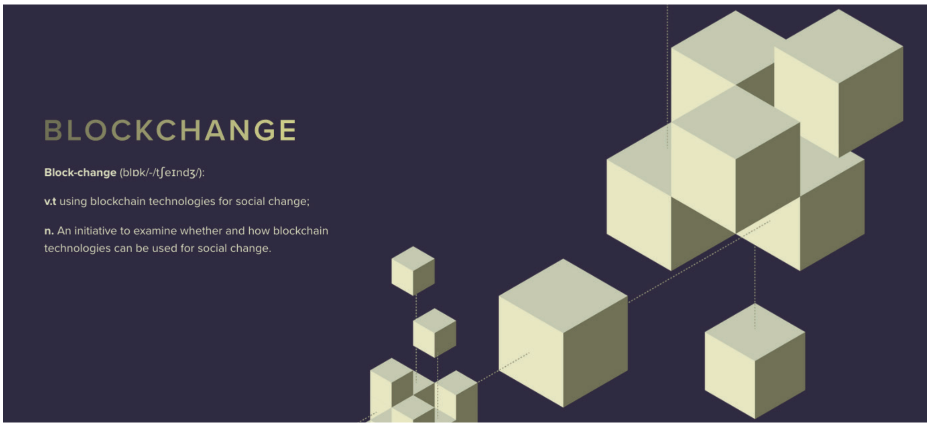
By providing new ways to identify individuals and organizations, and by recording various types of financial flows and transactions in a distributed manner, blockchain technologies have the potential to serve as a new tool to improve information disclosure. Yet, despite the earlier excitement around the use of blockchain platforms, uncertainties remain about what types of benefits the emerging technologies can actually deliver.

Important questions are being raised about whether blockchain technologies can contribute to solving governance challenges in the mining, oil and gas sectors. This report seeks to begin addressing such questions, with particular reference to current blockchain applications and transparency efforts in the extractive sector.

APPROACH

This paper summarizes extensive analysis, which commenced in mid-2018, by The Governance Lab (GovLab) at the New York University Tandon School of Engineering and the Natural Resource Governance Institute (NRGI). The research was funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) through the German International Development Cooperation (GIZ). Our goal was to explore how blockchain technologies are being used, or are planned to be used, in connection with specific activities at different stages of the extractives decision chain.[1] Our study focused in particular on three activity areas: licensing and contracting, corporate registers and beneficial ownership, and commodity trading and supply chains. Through an analysis of deployed and proposed initiatives across each activity area, we aimed to unpack whether blockchain technologies could lead to changes—good or bad—in the way extractives companies operate, civil society conducts oversight and states govern the extractive sector.

We conducted our analysis through detailed desk research, a literature review (see Annex), a series of stakeholder interviews and an expert meeting in Washington, D.C. These sources supported an examination into what circumstances would enable blockchain technologies to enhance or pose risks to the governance of the mining, oil and gas sectors, with an emphasis on transparency and accountability.



More resources on Blockchain for Social Change at The GovLab's https://blockchan.ge/

1 NRGI, *The Natural Resource Charter Decision Chain* (2015),resourcegovernance.org/sites/default/files/nrgi_NRC-Decision-Chain.pdf.

DATA CHALLENGES IDENTIFIED

Transparency norms help set the foundation for improving the governance of natural resources by enabling disclosure and analysis of data to inform sound policy choices and to hold governments and companies accountable. Our research identified several data management and data use challenges associated with transparency efforts in the extractive sector that blockchain technologies could potentially impact:

- **Availability.** When data are not made publicly accessible, relevant actors' ability to share and aggregate information is constrained, which can limit efforts to ensure public accountability.
- **Accuracy.** High transaction costs associated with validating information and lack of oversight over (or trust in) the actors providing information can create challenges to ensuring that data are accurate enough to inform strong policy analysis and sectoral monitoring.
- **Alignment.** Relevant actors often generate and share data that use different standards and formats, leading to critical challenges for comparability and analysis.
- **Attainment.** Many actors in the extractives oversight and governance communities have not attained the requisite data skills to effectively monitor relevant data streams and ensure public accountability in the sector.

BLOCKCHAIN ATTRIBUTES IDENTIFIED

To inform our analysis of current practice and the potential of blockchain, we reviewed the variables and attributes that determine the design and use of blockchain technologies. Blockchain technologies incorporate different attributes in different use cases. Some of these attributes are fixed across nearly all blockchain use cases, while others are optional. In this section we provide brief definitions of key blockchain concepts, introduce blockchain's fixed attributes and then describe some key optional attributes.

Core blockchain definitions

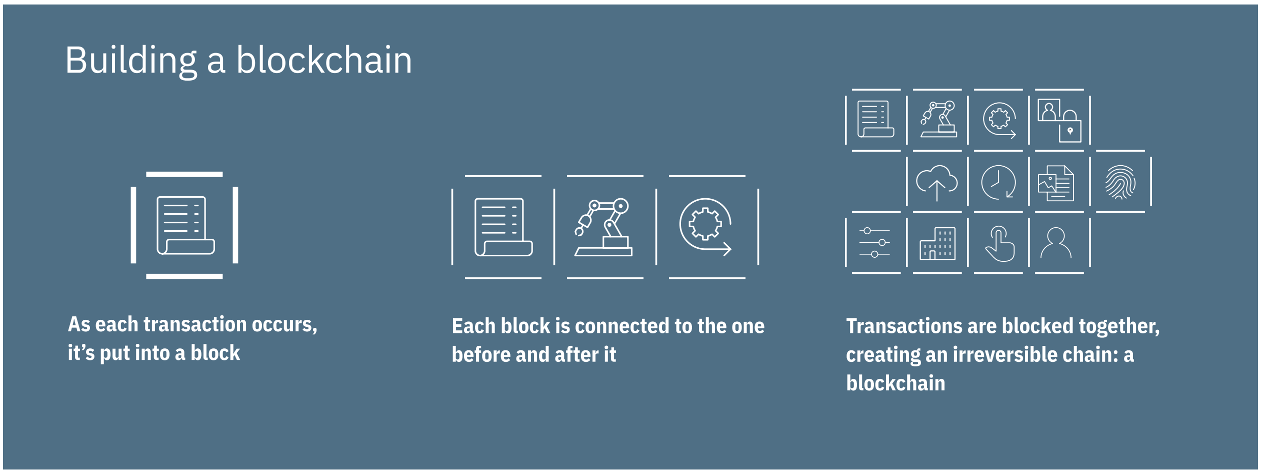
Blockchain. A system in which transactions are linked together, creating an immutable chain that logs all transactions. This irreversible log is often called the "ledger." Nodes form the infrastructure of the blockchain, so a blockchain exists on nodes.

Block. Each block represents an individual piece of information permanently stored as a unit of data. The first block of a blockchain is referred to as "genesis." Blocks are stored on "nodes" (which can be any device).

Distributed Ledger Technology (DLT). Blockchains are described as a distributed ledger technology because they record, store and replicate activities across a network of computers. As a result, no single person or entity controls a DLT.[2]

2 There are also examples of private blockchain projects from private sector initiatives. These cannot be accessed publicly and thus miss this key feature of the technology. See for example, see Wayne Vaughan. "Open vs Closed Blockchains — Let's End This Madness," *Medium*, 31 Jul 2015, medium.com/@WayneVaughan/open-vs-closed-blockchains-let-s-end-this-madness-8313e4095ead.

Figure 1. Building a blockchain[3]



Fixed blockchain attributes

Immutability. Blockchain ledgers exhibit a level of immutability not present in other database management systems. While administrators can alter databases, a blockchain-based system cannot be amended or changed. While questions increasingly arise around how immutable blockchains truly are,[4] it is generally "nearly impossible to alter information on the blockchain."[5] This immutability helps to ensure that all information is kept as "permanent legacies. If corrections are made, these will indicate how the ledger was changed, in the same way as a document including all track changes."[6]

Integrity. The distributed validation mechanisms that confirm additions to the blockchain cannot be gamed toward intentionally adding low quality or inaccurate information to the blockchain. This integrity of user information and activity is also the result of automated capturing of transaction metadata for all activity undertaken on each chain.

Resilience. The information security that blockchain offers comes from distribution of information and agency across nodes in the blockchain. Malicious attacks can strike centralized databases, but would require "an attack on every copy of the ledger simultaneously" in order to be similarly effective on a blockchain, given its distributed nature.[7]

3 IBM, *Blockchain* 101 (2018), www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=45015045USEN&.
4 Christina Comben. "Are blockchains actually immutable?" *The Merkle*, 7 Apr 2018, themerkle.com/are-blockchains-actually-immutable/.
5 Raúl Zambrano. *Blockchain: Unpacking the disruptive potential of blockchain technology for human development* (International Development Research Centre, 2017), idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/56662/IDL-56662.pdf.
6 Michael Mainelli. "Blockchain will help us prove our Identities in a digital world," *Harvard Business Review*, 16 Mar 2017, hbr.org/2017/03/blockchain-will-help-us-prove-our-identities-in-a-digital-world.
7 Philip Boucher, Mihalis Kritikos and Susana Nascimento. How blockchain technology could change our lives (European Parliamentary Research Service, 2017), www.europarl.europa.eu/RegData/etudes/IDAN/2017/581948/EPRS_IDA(2017)581948_EN.pdf.

Optional blockchain attributes

Permissioned versus permissionless data contribution. The permissionless versus permissioned dichotomy hinges on who has the rights to add transactions on the chain. For permissionless ledgers (e.g., the Bitcoin blockchain), anyone has the ability to write to the blockchain, whereas permissioned ledgers enable only a restricted set of users to add transactions on the chain.

Public versus private viewing of data results. Public blockchains (e.g., Bitcoin, Ethereum) are designed so that anyone can view, browse or audit transactions. In public blockchains, the entirety of information and metadata held on a chain is available for all users to view. Even though most public blockchains store some information off-chain, with only cryptographic hashes to identify the information made publicly visible, a core set of information on all transactions will be time-stamped and available for all to view. A cryptographic hash is a fixed length string that acts as a kind of "signature" for the data provided.

On the other hand, on private blockchains (e.g., Hyperledger and various business applications), the data are not publicly accessible. These blockchains can restrict access to information to a small set of pre-approved users to such an extent that transparency cannot be reasonably attributed. As we will see in this study, few blockchain use cases led by the private sector indicate that public transparency is a key objective.

Permissioned versus permissionless data "validation." Distributed validation mechanisms ensure that information added to the ledger is consistent and that a diversity of stakeholders can monitored it. Activities recorded on the blockchain are captured, stored and open to scrutiny by other parties who have the ability to read information held on the blockchain.[8] However, the scope of who can authenticate transactions can vary. Permissioned ledgers enable only a restricted set of users to authenticate transactions.

Disintermediation level. Bitcoin, the original use case for blockchain, was developed with a particular interest in creating a disintermediated monetary system, with users transacting peer-to-peer without involving central banks.[9] Blockchains, especially public blockchains, can enable such disintermediation, but not every blockchain implementation will similarly "cut out the middle-man." A private, permissioned blockchain, for example, implemented with selected, specific nodes, would exhibit vastly lower levels of disintermediation compared to something like the Bitcoin blockchain.[10]

8 Raúl Zambrano. "Blockchain: Unpacking the disruptive potential of blockchain technology for human development," *International Development Research Centre,* August 2017, idl-bnc-idrc.dspacedirect.org/bitstream/handle/10625/56662/IDL-56662.pdf.

9 Bank of International Settlements, Cryptocurrencies: looking beyond the hype (2018), www.bis.org/publ/arpdf/ar2018e5.pdf.

10 Anna Irrera. "The Public vs Private Debate on Blockchain," *Financial News,* 1 Oct 2015, www.fnlondon.com/articles/blockchain-fintech-the-public-vs-private-debate-20151001.

Table 1. Blockchain attributes[11]

Public	Permissionless	Private	Permissionless
Who can see the result? **Everyone**	Who can write to the blockchain/ transact? **Anyone**	Who can see the result? **Select/ verified participants**	Who can write to the blockchain/ transact? **Anyone**
Example: Bitcoin, Ethereum		*Example: Monax, Multichain, Federal Byzantine Agreement*	
Public	**Permissioned**	**Private**	**Permissioned**
Who can see the result? **Everyone**	Who can write to the blockchain/ transact? **Select/ verified participants**	Who can see the result? **Select/ verified participants**	Who can write to the blockchain/ transact? **Select/ verified participants**
Example: Land titles, university degrees		*Example: Medical records, KYC, AML*	

ACTIVITY AREAS EXPLORED

Our analysis explored the current state of blockchain technologies in the following extractive sector activity areas:

Licensing and contracting. The current use of blockchain technologies was not established in extractives licensing and investor-state contracting activities. Several blockchain use cases were identified in connection with land registries (e.g., in Sweden and Georgia), but these are outside of the extractive sector and, from a governance perspective, are too dissimilar from licensing and contracting processes to be highly relevant. If blockchain applications expand in extractives licensing, considerations should include:

- whether blockchain technologies are suitable for long-term preservation of records
- what advantages (if any) blockchain approaches could bring (particularly for government and public oversight) beyond geospatial databases currently being used for extractive license cadasters
- whether smart contract approaches will be suitable for handling the many determinations that must be made in extractives licensing (e.g., whether financial and technical capacity criteria have been met or addressing the complexity of negotiated terms)

Corporate registers and beneficial ownership. Our review found several cases where corporate registers leveraged blockchain technologies (e.g., in Canada and Switzerland). In May 2016, the U.S. state of Delaware announced a blockchain initiative which would enable companies to track share ownership and transfers on a distributed ledger.[12] There are some assertions that the "transparency,

11 Provided by Karen Ottoni, Hyperledger, during Expert Meeting on July 12, 2018 in Washington, D.C.
12 Delaware Office of the Governor, "Governor Markell Launches Delaware Blockchain Initiative", May 2, 2016, www.prnewswire.com/news-releases/governor-markell-launches-delaware-blockchain-initiative-300260672.html.

immutability, and security offered by blockchain makes it ideally suited for use in record-keeping, particularly with regards to the ownership of assets."[13] However, it is also notable that momentum around the Delaware blockchain initiative has slowed considerably.[14] While none of the current use cases are specifically focused on extractives companies, their scope is broad enough that ownership information regarding mining and oil companies would likely be included. Central questions will be whether blockchain technologies can offer strong solutions regarding public transparency, and the verification of provided beneficial ownership information.

Commodity trading and supply chains. Commodity trading and supply chain management were the activity areas where blockchain technologies appeared to be gaining the most traction in the extractive sector.

At the time of writing, there were signs that three commercial consortia within the commodity trading sector were seeking to develop blockchain applications to integrate trading across oil producers, traders and financial institutions.

	Easy Trading Connect	DLT platform for U.S. crude	European gas trading
IOCs	BP, Shell, Statoil	N/A	Total, ENI
Trading Houses	Mercuria, Gunvor, Koch	Trafigura	Freepoint, Mercuria, Gasprom, Wattenfall, Petroineos, MGN Energie
Banks	ING, Societe Generale, ABN-AMRO	Natixis	N/A
Tech	Ethereu	IBM, Hyperledger	BTL, Interbit

Figure 2. Blockchain commercial consortia

A potential concern is that the private nature of these applications could counteract progress on transparency norms related to commodity trading in the "traditional" data space.

Blockchain technology is also being tested in oil and mining supply chains. S&P Global Platts is working with the Fujairah Oil Industry Zone, regional regulator FEDCom and 11 terminal operators to use blockchain for oil inventory tracking. Using the open source Hyperledger Fabric framework, terminal operators will submit data to FEDCom on individual permissioned private channels. FEDCom will then use an automatic command to calculate and send data to S&P Global Platts on a more public channel. As with the current system, FEDCom will continue to have sole access to all figures, and only approved aggregated weekly numbers will be submitted to S&P Global Platts for global distribution. In the mining sector, BHP Billiton is working with BlockApps, a ConsenSys-incubated company, to develop a blockchain web application for supply chain traceability. The system will facilitate data exchange between BHP Billiton's various vendors, including geology and shipping companies.

13 Julia de Jong, Alexander Meyer and Jeffrey Owens. "Using blockchain for transparent beneficial ownership registers," *International Tax Review*, June 2017, www.wu.ac.at/fileadmin/wu/d/i/taxlaw/institute/WU_Global_Tax_Policy_Center/Tax___Technology/feat_blockchain_beneficial_ownership_COMPLETED.pdf.

14 Karl Baker. "Delaware eases off blockchain zeal, but why?" *The News Journal*, 2 Feb 2018, www.delawareonline.com/story/news/2018/02/02/delaware-eases-off-early-blockchain-zeal-after-concerns-over-disruption-business/1082536001/.

TEN TAKEAWAYS

Our analysis of blockchain's realized and potential relevance for the governance of the extractives sector yielded ten cross-cutting takeaways that could inform future research and experimentation:

1 **Blockchain has the potential, in some situations, to reduce existing transparency challenges and information asymmetries.** However, in cases where blockchain attributes do not align with the underlying operational conditions of the sector activity, the technology could run the risk of further entrenching these information asymmetries, exacerbating transparency and governance challenges. More specifically, in sector activities where transparency norms are present or advocated for, then permissioned and private blockchain applications will not suffice.

2 **Enthusiasm is growing, but a more nuanced understanding of problem definition, value proposition and blockchain attributes is needed in order to ensure that technical interventions could have a positive governance impact in the extractive sector.** Much of the technology literature has assumed a strong belief that blockchain can address a multiplicity of governance challenges, often while disregarding the socioeconomic and political context that will inevitably influence the success or failure of any such intervention.[15]

3 **Blockchain proofs of concept and pilot projects dominate the field, with little understanding of how to effectively scale up successful experiments, especially in countries with limited resources.** While it is important to demonstrate the feasibility and potential of a blockchain project, real world applicability will only be truly tested once projects have been effectively scaled.

4 **Compelling blockchain use cases and anecdotes abound, but meaningful impact evaluations or peer-reviewed publications that assess impact are still lacking, including on the implications of blockchain's emissions footprint.** This lack of evidence reinforces questions regarding which transparency challenges blockchain would address better than alternative methods that could be more inclusive, cost efficient and environmentally sustainable.[16] At this stage of the debate, blockchain efforts should be carefully examined to determine to what extent road-tested technologies already exist for achieving the same data disclosure or data management result.[17] Many alternative data sharing technologies have, for example, proven to have a much lower emissions footprint.[18]

15 Izabella Kaminska. "Why blockchain is a belief system," *Financial Times*, 11 Jan 2018, ftalphaville.ft.com/2018/01/11/2197546/why-blockchain-is-a-belief-system/.
16 Wendy Lin, Colin McDonnell and Ben Yuan. Blockchains and electronic health records. www.fer.unizg.hr/_download/repository/blockchain_ehr.pdf.
17 Paul Nelson. *Primer on Blockchain* (USAID), www.usaid.gov/sites/default/files/documents/15396/USAID-Primer-Blockchain.pdf.
18 Wendy Lin et al, *Blockchains and electronic health records.*

5 **Moving toward a blockchain-enabled system is likely to be smoother and more rapid in cases where digital records are already available than when there is an attempt to move from an analog identification system to one leveraging blockchain.** However, the quality of digital records is also paramount, as is true with all data-driven technologies. The use of blockchain is a "garbage in; garbage out," proposition; i.e., an inaccurate or poor-quality input to the chain will affect the quality of the output.

6 **Blockchain can only be effective if the stakeholders implementing have a firm grasp of the technology, its strengths, its weaknesses and how it fits into the broader governance landscape.** This is the case for any technology considered for improving the efficiency and legitimacy of governance. As it stands, the private sector is driving uptake and development of blockchain technologies, often with an emphasis on private and permissioned approaches. Efforts should be made by all stakeholders to ensure that blockchain applications in the extractive sector align with transparency norms in the sector, and that civil society and governments have an active and appropriate role in selecting, shaping, participating in and monitoring relevant blockchain technologies.

7 **An overreliance on, and the outsized empowerment of, blockchain technology vendors and startups can lead to lock-in.** Blockchain relies on a level of interconnection among multiple data sources and stakeholders. A fragmented, rather than cooperative, approach across data points and stakeholders can lead to the creation of unnecessary silos and can minimize interoperability.

8 **The presence or absence of intermediaries, such as financial institutions or registrars, and their effectiveness can affect the success or failure of blockchain applications.** As fully decentralized systems for many blockchain use cases are unlikely to reach a critical mass of public utility and accessibility for some time, effective intermediaries can enable engagement with both intended users and any legacy systems relevant to blockchain implementation. On the other hand, the absence of trusted intermediaries, or the presence of inefficient ones, could help to incentivize the creation and use of a more decentralized approach.

9 **The extractive governance community would benefit from a shared research agenda around blockchain to address the questions that are particularly ripe for future research.** Areas in need of additional study include how to ensure compliance in the use of blockchain with existing regulatory practices and policies; optimal roles and responsibilities for different actors tasked with governing blockchain technologies; and approaches for designing fit-for-purpose blockchain initiatives given specific governance needs, objectives and constraints.

10 **The blockchain field currently lacks design principles, governance best practices and open data standards that could ensure that the technology helps advance transparency and good governance in the extractive sector.** Such principles, best practices and standards are necessary before the implementation of a more concerted approach to the use of blockchain to improve extractives governance.

DESIGN PRINCIPLES

Our analysis points towards an initial set of design principles that could act as a starting point for undertaking a more targeted approach to the use of blockchain in improving extractives governance. These design principles take the form of the acronym GENESIS, reflecting the concept of the first block in the blockchain, which is also often the initial point of failure or risk.

Table 2. Blockchain design principles

Design principle	Description
Governance	Given the potential for positive and negative impacts of an immutable ledger that can automatically take pre-defined steps when an action occurs, a transparent, accountable and participatory process for decision-making should be in place to guide the development of blockchain technologies.
Ethically sound	Blockchain implementations should take into consideration any potential positive or negative impact on the diverse rights of individuals early in the design process. Practitioners should ensure that they avoid siloed experimentation that could further jeopardize already vulnerable communities.
Not technologies, but solutions	Like many new technologies, blockchain is often treated as the proverbial hammer in search of a nail. While the tendency toward broad experimentation is a worthy aim, a clear and actionable understanding of the problem to be solved is essential both for meaningfully addressing the issue at hand, as well as contributing to a greater understanding of if, when and how blockchain can positively impact governance and social change.
Ecological footprint	Certain blockchain technologies have a massive and growing ecological footprint resulting from high levels of energy powering proof-of-work data-mining activities.[19] If blockchain is going to have a positive impact on creating social change, validation mechanisms that limit their ecological footprint may be preferable.
Synchronized with existing initiatives	Many societal challenges are neither new nor unrecognized by existing institutions. While blockchain could offer a promising option for addressing some transparency and governance challenges, new efforts should seek to be complementary rather than redundant with existing efforts.
Interoperability and open standards	The private sector drives much of the current activity around blockchain's use for governance and social change. This is to be expected given where the vast majority of blockchain-related skills, investment and capacity exist. But while vendors are an important part of the blockchain ecosystem, without whom experimentation would be impossible, government and civil society must work to avoid long-term vendor lock-in and the patenting of blockchain protocols.[20] Ensuring the interoperability of different systems, and the development of open technical standards for these systems will be key for ensuring that the public sector's use of blockchain remains flexible and problem- rather than technology-driven.
Securing first block accuracy	While blockchain's attributes of immutability and integrity ensure a level of information accuracy and consistency, the first block in the chain remains an important potential point of failure. Consistent with the aphorism "garbage in, garbage out," the quality of information held on the blockchain is only as good as what is entered in the genesis block.

19 Adam Rogers. "The Hard Math Behind Bitcoin's Global Warming Problem," *Wired*, 15 Dec 2017. www.wired.com/story/bitcoin-global-warming/

20 Matt Asay. "Why big vendors could ruin Blockchain by making it a centralized service," *TechRepublic*, 4 Apr 2017, www.techrepublic.com/article/why-big-vendors-could-ruin-blockchain-by-making-it-a-centralized-service/

ANNEX. LITERATURE REVIEW

This review, compiled in 2018, provides a selection of the nascent, but growing, literature on blockchain technologies and extractive sector governance across six categories.

- Blockchain technologies and extractives – promise and current potential
- Blockchain technologies and the governance of extractives
- Beneficial ownership screening
- Land registration, licensing and contracting transparency
- Commodity trading and supply chain transparency
- Global governance and disclosure practices
- Industry-specific case studies

BLOCKCHAIN TECHNOLOGIES AND EXTRACTIVES—PROMISE AND CURRENT POTENTIAL

Adams, Richard, Beth Kewell, Glenn Parry. Blockchain for Good? Digital Ledger Technology and Sustainable Development Goals, *Handbook of Sustainability and Social Science Research*, 27 Oct 2017.

- This chapter in the *Handbook of Sustainability and Social Science Research* seeks to reflect and explore the different ways Blockchain for Good (B4G) projects can provide social and environmental benefits under the United Nation's Sustainable Goals framework
- The authors describe the main categories in which blockchain can achieve social impact: mining/consensus algorithms that reward good behavior, benefits linked to currency use in the form of "colored coins," innovations in supply chain, innovations in government, enabling the sharing economy and fostering financial inclusion.
- The chapter concludes that with B4G there is also inevitably "blockchain for bad." There is already critique and failures of DLTs such as the DAO, and more research must be done to realize whether DLTs can provide a more decentralized, egalitarian society, or just be another tool for control and surveillance by organizations and government.

Cullinane, Bernadette and Randy Wilson. Transforming the Oil and Gas Industry through Blockchain, *Official Journal of the Australian Institute of Energy News*, Dec 2017.

- In this article, Cullinane and Wilson elaborate four areas where blockchain can play a role in transforming the oil and gas industry.
    - Supply chain management
    - Smart contracts
    - Record management
    - Cross border payments

Da Silva, Filipe M. and Ankita Jaitly. Blockchain in Natural Resources: Hedging Against Volatile Prices, Tata Consultancy Services Ltd., 2018.

- The authors of this white paper assess the readiness of natural resources industries for blockchain technology application, identify areas where blockchain can add value and outline a strategic plan for its adoption.
- In particular, they highlight the potential for blockchain in the oil and gas industry to simplify payments, where for example, gas can be delivered directly to consumer homes using a blockchain smart contracting application.

Halford-Thompson, Guy. Powered by Blockchain: Reinventing Information Management in the Energy Space, BTL, 12 May 2017.

- According to Halford-Thompson, "oil and gas companies are exploring blockchain's promise to revamp inefficient internal processes and achieve significant reductions in operating costs through the automation of record keeping and messaging, the digitization of the supply chain information flow, and the elimination of reconciliation, among many other data management use cases."
- Data reconciliation processes in the sector, for example, are complex and can require significant time for completion. Blockchain technology could not only remove the need for some steps in the information reconciliation process, but also eliminate the need for reconciliation altogether in some instances.

BLOCKCHAIN TECHNOLOGIES AND THE GOVERNANCE OF EXTRACTIVES

(See also: Selected Readings of Blockchain Technologies and its Potential to Transform Governance)

Koeppen, Mark, David Shrier and Morgan Bazilian. Is Blockchain's Future in Oil and Gas Transformative Or Transient?, Deloitte, 2017.

- The authors propose four areas that blockchain can improve the oil and gas industry.
    - Transparency and compliance. The authors predict that employing blockchain will significantly reduce compliance costs, since it securely makes information available to all parties involved in the supply chain.
    - Cyber threats and security. The industry faces constant digital security threat and blockchain provides a solution to address this issue.
    - Mid-volume trading/third party impacts. "Boundaries between asset classes will blur as cash, energy products and other commodities, from industrial components to apples could all become digital assets trading interoperably."
    - Smart contract. "The sheer size and volume of contracts and transactions to execute capital projects in oil and gas have historically caused significant reconciliation and tracking issues among contractors, sub-contractors, and suppliers." With blockchain smart contracts this process can be executed automatically after all requirements are met. As a result, it improves contract efficiency and protects each party from volatile pricing.

Mawet, Pierre and Michael Insogna. Unlocking the Potential of Blockchain in Oil and Gas Supply Chains, 21 Nov 2016.

- The authors propose three ways blockchain technology can boost productivity and efficiency in oil and gas industry.
    - **"Greater process efficiency.** Smart contracts, for example, can be held in a blockchain transaction with party compliance confirmed through follow-on transactions, reducing third-party supervision and paper-based contracting, thus helping reduce cost and overhead.
    - **"Compliance.** Visibility is essential to improve supply chain performance. The immutable record of transactions can aid in product traceability and asset tracking.
    - **"Data transfer from IoT sensors.** Blockchain could be used to track the unique history of a device, with the distributed ledger recording data transfer from multiple sensors. Data security in devices could be safeguarded by unique blockchain characteristics."

Som, Indranil. Blockchain: Radically Changing the Mining Paradigm, 27 Sep 2017.

- In this article, the author proposes three ways that the blockchain technology can reshape the mining industry: improve cybersecurity, increase transparency through smart contracts and provide visibility into the supply chain.

BENEFICIAL OWNERSHIP SCREENING

(See also: Selected Readings on Blockchain Technologies and Identity).

De Jong, Julia, Alexander Meyer and Jeffrey Owens. Using blockchain for transparent beneficial ownership registers, *International Tax Review,* June 2017.

- This paper discusses the features of blockchain and distributed ledger technology that can improve collection and distribution of information on beneficial ownership.
- The Financial Action Task Force (FATF) and the Organisation for Economic Co-operation and Development (OECD) Global Forum regimes have identified a number of common problems related to beneficial ownership information across all jurisdictions.
    - "Insufficient accuracy and accessibility of company identification and ownership information;
    - "Less rigorous implementation of customer due-diligence (CDD) measures by key gatekeepers such as lawyers, accountants, and trust and company service providers; and
    - "Obstacles to information sharing such as data protection and privacy laws, which impede competent authorities from receiving timely access to adequate, accurate and up-to-date information on basic legal and beneficial ownership."
- The transparency, immutability and security offered by blockchain makes it ideally suited for record-keeping, particularly with regards to the ownership of assets. Thus, blockchain can address many of the shortcomings in the current system as identified by the FATF and the OECD.

- The authors suggest that a global registry of beneficial ownership using blockchain technology would offer the following benefits.
    - Ensure real-time accuracy and verification of ownership information
    - Increase security and control over sensitive personal and commercial information
    - Enhance audit transparency
    - Create the potential for globally linked registries
    - Reduce corruption and fraud, and increase trust
    - Reduce compliance burden for regulate entities

Herian, Robert. Trusteeship in a Post-Trust World: Property, Trusts Law and the Blockchain, *The open University,* Jan 2016.

- This paper discusses the often-overlooked topic of trusteeship and trusts law and their implications for blockchain technology.
- "Smart trusts" (on the blockchain) will distribute trusteeship across a network and, in theory, remove the need for continuous human intervention in trust fund investments, thus resolving key issues around accountability and the potential for any breach of trust.
- Smart trusts can also increase efficiency and security of transactions, which could improve the overall performance of the investment strategy, thereby creating higher returns for beneficiaries

LAND REGISTRATION, LICENSING AND CONTRACTING TRANSPARENCY

J. Michael Graglia and Christopher Mellon Blockchain and Property in 2018: At the End of the Beginning, *New America,* 2018.

- This paper claims "blockchain makes sense for real estate" because real estate transactions depend on a number of relationships, processes and intermediaries that must reconcile all transactions and documents for an action to occur. Blockchain and smart contracts can reduce the time and cost of transactions while ensuring secure and transparent record-keeping systems.
- The ease, efficiency and security of transactions can also create an "international market for small real estate" in which individuals who cannot afford an entire plot of land can invest small amounts and receive their portion of rental payments automatically through smart contracts.
- The authors describe seven prerequisites that land registries must fulfill before blockchain can be introduced successfully: accurate data, digitized records, an identity solution, multisig wallets, a private or hybrid blockchain, connectivity and a tech aware population and a trained professional community
- To achieve the goal of an efficient and secure property registry, the authors propose an eight-level progressive framework through which registries slowly integrate blockchain due to legal complexity of land administration, resulting inertia of existing processes and high implementation costs.

Level 0 - No integration
Level 1 - Blockchain recording
Level 2 - Smart workflow
Level 3 - Smart escrow
Level 4 - Blockchain registry
Level 5 - Disaggregated rights
Level 6 - Fractional rights
Level 7 - Peer-to-peer transactions
Level 8 - Interoperability

Thomas, Rod. Blockchain's Incompatibility for Use as a Land Registry: Issues of Definition, Feasibility and Risk, *European Property Law Journal*, vol. 6, no. 3, May 2017.

- Thomas argues that blockchain, as it is currently understood and defined, is unsuited for the transfer of real property rights because it fails to address the need for independent verification and control.
- Under a blockchain-based system, coin holders would be in complete control of the recordation of the title interests of their land, and thus, it would be unlikely that they would report competing or contested claims.
- Since land remains in the public domain, the risk of third-party possessory title claims are likely to occur; and over time, these risks will only increase exponentially.
- A blockchain-based land title represents interlinking and sequential transactions over many hundreds, if not thousands, of years, so given the misinformation that would compound over time, it would be difficult to trust the current title holder has a correctly recorded title.
- The author concludes that supporters of blockchain for land registries frequently overlook a registry's primary function to provide an independent verification of the provenance of stored data.

Vos, Jacob, Christiaan Lemmen and Bert Beentjes. Blockchain-Based Land Registry: Panacea, Illusion or Something In Between? Paper prepared for presentation at the "2017 World Bank Conference on Land and Poverty," Washington DC, 20-24 Mar 2017.

- The authors propose that blockchain is best suited for the following steps in land administration.
    1. The issuance of titles
    2. The archiving of transactions, specifically in countries that do not have a reliable electronic system of transfer of ownership
- Registering the transaction—the step in between issuing titles and archiving transactions—is the most complex. This step includes complex relationships between the "triple" of land administration: rights (right in rem and/or personal rights), object (spatial unit) and subject (title holder). For the most part, registrars do this step, and it is questionable whether blockchain technology, in the form of smart contracts, will be able to process these complex transactions.

- The authors conclude that one should not underestimate the complexity of the legal system related to land administration. The standardizing processes may be the threshold to success of blockchain-based land administration. The authors suggest that instead of seeking to eliminate one party from the process, technologists should cooperate with legal and geodetic professionals to create a system of checks and balances to successfully implement blockchain for land administration.
- This paper also outlines five blockchain-based land administration projects in the world.
    - Ghana/Bitland
    - Honduras/Factom
    - Sweden/Chromaway
    - Georgia/Bitfury
    - Cook county/Velox

COMMODITY TRADING AND SUPPLY CHAIN TRANSPARENCY

Ahmed, Shabir. Leveraging Blockchain to Revolutionise the Mining Industry, SAP, 27 Feb 2018.

- This makes the concept of "chain of custody" fundamental to transparency across the value chain. Simply put, it is the knowledge of every set of hands the minerals have passed through, from the moment it is extracted to when it lands in the hands of the final owner.
- In March 2017, SAP announced a partnership with Everledger to bring blockchain to procurement. One of the first applications is around smart contracts. With blockchain technology, existing trade contracts can be applied within the transactional system to enforce business terms at the point of transaction within the blockchain. This ensures rules are followed, while making business more digital and efficient.
- The article presents seven key uses of blockchain in the mining industry.
    - "Automation of ore acquisition and transfer: Mining companies often acquire ore from third parties to blend with their own. Blockchain enables the automation of ore acquisition and transfer between suppliers and the mining company, and between ore producers and traders.
    - "Automatic registration of mineral rights and IP: Blockchain can automate the registering process and replace the rush to government mineral rights departments when mining companies make a discovery.
    - "Visibility of ore inventory at ports: Ports receive ore from several different sources and owners. Blockchain can be used to declare and provide visibility for all the reception of ore.
    - "Automatic cargo hire process: Blockchain can bring more flexibility to the freight hiring process and create an Uber-like automatic cargo hiring process. Specialised systems could hire the ship and register the contract in

a distributed ledger system automatically, reducing freight costs and saving significant time.

  - "Process and secure large amounts of IoT data: Miners could use blockchain to more efficiently process the rapidly growing amounts of data being generated by connected devices. With the advent of Autonomous Peer-to-Peer Telemetry (ADEPT) systems that essentially enable a kind of self-managing IoT, ADEPT systems could, for example, enable autonomous vehicles to reorder consumable stock when supplies run low, with payments made automatically upon delivery.
  - "Reconciling amount produced and sent for processing: When coupled with precise measurement processes and technologies, blockchain can automate and enforce the reconciliation so that each value is registered in the ledger book automatically.
  - "Automatically execute procurement and other contracts: Mining companies are big consumers of fuel; mainly diesel, electrical energy, tires, reagents, consumables, spare parts and other products. Blockchain allows the automation of procurement of those items, using auction engines, leveraging their negotiating capabilities with the market and allowing opportunistic purchase strategies. Contacts are established and registered automatically. Miners could also use blockchain to host smart contracts to execute contracts automatically across multiple jurisdictions. By automating the process, such smart contracts could also help reduce license-to-operate risks in developing countries."

Brooks, Michael. Blockchain and the Fight Against Illicit Financial Flows, The Policy Corner, 19 Feb 2018.

- "Because of the inherent decentralization and immutability of data within blockchains, it offers a unique opportunity to bypass traditional tracking and transparency initiatives that require strong central governance and low levels of corruption. It could, to a significant extent, bypass the persistent issues of authority and corruption by democratizing information around data consensus, rather than official channels and occasional studies based off limited and often manipulated information. Within the framework of a coherent policy initiative that integrates all relevant stakeholders (states, transnational organizations, businesses, NGOs, other monitors and oversight bodies), an international supply chain supported by blockchain would decrease the ease with which resources can be hidden, numbers altered, and trade misinvoiced."

Conflict Free Natural Resources. Global Opportunity Report 2017. Global Opportunity Network, 2017.

- "Technology is driving an opportunity to ensure that every physical product has a digital history, permitting consumers to trace and confirm its origins, attributes, and ownership to ensure conflict free natural resources. Blockchain technology is well-suited for tracking objects and transactions, making it possible for virtually anything of value to be traced. This opportunity is about creating transparency and product traceability in supply chains."

- RCS Global and the International Council of Minerals and Mining, Blockchain for Traceability in Minerals and Metals Supply Chains: Opportunities and Challenges (2017).
- This report is based on insights generated during the Materials Stewardship Round Table on the potential of blockchain technologies for tracking and tracing metals and minerals supply chains, which subsequently informed an RCS Global research initiative on the topic.
- Insight into two key areas is increasingly desired by downstream manufacturing companies from upstream producers of metals and minerals: provenance and production methods.
- In particular, the report offers five key potential advantages of using blockchain for mineral and metal supply chain activities.
    - "Builds consensus and trust around responsible production standards between downstream and upstream companies.
    - "The immutability of and decentralized control over a blockchain system minimizes the risk of fraud.
    - "Defined datasets can be made accessible in real time to any third party, including downstream buyers, auditors, investors, etc. but at the same time encrypted so as to share a proof of fact rather than confidential information.
    - "A blockchain system can be easily scaled to include other producers and supply chains beyond those initially involved.
    - "Cost reduction due to the paperless nature of a blockchain-enabled CoC [Chain of Custody] system, the potential reduction of audits, and reduction in transaction costs."
    - Additionally, the authors note six challenges for achieving blockchain's potential in the space.
    - "Finding a consensus around CoC data and responsible production standards amongst companies with different risk exposure and supply chain positions.
    - "Technical challenge around data input – "garbage in, garbage out."
    - "Transforming paper-based, non-standardized CoC systems into a digital system.
    - "Complex points of aggregation, mixing and processing depending on the mineral/metal that make it difficult to control material flows.
    - "High cost due to the amount of computing power needed and large operational costs (estimates range from USD 100 per GB to USD 50,000 – 100,000 per user)
    - "Blockchain's application in supply chains is still in an experimental phase and is largely untested."

Van Bockstael, Steve. The emergence of conflict-free, ethical, and Fair Trade mineral supply chain certification systems: A brief introduction, *The Extractives Industries and Society,* vol. 5, issue 1, Jan 2018.

- This introduction to a special section considers the emerging field of "'conflict-free,' 'fair' and 'transparently sourced and traded' minerals" in global industry supply chains.
- Van Bockstael describes three areas of practice aimed at increasing supply chain transparency.
    - "Initiatives that explicitly try to sever the links between mining or minerals trading and armed conflict of the funding thereof.
    - "Initiatives, limited in number yet growing, that are explicitly linked to the international recognized 'Fair Trade' movement and whose aim it is to source artisanally mined minerals for the Western jewelry industry.
    - "Initiatives that aim to provide consumers or consumer-facing industries with more ethical, transparent and fair supply chains (often using those concepts in fuzzy and interchangeable ways) that are not linked to the established Fair Trade movement" – including, among others, initiatives using blockchain technology "to create tamper-proof supply chains."

GLOBAL GOVERNANCE AND DISCLOSURE PRACTICES

Lafarre, Anne and Christoph Van der Elst. Blockchain Technology for Corporate Governance and Shareholder Activism, *European Corporate Governance Institute (ECGI) - Law Working Paper No. 390/2018*, 8 Mar 2018.

- This working paper focuses on the potential benefits of leveraging blockchain during functions involving shareholder and company decision making. Lafarre and Van der Elst argue that "Blockchain technology can lower shareholder voting costs and the organization costs for companies substantially. Moreover, blockchain technology can increase the speed of decision-making, facilitate fast and efficient involvement of shareholders."
- The authors argue that in the field of corporate governance, blockchain offers two important elements: "transparency – via the verifiable way of recording transactions – and trust – via the immutability of these transactions."
- Smart contracting, in particular, is seen as a potential avenue for facilitating the "agency relationship" between board members and the shareholders they represent in corporate decision-making processes.

Myung, San Jun. Blockchain government - a next for of infrastructure for the twenty-first century. *Journal of Open Innovation: Technology, Market, and Complexity*, December 2018.

- This paper argues the idea that blockchain represents a new form of infrastructure that, given its core consensus mechanism, could replace existing social apparatus including bureaucracy.
- Indeed, Myung argues that blockchain and bureaucracy share a number of attributes.

    - "First, both of them are defined by the rules and execute predetermined rules.
    - "Second, both of them work as information processing machines for society.
    - "Third, both of them work as trust machines for society."
- The piece concludes with five principles for replacing bureaucracy with blockchain for social organization: "1) introducing Blockchain Statue law; 2) transparent disclosure of data and source code; 3) implementing autonomous executing administration; 4) building a governance system based on direct democracy; and 5) making Distributed Autonomous Government (DAG)."

Peters, Gareth and Vishnia, Guy (2016). Blockchain Architectures for Electronic Exchange Reporting Requirements, EMIR, Dodd Frank, MiFID I/II, MiFIR, REMIT, Reg NMS and T2S, Aug 2016.

- This paper offers a solution based on blockchain architectures to the regulations of financial exchanges around the world for trade processing and reporting for execution and clearing. In particular, the authors give a detailed overview of EMIR, Dodd Frank, MiFID I/II, MiFIR, REMIT, Reg NMS and T2S.
- The authors suggest the increasing amount of data from transaction reporting should start to be incorporated on a blockchain ledger in order to harness the built-in security and immutability features of the blockchain to support key regulatory features.
- Specifically, the authors suggest 1) a permissioned blockchain controlled by a regulator or a consortium of market participants for the maintenance of identity data from market participants, and 2) blockchain frameworks such as Enigma to be used to facilitate required transparency and reporting aspects related to identities when performing pre- and post-trade reporting as well as for auditing.

OECD, Blockchain Technology and Competition Policy - Issues paper by the Secretariat, 26 Apr 2018.

- A recent OECD issues paper asks questions about how blockchain technology might increase the relevance of new disclosures practices.
    - "Should competition agencies be given permission to access blockchains? This might enable them to monitor trading prices in real-time, spot suspicious trends, and, when investigating a merger, conduct or market have immediate access to the necessary data without needing to impose burdensome information requests on parties."
    - "Similarly, easy access to the information on a blockchain for a firm's owners and head offices would potentially improve the effectiveness of its oversight on its own subsidiaries and foreign holdings. Competition agencies may assume such oversight already exists, but by making it easier and cheaper, a blockchain might make it more effective, which might allow for more effective centralised compliance programmes."

Pisa, Michael and Matt Juden. Blockchain and Economic Development: Hype vs. Reality, Center for Global Development, 2017.

INDUSTRY-SPECIFIC CASE STUDIES

Chohan, Usman. Blockchain and the Extractive Industries: Cobalt Case Study, 2018, doi:10.2139/ssrn.3138271.

- Usman studies the pilot use of blockchain in cobalt mining industry in the Democratic Republic of Congo (DRC). In this case, blockchain is used to track the movement of cobalt from artisanal mines until it is used in devices such as smartphones and electric cars.
- The problem that this project is trying to address is child labor and conflict minerals. Cobalt mining in developing countries often involved forced child labor. It often takes place in conflict zones, which means that purchasing cobalt from these areas financially supports violence.
- In this scenario, the cobalt attributes that the digital ledger records are weights, dates, times, images, etc. and the input process may be done via mobile devices.
- Chohan, Usman. Blockchain and the Extractive Industries #2: Diamonds Case Study, 2018, doi:10.2139/ssrn.3141883.
- The second case study from Usman investigates the application of blockchain technology in the extractive industry by studying Anglo-American (AAL) diamond DeBeer's unit and Everledger's blockchain projects and identify the progress that has been made in improving accountability and transparency in the diamond business process.
- In this study, the author finds that AAL uses blockchain to track gems starting from extraction and onwards, including when the gems change hands in trade transaction.
- The purpose of this application is to verify the authenticity of the diamonds, ensure that they are not extracted from a conflict zone and distinguish synthetic gems from authentic ones.
- Everledger's blockchain was used in this case, where the attributes of the diamond (carat, color and certificate numbers) are recorded in the blockchain, which ensure security and authenticity of the gems.

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