Spring 2020

Blockchain Technology Changing Resource Management: A Case Study on How Even Botswana Can Improve their Level of Accountability in Diamonds

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Senior Project Submitted to
The Division of Social Studies
of Bard College

by
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Annandale-on-Hudson, New York
May 2020

Acknowledgements

I wish to thank all the people whose assistance was a milestone in the completion of this project. I would like to show my gratitude to my senior project advisor Leanne Ussher for helping me along this entire journey. She was there to help every step of the way and went above and beyond to help me. I would also like to show my appreciation to Sanjaya De Silva for being my academic advisor for most of my career at Bard College. He has offered guidance as I have found my path in economics. I wish to acknowledge the support and great love of my family. Firstly I would like to acknowledge my parents Jordan Soko and Naomi Soko for being my support team and biggest fans throughout my pursuit of education. I would not be the person I am today if not for them. Next, I would like to thank my brothers, Bongani, Chenyani and Jordan Jr. for believing that I could accomplish anything I set my mind to and believing I could do great things. And lastly I would like to thank Ioli and Lovanee for being here for me since freshman year. I would not have made it this far without you.

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Abstract

The African continent is rich in resources yet still lags behind, in terms of economic development, in relation to a large portion of the world. There are mines all over the continent yet mineral ores leave the countries without a trace and nothing to show for the hard work it took to retrieve them. There are many factors that have led African countries to where they are now, but what if an improvement in; resource management, the ability to track property ownership, value added or environmental externalities at each step could help change things around. The countries would be able to avoid expropriation, theft, exploitation, degradation, slavery, war pillages etc. So how does one tackle this decades long problem, how about through something that has only surpassed a decade, blockchain technology. Blockchains are a form of distributed ledger technology (DLT) that is part of an ever growing phenomenon, a distrust of big governments, big business, big finance and big tech. This paper hopes to propose a way in which blockchain technology and resource management can go hand in hand, looking at Africa's gem, Botswana, as a case study. Botswana is a perfect example of how resources can improve the country for the better. The mining of diamonds has been a pivotal part of the history of Botswana. Diamonds were able to transform Botswana from one of the least developed nations at its independence to being one of Africa's few middle income countries. With the resource curse averted and with steady economic growth it is still worrying that Botswana ranks within the top 10 most unequal countries. ."In 2010, for instance, when the stated export value of diamonds is compared to the production value at mine-gate, over $438 million vanishes—an undervaluation of $19 per carat. "(Sharife, 2016, p.81). This proposal shows how even Botswana could improve on their resource management to help the entire country progress into a more

equally distributed society. This paper argues that the centralized private-public partnership of the Botswana diamond mining sector can be seen as being the root cause of the problem. While most remedies to the commodity curse have been government controls or industrial consolidation, which often lead to private or public sector monopolies, as these monopolies can withstand price volatility. They also lead to the expropriation of the surplus, lack transparency, result in bureaucratic kickbacks and corruption, are undemocratic, and most of the surplus is siphoned off into international tax havens rather than returning to the original owners of the buried treasure. Blockchain is a new technology and governance structure that gives hope for indigenous property rights, allows for decentralized coordination, offers the potential for a fairer distribution of the surplus, gives greater transparency to the process, can incorporate fines and records for environmental damage. It overall offers a way for the management of primary resources and their supply chain which has previously been left up to those in power. The centralized nature of the mining sector allows such a proposal to exist. By utilizing blockchain technology, Botswana can improve the value added on their diamonds through the transparency of blockchain, as well as the government and private sector being held accountable for any monetary loss that occurs through unmonitored agreements.

Introduction

Resources in Africa:

Africa, a continent rich in language, food, culture, and most importantly, resources. There is no continent quite like it. What other continent would you find; crude oil, diamonds, gold, copper, coffee, cocoa beans, aluminum, rubber, petroleum and much more. The answer is, none. Having said that, the resource riches came at a price. It began with the Scramble for Africa (in the colonial period) and has led to most countries succumbing to the Resource Curse. The Resource Curse is the ultimate developmental economics paradox(Chen, n.d.). It has been proven time and time again that a disproportionate number of countries that are resource rich, end up socio and economically poor. How? Simple, resource abundance means nothing without effective resource management, and property rights over the value added further down the supply chain. According to USA Today, in 2019, the top ten poorest countries were as followed (in descending order); Central African Republic, Burundi, Democratic Republic of the Congo, Niger, Malawi, Liberia, Mozambique, Madagascar, Sierra Leone and the Gambia. All ten of these countries are located in Africa. Yet, the Central African Republic, used as an example, is rich in uranium, diamonds, cobalt, gold, crude oil, hydropower and lumber. There is most definitely a better way to manage these resources, and this paper is an exploration as to how blockchain might offer that solution.

Blockchain Technology

Diamonds are forever, and so is blockchain.

Who do you trust, when you can't trust anyone? This question essentially launched blockchain technology into the public eye. Not everyone has heard of blockchain, but a lot more

people have heard of Bitcoin. Bitcoin came about after the 2008 Global Financial Crisis, from Satoshi Nakamoto, who felt that the banking sector led to the greater impact of the crash.“… financial institutions cannot avoid mediating disputes. The cost of mediation increases transaction costs, limiting the minimum practical transaction size and cutting off the possibility for small casual transactions, and there is a broader cost in the loss of ability to make non-reversible payments for nonreversible services. With the possibility of reversal, the need for trust spreads…A certain percentage of fraud is accepted as unavoidable. These costs and payment uncertainties can be avoided in person by using physical currency, but no mechanism exists to make payments over a communications channel without a trusted party.What is needed is an electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party.”(Nakamoto, n.d.) . The tantalizing aspect of Bitcoin that helped it gain its traction was the complete removal of a middleman. In the wake of the Global Financial Crisis it was the seemingly perfect option. The accountability and transparency of blockchain technology has the potential to revolutionize how Africa handles its mineral resources. This was also fueled by concerns of privacy, security, anti-government or anti-third party movements. Blockchain is trying to displace the old system of a central entity aggregating, controlling, and mediating the flow of information. But that is not all that blockchain technology can accomplish. Blockchain technology is a form of distributed ledger technology that can be implemented in any sector. It decentralizes systems, provides public or private immutable records, provides data provenance, as well as security.

This paper proposes a method in which resource management and blockchain technology can go hand in hand to better the lives of citizens of countries that suffer from the resource curse. Resource management is an immense subject and there are probably hundreds of ways to implement blockchain. For this reason this paper will use "Africa's Gem", Botswana, as a case study to show how even Botswana can improve their resource management.

Case Study:

A girl's best friend and Botswana's main source of income, diamonds, have the ability to shape a nation.

The Republic of Botswana is a Southern African landlocked nation that gained its independence from being the British protectorate of Bechuanaland in September 1966. The country is about the size of France but with 2.254 million citizens. In Botswana democratic elections are peaceful and predictable. 50 years ago Botswana was in the top 10 poorest countries in the world but now it's one of Africa's few middle income countries. Diamonds have changed Botswana's trajectory for the better (Sharife, 2016).During the time of its independence it ranked amongst the top 25 poorest countries in the world. All that was about to change not even a year later when diamonds were discovered, and its trajectory was changed for the better.

So how does good, get better?

Even with all the success Botswana has achieved in its near 54 years of independence, it still has some rather worrying statistics. Although one of Africa's few middle income countries, Botswana ranks in the top ten most unequal nations. For a country that has seemingly avoided

the resource curse, is it still suffering from resource curse problems primarily in terms of inequality and accountability..“In 2010, for instance, when the stated export value of diamonds is compared to the production value at mine-gate, over $438 million vanishes—an undervaluation of $19 per carat. ”(Sharife, 2016, p.81). Through the implementation of blockchain technology the treasure that diamonds offer to Botswana can be more fully harnessed and their value can be accounted for and distributed in a way that is fairer and stays within its borders.

Chapter 1:Blockchain

1.1 Distributed Ledger Technology

Blockchains are a form of distributed ledger technology (DLT). A distributed ledger is “a ledger of any transactions or contracts maintained in decentralized form across different locations and people, eliminating the need of a central authority to keep a check against manipulation” (Majaski, 2019). Although this is the broadest umbrella in which they fall under, there are different types of blockchains. There are two terms we must make note of, blockchain technologies vs blockchain ledgers. This separation is discussed in the book *The Basics of Bitcoin and Blockchains* by Antony Lewis. “Blockchain technologies are the rules or standards for how a ledger is created and maintained” (Lewis, 2018, p.326). “Blockchain ledgers themselves are specific instances of ledgers that contain their respective transactions or records”(Lewis, 2018, p.326). Blockchains have four concepts according to Lewis,

1. A database that records every change in the data. It has most commonly been financial transactions, but all types of data can be stored.
2. “Replication of the data stored across a number of systems in real time. ‘Broadcast’ blockchains, such as Bitcoin and Ethereum, ensure that all data is sent to all participants;

they are public ledgers where everyone sees everything. Private ledgers are selective about where data is sent and who sees what"(Lewis, 2018, p.331).

3. 'Peer-to-peer' rather than a centralized client-server network architecture. There is not a need for a single governing source to distribute data, but rather each participant can do so for themselves.
4. Cryptographic methods such as digital signatures to prove ownership and authenticity, and hashes [a digital signature] for references and sometimes to manage write-access (Lewis, 2018, p.331)

1.2 Concepts

Blockchain is made up of five fundamental building blocks. The fundamentals are distributed database, peer-to-peer transmission, public or private transparency or tracking with pseudonymity, irreversibility of records and computational logic. These fundamentals are stated with the description below.

1. Distributed Database: in blockchain each party has access to the entire database and its complete history. All of this information can be verified without the use of an intermediary through consensus
2. Peer-to-peer Transmission amongst the miners or validators: communication occurs directly between peers instead of control nodes. The role of each node is to store and forward information to all other participants.
3. Transparency with Pseudonymity: every transaction is visible to anyone with access to the technology. Each user has a unique 30-plus character alphanumeric address that they

use when participating with the system. Users have the ability to remain anonymous or reveal their identities to others.

4. Irreversibility of Records: once a transaction is entered it cannot be altered. Various computational algorithms and approaches are deployed to ensure that the recording on the database is permanent, chronologically ordered and available to all.
5. Computational Logic: digital ledger means it can be programmed. Users can create 'smart contracts' and set up algorithms and rules. (Gupta & Knight, 2017)

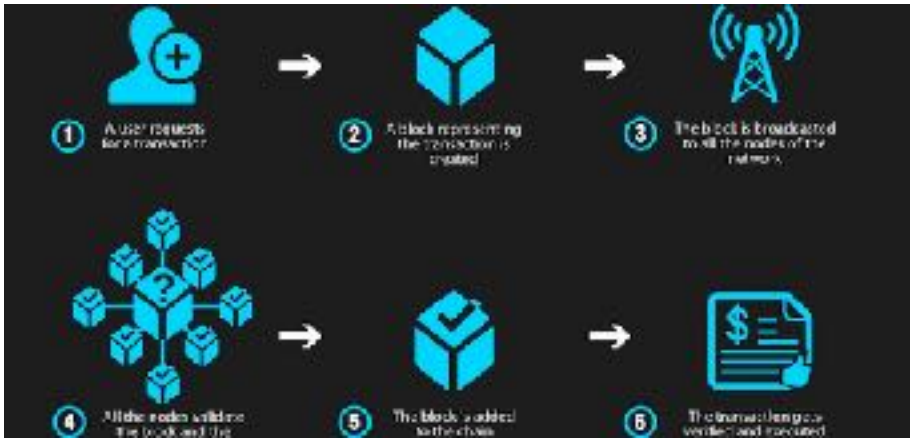
1.3 Mechanics

Now that we have an understanding of blockchain, we can look into some critical factors blockchain has in relation to development. According to the article *Blockchain and the Movement Value in Africa*, there are three key factors that are necessary to increase a country's development that blockchain addresses. These factors are enforceable contracts, strong credit systems, and robust property rights. As mentioned before, there are two terms, blockchain technology and blockchain ledgers. This paper will focus on the technology aspect more so, as a blockchain ledger is simply the place in which all the data is stored. "Blockchain Technology is a digital distributed ledger that provides an immutable record of transactions and information where the record is fraud proof"(Macomber et al., 2019) p.2). It must be noted that although the records are fraud proof, the original data put on the ledger might not be.Transactions and information are impossible to change. The distributional component is from the fact that there is no central place for the technology, rather, it is controlled by a group of computers called nodes. Nodes, sometimes referred to as miners, are people who have access to the transcription of the

blockchain. They do not know each other in real life and thus cannot discuss anything related to blockchain and its data. In theory, anyone can be a node. Although there is no third party controlling the way the information is being recorded or what is being recorded, nodes are all governed by the same rules, 'protocols'(Macomber et al., 2019). There is an agreement on a specific transaction and it is only reached when the majority agrees on the latest state of the transaction and ledger. This achieves a consensus. Figure 1 shows a simple of how blockchain works. A notable example of blockchain is Ethereum. It is said that Ethereum functions as a massive distributed and decentralized computer that uses smart contracts to run its programs (Macomber et al., 2019). Smart contracts are used to digitally facilitate or enforce the performance of any and all contracts. They are "are lines of code that are stored on a blockchain and automatically execute when predetermined terms and conditions are met" (Gopie, 2018). It is argued that users can trust the outcome of smart contracts without governance for they are prewritten codes. It is a hot debate on whether laws and penalties can be simply automated and executed without human intervention. However there is an argument that perhaps simple and easy to verify regulations might be implemented in such a way.

Figure 1

How Does a Blockchain Work: A Step by Step View



Note. This figure was produced as step by step view of how blockchain functions. From "The Ultimate Blockchain Technology Guide: A Revolution to Change the World".https://101blockchains.com/ultimate-blockchain-technology-guide/#prettyPhoto. 2018

There is a reason that blockchain is a topic of interest in the financial world today. What blockchain is said to offer is of great value in many cases. Blockchain offers: transparency, decentralization and immutability. Transparency is ensured by universal access to transaction data. Decentralization comes from distribution (multiple nodes) of the transactions as opposed to the requirement of a trusted intermediary. The idea of decentralized consensus plays an important role in blockchains design (rules and incentives behind the protocol). Immutability is an appealing quality where fraud and corruption is very prevalent.

1.4 Smart Contracts

Let's take a closer look into smart contracts. Smart contracts represent a huge opportunity to drive efficiency as well as reduce and eliminate unnecessary participants and untrustworthy middlemen who add transaction costs or can infuse corruption and create leakages in the transactions of the whole system. The smart contract feature is done digitally with no need for a third party to handle. Ethereum blockchain is the most common standard to code smart contracts (Macomber et al., 2019). The coding of these smart contracts are done through what are known as oracles. Oracles are an agent that finds and verifies real-world occurrences using artificial intelligence or machine learning and submits this information to a specific blockchain to be used by smart contracts. There are three types of oracles, hardware, software and consensus based oracles. An example of both software and hardware oracles are Internet of Things (IoT) (Macomber et al., 2019). An IoT is the idea of connecting devices to the internet and to each other (Clark, 2016). IoT devices, in hardware form, could be used for monitoring data, possibly in the form of sensors in factories that can track the movement of goods. If software or hardware oracles cannot be used to verify transactions, we then would turn to consensus based oracles.

Consensus based oracles are used to confirm a particular outcome. Multiple oracles may be used to verify this outcome. A notable example of a consensus based oracle is a firm called Augar. It is a blockchain based betting platform that uses a consensus based oracle system to confirm the occurrence of events (Macomber et al., 2019).

1.5 Blockchain Governance

Although we have mentioned the general gist of blockchain technology, we must mention that there are different types of blockchain. Firstly, there is a private blockchain. A private blockchain is implemented if there is a need for a single entity, multiple users within that entity, to control the functionality of a specific blockchain. In this type of blockchain, consensus is determined within that specific entity. Secondly we have public blockchains. This is the most well known type of blockchain considering Bitcoin utilizes this version. A public blockchain is implemented if there is a rationale for decentralization and there is no need or desire for a single entity to control the functionality. This idea is then coupled with a need for transparency. The last type of blockchain is known as the hybrid blockchain. This blockchain is useful if there is a need for a group of entities to control the functionality of a system but the consensus is determined by a specific group of entities (Macomber et al., 2019).

1.6 Blockchain Use Cases

Blockchain has the ability to be used in many sectors and has already begun its integration into the world we live in. In the article *Blockchain and the Movement of Africa,* by John Macomber, Liang Wu and Ina Folea*,* the authors propose several sectors in which blockchain technology could help improve some systems already set in place. The article mentions three areas; foreign aid in Africa, remittances for individuals and the funding gap for

SMEs: Kenya as a specific case study. “A funding gap is the amount of money needed to fund the ongoing operations or future development of a business or project that is not currently funded with cash, equity, or debt.”(Frankenfield, 2019) Pursuing their outlook on foreign aid in Africa, they found that there is a strong correlation between the balances of foreign aid provided to Sub-Saharan African countries and growth prospects of the country. The evidence for this claim was found in the article *Do Corrupt Governments Receive Less Aid?* by Alberto Alsenia and Beatrice Weder. Alsenia and Weder came to the conclusion that the answer is in fact, no, corrupt governments do not receive less aid. This led the authors to ask the following questions, is there a system to track and audit the use of foreign aid, what would be the effect, what are the steps to utilize immutable transactions and how could we motivate main stakeholders to truthfully participate? As it stands the current system lacks transparency, efficiency and accountability. The lack of transparency is because there is no clear map or record regarding how funds are used, which in turn reinforces the lack of accountability. This then leads to further inefficiencies.

When looking at remittances for individuals, the problem arises with the substantial transaction costs. Africa is the most expensive region to send money to and regardless of that fact, millions of dollars are being sent back. When it comes to the funding gap for SME, small and medium enterprises, the article looks at the Deloitte paper “Kenya Economic Outlook 2016”. The report notes SMEs are hindered by inadequate capital, limited market access, poor infrastructure, inadequate knowledge and skills and rapid changes in technology(Macomber et al., 2019).

We shall now look at the proposed way in which blockchain technology can be used as a potential solution for these problems. Blockchain technology in foreign aid would help because of the possibility of transparency. Independent third parties could work with each stakeholder, gathering information about the whereabouts and use of the aid being sent to a country. A possible risk of this idea would be that the single third party can be manipulated into altering the data. This problem can be solved with smart contracts. Simply set the conditions for which must have taken place for the code to run. One can make sure that the conditions can only be coded with deterministic outcomes. Thus smart contracts and accounting can provide historical data of the use of funds in a country.

The promotion of blockchain technology for individual remittances has grown because remittances sent to Africa incur around 10% transaction costs (Macomber et al., 2019). Blockchain technology and stable cryptocurrencies could stop the use of midway costs . Although this seems like the absolute best option there are some downfalls. There are three main problems with this approach, by law you must know your customer (KYC) and find ways to create anti-money laundering, consumers must be tech savvy, and if something goes wrong there is no one to complain to (Macomber et al., 2019). All these problems make it hard for blockchain to get a foothold in this market, although the authors found it important enough to mention.

The use of blockchain for SMEs and financing is a different phenomenon. In this instance one could use blockchain to crowdfund sourcing small amounts of financing around the world intermediated by the internet. This allows the companies to have access to a larger market willing to fund their ideas.They would be less constrained by their country's currency, policies and international relations if they financed in crypto. Those abroad that would like to invest in

SMEs would be able to use a loan history to weed out the companies that cannot be trusted, the ‘bad ones’.

1.7 Problems

Some problems and other possible issues that may arise with the implementation of blockchain technology. Firstly there are short term implementation hurdles to overcome.

Another problem is the reliability of initial data input. No matter the efficiency or the technology, if the initialization data is tainted or wrong then the error can continue throughout the system without ever being corrected. There would need to be incentives for parties involved to begin with truthful input and to avoid collusion.

An additional point is the cost comparison of existing alternatives and blockchain technology. There are likely alternative cheaper centralized ledger services which could implement ‘smart contracts’ with some similar features, although not of the same degree of trust in terms of transparency, immutability, and security. , But again these would need to be implemented by a trusted third party, and this is the critical element that blockchain offers.

While the processing power of blockchain technology is quite substantial, it is not easily implemented and requires users to understand the technology in order to interact with it . Depending on the sector in which blockchain is implemented, it may be hard for some users to partake. Lastly there are ‘Know Your Customer’ (KYC) and anti-money laundering (AML) considerations to make note of in financial use cases (Macomber et al., 2019).

1.8 LeapFrog Development

Blockchain technology is opening doors in places and areas that were untouched before. The potential it has in the world is vast and hindered only by its technicalities.

Blockchain has the ability to set systems in play in a more efficient manner that could propel communities and countries. This is the idea behind the paper, *How Blockchain Could Help Emerging Markets Leap Ahead* by Vinay Gupta and Rob Knight 2017. This paper brings up the idea of leapfrogging. They define leapfrogging as using the lack of existing infrastructure as an opportunity to adopt the most advanced methods (Gupta & Knight, 2017). Noteworthy examples are Kenya and South Africa with their focus on growing their 3G network system instead of expanding the installation of copper cables. They switched their scope from desktops to smartphones. The most celebrated leap, however, came from Japan. Japan's quality control revolutionized manufacturing in the 1960s-1970s. Today, M-Pesa, a phone based service used in money transfer and financial services, in Kenya and Tanzania are modern examples of leapfrogging (Gupta & Knight, 2017). The technology lets people bank in their national currency on their mobile phones. The effects of this innovation is that it has boosted development in these countries.

Now, where does blockchain fit into all of this? If the claim that decentralized micro processing can be installed with greater efficiency and lower cost pan out, then the decentralized nature of blockchain means the distance to financial infrastructure or data centers, does not hinder a citizen's participation in the economy. Blockchains can address the more pressing needs of developing world governments through the modernization and digitization of government functions by local communities. The economist Hernando de Soto (Casey, 2016)posed possible reasons why poor people do not have access to the formal economy. He boiled it down to two reasons, the unreliability of record keeping and that people will not give up their personal information because they do not trust their governments. Blockchain is designed for

environments where trust is not present. It is extremely secure once initiated, relatively immune to being tampered with, and thus there is less potential for fraud and corruption (Gupta & Knight, 2017).

Blockchain technology has the potential to break down boundaries. Distributed ledger technology can lower transaction costs and enhance intellectual property ownership, distribute ownership, internalize negative externalities and make payments more transparent(Felin & Lakhani, n.d.). That is only a small taste of its actual power.

1.9 Audit Trail

The ledger records and verifies transactions and terms of engagement. This can be used to prove reputation or origins of supply. There is a confidence that records of interactions will be fully memorialized once noted on the ledger. Blockchain can be used to interact with a lot of different stakeholders in a community and along the supply chain. The ability of verification and restriction of digital copying allows for micropayments to those who contribution to intellectual property (Felin & Lakhani, n.d.). You are able to see the breakdown of royalty payments, the data on sales and even distribution of surplus in real time. Smart contracts can be used to simplify legal and royalty negotiations.

The whole success of blockchain technology depends on the incentives for users to use the technology. Sometimes an incentive could be the adoption by others in the industry. Even users that help create market share and thereby profits for the initial startup can earn micro payments that recognize their contribution to the success and adoption of a new technology. Blockchain is one solution to establishing a history of ownership (Felin & Lakhani, n.d.).

1.10 Criticisms of Blockchain

Blockchain is not without its criticisms. Although there are many benefits to blockchain technology there are some problems that it produces as well. For example, real-world data can still be fraudulent and manipulated. This is the garbage in and garbage out scenario. No matter how well blockchain technology can help, if the right information is not cited on the blocks the whole system can be a perpetrated lie (Macomber et al., 2019).

Some say a problem is the scalability of the system and the reduced transactions per second. Why is a distributed database on a blockchain even needed? It is far easier to operate and scale a centralized database? This argument however, only stands if the third party is trustworthy and it can't be hacked. Essentially the adoption of blockchain depends on users seeing value in the security of a network and for there to be enough participation by individuals to run the nodes. This places a lot of responsibility on the individual and the community(Macomber et al., 2019).

Because of the way the system of nodes is utilized, users do not have the consumer protection that they would otherwise receive if anything were to go wrong via a third party. Mistakes or manipulations can become entrenched and become facts. Another point to make is that oracles feeding data may pose security risks and may not have the same level of cryptographically secured data as the core of blockchain technology. IoT devices are not without fault as they can be hacked and manipulated. When it comes to consensus based oracle systems, enough bad actors can collude and alter the data for their own benefit. It is because of this that the manner in which incentives are designed is critical for the success of the blockchain system (Macomber et al., 2019).

1.11 Why Blockchain?

Before thinking about the ways in which to implement blockchain, one must ask if blockchain is even needed. The following questions attempt to do just this.

1. Does the problem require a database at all
2. Does the database require other editors to have "edit" access?
3. Are editors known and trusted?
4. Do you want or need a single party to run things? (Macomber et al., 2019)

Chapter 2: Blockchain for Primary Resources: Why Bother?

As we have seen from the previous chapter, the scope of applications with blockchain technology is vast. Blockchain can help with many accountability issues that plague a lot of resource management. The biggest question to ask ourselves is, why bother? Why bother going through the hassle of blockchain? The answer comes in two parts, the first being transparency in the resource market and the second, the value added from the traceability of resources.

The first part of this question will be answered later on in this paper when we take a look at Botswana, the resource management case study. The second part on traceability relates to increased awareness of social accountability. It's 2020 and the rise of people demanding governments, firms and industries to be held accountable for their externalities, and coordination failures is at an all time high.

2.1 Responsible Sourcing

This paper is addressing how blockchain can be used to help the growing need for more fair and sustainable policies in primary resource management. This is driving the need of what the International Council on Mining and Metals (ICMM) is calling responsible resourcing.

Although an international version of responsible sourcing, the British Standards Institution (BSI) has their own definition with the ICMM, this paper shall use the definition that, “responsible sourcing is the management of sustainable development in the provision or procurement of a product”.

Responsible sourcing is the driving force of a lot of industries searching for the best social and environmental approaches. This trend is being driven by specific issues such as the resource curse, climate change, conflict minerals and ensuring fair labour practices. It is also being driven by leading organizations that want to improve the environmental, social, and governance performance of the companies they do business with. Some governments are also interested in the opportunity responsible sourcing may offer for furthering economic development, environmental stewardship and socially responsible practices.

Conflict minerals and ensuring fair labour practices are two areas that a public blockchain can deal with. The traceability of blockchain will allow transparency about who the players all along the value chain are, allow them to know where the materials come from and go to, and learn how the value is added and distributed between all participants. This knowledge can help with a company's reputation as well as align with their core values.

In the ICMM’s report of *Demonstrating Value: A Guide to Responsible Sourcing*, under the chapter on Developing Effective Programmes and Standards, the ICMM stated that “Traceability and CoC [chain of custody] - a transparent and independently verifiable CoC between the source and the end-use market is key for marketplace credibility and to prevent accusations of “greenwashing” (it should be noted that some programmes, such as the WGC [World Gold Council] and the LBMA [London Bullion Market Association] conflict-free efforts,

are credible but have only a limited CoC component)"(*Demonstrating Value - A Guide to Responsible Sourcing*, 2017).

2.2 The Kimberley Process Certification Scheme

The Kimberley Process Certification Scheme (KPCS) is a set of "requirements for controlling rough diamond production and trade". It was developed in 2002 and "provides assurance that diamonds being sold internationally have conflict-free origins, and are developed with the participation of the United Nations, governments, diamond-producing companies and NGOs."(*Demonstrating Value - A Guide to Responsible Sourcing*, 2017). The process was "aimed at protecting the legitimate diamond industry, upon which many countries depended. The Process led to the emergence of the international Certification Scheme for rough diamonds… which is based primarily on national certification schemes and on internationally agreed minimum standards"(*GENERAL ASSEMBLY REAFFIRMS STRONG SUPPORT FOR 'KIMBERLEY PROCESS', AIMED AT ELIMINATING USE OF ROUGH DIAMONDS TO FUEL CONFLICT*, 2004).

The KPCS not only helps bring light to the use of diamonds in conflict zones but the UN also supports it because, according to them, they recognize that it "can help to ensure the effective implementation of relevant Security Council resolutions containing sanctions on the trade in conflict diamonds, the Assembly called for the full implementation of existing Council measures targeting the illicit trade in rough diamonds that play a role in fueling conflict"(Ibid).

The KPCS is a great example of what the transparency and traceability of blockchain could accomplish in a well incentivized environment. Although blockchain isn't a must in the KPCS, it will potentially make things easier for existing members as well as those wanting to

join. With all the data in the ledger, and smart contracts there would be fewer questions about the sincerity of the participants.

2.3 The Dodd-Frank Act

The mainstream acceptance of these trends has risen with the United States through adopting the Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank Act). It was created by the Securities and Exchange Commission (SEC) in Section 1502, the conflict minerals and statutory provision. The act is required by all participants of the Securities Exchange Act of 1934.

Conflict minerals as defined by the Dodd-Frank is "columbite-tantalite (coltan), cassiterite, gold, wolframite, or their derivatives; or any other mineral or its derivatives determined by the Secretary of State to be financing conflict in the Democratic Republic of the Congo or an adjoining country" (*Dodd-Frank Wall Street Reform and Consumer Protection Act*, 2018, p.372). The act requires as well as states many requirements that conflict-free minerals must have. This means that it is even more vital for countries adjoining the Democratic Republic of the Congo to be under even more pressure to be held accountable and have open access traceability for its partners. The Dodd-Frank act is a plan to provide guidance to commercial entities seeking to exercise due diligence on and formalize the origin and chain of custody of conflict minerals used in their products and on their suppliers to ensure that conflict minerals used in the products of such suppliers do not directly or indirectly finance armed conflict or result in labor or human rights violations (*Dodd-Frank Wall Street Reform and Consumer Protection Act*, 2018).

2.4 The European Commission

The US is not the only one trying to play their part in ensuring that they know where all their minerals are coming from. The European Union also has a form of regulations and standards they want the minerals entering the territory to abide by. The European Union Conflict Minerals Legislation focuses on regulating importers of tin, tantalum, tungsten and gold, or better known as 3TG. The legislation was established in 2010 in the wake of the Dodd-Frank Act. The legislation is derived from the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas. The EU hopes to solve three main problems that arise from the minerals in conflict-affected areas. The problems being "the continued financing of armed groups via the (proceeds of) extraction and trade of minerals in conflict-affected and high-risk areas"(European Union, 2014, p.2), "the implementation challenges faced by EU downstream enterprises attempting to sustain legitimate trade, or voluntarily, performing due diligence within the current frameworks"(European Union, 2014, p.3) and "market distortion in the form of reduced demand and prices in formal sector for minerals from the DRC and other Great Lakes Region countries"(European Union, 2014, p.3). There are two types of objectives the EU would like the legislation to tackle, specific objectives and operational objectives. (EU Commission).

Specific Objectives	Operational Objectives
Increase the proportion of EU and global smelters/refiners that perform due diligence.	Provide enhanced visibility and transparency for due diligence practices (and level of compliance) of EU and global smelters.

Raise the level of public accountability for due diligence performance (and level of compliance) by EU and global smelters.	Raise awareness of due diligence, ethical dimensions, and the importance of improving due diligence compliance with governments of main non-EU smelters/refiners.
Increase the ability of EU downstream companies to successfully identify smelters/ refiners.	Empower downstream users by providing a mechanism to identify due diligence compliant operators (including smelters) and thus to facilitate switching of suppliers.
To improve the bargaining position of EU downstream companies (on due diligence) vis-à-vis companies further back in the supply chain.	Introduce certainty and transparency in the supply chain nearer to downstream users.
To improve awareness of due diligence, of the importance of due diligence compliance, and of ethical dimensions throughout the supply chain – both inside and outside the EU.	Promote increased awareness of due diligence and ethical dimensions among EU operators.
To increase the uptake (performance) of due diligence practices by downstream companies.	Create additional financial incentives in order to promote/support due diligence practices among downstream users
To offset/reduce the adverse commercial incentive created or exacerbated by US DFA [United States Dodd Frank Act].	Support the uptake of OECD Guidance among smelters/refiners willing to source in conflict- affected areas.
	Support demand from conflict-affected areas: facilitate switching by EU operators to due diligence compliant smelters/refiners sourcing in those areas.

(European Union, 2014, p.3-4)

The Kimberley Process Certification Scheme, the Dodd Frank Act and the European Commission are all required criteria of certifications that govern some important minerals around the world. The transparency that blockchain technology offers would allow for the resource it is managing to easily fulfill these criteria. The immutable records and accountability will also allow for a smooth transition if there were to be a change in criteria.

2.5 Advantages of Blockchain Technology Above Other Types of Traceability

The characteristics of blockchain technology allows it to be set apart from other types of traceability technology. According to the RCS Global report, there are six ways in which blockchain can be used as an advantage; consensus mechanism, immutable, un-corruptible records, decentralized control, shareable but encrypted supply chain information, scalability and costs reduction.

Consensus mechanism

The use of consensus in this particular context means an agreement on governance. In the frame of reference of responsible minerals and metals, this would encourage downstream and upstream companies to agree on responsible production standards as well as the role auditing will play. However,there is already the use of consensus created by organizations such as the ICMM, the Cobalt Institute(CI), the Responsible Minerals Initiative (RMI) and other associations to create standards and frameworks.

Immutable, un-corruptible records

As soon as a transaction (block') has been successfully added to the blockchain, it is time-stamped, validated, and linked to the block before and after it. This minimizes the risk of fraud.

Decentralized control

Shared ownership means that the system cannot be controlled or corrupted by a single entity. Although the data is stored on a server, it is self-executing. This endorses trust across all parties involved.

Shareable, but encrypted supply chain information

The data can be made accessible to any third party, including downstream buyers, auditors, investors, shareholders, insurers etc. With this new direct and easily accessible information, supply chain efficiency can be improved. "Certain blockchain providers specialise in solutions whereby third-party access can be managed to avoid confidentiality concerns. This mechanism could be used to attach a responsible sourcing claim to material and provide this information to customers in the downstream. The possibility of sending encrypted proof of a fact rather than data itself to external counterparts...allows companies to demonstrate dynamic and continuous compliance to external stakeholders while retaining confidentiality over sensitive supply chain information "(RCS Global, 2017, p.14).

Scalability

As a consensus and a system is established, there are hardly any technical (non-financial) limits to the number of users who can use the platform. The benefit this provides is a quick scalability of a pilot project.

Costs reduction

"There are several ways in which a blockchain-based CoC stem could reduce costs. Firstly, it provides a paperless system, which reduces the time and effort required to enter and access CoC data. Secondly, it reduces potential audit burden as certain audit information—depending on the consensus governing the stem- could be accessed more easily. Thirdly, the trust being built could reduce transaction time from days to near instantaneous"(RCS Global, 2017).

Chapter 3: Botswana

3.1 History:

The Republic of Botswana is a Southern African landlocked nation that gained its independence from being the British protectorate of Bechuanaland in September 1966. The country is about the size of France with 2.54 million citizens. In Botswana democratic elections are peaceful and predictable. 50 years ago Botswana was in the top 10 poorest countries in the world but now it's one of Africa's few middle income countries. Diamonds have changed Botswana's trajectory for the better (Sharife, 2016). At the time of its independence it ranked amongst the top 25 poorest countries in the world. All that was about to change not even a year later.

3.1.1 Discovery of Minerals

In 1967 there was a great discovery of diamonds and other minerals. This discovery would soon change Botswana's future. There are three major mining regions in Botswana; Orapa, Selebi-Phikwe and Jwaneng. Although diamond mining has taken off since Botswana's independence the modern mining era actually began in 1855 when De Beers was granted concession to prospect for diamonds. During this prospect they came across the first promising

finds, nickel and copper. The actual agreement to prospect for nickel and copper was made with the Bangawato people because at this time tribes held the mineral rights to their land. It was only when Botswana gained independence that the government revised their mineral development policies. There was a shift of mineral rights ownership to the central government. Although this move was a way to secure a more central governance, "officials were aware that not only nickel and copper, but also diamonds, coal and other minerals would be located, and that the deposits were almost certain to be commercially viable."(Curry, 1987).

3.1.2 Diamond Pipes

Quite soon after Botswana gained independence De Beers located their first commercially viable diamond pipe in Orapa. The Debswana Diamond Company Ltd. was only first registered 1969 after the discovery of diamonds in Orapa. The discovery of diamonds in Orapa prompted De Beers to construct a plant, as well as a mining town. This all cost approximately $15 million(Curry, 1987). Production of the first *pipe* began in 1971 and yielded over 2 million carats making it the second largest known pipe at that time. In 1975 there was a second pipe located at Orapa and production speedily went under way in 1976. In the spirit of pipe discovery, 1977 was the year De Beers discovered yet another pipe 40 kilometers south of Orapa at the village of Letlhakane and their biggest discovery in diamond mining history, Jwaneng. It is the richest and largest of all three. A mining complex was developed by De Beers at cost exceeding $250 million (Curry, 1987). Essentially, when full productive capacity is reached, Jwaneng annual yield would exceed 5 million carats and make Botswana the world's most important diamond producer. The mineral wealth was key to the country's ability to experience an economic expansion on a macro level (Curry, 1987). In 1994 the three major

diamond mines; Orapa, Letlhakane and Jwaneng, produced 15,54 million carats (Botswana Diamond Mining). Not only that, but it is one of the largest in the world.Today, Debswana is a 50/50 partnership but it did not start this way. Before 1975 the government's shareholding increased from 15% to its current 50%. The appointment of directors on the board are divided equally.

3.1.3 Bargaining Power

At the beginning of the diamond mining endeavor, bargaining strength favored the companies involved but effectively shifted to the government. This shift can be attributed to two factors. The first being that "as progressively greater investments were made—particularly by DeBeers—the companies became less able to abandon projects into which investments had been made."(Curry, 1987). The second is that "the vastness of the country's mineral wealth has surpassed the Government's and the companies' expectations. This has induced DeBeers to commit to [a] longer time frame than originally envisioned."(Curry, 1987). As both De Beers and the government of Botswana were bargaining, neither one truly knew how monumental these mines would come to be.

3.1.4 Inequality

Botswana has a fast economic growth rate but worsening inequality. This has been true from even before the 21st century and can be seen today. Botswana's annual growth in real GDP averaged 10.9% in the years 1981-90. This was faster than even many fast growing Asian countries. The economy recorded an increase in the growth rate of 9.1% between 2000 and 2001 compared to the 8.1% between 1999 and 2000 (Maundeni, 2003) . This growth is attributed to the growth of the mining sector. Since the turn of the century, Botswana's economic growth rate

has not been as steady, usually aligning with the global conditions. The worst they faced in the 21st century was in 2009, as expected. According to The World Bank data, Botswana's annual growth rate was 4% in 2019(). With a total outstanding government external debt of approximately US$427 million, and a debt service ratio of only 3.9 % in 1992 compared to an average debt service ratio of 25 percent in Sub-Saharan Africa and 21 percent in all developing countries, Botswana's debt obligations are easily manageable. (Maundeni, 2003)

Even with these outstanding figures Botswana suffers from high inequalities within its borders. By 1994 diamonds accounted for 80% of the country's export earnings at $1.74 billion (*Botswana Diamond Mining*). The diamond mining industry is dominated by Debswana Diamond Company Ltd. The company is owned by De Beers Centenary AG and the government of Botswana. It is the country's biggest as well as largest private sector employer with 6000 employees of whom 90% are Batswana (*Botswana Diamond Mining*.).

3.1.5 Differing Views on Macroeconomic Management

Dr. Mohanan Pillai argues in his paper entitled *Decentralized Governance and Participatory Development: Issues, Constraints and Prospects* that through prudent macroeconomic management Botswana succeeded in transforming a diamond boom into sustained economic growth without falling into the trap of the resource curse. M K Sukumaran Nair counters his argument with the idea that Pillai does not analyze the sources of growth, except touching upon the contribution of the diamond mining sector. Nair insists that a transformation took place in Botswana in the early 1980s. Nair believes it may be inappropriate to call Botswana's diamond management a structural transformation. He believes it presents a

wider connotation of dynamic growth through inter-sectoral links, when at best it was a structural break.

3.1.6 Diamond Dependency

Diamonds seems to be the only thing that Botswana can offer. The country's reliance on diamond exports with no diamond manufacturing base gives rise to the need for economic diversification (Molefhe, 2018). Such a reliance with no alternatives will leave Botswana in dire straits when the mines eventually run out. Unemployment is rising with only 1,000 jobs available in the formal sector for 10,000 graduates each year. (Molefhe, 2018).

3.1.7 Corruption

It is now common for the words 'Botswana', 'tax haven', 'money laundering' and 'corruption' to all be said together. These familiar links are a cause for concern for Batswana. With only a few amassing wealth the chasm between the haves and the barely surviving has widened (Ibid). This is an ongoing problem that plagues the nation today.

3.2 De Beers:

3.2.1 History

With diamonds in Botswana comes De Beers, the two are almost one and the same. De Beers is Botswana's primary business partner. De Beers and the government of Botswana have the longest running public-private partnerships of its kind. De Beers founded De Beers Botswana Mining Company, Debswana, in 1968. Initially Botswana held only a 15% share in the company but it has since increased to 50%. Not only does Botswana hold a 50 % share in Debswana but in 2004 Botswana acquired a 15% share in De Beers Centenary AG (Sharife, 2016).

3.2.2 Orapa

The National Assembly approved the Orapa agreement in 1970. The agreement meant that higher? taxes were imposed on the company's profits, royalties were to be paid to the government based on production and that the government would also receive 15% free equity share in the operation. One of, if not the sole saving grace of the agreement was the 'abnormal circumstances' clause. This clause allowed Botswana the legal ability to benefit from future profits that the diamond sector could offer. The clause would come into effect if the operation experienced some form of abnormal circumstances and that would call for a renegotiation of any aspect. The abnormal circumstances clause was invoked in 1974. With this clause in place the government was able to establish a firm willingness and ability to conduct tough and acrimonious bargaining (Curry,1987). The clause implementation had an immediate impact on the distribution of gross profits less retained earnings during early years of production. Taking a look at Table V it can be seen that the government share was less than one third between 1971 and 1973 but between 1974 and1976 it approached 60% (Ibid). The government bargaining was effective in having the burden of an economic failure fall heavily on companies as opposed to them. An agreement was reached in 1977 and the government received royalty payments in exchange for mineral exploitation rights. Through this agreement they received a dividend share of the operation's net profits after tax and the ability to place taxes on gross profits (Ibid). By acquiring royalty and dividend revenues, the government has more direct access to gross revenues. As of now the government of Botswana owns 50% of shares in Debswana. As a 50% owner, they can police transfer-pricing and other inter corporate policies which would serve to reduce gross and net profits (Ibid).

3.2.3 Relationship between De Beers and the Botswana Government

Currently the tie between De Beers, the government of Botswana and the political party in place, Botswana Democratic Party (BDP), provides stability but as well as a blurring of corporation and state. This blur may be costing the nation hundreds of millions in lost tax revenue. De Beers and the leading party have woven themselves together, "De Beers and the BDP have knit the political and corporate structures together in such a way that they undermine accountability and regulatory systems with a culture of secrecy (framed by De Beers as "confidentiality")" (Sharife, 2016, p.78) . Since De Beers is a private entity their dealings are protected. Although Botswana and De Beers are harmonious, De Beers has caused some problems elsewhere. Unlike the European Union and the United States of America where governments once banned or prosecuted De Beers for price fixing and other anti-competitive activities, Botswana is a direct collaborator (Sharife, 2016).

"By partnering with De Beers, Botswana is party to the secretive, monopolistic business practices that underpin the diamond industry. Botswana's government's ability to reel in corporate misbehavior is hamstrung by the fact that it works so closely with De Beers—the most important player in the system that keeps diamond prices high through artificial pricing and scarcity. It's a system that benefits Botswana through elevated diamond prices, but at the same time, De Beers also seems to participate in business transactions that deprive Botswana of taxes."(Sharife, 2016, p.81).

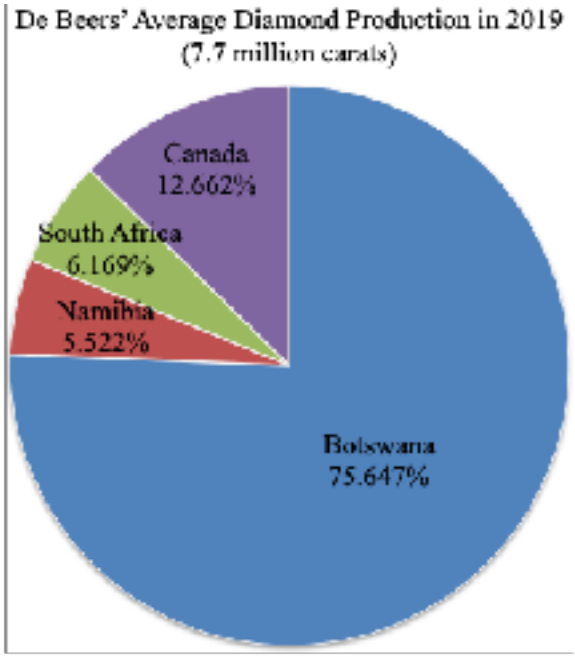
3.2.4 De Beers' Diamonds

By producing the bulk of De Beers' diamonds, Botswana has a lot of leverage over the company. De Beers owes a good amount of its success to Botswana. In 2013 De Beers recovered 31.1 million carats in Namibia, South Africa, Botswana and Canada combined. Botswana

produced 22.7 million of those carats. This warranted it providing more than 70%, $4.2 billion, of De Beer's total revenue of $5.9 billion (Sharife, 2016). Contrary to some people's beliefs, De Beers needs Botswana more than Botswana needs De Beers. One of the biggest events to shock the public-private relationship was in 2004 when the government of Botswana received 15% share in De Beers in exchange for 25 year renewals on 4 mines including world's largest diamond mine, Jwaneng. If not for this exchange De Beers' mining license was to expire in 2017. Figure 2 shows the percentage of diamonds De Beers produced in all 4 mining stations in 2019. As has been the case for many years, Botswana provides De Beers their largest diamond production.

Figure 2

De Beers' Average Diamond Production in



Note. Through data acquired by De Beers Group's

3.2.5 Relocation of the Diamond Sorting Center

Diamonds generate over 80% of Botswana's foreign exchange earnings and almost half of its government revenue. According to De Beers, the diamond industry directly accounts for one in 20 jobs in the country. De Beers does not only mine diamonds in Botswana but in 2013 they relocated their aggregation (or sorting) center from London to Gaborone. This move increased the liquidity of the Bank of Botswana because of the large sums of money flowing through the country.

> "The bank"s annual report discloses that while the revenue generated from the diamond sorting process is not substantive and "largely offsetting", the net re-export of

> diamonds from the aggregate center "is important for balance of payment surpluses. That is, the money helps the bank but does not remain in the country. A former senior Bank of Botswana employee said, on the condition of anonymity, "De Beers is controlling the State of Botswana, because it's [helping] guarantee the liquidity of its Central Bank." (Sharife, 2016, p.78) .

This in essence means that De Beers' diamonds from around the world are brought to Botswana, sorted and then exported again, from Botswana as well as from their country of origin. Along with the sorting and re-exporting of diamonds comes the flow of money in and out of the country. This inflow of money allows the Bank of Botswana to have a large sum of liquidity at their disposal as they look to manage their monetary and financial stability.

3.2.6 De Beers Trying to be Transparent

The monumental exchange of 2004 mining licenses granted to De Beers reaffirmed the company's right to control the price, pace of production, purchase partners and other concessionary terms of the mining industry. Essentially De Beers held all control. It was up until 2014 where financial details were under wraps. If you were not part of De Beers and the government's higher ups you had no idea what the true benefit of this partnership entailed. However in an effort to show value gained by Botswana through the relocation of De Beers' sorting center, De Beers published what is said was a first attempt "to quantify the economic value generated by the Partnership in Botswana in any one year"(Sharife, 2016, p.79). They calculated that they provided Botswana with $6.9 billion worth of revenue in 2014. According to the report the largest portion approximately $2.3 billion invested in rough diamond imports from South Africa, Namibia and Canada, which were then aggregated in Botswana to be sold to bulk

buyers. The remaining figures read as follows; $0.6 billion in service fees, $0.3 billion in retained earnings and $2.2 billion remitted in government taxes, royalties and dividends (Sharife, 2016).

3.2.7 De Beers and Botswana Deeper History

The relationship between De Beers and Botswana runs as deep as the history of the nation. In his memoirs, the former minister of mineral resources, David Magang mentioned that De Beers financially supported former presidents. One case was confirmed by the local media, De Beers used a shell company located in Panama to send money to a deeply indebted business owned by the then-President Quett Ketumile Masire (Sharife, 2016). The response to these findings was that the money sent were merely "donations" to the president. At that time De Beers was also funding consultants to guide the political direction of BDP. From donations to orchestrating elections. If the lines were not blurred before, there is no line now. According to Wikileaks, Debswana paid Lawerence Schlemer, a consultant selected by De Beers, to reorganize the internal structure of BDP. Schlemer was first contracted after the 1994 election (Sharife, 2016). Sadly the structure of the mining contracts and the exact value of extracted diamonds, as well as Botswana's 15% share in De Beers is still unclear. On a few occasions, a small number of unknown beneficiaries have received about 1% of company shares. This is not a small amount, in a multi-billion dollar financial empire it becomes a fortune, but tax havens for central financial structures makes it impossible to know who is really involved in the entire scheme (Sharife, 2016).

3.2.8 Debswana

The corporate structure of Debswana functions through secrecy jurisdictions, such as Luxembourg and British Virgin Islands. These jurisdictions allow shareholding and associated companies to withhold details about real beneficiaries of the companies. Without these details, the paper trail leads nowhere.

3.2.9 De Beers' Control

De Beers does not just own half of Debswana, through their dealings, they essentially own the entire diamond industry in Botswana. Sight holders and bulk diamond buyers are approved by no one but De Beers. This allows them to manipulate the diamond trade out of the public eye. The contracts with sight holders are kept a secret. In order to be chosen by De Beers, De Beers must be sure that the sight holders will keep the whole process hidden. This act allows De Beers to determine the quality and value of diamond purchased and to whom and where the sight holders can sell or trade. They also demand to know clients, markets, profits and other details(Sharife, 2016). The sight holders can refuse pre made diamond parcels but cannot pick and choose diamonds from within the package. This leaves the sight holders vulnerable to De Beers. The bottom line is that De Beers has learnt every aspect of the diamond mining business.

In theory sight-holders are required to cut or polish some diamonds within the country of purchase, Botswana. Things get tricky as the cost of cutting and polishing diamonds varies across nations. The cost of such a process in Botswana costs $60-$120 per carat whereas in India it costs $10-$50 per carat (Sharife, 2016). Any profit maximizing company will see this difference and choose to take their processing plant to India. The exact figures are not public as of yet but in practice, high costs means little beneficiation actually takes place in Botswana. Keeping the processing of diamonds in Botswana despite the higher labor cost will

3.2.10 Lack of Transparency

The lack of transparency along the value chain makes it easy for companies to avoid following rules and regulations. A contract negotiated between De Beers and prominent sight-holder, Diacore, showed De Beers traded high-value diamonds through corporate structures that operated entirely through tax havens.

There is no official exceptional diamond registry in Botswana, so it is impossible to know the volume and value of exceptional diamonds exported either monthly or annually. In this way, it is nearly impossible to track who owns what, where the money is going, and how much money is flowing out of the country. (Sharife, 2016).

3.2.11 De Beers' Power

Diamonds mined in Botswana are internally valued by De Beers. No part of the diamond mining process is monitored or overseen by independent agencies.

"According to a former De Beers director, Berke Lincoln, in a rare quote given under oath at a South African court, the government's only role is as "an auditor". Lincoln told the court, "The value is the price which is in the [De Beers] Price Book. So the government valuator has got no input into the value of a diamond." (Sharife, 2016).

Through this process, De Beers can essentially set its own tax rate by determining the cut of diamonds which government fees are levied. There are other ways for tax evasion. Another way of avoiding taxes is to import high-value and low-value rough diamonds and re-export the same diamonds in parcels with high-volume domestic rough diamonds.

“In 2010, for instance, when the stated export value of diamonds is compared to the production value at mine-gate, over $438 million vanishes—an undervaluation of $19 per carat. As the sole valuator in Botswana, De Beers runs the show.”(Sharife, 2016)

3.3 Comparisons:

It would seem that Botswana has done incredibly well for itself in terms of its resource management. To help understand how Botswana fairs in the world it shall be compared to two countries, Norway and the Democratic Republic of the Congo. These countries represent a better and lesser way of resource management, respectively.

3.3.1 Norway

3.3.1.1 Similarities:

Botswana and Norway share two notable similarities in their resource management. The first similarity is government control and the second is the high percentage of exports that the resources have in the country.

When oil entered the Norwegian economy in the early 70s there was a political consensus in favour of distributing oil jobs to regions in need of new employments, although this did not happen as the oil cities simply grew in size (Hansen, 1983). In Norway the oil and gas industry is not only the largest, but it is also the most important. The industry accounts for 40%-70% of Norway's exports. They are the 8th largest producer of oil and 3rd largest of natural gas in the world (McKay, 2019). This has not always been the case though. Before1959 there was no hope that Norway’s Continental Shelf (NCS) would be a major player when it came to oil

and gas, and then in 1959 gas was discovered at Groningen, the Netherlands (McKay, 2019). With this new discovery came new attention. The first company to try to get in on this action was Phillips Petroleum. They applied to explore NCS for possible oil and gas in 1962. This offer was seen as an attempt to lock up the entire area for one company. The Norwegian government actually rejected the idea. They were keen on opening up resources to several different companies, not to create a monopoly (Ibid). In 1963 the Norwegian government proclaimed sovereignty over all natural resources in the area and started issuing licenses to explore for potential oil fields.

3.3.1.2 Differences:

Botswana and Norway have important similarities but it is their differences that set them so greatly apart. There are four notable differences between the two countries; the volatility of resources, oil more volatile than diamonds, Norway's ability to keep money in the country, Norway's investment of oil wealth and their ease off of oil dependency.

Price Volatility

Price volatility is a difference that serves Botswana well. The price of oil is one of the first resources to drop during an economic crisis. However, with that said Botswana should be doing a better job.

Keeping the Oil Money in Norway

With the discovery of the well in Ekofisk came the oil money. As with all nations who deal with natural resources as their main exports, the question becomes, what to do with the influx of money. Norway began its solution in 1972. It was the year that Statoil, a Norwegian

state-owned oil company, was established. The government introduced the principle that 50% of each oil license should be state-owned. This was their attempt at making sure Norway was reaping the benefits of the oil and gas that was being drilled for in their nation (McKay, 2019). This is a similar tactic as Botswana with De Beers. The principle has since been reorganized over the years. In 1985 operations were split between Statoil and SDFI, a direct investment in oil by the state. The operation took on this form based on the reasoning that since the oil production plot (oil well) was split among different countries, the Norwegian state needs to be involved in mining decisions and processes (Ibid). It allows the government to directly benefit from oil and gas, than for them to see profits go elsewhere. Statoil was later privatized and listed on the Oslo stock exchange as well as the New York Stock Exchange. In a similar but more extreme case than Botswana, the Norwegian government held 81.7% of its shares. In 2007 Statoil merged with the oil and gas division of Norsk Hydro, Norway's chief producer of hydroelectric power. The company changed to StatoilHydro and in 2018 changed to Equinor. The Norwegian government let go of the reins a bit and in 2019 when they reduced ownership to 67% but are still the largest shareholder. Due to state involvement in the petroleum industry, Norway experiences economic surplus every year since they first started pumping oil (Ibid). This means that on top of normal sovereign earnings, Norway has income coming in from its shares.

Investment of Oil Wealth

In 1990 the Norwegian government created an Oil Fund (Oljefondet) or Government Pension Fund Global (GPF-G). The purpose of this fund is to invest parts of the large surplus accumulated from the petroleum industry. Doing so creates a significant shock absorber in the economy (McKay, 2019). This means that Norway is not at the mercy of oil prices for financing

their entitlement program, which is an essential topic when relying on natural resources so heavily. The fund is managed by a division of the Norwegian Central Bank. It is the largest pension fund in the world. It is unique because it is backed by the profits from oil, not on individual tax collections or private investments. As of 2017 it was valued at $1 trillion. 65% of the portfolio is in equities and the rest is in real estate and fixed income investments (Ibid). GPF-G is the largest owner of European stock with 2.33% of all stocks in Europe.

Challenges of the Oil Fund

The oil fund is a unique way in which Norway is trying to avoid the resource curse but the oil fund does face some challenges. The government is allowed to spend the fund's inflation-adjusted return up to a maximum of 3%. This was reduced from 4% in 2017. The change was supported by every political party except the right-wing Progress Party. They argue that more of the fund should be spent now on infrastructure and a welfare state (Ibid). Norway had its first ever withdrawal from the fund in 2016 when the government spent NOK 6.7 billion (US$780 million) from the fund to counter an economic downturn caused by low global oil prices. The fund did what it was meant to do which showed the world that Norway's unorthodox method of resource management was a brilliant idea. The fund has also had a strong ethical link since 2004. The Norwegian government has a list of companies which they won't invest in. These are mostly tobacco companies or companies that produce a lot of environmental damage. Ironically in 2019 they divested from oil exploration companies (Ibid). The GPF-G is still interested in petroleum companies such as BP and Shell that have significant investment in renewable energy. The fund will sell its stakes in 134 companies and the announcement knocked $150 million off its combined stock market values.

When the Oil Runs Out

Global low oil prices caused a drop in Norway's economy and resulted in a loss of many jobs in the oil industry. There has been a recent recovery however. The GPF-G is a good start and currently at over 300% of Norway's GDP (McKay, 2019). Surprisingly Norway is not heavily reliant on oil and gas. 98% of the country's electricity is hydropower and a lot of consumers are choosing electric vehicles. Norway also has the goal of emission-free fjords and a completely emission-free shipping fleet. This is set to be implemented over the next couple of decades. Shipping fleets account for almost all of Norway's oil use and thus having their fleets move away from oil which will benefit the entire country (Ibid). Once the petroleum industry declines there will be increasing numbers of skilled workers competing for the available jobs. Expertise in the hydropower industry might help cover some of the shortfall with global growth in renewable energy (Ibid). Norway is trying to also encourage other sectors of the economy. Their tourism industry is exploiting Norway's stunningly beautiful landscape and continues to expand (Ibid). The former prevalent industry of fishing still continues as it seems to be robust. The International Monetary Fund believes Norway's transition should be relatively smooth as long as it is constantly aware of the future (Ibid).

While Botswana has a top-down elitist approach to the distribution of revenue amongst the citizens, Norway is the complete opposite. Norway not only created the largest pension fund in the world, they have proven that it does work. Seeing that the population of Botswana is about half of Norway's they have the potential to mimic this model.

3.3.2 The Democratic Republic of the Congo

Let's take a look at a country that is not faring as well as both Norway or Botswana, the Democratic Republic of the Congo (DRC).

3.3.2.1 Similarities:

Botswana and the DRC also have two similarities, although not as strong as with Norway. The first similarity is the presence of a single foreign producer of their resource and the second is the presence of mining booms.

History:

In DRC tantalite was first discovered in 1910. The country has substantial sources of tantalum-bearing ores, coltan being the most common. The main coltan deposits are located in the east of the country and the North and South Kivu provinces. The mines are typically in easily-mined alluvial or soft-rock deposits which are suitable for artisanal mining. By 2009 there were 23 coltan mining sites in eastern DRC, 14 in North Kivu and 9 in South Kivu. The other most important source of tantalum hard-rock tin-tantalum deposits are in Katanga province. The precise data on artisanal mining employment in DRC is not available but it is estimated that coltan mining and trade employed around 300,000 people in the DRC in 2009. It is also estimated that artisan mining (including other minerals) supports up to 16% of DRC's population (Usanov et al., 2013). The coltan produced in the DRC is around 8% of the world's resource base. Although significant, DRC is far behind the tantalum production of Brazil and Australia, which together equal about 60%.

Tantalum Mining Before the First Congo War

Before the 1990s tantalum was extracted mainly as a by-product of tin mining. The principal producer of tin was a Belgian-Zairian company *Société Minière et Industrielle du Kivu (SOMINKI)*. It was formed in 1976 by Belgian mining firms and the government of Zaire. They owned extensive mining concessions in eastern Congo allowing them to be a large producer of gold and tin. Seeing that tantalum extraction was a by-product, it was a limited product (Usanov et al., 2013). The share of coltan in SOMINKI's total output by value was negligible compared to gold and cassiterite mining. Troubles in Zaire in the 1980s caused economic difficulties for the company and the crash of tin prices in 1985 led it to close some industrial mines in eastern Congo. As a response to these unfortunate events they decided to let individual miners engage in artisanal mining on its concessions. Some of the laid-off workers became artisanal miners instead (Usanov et al., 2013). By 1991 Congo's production reached 57 tons of coltan concentrate or 16 tons of tantalum content. The decline of state institutions and deterioration of infrastructure under rule of Mobutu led to sharp fall in production (Usanov et al., 2013). By 1995 production dropped to 1 ton. In the same year Belgian shareholders of SOMINKI sold shares to Canadian company Barno. With the beginning of the First Congo War in 1996, industrial mining of tantalum ceased completely.

The First Coltan Mining Boom

All of sudden in 2000 there was a boom in coltan. Tantalum prices spiked between 2000-20002. This surge acted as an adrenalin shot for coltan mining in DRC (Usanov et al., 2013). Prices started to rise rapidly in June 2000 and reached its peak in early 2001. Prices increased by more than a factor of six. The price surge caused massive expansion of artisanal

mining (Usanov et al., 2013). In 2000 the DRC accounted for 12% of the world's primary production of tantalum.

This drew the Congolese to coltan mines as a way to get rich. Despite high risks (low physical safety in mines due to landslides and collapsing miner walls; insecurity created by armed rebel groups and criminals) coltan mining is viewed as more attractive than agriculture (Usanov et al., 2013). Coltan became more profitable than other minerals like gold or diamonds and it brought a lot of money to the East.

The Second Coltan Boom

For years after the first coltan boom there was a huge decline in coltan production in the DRC. In 2006 it accounted for 1.6% of the global primary tantalum production. But suddenly in 2007 there was a second coltan boom. Tantalum production jumped close to the same levels of the first boom and it lasted longer. In 2010 the DRC's share of global tantalum production was approximately 20%. Between 2009 and 2010 the DRC are believed to have been the second largest producer of tantalum after Brazil. Driven by the increasing price of tantalum it was being mined more and more. The good thing about artisanal mining is that it is very flexible. This means that it can react quickly to price incentives, and this is good for the miners (Usanov et al., 2013). During this time coltan mining in DRC substituted a large part of Australia's supply(Usanov et al., 2013).

3.3.2.2 Differences:

There are four differences between the countries that are of note. The first is the type of mining that Botswana and the DRC participate in. Next is the lack of a single larger player in

mining. Thirdly is that tantalum is extremely volatile and lastly is that the DRC faced civil wars.

Artisanal Mining, Lack of Large Players and Price Volatility

The prevalence of artisanal mining, small operations in a more competitive environment, is quite different to the monopolies that exist in Botswana or Norway. The small operations keep their operations doomed to thin profit margins, and open to capture by larger transnational monopolies that process and do higher value added.The first coltan mining boom was quite short-lived. Prices fell fast in early 2001 and by August of 2001 it crashed to about the same level as 1999 and early 2000. The price collapse had a direct impact on the profitability and attractiveness of the mining of coltan. Many miners went back to agriculture or moved to other sites to mine cassiterite and other minerals (Usanov et al., 2013). Some did not give up on coltan but treated coltan mining as seasonal, when agriculture was slow. By 2002 total coltan production in DRC dropped more than 50% compared to the previous year. Total revenue from coltan mining and trading activities declined by a factor of 10.

History of Illegal Exploitation and Exports of DRC Resources

"The Second Congo War of 1998–2003, sometimes referred to as 'Africa's world war', was largely motivated by the interests of many countries – from neighbours to distant trade partners – in controlling the DRC's significant natural resources, especially minerals (Ballentine and Nitzschke 2005" cited in Putzel, 2011). Towards the end of the Second Congo War in 2002 the UN Security Council commissioned a group of experts to study illegal exploitation of natural resources and other wealth in DRC. The study identified 11 African countries as points of transit for illegally mined minerals (Putzel & Kabuyaya, 2011). They recommend placing financial

restrictions on a number of companies and travel bans on certain individuals. They published a list of 85 companies considered in violation of OECD guidelines for multinational corporations. The national origin of the corporations, mostly mining companies, where; Belgium, UK, USA, South Africa, Canada, Germany, Zimbabwe, Switzerland, Finland and France. In Asia it was China, Hong Kong, Malaysia and a Thai timber company (Putzel & Kabuyaya, 2011). Around the official end of the Second Congo War in 2003 efforts were being made to stop illegal exploitation of resources which were both a cause and an effect of civil problems. The UN-sponsored investigation and implemented the Kimberley Process for diamond trade. In September, the DRC President Kabila issued a ban on mining in the eastern provinces of North-Kivu, South-Kivu and Maniema as a response to the continued abuses by rebel groups and associated 'mafias'(Putzel & Kabuyaya, 2011). In the same month the US Congress passed the Dodd-Frank Wall Street Reform and Counter Protection Act. The act was aimed at promoting 'financial stability by improving accountability and transparency in the financial system' (Putzel & Kabuyaya, 2011). Minerals and their derivatives are sources of armed conflict. They are subject to disclosure measures to ensure due diligence on material's route and chain of custody. "To date, resources have bled across DRC's porous borders, unprocessed, mostly unaccounted for except perhaps by those few recipients of corruption money necessary to keep the process going" (Putzel & Kabuyaya, 2011). With growing stability, legislative reform and a number of political efforts, processing of resources and value-adding with the DRC is likely to increase. All this along with better control of exports and closer international attention to due diligence in sourcing (Putzel & Kabuyaya, 2011). The DRC Mining Law of 2002 and associated Mining Regulations of 2003 instituted major reforms of governance in mining sectors. This was to attract

investors/investment in the sector. It represents liberalization in terms of access by new actors, at the same time modernizing institutions and guidelines for granting land and managing environmental and social impacts (Putzel & Kabuyaya, 2011).

Conclusion

Through the comparison of Botswana with Norway and the DRC it is seen that although they are quite far from reaching level to match the high income countries, they also have earned their title of being Africa's Gem. Norway's advantage over Botswana is what this proposal hopes to accomplish. With a greater sense of transparency and accountability, the government of Botswana could also keep money within the country, invest their wealth and prepare for life after diamonds. In comparison to the other African countries, it is easy to see why Botswana's flaws can be overlooked seeing as they are ahead of the pack. Being ahead but falling short of its capabilities is not the ideal situation for any country.

Chapter 4: Proposed Solution: Transparency and Blockchain

4.1 Introduction:

With this explanation of blockchain, Botswana's diamond industry, and the problems that Blockchain might solve, this section offers a proposal highlighting the ways that would be required to tie them all together. Through this blueprint of blockchain implementation in diamond mining Botswana's would fully gain from their land's resources.

4.2 Previous Problems:

From all the information gathered before we can pinpoint two major problems that Botswana currently faces when it comes to diamond mining, inequality and the 'flow of dark money'. Inequality stems from the top down approach that many governments and transnationals rely on for their existence.One of blockchain's fundamental promises is its ability to offer accountability. By having the largest source of Botswana's income monitored, money that flows to offshore shell companies and tax havens can be estimated and to a large extent traced prior to it leaving the DeBeers company or the country. Tax revenues can be properly assessed and enforced without kickbacks to government officials. Government income can be tracked and even traced to its end use if there are dedicated spending lines. The expected increase in funds from the diamond industry could be invested in other sectors to diversify Botswana's industrial base, limit its political capture by transnational corporations, and be more inclusive in its economic growth.

The ability to have shareable but encrypted supply chain information allows blockchain to be the best option for improving resource management. The next problem is the money outflow. As mentioned before although De Beers moved their sorting center to Gaborone, the money and value added production facilities are still not staying in the country. With the use of blockchain technology, the government of Botswana would be able to find out how much of Botswana's unprocessed diamonds are leaving the country, to thus tax appropriately and incentive domestic processing. This will also allow other parties like sightholders to no longer use tax havens to conduct transactions, meaning the people of Botswana will get more of the value which they have added through their hard work and origination.

4.3 How Diamonds Are Mined:

Exploration

Before we dive into our proposed implementation of blockchain we must explain the diamond mining process. Using the explanation in the article *The Diamond Mining Life Cycle*, each step will be explained. The diamond mining begins before a mine is even opened. The first step to diamond mining is the exploration, and search for kimberlites which are volcanic eruptions that bring material from the depths where diamonds can form. There are multiple methods in locating kimberlites. These methods include the use of satellite remote sensing, geophysics and reconnaissance sampling (*The Diamond Mining Life Cycle - Mining for Schools*, n.d.). The discovery of kimberlites allows for drilling to find if there are economically viable diamonds. Extracting the core for analysis gives an indication of the grade, cost per tonne and average value per carat that will be found in this deposit.. Once a pipe line is seen to be profitable, the actual mining begins. There are three types of diamond mining.

Mining

The first type of mining is what is known as pipe mining, which is mining of a primary deposit. Pipe mining falls into two types, open-pit and underground mining. All of Botswana's diamond mines are mined using open-pit mining. Open-pit mining involves removing layers of sand and rock found above kimberlites. Once exposed the ore in the pit is broken apart by explosives/blasting. A single blast can break approximately 45,000 tons of ore (*The Diamond Mining Life Cycle - Mining for Schools*, n.d.). After the ore is broken down excavators load the ore onto haul trucks and transport them to a primary ore crusher. The diamond process begins here. When it comes to underground mining, miners tunnel into the earth's crust through kimberlite pipes. The tunnels were constructed on two levels about 25m vertically apart. The

upper level is used for undercutting the ore zone to initiate caving. The lower production level is used to extract the bulk of ore through funnel-like excavations from the upper level (*The Diamond Mining Life Cycle - Mining for Schools*, n.d.).. In the lower level haul dumpers are loaded as they collect broken ore and take them to the crusher before being taken to the surface for processing. This type of mining is known as block caving. It is well established and a safe mechanized mining method. It is now used extensively as an underground mining method. It allows for bulk mining or large orebodies and enables higher ore extraction percentage compared to other underground mining methods (*The Diamond Mining Life Cycle - Mining for Schools*, n.d.).

The second type of diamond mining is called alluvial mining and these are mined from secondary deposits. There are kimberlite pipes that reach the earth's surface and are then eroded by wind, rain and water. The eroded kimberlite bear rough diamonds that are carried downstream from rivers to coasts and some into the ocean. The gravel in which these diamonds are found are covered under layers of sand, mud, clay and underwater plantlife. Once the gravel layer is reached, it is collected and hauled to a production plant for processing. Due to the act of being washed downstream, alluvial diamonds are comparatively small but have a high quality and value (*The Diamond Mining Life Cycle - Mining for Schools*, n.d.).

The last method of diamond mining is marine mining. This mining involves extracting diamonds from the seabed hundreds of meters under water. The earliest form was shore diving, swimmers collecting diamond-bearing gravel from the shallow seabed. The method has become more efficient with the use of specialized ships. These use powerful crawlers to suck up gravel

on the seabed through flexible pipes. Sometimes large-scale drills are mounted onto ships and are then used to excavate for diamonds (*The Diamond Mining Life Cycle - Mining for Schools*, n.d.).

Ore processing

Following the mining process is the processing of the ore. Diamonds are recovered from ores in four stages. The first stage of recovery is crushing. First, gravel is collected and transported to what is known as the primary crusher. The primary crushers reduce the size of ore into smaller manageable pieces measuring not more than 150mm. After this the pieces are taken to a secondary crusher or roll-crusher and may possibly be reduced in size again. After the crushing stage the ore moves on to scrubbing. Here the ore is scrubbed to remove loose excess material and then is screened. Material smaller than 1.5mm discarded —too costly to extract diamonds from such small ore. The third stage is the dense media separation. During this time diamond-bearing ore is mixed with a solution of ferrosilicon powder and water that is measured to a specific relative density. The solution is put into a cyclone to force the separation of material. High density material sinks creating layers of diamond rich concentrate. The last stage of ore processing is the recovery. The diamond rich concentrate undergoes a lot of processes; magnetic susceptibility, X-ray luminescence and crystallographic laser fluorescence.These are calculated based on specific properties of diamonds. These processes are designed to separate rough diamonds from other heavy density materials collected by cyclonic separation plants. For example, diamond's fluorescence when exposed to X-rays. Sensors detect flashes of light emitted by diamond and send a signal to a microprocessor that fires blasts of air to diamond, then the diamond is spat into a collection box.

Cleaning, sorting and packaging:

Now that we have diamonds, the process moves to cleaning, sorting and packaging. Diamonds are collected and delivered to a sorting facility. Here they are cleaned in an acid solution and washed before the sorting begins. Rough diamonds are sorted by size (carat weight). Each size is sold in quality ranges depending on the stone's colour and clarity. Gem quality diamonds are separated from industrial diamonds.

Industrial Diamond Sorting

We shall leave the gem quality diamonds for now and focus on the industrial diamonds. The next step then becomes industrial diamond sorting. Industrial diamonds are considered as a byproduct of the gemstone market. 80% of mined diamonds are unsuitable for use as gemstones and therefore are used industrially (*The Diamond Mining Life Cycle - Mining for Schools*, n.d.). Within the category of industrial diamonds there are subcategories such as the lowest-quality, mostly opaque stones, known as boart. Industrial diamonds are used for cutting and grinding tools. They are used to make diamond-tipped drill bits and saws as well as powder used as an abrasive.

Sale of rough diamonds

Now we come back to the rough diamonds that will make it to the public. The sale of rough diamonds usually takes place by a tender process. Participants view many assortments of rough diamonds and place confidential electronic bids on the parcel of their choice. At the end of the tender, the highest bidder wins. The diamonds are sold to traders with diamond trading licenses. Traders usually send diamonds for cutting and polishing then to retailers. Retailers sell to the public or the diamonds are sold on diamond bourses or exchanges. This is the standard but not always the case. As we mentioned before, De Beers sells to sightholders. Diamond Trading

Company (DTC), subsidiary of De Beers markets rough diamonds from De Beers operated mines, sells parcels of rough diamonds via its sight holder system. Sight holders send diamonds to cutting facilities to be cut and polished in preparation of gemstone sales. Rough diamonds are packaged in sealed containers for transport. In accordance with the Kimberley Process, mentioned earlier, containers are sealed with tamper resistant seals, numbered on site and a certificate of origin is issued.

Cutting and polishing

The next stop on the rough diamond's cycle is cutting and polishing. There are six phases to this stage; marking, sawing, bruting and girdling, blocking, a second bruting and girdling and brillianteering. During the marking phase there is an examining and measuring of rough diamonds. Inclusions are noted and the yield of rough diamonds are determined. The diamond market may decide to mark two or three diamonds from one piece of rough diamonds depending on characteristics and inclusions present in the diamond. It makes more sense to polish two diamonds from one large rough around inclusion to yield two smaller stones with higher clarity as opposed to one larger stone with low clarity grade. By using a 3D laser scanning technology rough diamonds are marked to guide the diamond cutter.

After marking the diamonds undergo sawing. Here, marked rough diamond are placed on sawing spindle with blades made from copper, layered with a mixture of oil and diamond powder. Rough diamond are then lowered to a blade and cut where marked. Because only diamonds can cut another diamond, the diamond powered physically cutes diamond not the copper blade.Following sawing, we come to bruting and girdling. Rough diamonds set onto what is a dopsticks, a metallic rod that holds stone while it is undergoing processing, using a special

type of cement to secure it. Two rough diamonds rub together and the friction wears down the corners of a diamond until it is round in shape.

The following phase is blocking. A diamond is set into a tang, traditional polishing tool, and lowered onto a scaife, a wheel containing oil and diamond powder. This wheel revolves at 3,000 revolutions per minute(*The Diamond Mining Life Cycle - Mining for Schools*, n.d.). A diamond cutter polishes four main crowns and four main pavilion facets. The facets are divided into another four facets on the top and bottom which are polished to create an eight square. The diamond then undergoes another bruting and girdling to ensure the stone is perfectly round. The last phase of these gemstones before they are done with this stage is brillianteering . Reaming facets are polished and shaped to refract and reflect the optimal amount of white light. This stage determines how much fire, brilliance and scintillation the diamond will have. The ultimate goal is to obtain ideal proportions and perfect symmetry. Now that the gemstones are cut and polished to the best of their abilities, they are reading for the next stage, sales. The gemstones we had briefly mentioned are simply sold to the public or to diamond bourses or exchanges. There are around 30 registered diamond exchanges in the world. Wholesalers and retailers can buy small lots of diamonds at exchange and then the gemstones are prepared for final sale to consumers.

Closure and rehabilitation

The last stage of diamond mining is where it all began, the mines. This stage is called closure and rehabilitation. Once a diamond reserve at a mine is exhausted the owner must close and rehabilitate the site. This may result in underground tunnels being stabilized and entrances closed. Rehabilitation is the process of returning mined land to its pre-existing condition or another agreed condition.

4.4 A System of Blockchain Implementation:

Now that we know how diamonds are mined, we can look at where blockchain can be utilized and the value added. On average it takes about one ton of ore to get 1.4 carats of rough diamond. Jwaneng mine moves on average one ton of ore to get 1.4 carats of rough diamond. Now yearly it moves 8 million tons of ore a year selling at an average of $134 a carat. This would bring in about $1.5 billion in revenues from a single mine, creating a profit margin of 24% (Pisani, 2012).

We shall use this rough estimate as the starting point.

Step 1: Exploration

Blockchain technology can be utilized even before the mining begins. The exploration phase is a very crucial step in the diamond mining process and can be woven with blockchain. Before a deposit is mined, there are two fundamental models of quantitative mineral resource assessments. Descriptive and grade and tonnage models are the foundations in which other models are built. The role of a descriptive model is to communicate information to help find and evaluate mineral deposits. “A mineral deposit model is the systematically arranged information describing the essential attributes (properties) of a class of mineral deposits (Barton, 1993).”(Singer & Berger, n.d., p.73) . This model has two parts, firstly it describes the geologic environment in which deposits are found and the second is that it gives identifying characteristics of the deposits. The “frequency distributions of tonnage and average grades of well-explored deposits of each type are used as models for grades and tonnages of undiscovered deposits of the same type in geologically similar settings.”p.72. The data used shows the average grade of the minerals and “the associated tonnage based on the total production, researches, and resources at

the lowest possible cutoff grade.”p.73. As these models are being produced, they can be written onto a blockchain. With this information the government of Botswana could know the following; the amount and grade of diamonds predicted to come from the mine, the number of years this mine can run for and how much revenue could be received. With all this data noted before the mining begins, the government could budget their spending for the year. Since there is an expected amount of diamonds to be produced, a smart contract would be used to ensure that these estimates are met, within a tolerance limit. Any anomalies to this data can be immediately flagged.

Step 2: Mining

In order to be sure that the blockchain technology can be utilized to its full potential, we must make sure that the information going onto the ledger is correct. Considering blockchain is praised for its immutability, once false information is placed on the blockchain, it will carry on throughout the chain of blocks. The way we are choosing to tackle this issue is by having the blockchain start at the mining site. Using the diamond production figures by De Beers, it can be calculated that approximately 44,675 tons of ore are mined daily. With our average of 1.4 carats a ton this will give us roughly 62,546 carats a day. With this information our second contact of blockchain technology will come with the use of weighted scales and more smart contracts. As mentioned earlier, after the ore is blasted, the ores are put into haul trucks. Using hardware oracles it can be programmed into the sensors that for each ton of ore that is placed into the trucks the 1.4 carats should be expected and in turn 62,546 carats should be noted that day. Due to the smart contract, any discrepancies between the amount of estimated carats per day and the figures that are expected along the blockchain will allow for a quick and efficient third party

audit. This has two positive effects. The first effect of note is that the mining company now has a way to account for the trucks of ore that leave the site and arrive at the ore processing locations. The second effect is that now the government of Botswana is aware of how many diamonds they should expect to tax. The information will become more accurate as the processing continues and diamonds are quantified with each step. Red flags will be raised by the smart contracts if actual amounts are 'significantly' different from expected amounts at each stage. But also significant governance can be specificed and documented with smart contracts e.g. registry of child labor, beneficiaries linked to war crimes, etc..

Figure 3

De Beers Group's Diamond Production Data

	Notes	Units	Q1 2018	Q2 2018	Q3 2018	Q4 2018	Q1 2019	Q2 2019	Q3 2019	Q4 2019	Q1 2014	Q2 2014	Q3 2014	Q4 2014	Q1 2015	Q2 2015	Q3 2015	Q4 2015	Q1 2016	Q2 2016	Q3 2016	Q4 2016	Q1 2017	Q2 2017	Q3 2017	Q4 2017
-> Diamond Production																										
---> QUARTERLY DIAMOND PRODUCTION																										
-----> Botswana																										
-------> Botswana		Million carats	5.8	6.3	5.7	6.3	6	5.7	5.7	5.9																
-> ARCHIVE																										
---> QUARTERLY DIAMOND PRODUCTION																										
-----> Botswana																										

-------> Botswana		Million carats									5.8	6.3	6.2	6	5.6	5.9	4.1	4.7	5.3	5.2	4.5	5.4	5.2	5.9	6.1	5.5
Average Per Quarter in Each Year			2014	201	201	201	201	201																		
			6.075	5.07	5.1	5.67	6.02	5.82																		
Average Per Quarter for for last 5 years			5.629166666																							

Note. De Beers Group. *Archived Quarterly Diamond Production from 2014-2019[Excel Spreadsheet]* https://www.debeersgroup.com/reports/production-report

Figure 4

Calculated Carats Per Day

Approximation of Carats Mined Per Day	
(5.62917*1,000,000)/1.4=4,020,835.174	(Tons of Ore Per Quarter)
(4,020,835.174)/90=44,675.95238	(Ton Per Day)
(44,675.95238)*1.4= 62,546.33	(Carats Per Day)

Note. Using data from figure 3 the calculations we made.

Step 3: Ore processing

The smart contracts set in place before the trucks arrive will be noted and thus given what has been predicted before processing, the amount of carats should align,within an agreed tolerance limit . As the ore goes through the many steps of ore processing just before moving on

to step 4 the diamonds can now be individually marked and placed on the blockchain ledger. As the diamonds undergo the processes of magnetic susceptibility, X-ray luminescence and crystallographic laser fluorescence, their signature markers can be placed.

Step 4: Cleaning, sorting and packaging

During the cleaning, sorting and packaging step of diamond mining, the diamonds are sorted by quality. Since all the diamonds are already on the ledger the government would be able to see the exact amount of diamonds in each grading criteria. This shows the advantage that accountability provides the government of Botswana. During this stage the government would have a better sense of the future revenue to be made off of a particular batch of diamonds. And it also becomes more fair on the mining company's part as they are not taxed for high quality diamonds that may not have been discovered. Also, when accounting is taken through an auditing process, it would be easy to point out any anomalies that may be present.

Step 5: Industrial diamond sorting

This step requires a slight alteration of the blockchain ledger. Since not all diamonds are going to become gemstones, a fork is placed during the industrial diamond sorting. At this point the diamonds that are to become gemstones will stay on the original blockchain ledger but the diamonds that will be used industrially will be placed onto a different ledger. There is still money to be made off of the industrial diamonds, taxes, therefore keeping a ledger of these diamonds is also important. With a ledger all diamonds, industrial or gemstones can incur the appropriate duties and be given a heritage and origination. The government will have records of where each of the diamonds are heading. They can then choose how to tax different types of diamonds accordingly.

Step 6: Sales of rough diamonds

Now that each diamond, industrial or gemstone, has been forked from the initial blockchain ledger, each diamond has its own traceability and future downstream visibility. Since the diamonds have been on the ledger since processing, they all have verifiable traceable markers.“Rough diamonds are packaged in sealed containers for transport. In accordance with the Kimberley Process*These containers are sealed with a tamper resistant seal, numbered on site, and a certificate of origin is issued”(*The Diamond Mining Life Cycle - Mining for Schools*, n.d.), and so adding a blockchain would allow for an additional guarantee of conflict-free diamonds. The diamonds can be traced in accordance to the Kimberly Process guaranteeing a universal ethical standard. It is also worth noting that a way of avoiding taxes is to import high-value and low-value rough diamonds and re-export the same diamonds in parcels with high-volume domestic rough diamonds. With the blockchain ledger the smart contracts would raise flags at precisely the point at which it vanished.

Step 7: Cutting and polishing

In theory sight-holders are required to cut or polish some diamonds within the country of purchase, Botswana. Things get tricky as the cost of cutting and polishing diamonds varies across nations. The cost of such a process in Botswana costs $60-$120 per carat whereas in India it costs $10-$50 per carat (Sharife, 2016). Any profit maximizing company will see this difference and choose to take their processing plant to India. The exact figures are not public as of yet but in practice, high costs means little beneficiation actually takes place in Botswana. Considering sight holders are already supposed to cut and polish some diamonds in Botswana, a specified amount of diamonds can be cut and polished in Botswana. The ledger will allow for the

government to see which diamonds are being cut and polished, as well as the amount that should be earned. Now the people of Botswana can be paid for their work as well as an increase in jobs for the country. Botswana could then provide proof that these diamonds were sorted in an ethical environment, meaning their workers were paid fairly and the conditions are up to standard. This is an important point because India is now using blockchain in their sorting centers which could possibly increase the value added of their diamonds as they have more of a traceable origin and earn a premium by having an ongoing downstream visible . This is also increasing the value of India's sorting above others.

Circulor Example:

Blockchain can be used in a wide variety of sectors, from healthcare in Estonia to crowdfunding in China. As we focus on blockchain's use in resource management, we come to the case study of Circulor and Hyperledger. Hyperledger is a firm that offers blockchain technology to businesses. They work in a number of different sectors, most notably, they worked alongside Walmart in their food supply chain. Their work with the firm Circulor is of great reference to this paper. Circulor is a UK based firm that "created a system that ensures tantalum is mined, transported, and processed under approved conditions with an unbroken chain of custody"("Tantalum from Rwanda Case Study," n.d.). This firm is remarkable because "the system uses facial recognition and QR codes to deliver a world first: mine-to-manufacturer traceability of this vital resource"(Ibid). Such a system did not exist before. Tantalum is a mineral that is used in many devices such as phones and laptops. For this reason controlling a supply of tantalum is good money. This mineral is produced primarily in Africa, 60% of the entire world's supply (Ibid). A huge player in tantalum mining is Rwanda Tantalum is

considered a conflict mineral and thus falls under the scrutiny of the Dodd-Frank Act mentioned previously. It is for this reason, that being able to trace the origins of the mineral is crucial. Rwanda was using the only method available for tracing tantalum, which was by tagging the mineral and then filling out the required paperwork. This system was very vulnerable to clerical errors and fraudulent behavior. Circulor decided to eliminate these risks and began their work with the Rwandan government to track the production of tantalum from the mine to their manufacture. They began by mapping out each step of the mineral's process. Once each step was thoroughly mapped out, digital procedures were then able to be put in place to go from paper to digital. Their biggest problem was to avoid garbage in, garbage out. The mapping allowed Circulor to swap out the paper checklists with online systems. These systems involved "scanners, sensors, weigh scales and smartphones" (Ibid). Their unique approach to make sure there was no 'garbage in' was a "facial recognition system they call URU " and through tracking the ore using smart contracts. "The Circulor Protocol is the family of smart contracts that connect one segment of the supply chain to another through a material-processing step," (Ibid).

Circulor was not just a theory but actually ran in 2018 in three Rwandan mines as well as a refinery in Macedonia operated by Power Resources Group (PRG). Blockchain has made this whole process run smoothly. "What's really appealing to our company is that the blockchain system works alongside our existing due diligence and compliance programs. We haven't had to overhaul our procedures," says Ray Power, CEO of PRG. "So we're getting a lot of traceability for very little extra work." (Ibid). Circulor did what had never been done, through blockchain they were able to map out an entire chain-of-custody.

Conclusion:

So blockchain does not have to be the be all and say all but as seen in Circulor's successful implementation of blockchain to tantalum mining, but blockchain can have an amazing impact. By starting the blockchain implementation from the mining stage allows for a more trustworthy blockchain. By avoiding the garbage in garbage out problem the ledger holds significant value. Once the diamonds are marked, the whole system essentially runs itself. Not only can the government of Botswana make DeBeers more accountable, but DeBeers can keep track of its employees and management processes. The use of blockchain would also provide an immutable record that could be used in a court of law.

Chapter 5: Challenges

5.1 Implementation:

We have now seen how through blockchain technology Botswana could improve on their management of diamonds. The proposal seems straightforward and easy enough, but it is not. Although there are benefits of including blockchain in the diamond mining process, there are also challenges.

5.1.1 Audits

Although blockchain technology would automate the majority of the supply chain of diamonds, there is one factor it cannot automate, auditing. Auditing could take place for two reasons, to verify that the system is working and to fix issues as they may arise. These issues would arise from the system flagging an inconsistent point of data. One cannot predict how often this would happen, nor how long it would take to finish the audit.

5.1.2 Slow Digitization

The proposal talks about the easy book keeping that blockchain has, but that is only the case once everything is digitized. Not every process is already digitized and thus it will take a lengthy process to switch from paperwork to digital. This is further hindered by the fact that companies spend time creating their current systems and implementing blockchain would push against the grain. “"In theory, this all makes sense, but supply chains are very hard to change and adapt," … "Typically, companies spend years putting [supply chains] in place and refining them. It is not very easy to insert [a] new technology inside established supply chain systems because the integration challenges are not to be underestimated.””(Earls, 2016).

5.1.3 High Cost of Blockchain Systems

The whole system of blockchain is a very powerful tool. All the data that goes onto the chain is stored indefinitely. In order to have such a feature, there needs to be an enormous amount of computing power to run the system. This computing power comes at a high cost. “There are many problems that could be addressed with blockchain technology, but without an understanding of what a blockchain solution will cost, it is impossible to say whether economic efficiencies can be achieved” (Omaar, 2017). According to Jamila Omaar in her article *Forever Isn’t Free: The Cost of Storage on a Blockchain Database*, there are three types of costs to blockchain. The first is, as expected, the storage costs. A huge amount of data can be stored on the ledger and thus a large storage cost. The next is intracluster communications costs. “Intracluster communication costs are the costs of transferring data from one node to another within the same cloud network, whereas intercluster costs are for outbound data transfers”(Omaar, 2017). The last type of cost is fixed cost. These costs include operation costs such as; staff, facilities, accounting, legal etc.

5.2 Shortcomings:

The challenges of this proposal does not only lie in the implementation of the system, but in the system itself.

5.2.1 Largely Untested Technology

Blockchain technology is a relatively new form of technology. People are still trying to discover ways in which it could help a number of sectors. For this reason, blockchain is greatly untested. Pat Bakey, the president of industry cloud at SAP, stated in the article *Blockchain not a panacea for supply chain traceability, transparency*, “"Even though a solution like blockchain might provide features that foster honesty and trust, [the challenge of] accommodating functions like process design, partnership and business terms should not be underestimated,"” (Earls, 2016). Through the lack of testing, the world is yet to know how well blockchain can truly work.

Conclusion:

The implementation and shortcomings of blockchain technology have the capability to hold back a potentially viable method of resource management. The proposal has potential, but also requires a heavy amount of work to incorporate.

Chapter 6: Implications

6.1 Botswana:

A proposal has been given, but what would it mean for Botswana. There was some mention of the implications but now we shall look a little further. The first result of this proposal would be an increase in employment. Since it was noted that there is a required amount of diamonds that must be polished in Botswana, the government could require a percentage of

diamonds to be polished in the country to create a desired amount of new jobs. This would help drop Botswana's 2019 unemployment rate of 18.19% (*Botswana - Unemployment Rate 1999-2019*, n.d.). This rate was actually an increase from the 2018 rate of 17.97% (*Ibid*). Not only will there be an increase in jobs, as Botswana gets more efficient in polishing, it could then compete with India. As of right now, India holds the comparative advantage in diamond polishing, and thus attracting more business. With a rise of efficient polishing in Botswana, Batswana diamonds could increase in some form of value, be it monetary or ethically. An important result that could come from the successful implementation of this proposal would be the possibility of easing off of diamond dependency. Currently, Botswana's main export and source of income is diamonds. We can see that this setup is working, but only for now. As Botswana guarantees they are getting their money's worth in diamonds, the additional income could be used to help prop up other sectors of the economy. Therefore, the day that the mine runs dry, Botswana will not panic for they are prepared.

6.2 Other Companies:

The integration of blockchain technology is sweeping the world. The idea of blockchain and the mining sector is not limited to this paper and Circulor. Broken Hill Propriety Company Ltd. (BHP), formally known as BHP Billiton, is also utilizing this technology to increase their efficiency. BHP is the largest mining company by market capitalization. At the second annual Global Blockchain Summit they revealed their plans to implement blockchain technology. A BHP blockchain is to be used to record the movements of wellbore rock and fluid samples. It will also better secure real-time data during delivery (Rizzo, 2016). The intention is that the new system will improve internal efficiency and be more effective in working with partners. "BHP

relies on vendors at nearly every stage in the mining process, contracting with geologists and shipping companies to collect samples and conduct analyses that drive business decisions that occur with parties distributed across continents." (Rizzo, 2016). In this situation, blockchain will be an alternative to the current use of spreadsheets. Seeing as the largest mining company is seeing value in blockchain, would it not be wise to follow suit?

Conclusion:

Through this proposal Botswana has the possibility to combat; unemployment, a shift in comparative advantage and the possibility of easing off of diamond dependency. These areas would be the ways in which an improvement of resource management could help better "Africa's Gem". This proposal is not out of the question considering BHP have also decided to undergo the transition to blockchain. They face the same challenges that Botswana will and yet, think that blockchain technology will be worth the hassle.

Conclusion

Resources in Africa are abundant and sadly poorly managed. This is a tale as old as time, but also a future we do not want to continue. Resource management is not an easy task but with the rise of technology, the task may have just gotten easier. Blockchain technology is a whirlwind advancement that has the ability to change the game. Botswana could be the country to lead the rest. As we have come to see, there are actually several reasons to make the change. As the trend of transparency along the supply chain rises, so do legal requirements. As part of the Kimberley Process Certification Scheme, Botswana already has a legal reason to uphold provenance in its diamond mining industry. They have also had a very unique history with their diamonds. One of the 25 poorest countries at independence to one of Africa's few middle income

nations, the diamond industry has carried them far. Their unique partnership with De Beers has given them a power that no other country possesses, a 50/50 private-public partnership.

Through the use of smart contracts and digital tagging, the government of Botswana can account for all the diamonds that it exports. The blockchain system will not only track the life of the diamonds that will make it to the jewelers, but also the diamonds that will go towards industrial processing. This will allow for Botswana to truly get their money's worth. If implementing blockchain was so simple, it would be done all over the world in every sector, sadly it is not. Unfortunately execution problems and shortcomings means that in order to implement this proposal, Botswana has a mountain to climb. If they did climb that mountain, the results could allow them to progress as a country. Botswana would have a decrease in unemployment, a competitive edge over India in diamond polishing and a set up in easing off of diamond dependency. This paper is proposing something that has never been done before. Until blockchain technology is truly adopted by the masses, we could not know if this theory could work. It is possible that this paper is ahead of its time or even so, blockchain does not rise to its full potential and this paper could mean nothing at all. Regardless, it is worth noting that an improvement in resource management on the African continent is much needed, but also that technology will be the way forward, be it blockchain or whatever new trend arises.

To show the potential blockchain has in resource management, Botswana was the case study, but that does not mean this proposal has to stop there. The creation of this proposal was only possible due to the top-down management of Botswana's mines. However, this is not the norm elsewhere. Although this paper does not explore another form of management, a paper could be written about a bottom-up approach. Such a paper in conjunction with this would offer

Africa more options when it comes to their resource management approach. Africa is rich in resources and abundant in poor management, thus ways of improving resource management has a promise to benefit citizens of these nations. Looking back at some of the countries on our top ten list, what would Niger look like with a properly managed uranium sector? Or Sierra Leone and their plethora of resources? Maybe Africa would have more gems.

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