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Legal smart contracts for derivative trading in mining

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Abstract

This research demonstrates financial derivative trade of unprocessed materials, for the mining industry through legal smart contracts. Within the mining supply chain, a stock of mined resources can reside in a mineral stockpile for over twenty years without gaining financial interest and without undergoing the mineral extraction process to derive value from the asset. This research elaborates on a blockchain solution implemented to increase miners' short-term cash flow for business operations through the issuance of derivative assets on mineral stockpiles which can be traded through legally binding smart contracts. The system is the first to enable mining companies' access to the underlying asset's value earlier in the production lifecycle through smart contract technology whilst providing hedge funds with access to new financial products for investment portfolios.

Introduction

At the time when minerals and precious metals are extracted from the earth, they exist as minute quantities within excess rock and waste materials. Once the ore has been extracted from the earth, haul trucks are used to transport the ore into mineral stockpiles which are categorized by the grade of metals and minerals contain within each respective stockpile. The mineral stockpiles are stored on the order of magnitude of tens of thousands of tonnes, and the underlying material composition of each respective stockpile is identified in a report produced by geologists by performing tests on the unprocessed minerals. Through the application of blockchain technology to store contract-backed derivatives, miners are able to transfer the future right to own a stockpile assets as a financial derivative which can be exchanged for money

in an over-the-counter style of financial security transaction, with each transaction being recorded with automated smart contracts.

Smart contracts for derivative trading

When a digital agreement to enter into a legally binding contract is made between two willing and capable individuals, and the contract is hosted in Australia, Australian Law recognizes the contract as legally binding given that sufficient conditions are met for the contract to be legally permissible (Argy *et al.*, 2001). A distributed ledger system can be configured to enable transactional smart contracts to contain the expression to participate in the value transaction along with the necessary contractual terms for the contract to be considered consistent with Australian Contract Law (York *et al.*, 2016; Riveret *et al.*, 2018). The necessary terms within Australian Contract Law for a value exchange to be legally enforceable include an offer made by one party, the acceptance of the offer by a second party and a consideration, which is often money, is required to be paid between the parties. Additionally, both parties involved within the contract are required to have a mutual intent and capacity to enter into a legally binding agreement (McLauchlan, 2007). The smart contracts are executed through permissioned user interaction within the system, as an automated feature of the value exchange for derivatives between system users. Interactions are triggered through a client program hosted on same server as the blockchain and operating through a separate server port to enable communications between the separate system modules.

Value exchanges

The value exchanges are conducted over options and futures contracts, as tradable units which specify the legal right to purchase an asset at a specified date and time in the future. The demarcating difference between options contracts and futures contracts is that options give the buyer the right but not the obligation to purchase an asset at the option expiry for European Style options (Black and Scholes, 1973), while futures obligate the buyer to purchase the asset at the date specified in the futures contract. Authenticated Users listing minerals would utilize a service standardized by mine engineers to derive the net value of the minerals after the processing costs were factored into the extraction. Utilizing blockchain technology to store the smart contracts ensures immutability of the data and the provenance of the transaction. After purchasing a quantity of options contracts from a miner, the purchasing party is able to re-list the financial option or to sub-divide the contract and sell separate units of the financial derivative. The system allows for contract settlements between multiple parties after the reselling of the financial derivatives by market traders. A monetizing feature is included in the system whereby the purchaser of digital options and futures contract is automatically charged a minor transaction fee through the chain-code, with the fee being deducted from the user's represented monetary balance within the system which is distributed to the owner of the blockchain for facilitating the contract-backed transaction. The system is currently set to charge the asset purchaser a transaction fee of 1.5%, deducting the purchaser's account balance by the necessary fee. The monetary value deducted through the transaction fee is allocated such that one-third returns as royalties to the miner role who listed the items with two-thirds being allocated to the product owner user role within the system.

The information system

The application utilizes IBM's Hyperledger Fabric as a digital business network which stores transactions in the blockchain after consensus is performed through the Apache Kafka ordering service (Hyperledger Architecture, 2017, 2018). The information system for the application is implemented through a micro-service software architecture. Separate micro-services have been set up for the blockchain module, the off-blockchain module and the web-based user interface (UI). The UI interactions are facilitated through the hosting of micro-services on a separate port of the web server. The off-blockchain software service played a pivotal role in computing logic which would have been rejected by the consensus peers if the same logic was processed from within the blockchain such as external HTTP requests. When an external

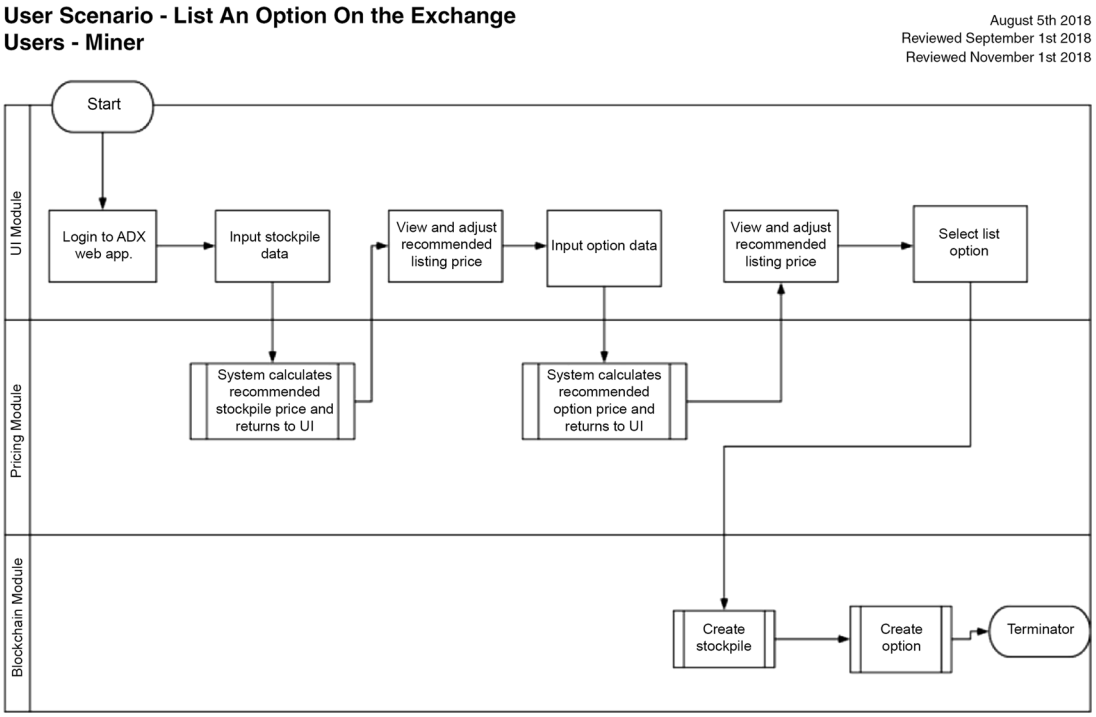

Figure 1 List on option on the exchange user scenario

HTTP request is made from the within the blockchain, all of the peer nodes endorsing the transaction are required to perform the same request. This results in n HTTP requests being made, where n represents the number of peer nodes required to endorse the transaction. When performing external API requests such as for real-time commodity prices, the time between each endorsing node's API requests can reflect a data variance between each of the successive requests from the endorsing peers. When the endorser nodes certify updated blockchain data with varied values, the consensus mechanism fails leading to the transaction being rejected. The solution for processing logic which could compromise transactions such as external API requests was to create a web service to perform and process the requests before forwarding the data to the blockchain, through the communication port which the blockchain module is configured to listen upon. The micro-services communicate through Representational State Transfer (REST) Application Programming Interfaces (APIs) to enable a wholly web-hosted software system with an interface for user interactions.

System interactions

To ensure proper functioning of the smart contract exchanges, a permission hierarchy of user roles was established for system interactions. Representatives from mining companies are assigned a user role which is able to list mineral derivatives, which is distinct from trader roles who are able to perform secondary and tertiary trades upon the mineral assets. Administrator functionality provides the rights to the system owners to promote user functionality, modify the access of users to the system and to override transactions. Enabling such functionality mitigates the risk of uncontrolled money laundering whilst promoting a system which can be governed according to the legal jurisdiction of the entity owning the software. To promote system interactions, user workflows were implemented between the system's micro services. As per Figure 1, workflows were defined for the listing of digital assets onto the blockchain, with the respective calculations of recommended prices being offered to the asset lister. The mining company user role has to undergo multiple stages including the valuation of the minerals, valuation of the derivatives and agreements with the necessary terms and conditions of user before the stockpile assets are listed on the blockchain. Additional workflows were implemented to enable the trade of listed

derivatives, to handle the exercising of financial options and real time multi-user interactions. In doing so, the technology can be described through multiple user types performing unique activities to facilitate the conversion of physical assets to digital assets, to trade risk and return through financial derivatives.

Architectural considerations

The underlying architecture for a system to enable the trade of derivative contracts is demonstrated through smart contracts on a private blockchain. Traditional databases and paper records are able to be utilized to trade derivative instruments. Smart contracts are irreversibly recorded which mitigates vulnerabilities of untraceable fraudulent transactions. It is possible to manually implement recording mechanisms within traditional databases to include features which are inherently present within smart contract databases; however, it is also possible to switch off the features when performing fraudulent or similarly malicious activities such as removing and alternative of database records. The recording of blockchain transactions is irreversible, meaning all activities are included as features of the database. When a fraudulent activity is observed within a blockchain database, the transactions are able to be reversed given sufficient business logic is implemented for database administrators to facilitate transaction reversals. When selecting an underlying architecture for derivative exchange, it is the responsibility of the representative of the owning legal entity to handle regulatory compliance including mechanisms to handle fraud and improper contract execution. Smart contracts are immutable, are capable of automatic execution and a recording of the transactions exists permanently within the database. Routine backups of all exchanges should be considered to ensure data integrity is maintained. At the time of publishing, there exists mechanisms to trade options on Bitcoin and similar cryptocurrencies, as demonstrated by Hong Kong based Deribit (Zaitsev, 2019), this paper documents the first trade of options on mineral resources through blockchain technology. When selecting the underlying infrastructure for contractual trades of assets, it is the responsibility of the representative of the owning legal entity to ensure that system is secure taking software and business concerns into account.

Implementation risks

Risks within the proposal include regulatory risks, trading risks and architectural risks with the associated software. In orchestrating a derivative trading platform, additional business risks such as liquidity, acquiring a user base, churn rates and account security risks. In utilizing a private and permissioned blockchain database, an inherent security risk is the versioning of the underlying blockchain, as security flaws in software are regularly patched as vulnerabilities are discovered. From an implementation perspective, risks include a lack of software test coverage to validate expected software performance and expose flaws within the business logic implementation. Ensuring that user access has sufficient security protocols such as minimum password length and multifactor authentication (MFA) for trade permissions and account access should be prioritized to mitigate the risks of accounts being hacked. It is recommended to ensure that users agree to a terms of service and that the terms of service subscribes to the laws of the country which the system is being deployed within.

Australian regulatory considerations

Regulatory compliance and reporting are necessary in order to conduct financial service operations within Australia. The Corporations Act (2001) is the source of regulatory law for conducting activities as a financial entity in Australia. The legal ramifications for non-compliance, misconduct, market manipulation and other potentially destructive behaviour involved with financial service and are described in detail in Chapter 7 of the Corporations Act (Corporations Act, 2001). For the issuance of over-the-counter derivatives, a company is required to hold an Australian Derivatives Trade Repository License (ADTR) (Comission, 2015) and to comply with the Australian Security and Investment Commission's (ASIC) Derivative Trade Repository Rules (Harvey). Reporting requirements, whilst operating as a financial service company, are further detailed by ASIC in their Regulatory Guide 251 to ensure transparency between

the transacting parties (Australian Securities & Investment Comission, 2015). Being a financial platform, the system is required to subscribe with the anti-Money Laundering and Counter Terrorism Act (2006) in addition to the wider corpus of Australian Law. In addition to the necessary company registration, business registration, reporting and licensing,a security audit of the software system would be necessary before conducting transactions with real monetary values.

Market landscape

Unprocessed ore is stored by mining organizations on the order of magnitude of tens of thousands of tonnes of materials on each mine site. The reasons for wanting to delay the mineral extraction process can vary. One reason for delaying the extraction process is due to the ore grade being of marginal or low purity within the unprocessed materials. Ore being of low or marginal grade limits the profitability from undergoing metal extraction at current market prices for which the metals can be sold. Often the mines are re-mined many years later when commodity prices and commodity types which are in demand changes. Knowing that market prices change and that extraction techniques improve over time, it is often the case that stockpiles which were historically of a marginal grade change to be of a profitable grade for mineral extraction. Another reason for wanting to delay the mineral extraction process is to promote market stability and price resistance. When a mining company has a surplus of specific resources, it would not be economically feasible to extract and sell the resources as fast as possible; doing so has the potential to disrupt the global market prices by creating a mass surplus of supply (Li, 2009). Naturally, there exist time-valued cost inefficiencies within the mining supply chain which restrict the ability of companies to extract the full potential of materials from mined ore and that market speculators are able to capitalize on time associated volatilities in financial market prices.

As demonstrated in the conference paper ‘Derivative Trades through Legal Smart Contracts’, presented at 3rd Symposium on Distributed Ledger Technology, the research enables mining companies to sell contracts containing the future right to pre-refined ores at discounted rates in a market environment through smart contract technology (Julian and Stephanie, 2018). By enabling companies to create securities on the lower-grade ores, mining companies are able to list and sell options and futures contracts as the future right to purchase ore at future prices, through a many-to-many style of market interactions.

Project solution

The project demonstrates an over-the-counter asset-backed securities trade system, with the securitization process being financial options calculated through the Black Scholes algorithms. Trade of the created financial securities is automated through smart contract technology running on blockchain infrastructure. The platform securitizes unprocessed materials so that derivatives can be sold by miners for increased cash flow and royalties. The value being priced into the security is the future work of extracting the minerals which can be sold on a market exchange discounted with respect to the risk associated with the underlying asset’s market volatility. While the system offers a pricing calculation for derivatives of unprocessed materials, the user role associated to mining companies which creates the derivatives is capable of modifying the listing value. This feature was offered to facilitate the individual value calculations used internally by mining companies. The market traders are provided with the full set of information regarding the listing assets to ensure that they understand the respective attributes of the derivatives and the underlying assets.

Market drivers

As per Australian Legislation, a transaction required two willing and able parties that are required to exchange an asset for a consideration, which is often money. More importantly, the willing buyer and seller would require motivation to partake in the exchange, often monetarily related (McLauchlan, 2007). The platform incentivizes miners to list assets through multiple avenues. In addition to deriving value from materials earlier in the supply chain, the administrative overhead of contract creation is

alleviated. Furthermore, the system has been set up to offer financial interest to the miner for every derivative trade on an underlying asset which a given miner owns to facilitate compounding returns and mine site restoration funds to better rejuvenate mining landscapes. Hedge funds and private investment vehicles specializing in commodity trading have been identified as fulfilling the role of market demand. The incentive for market demand is the possibility to profit on commodity speculation. The volatility of potential extraction rates is suited to financial option styles of derivatives such as European, American and Asian financial options. By using the platform, market traders can know that a portion of their transaction fees is allocated towards positive social and environmental activities.

Conclusion

This paper set out to elaborate on the application of a blockchain solution to the mining industry through automated smart contracts in order to facilitate the trade of financial derivative contracts. The solution has been implemented through the interaction of micro-services to enable the contract transfers to be immutably processed through on-blockchain logic. The smart contracts have been hosted on Australian servers and are implemented in such a way to adhere with Australian Contract Law for meaningful value transactions.

Future research

Further research and development would apply the contract-backed derivative to order book-style trading. Doing so would enable market-based competitive trading over mineral deposits and stockpile-backed financial derivatives. While the proof of concept has been demonstrated, the research still requires regulatory compliance and to undergo a security audit before the blockchain system is legally permissible to enable market interactions of real monetary value. Additional developments would see other derivative types being applied and tailored to the business challenges faced by miners with different materials. Discussions are underway to include an additional user role representing a sustainable development fund user, which acquires a portion of each transaction fee. The sustainable development fund user would be able to allocate the capital acquired towards mine rejuvenation and energy offsets for the miners who issue financial derivatives upon their underutilized minerals. Doing so would ensure that the mining companies have a positive social and environmental impact whilst utilizing the platform.

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