

Abstracts y Papers finalistas
2nd WPC Spanish Oil&Gas Youth Awards

GANADOR

Impact of Blockchain in the Oil and Gas Industry

Juan Benavente Blanco

Key Words:

Blockchain, O&G, Digitalisation, Technology.

Abstract:

Fair or not, the first word that comes to our minds when we think of blockchain is "Bitcoin", the most famous digital currency considered by many a risky and volatile asset. It has been severely criticized and discredited by many distinguished economical figures over time, who discouraged markets to invest in it.

However, blockchain applicability is not limited to currency exchange neither just the financial sector. Blockchain technology is meant to completely revolutionize world's economy, reaching every single country and industry. When referring to the Oil and Gas (O&G) sector, many of its main characteristics, such as ecosystem complexity, global reach or stringent regulatory standards, anticipate great applicability. Across all its stakeholders and activities, there exist numberless opportunities for transparency and efficiency.

Marketing buzzwords, misinformation and lack of clarity have created confusion about what blockchain really is and how it can be truly helpful for us. In this paper, we will offer a high-level summary of how blockchain works and analyze the potential of such technology in the O&G sector.

O&G companies must deal with an increasingly demanding landscape. High price volatility, drop of field discoveries or high safety and environmental standards are just some examples of the challenges they face. This complex environment has forced O&G companies to look for new and innovative ways of improving operational efficiency, increasing asset productivity and generating new decision-making capabilities. Blockchain business opportunities exist through the whole O&G value chain. We will analyze what are the current main barriers for its adoption as well as present several use cases and real world references that show its actual applicability, from upstream to downstream.

Blockchain business opportunities exist through the whole O&G value chain. We will analyze what are the current main barriers for its adoption as well as present several use cases and real world references that show its actual applicability, from upstream to downstream.

Introduction

Fair or not, the first word that comes to our minds when we think of blockchain is “Bitcoin”, a digital currency that has been around for few years already and was meant to revolutionize the financial sector.

Bitcoin genesis was uncertain and infamous. Of unknown creator and related to cypherpunk¹ movement, it is considered a risky and volatile asset used to perform illegal payments in the black market. In fact, many distinguished economical figures such as Warren Buffet [2] or Jamie Dimon [3] have severely criticized and discredited Bitcoin over time, discouraging markets to invest in it.

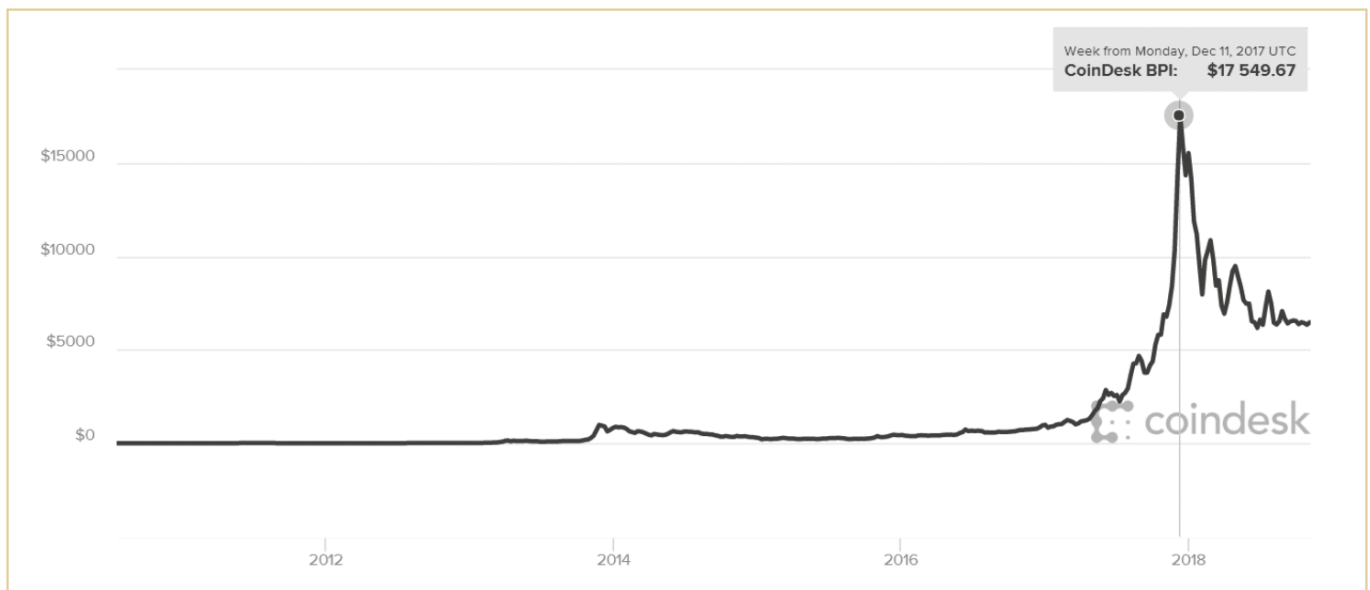
Nowadays, it is still difficult for many of us to understand how Bitcoin could potentially remove the necessity for intermediary entities in order to carry out monetary transactions, putting at risk the business of players that currently hold a dominant position, such as banks or government institutions. However, its unstoppable movement has allowed it to go from the fringe to the mainstream: its value has grown from a few cents to thousands of dollars (see Figure 1); the amount of transactions completed every day is well over two hundred thousand (see Figure 2) and we hear of new cryptocurrencies² created almost every month.

Despite Bitcoin’s monopoly on headlines, the potential of blockchain technology goes well beyond cryptocurrencies, which just represent its first application at global scale. Blockchain is much more than a digital solution for transaction recording; it allows both companies and individuals to exchange value over a completely different trust model. According to Noble economist Douglass C. North, “throughout history, institutions have been devised by human beings to create order and reduce uncertainty in exchange” [7].

The well-established figure of institutions generates a framework for trust in which the uncertainty of carrying out transactions with one another, even with unknowns, is greatly reduced.

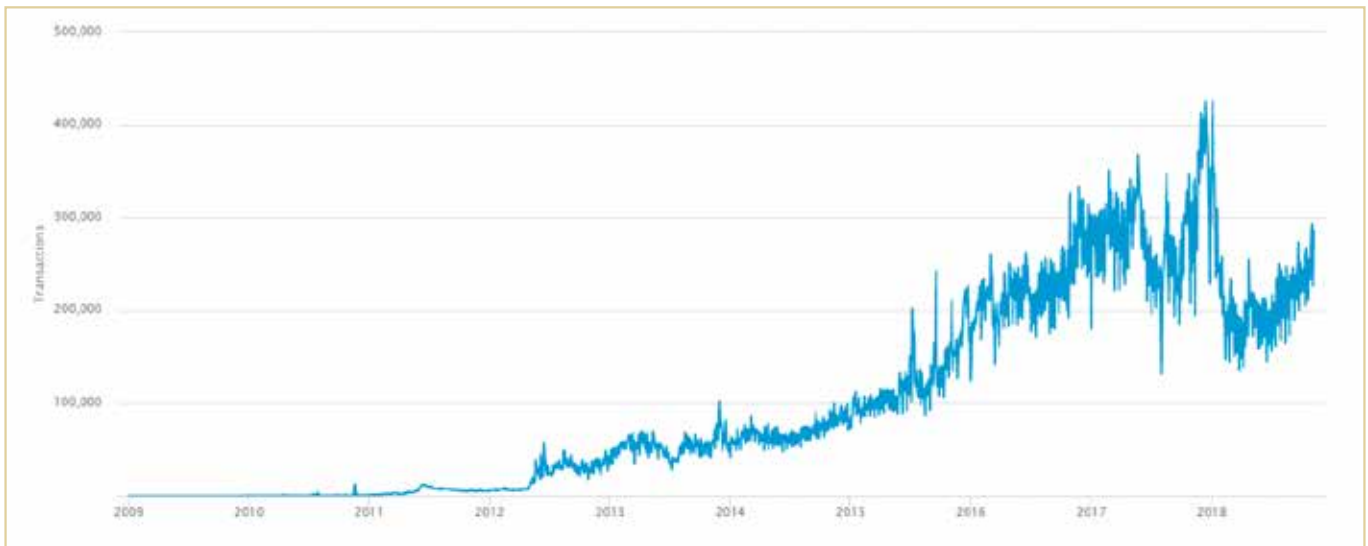
This model has persisted for a long time and even big technological revolutions, such as the Internet, have not affected its basic mechanics. Blockchain, however, does bring in a completely different approach in which, thanks to cryptography, ledger distribution and different consensus protocols for transaction validation, there is no need for central authorities to prevent fraud or avoid double spending. As suggested by The Economist, blockchain is a machine for creating trust [8].

Figure 1. Bitcoin USD price from 18th July 2010 to 7th November 2018 [4]



- 1 A cypherpunk is any activist advocating widespread use of strong cryptography and privacy-enhancing technologies as a route to social and political change. Cypherpunks have been engaged in an active movement since the late 1980s. [1]
- 2 A digital currency in which encryption techniques are used to regulate the generation of units of currency and verify the transfer of funds, operating independently of a central bank [6].

Figure 2. Bitcoin confirmed transactions per day from 3rd January 2009 to 7th November 2018 [5]



Although we have been talking a lot about currencies, blockchain applicability is not limited to money exchange neither just the financial sector. In this paper, we will offer a high-level summary of how blockchain works, analyze and discuss the potential of such technology in the Oil and Gas (O&G) sector, and present different use cases and real world references that show its actual applicability.

The following quote from Eelco Hoekstra, Chairman of the Executive Board and Chief Executive Officer at Royal Vopak, offers a great summary of blockchain core values: transaction efficiency, transparency and cooperation.

“Blockchain technology and smart contracting will not only disrupt the financial sector, but will also automate transactions and deliver more transparency in the Oil and Gas global value chain. As these innovations allow for direct transactions between parties in the value chain, they will be an enabler to lower the costs for all parties.” [9]

The Blockchain

Marketing buzzwords, misinformation and lack of clarity have created confusion about what blockchain really is and how it can be truly helpful for us. In this section, we will introduce blockchain basic concepts as well as an overview of the current state of the art technology.

Blockchain 1.0

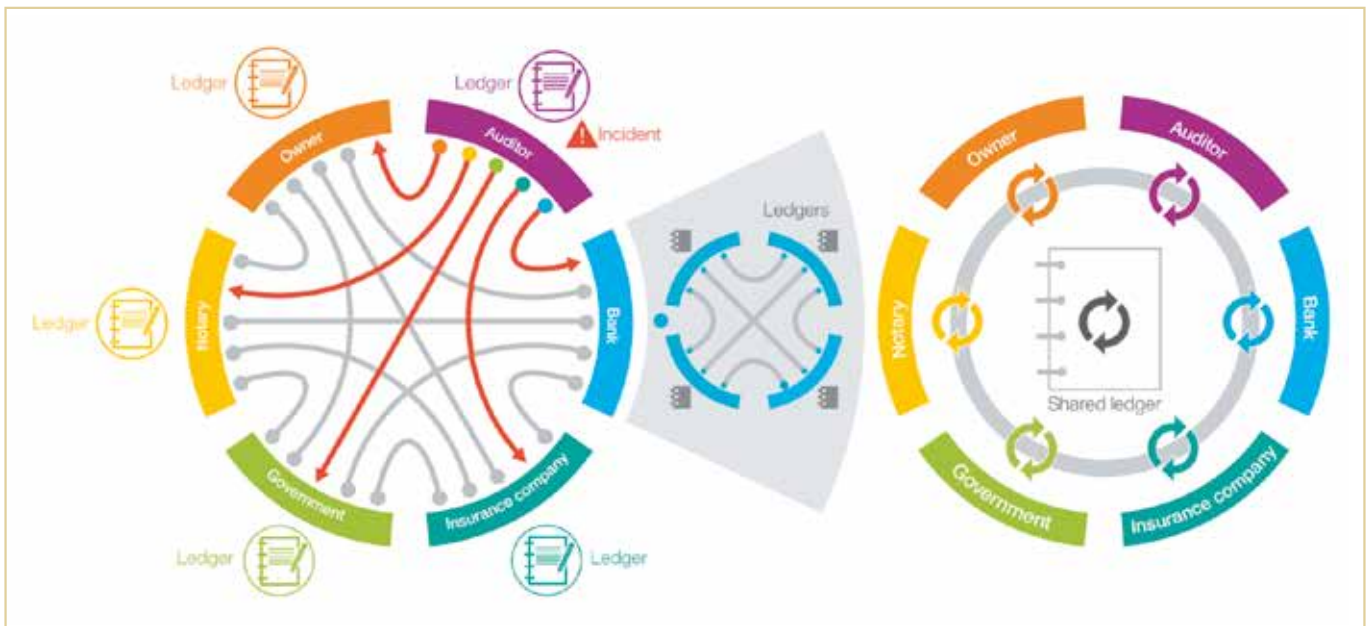
In the same way that bankers used to hold ledgers, books where

they would register all of their client’s transactions in order to calculate different balances, blockchain technology provides the tools for digitally generating and distributing a common ledger shared across the network. In a blockchain, there is no central authority. Each node in the network holds a copy of the ledger, so there is no single point of failure neither information siloes. Every time a new transaction is registered, different consensus mechanisms are used for validation among the participants before the transaction can be written to the ledger. Since validation comes from collective consensus, the only option to trick the system is by gaining control of more than half the nodes of the network. Therefore, the more participants, the more secure it gets.

Actually, transactions are not written plainly in the blockchain. They are grouped and packed together within blocks that are linked to each other shaping a chain. Moreover, blocks are mathematically encrypted so, once a block is validated and appended to the chain, the information it contains is immutable. Any attempt to modify an existing block would break the chain and be instantly detected, consensus would never be reached and modification would be rejected.

Up to this point, we have already introduced much of blockchain core underlying concepts: shared ledger, consensus mechanisms and cryptography. All these together shape what is known as Blockchain 1.0, the first stage of blockchain evolution, tightly coupled with cryptocurrency applications. Any application built on top of this technology could already benefit from:

Figure 3. Individual ledger versus share ledger. Incident complexity [10]



- **Operational efficiency.** Not only is the number of intermediaries required to carry out a transaction reduced, but also record keeping and reconciliation efforts, since data siloes are removed.
- **Transparency.** The shared ledger consists of the only source of truth. Any information on the chain can be audited and therefore proving regulatory compliance is easily achieved.
- **Security.** Consensus procedures and cryptography form a great team in order to grant data immutability and system security.

The following example shows the complexity of managing different ledgers within an ecosystem and the impact of a reconciliation incident in contrast with a shared ledger ecosystem.

Blockchain X.0

Even with previous considerations, current blockchain solutions have still much more to offer. Blockchain has evolved following market needs and currently offers different platform configuration possibilities, each of them best suited for different business scenarios:

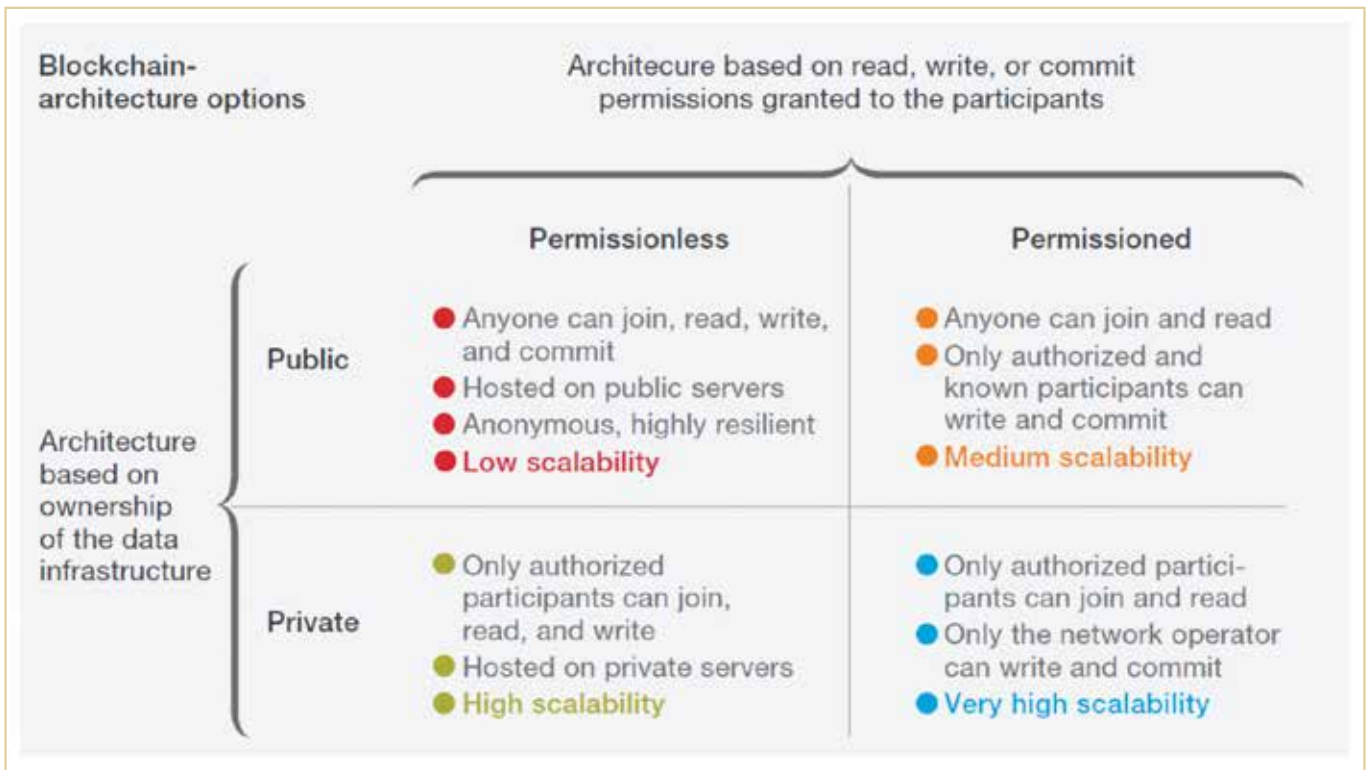
- **Public vs. Private:** public blockchains allow anyone to join freely as a participant, whereas private ones only allow verified admitted participants to join.

- **Permissionless vs. Permissioned:** permissionless blockchains allow any participant to operate freely on the blockchain, whereas permissioned blockchains access to data and network participation through identity-based policies. Permissioned blockchains are also more efficient at data consistency control Figure 4.

As shown on figure 4, previous distinctions can be combined to shape the best choice for each need. One aspect worth mentioning is that, on private-permissioned blockchains, the lack of central authority is not completely true, as there must exist a figure in charge of operating the blockchain to some degree, such as granting access or managing each participant's permissions.

Additionally, one of blockchain's greatest value propositions are the so-called Smart Contracts. Simply speaking, they are contracts that can be read and executed by machines. These contracts are actually computer programs registered in the blockchain that consist of a set of conditions and actions, which will trigger as soon as conditions are met. A Smart Contract signed between an airline and its customers could automatically refund flight tickets when the flight is late as soon as the plane is landing at its destination. An insurer could develop a policy based on driver behavior, which would change its tariffs based on real vehicle data.

Figure 4. Blockchain architecture options [11]



The amount of use cases for Smart Contract application is infinite and so is its potential. However, if there exists a scenario where Smart Contracts become very useful, that is when they are able to interact with the real world, and that is achieved through the Internet of Things (IoT). This leads us to two additional concepts worth introducing due to the huge presence of IoT in O&G world: digital tokens and off-chain technologies.

In order for blockchain to exchange value, it must be digitized. When value refers to native digital assets, such as digital currencies or equities, it's exchange and management is straight forward, conducted through the record of the transaction on the blockchain. However, when the value refers to physical assets, like diamonds, two extra needs must be considered:

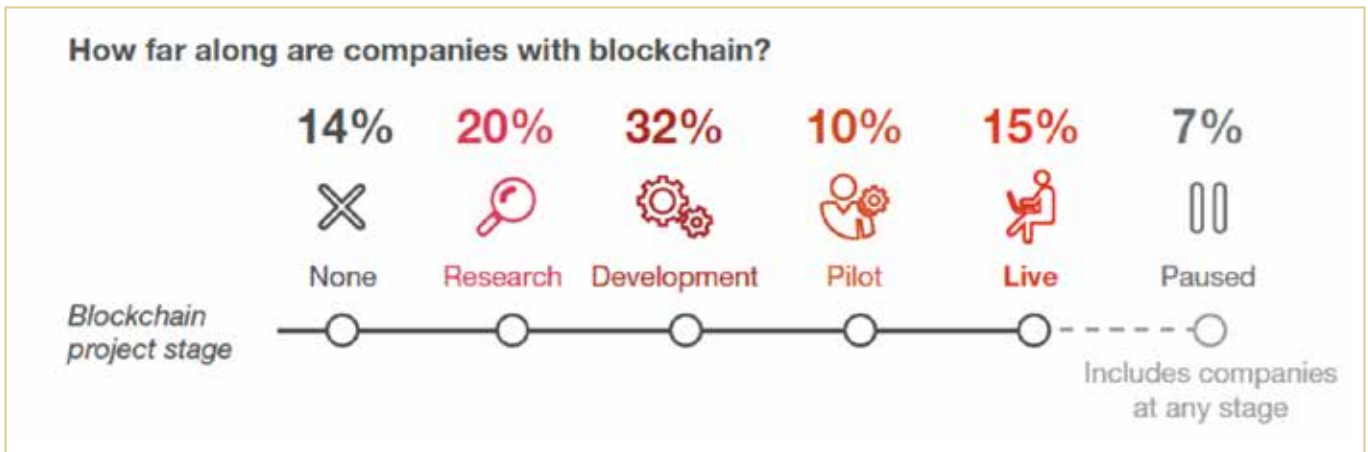
- Firstly, the asset must be digitized. In order to do so, digital tokens representing the asset (or different assets) are generated.
- Secondly, as the asset has been digitized, it must be connected and secured to the blockchain, what will require the integration of off-chain technologies, such as IoT for asset tracking.

Off-chain technologies are technologies that integrate with the blockchain, such as IoT on the previous scenario. These technologies can introduce vulnerabilities in the ledger because, while tricking blockchain systems is almost impossible, blockchain cannot assess whether an input from an external system is truthful or accurate.

All these aspects make blockchain a powerful platform for value exchange in most, if not all, industries. We could still introduce many other of its capabilities. However, it is not the objective of this paper to present every single blockchain feature, but only those necessary to give a high-level overview of the technology in order to understand its applicability within O&G. In fact, blockchain is still evolving at an incredibly fast pace and most probably it will have many new features to offer in the near future. From Blockchain 1.0, different authors discuss whether we are already at the 3.0 or 4.0 stage of its evolution.

According to PWC's 2018 blockchain survey [12], currently 84% of organizations have already some involvement with blockchain technology. However, when looking at their involvement stage, just 15% of them manage productive blockchain solutions, whereas 62% are still in research, development or piloting stages.

Figure 5. Blockchain project stage survey [12]



Despite blockchain perhaps currently being at an immature stage or at least not enterprise ready, many well-known firms have put huge expectations on it. The World Economic Forum [13] expects 10% of global GDP to be stored on blockchain by 2027. According to Gartner blockchain productivity plateau will be reached in a five to ten year time period [14] and will create \$3.1 trillion in business value by 2030 [15]. Bain & Company estimates that blockchain could increase global trade volumes by \$1.1 trillion by 2026 and increase the global banking industry's annual revenue from documentary trade financing by \$2 billion by 2026 [16]. Moreover, many, if not all, big technology players are also heavily betting on blockchain and we already see great examples of its application.

Back in May, ING and HSBC carried out the first commercially viable financial transaction [16], which consisted of an end-to-end trade of Cargill's soybeans shipped from Argentina to Malaysia and included within the operation the buyer and seller together with their respective banking counterparts. A process that used to take from five to ten days to complete, was carried out in less than twenty-four hours over a blockchain platform.

We can also find great examples outside of the financial sector. TradeLens [17] is the blockchain based shipping solution co-built by Maersk and IBM in order to improve efficiency through the global supply chain. To date more than 90 participants, such as shippers, shipping lines, ports or terminal operators, collaborate on the platform by securely sharing information through a blockchain.

Also in the supply chain business, provenance of goods is of great importance. Thanks to blockchain, a manufacturer can demonstrate

its products are of maximum quality, certified origin and that its end-to-end process respects the higher safety standards as well as human rights. This use case applicability goes from diamonds to lettuce. Precisely, Walmart [18] is currently working on E. Coli fight through the certification of its lettuce supplies thanks to blockchain technology.

Applicability in O&G

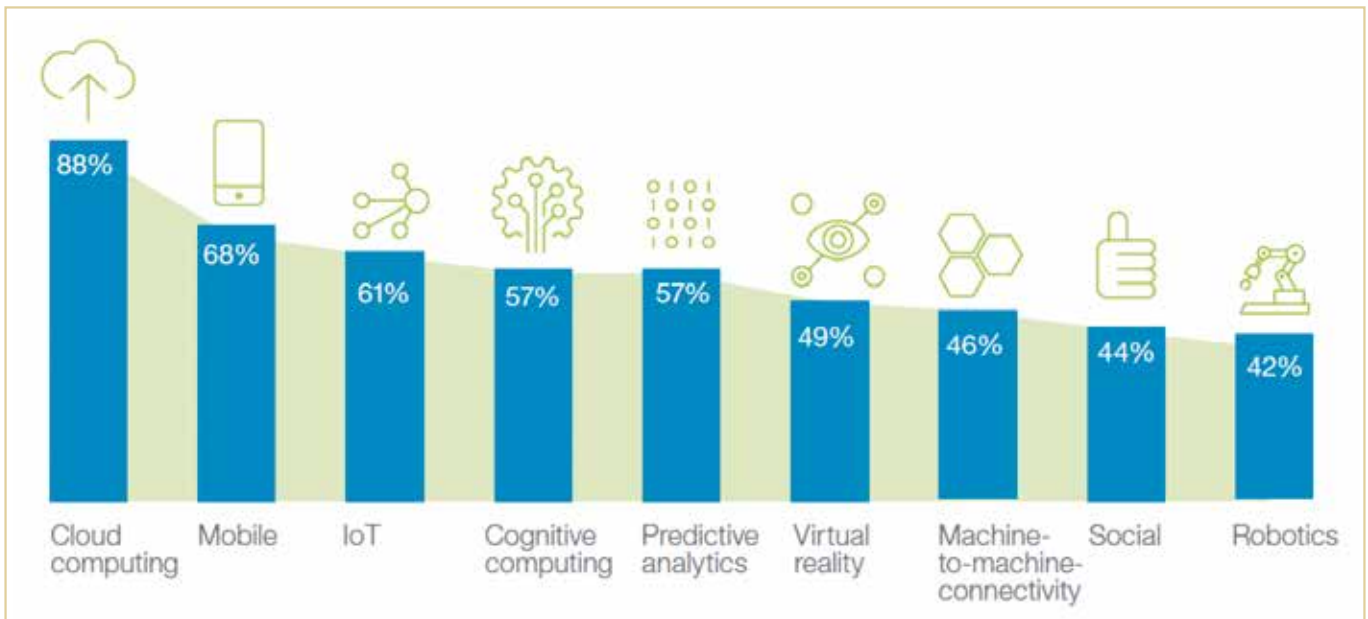
Blockchain technology is meant to completely revolutionize the world's economy, reaching every single country and industry. When referring to the O&G sector, many of its main characteristics, anticipate great applicability. Across all its stakeholders and activities, there exist numerous opportunities for transparency and efficiency.

In this section, we will analyze which are the main barriers for blockchain adoption as well as the business opportunities through O&G value chain. O&G companies must deal with an increasingly demanding landscape. High price volatility, drop of field discoveries or high safety and environmental standards are just some examples of the challenges they face. This complex environment has forced O&G companies to look for new and innovative ways of improving operational efficiency, increasing asset productivity and generating decision-making capabilities.

Adoption Barriers

Although the industry has traditionally been open to cutting-edge production technologies, such as robotic rigs or 3D geological modelling, there has not been the same degree of openness for digital transformation technologies. Today, many O&G companies are still lacking integrated digital strategies as well as digital capabilities, which can provide them with a sound competitive advantage.

Figure 6. Critical technologies for O&G business strategies [22]



Advanced analytics, cloud or IoT are all technologies already familiar to the sector and have a reasonable degree of penetration within O&G operations, although there is still a long path for reaching a real productivity plateau. Great examples are the Chevron and General Electric's tech alliance [19], Total and Google Cloud AI agreement [20] or Woodside and IBM project to apply cognitive computing on offshore rigs [21] Figure 6.

In the case of blockchain, despite being on everyone's lips these recent times, its actual current impact has not been perceived yet. O&G industry intrinsic characteristics, such as worldwide reach and complex business ecosystem of companies, providers, regulators and governments, make us anticipate huge potential. However, there is currently a small benchmark framework both inside and outside the industry for O&G leaders to assess blockchain value, while the risk of creating fatigue at C-Level is running.

Many of the concerns usually discussed when looking at blockchain capabilities have to do with its core technical features: transaction latency and throughput, energy consumption, scalability, security or interoperability. Nevertheless, all these aspects are actually related to system design choices, which should be considered by the participants of the ecosystem when approaching their particular business scenario. Taking Hyperledger Fabric as a reference, there exists research that shows how parameters such as block size or endorse-

ment policy affect platform performance, as well as how different optimizations can result in a sixteen-factor throughput increase [23]. Therefore, we cannot currently say that blockchain technical features form an obstacle for its adoption.

After all the terms and concepts introduced in previous chapters, we might think blockchain is just about bytes, cryptography, servers and algorithms, but its implications go far beyond that. A huge mindset shift is required in order for companies and individuals to take advantage of its full potential. Actually, this shift seems to be a larger barrier to entry than the technology itself.

Blockchain is about connecting and cooperating, rather than isolating and competing. It applies to scenarios where different parties are currently exchanging value at a high transaction cost, low or deficient trust, and creating information siloes. Blockchain brings in a culture of co-competition – cooperative competition – in which traditional competitors need to collaborate and share with one another in order to benefit from the network power.

In order for a blockchain platform to be high-potential it must be formed by multiple parties. Industry and cross-industry consortia need to work together in order to build these alliances and frameworks, as the benefits will increase with the size of the consortia. However, the more participants, the more complex it becomes to

coordinate. Therefore, consortia need to establish clear roles and responsibilities and align strategic incentives of the members. Blockchain platforms are formed and managed by consortia who cooperate and share their models, protocols and standards.

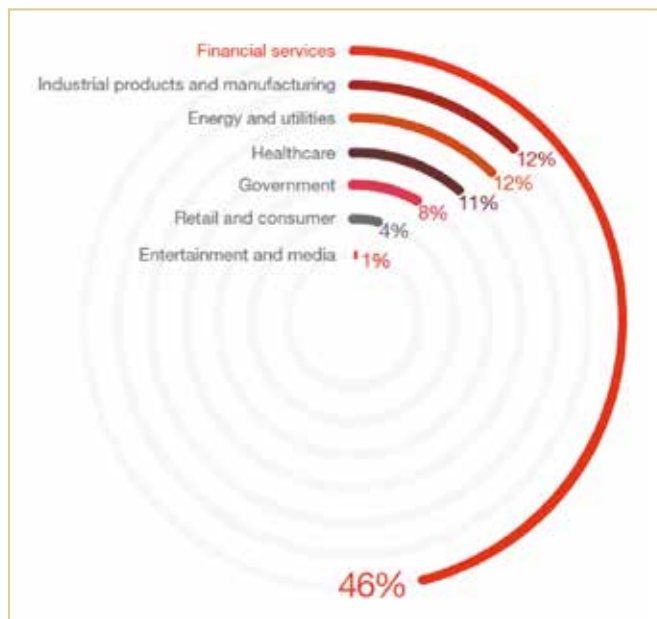
Technologies can be rapidly adopted once the strategy is drawn and investment is planned. However, embracing new ways of working that directly confront traditional behaviors is not an easy task. O&G companies are used to safeguarding trade secret, such as reservoir locations or geological data. After all, resources are nonrenewable. However, information privacy is not black or white and much information can be shared on a blockchain without jeopardizing business secrets. Additionally, blockchain provides mechanisms for keeping information visible just to selected actors.

A blockchain consortia are increasing at a fast pace and more than sixty can currently be found [24]. Some are worth mentioning:

- R3 groups more than 200 members [25] from different sectors, mainly finance, insurance and technology.
- The mobility open blockchain initiative (MOBI) groups some of the world’s largest auto manufacturers [26], such as BMW, GM or Ford.
- Alastria, the first multi-sectoral blockchain consortium in Spain, joins companies from different sectors and size. All main energy companies are currently part of this consortium, including Repsol and Cepsa, from the O&G industry [27].

Both PWC’s [12] and Deloitte’s [28] executive blockchain surveys position regulation as the main entry barrier for blockchain adoption, which comes as no surprise, since we have seen already how ICOs³ have generated contrary reactions within different countries in the past, from no regulation in South Korea, to being banned in China [29]. The absence of a clear regulation prevents blockchain from scaling to real business scenarios. However, while regulators are currently challenged to keep up with the speed of blockchain evolution, this technology itself can facilitate some of their main objectives by improving regulatory reporting and avoiding fraudulent transactions. Governments themselves could benefit from blockchain applications in digital currency, health care and identity management. Both these facts make possible blockchain and regulation alignment. Ad-

Figure 7. Industries seen as leaders in blockchain [12]



ditionally, the work carried out by industry consortiums is helping regulatory bodies to understand and shape blockchain legislation.

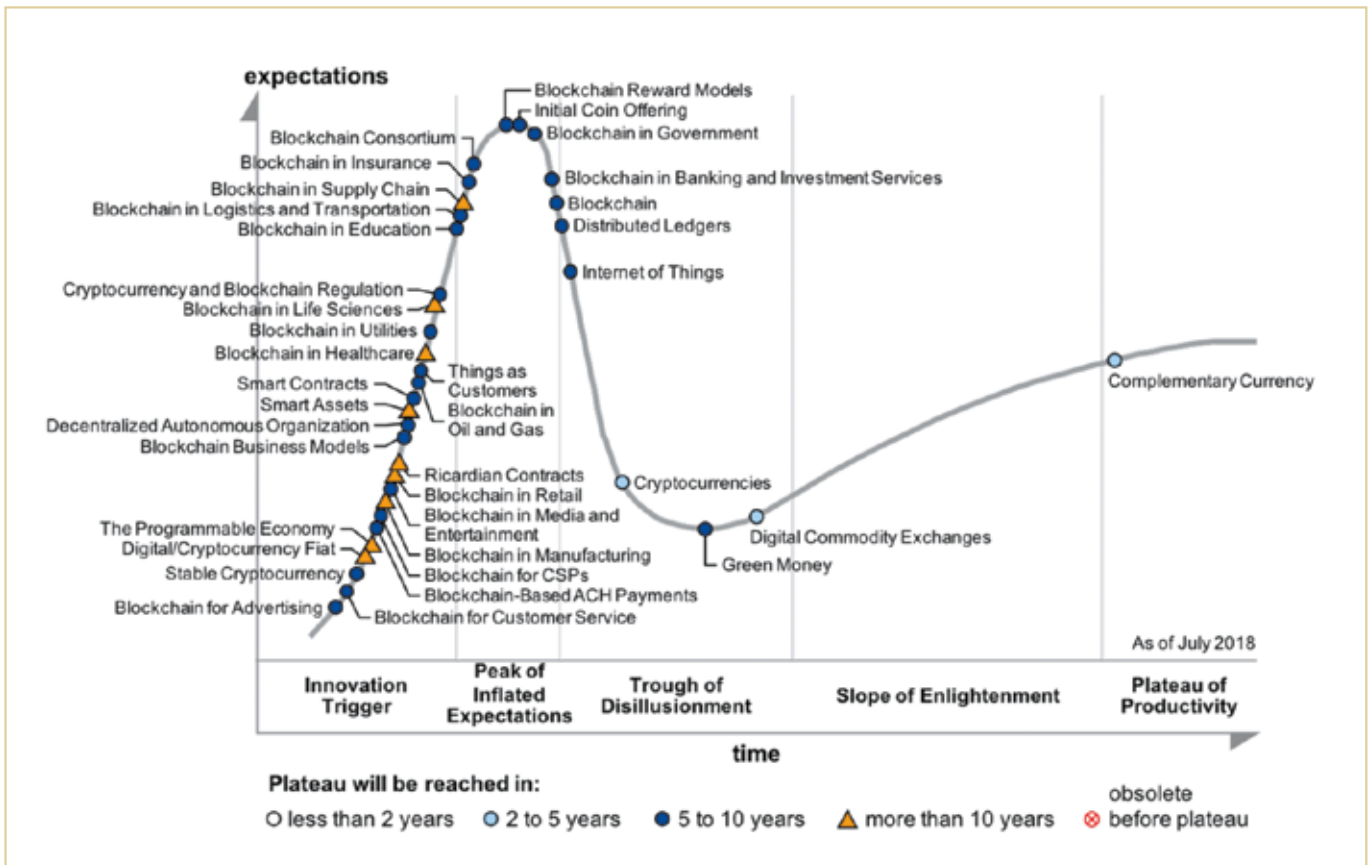
Despite all mentioned barriers, when we look at different industries and how fast they are adopting blockchain (see figure 7), energy companies together with manufacturers appear in second place, of course far away from financial services companies, which have been clear leaders from the very beginning. However we still expect it will take five to ten years for O&G companies to reach its productivity plateau in their use of blockchain (see figure 8).

Potential impact

Since blockchain in O&G is still at the very beginning of its hype cycle (see figure 8), it is hard to develop accurate estimations of how this technology could economically transform this sector. In fact, at the time of writing this research, we have not found any of the main strategic well-known consulting firms clearly presenting their predictions at the industry level. However, the information presented so far allows us to understand already how this technology can be applied along the O&G value chain, from upstream to downstream. In this section, we will analyze blockchain’s main

3 Initial Coin Offerings.

Figure 8. Hype Cycle for Blockchain Business, 2018 [30]



applications within O&G business, focusing on those related to its core business activity and on which we anticipate a higher economic and cultural impact.

Upstream

Many activities need to be carried out by O&G companies before a single drop of crude oil can be put into a barrel. From exploration to production, including land ownership, financial terms or well drilling, this segment is one of the most complex within O&G value chain and hundreds of companies come into play at different stages in order for the full lifecycle of an oil well to complete. Precisely this complex and multi-party nature is what makes upstream a great area for blockchain adoption.

One of the first challenges O&G companies must face is to determine the ownership of a specific portion of land in order to get needed authorizations to initiate E&P activities. Usually land ownership

records are confusing – duplicated, non-standardized, managed at different offices or levels, etc. – what requires a great amount of manual effort and legal procedures to clear things out. Recording land ownership on a blockchain as digital assets would avoid much of this effort by providing a unique shared source of truth on which any land transaction would be recorded. Government commitment would be required, as overall responsible of such records, and we can find already initiatives that pursue this goal, such as the Swedish government blockchain tests [31].

Contracted services, some of which require high workforce specialization, need to be provided and certified in a highly regulated and risky environment, where compliance and responsibility tracking is a key matter. Plenty of time could be saved if all the certifications required for each individual to perform their assigned tasks were recorded on a shared blockchain, where both contractors and auditors could transparently consult it. Every piece of work done could be

certified, so that not only the tools and workers compliance could be tracked, but also health and safety standards are respected through the execution and inspections grant the required quality and quantity of performed labor. Smart contracts could consolidate these elements together with economical agreements in such way that service providers could automatically receive their payments once their job is attested, avoiding tedious reconciliations efforts and ensuring full auditability through a transparent record of transactions. On top of that, smart contracts could also consider performance metrics, such as quality goals fulfilment or milestone fulfillment, which could automatically recalculate and execute provider payments.

Once production begins and revenues start flowing, different types of interests need to be addressed, such as royalties and ORRIs (Overriding Royalty Interests). Its calculation usually includes multiple parameters, including fixed and variable taxes or monthly hydrocarbon production quantities, qualities and average prices. Agreements behind these contracts are subject to continuous supervision and its automation through blockchain smart contracts would increase efficiency both during its execution, auditing and reconciliation stages.

Midstream

Once resources are extracted, they must be delivered to different destinations, which many times are not located in the same geographical region. This involves transportation, storage and processing activities, where ecosystem complexity and high regulation are common factors in upstream and downstream segments. Therefore, many aspects discussed in the previous section do also come into play in midstream segment. Additionally, midstream is characterized by its cross-border implications, environmental concerns and capital intensity.

The singular nature of both oil and gas will always involve multiple actors through its supply chains. Pipelines and vessels, maintenance and inspection companies, are all shared in an asset-intense global ecosystem where no enterprise can work alone. Currently, each participant must hold track of its own records, which leads to duplication, inefficiencies and reconciliation efforts that often head to disputes. According to Hernando de Soto, a renowned Peruvian economist, "Some 5 billion persons and 20 trillion dollars have been

shut out of the economy due to disputed assets" [32]. A shared blockchain could track commodities, register contractual agreements, and serve as a tamperproof register for trade documentation (see figure 9). This would not only increase efficiencies, by avoiding duplicated efforts and disputes, and automating contract execution, but also would reduce system vulnerabilities. Blockchain would certify commodity provenance and quality as well as health, safety and environmental standard compliance.

Another great potential use of blockchain within midstream is transportation asset inspection. Many environmental disasters occurred in the past have made both governments and O&G private companies to focus on stringent quality controls of pipelines and vessels. In the case of vast pipeline networks, were many different companies must coordinate to inspect every mile of pipeline, blockchain would serve as a shared platform where these companies could attest the conditions of specific infrastructure sections together with the required workforce and tool certifications needed to perform the task. This information could be transparently audited to grant compliance and will increase coordination efficiencies among inspection companies.

Regarding vessels, they must undergo strict vetting inspections that help traders and charterers to analyze transportation risks. There exist different industry standards, such as SIRE⁴ or CDI-M⁵, and accredited inspectors who are in charge of carrying out required controls. Moreover, other factors of a different nature are considered during the vetting process, like ship casualty data or crew experience. Blockchain platforms could serve as a shared ledger where different parties, such as ship owners, inspectors, charterers or traders, could access either to certify and record new facts (i.e. new inspection carried out) or to consult information, such as O&G companies before a new trade operation is closed.

Downstream

Downstream is the last step for oil and gas before reaching its end consumers. Regarding blockchain, many activities performed in downstream segment are similar in nature to those already explained before, such as complex supply chains, industrial process traceability or intensive quality control, and therefore might have good acceptance and penetration. However, down-

4 Shipping Inspection Reporting Program.

5 Chemical Distribution Institute – Marine.

Figure 9. Tamperproof documentation trail [33]

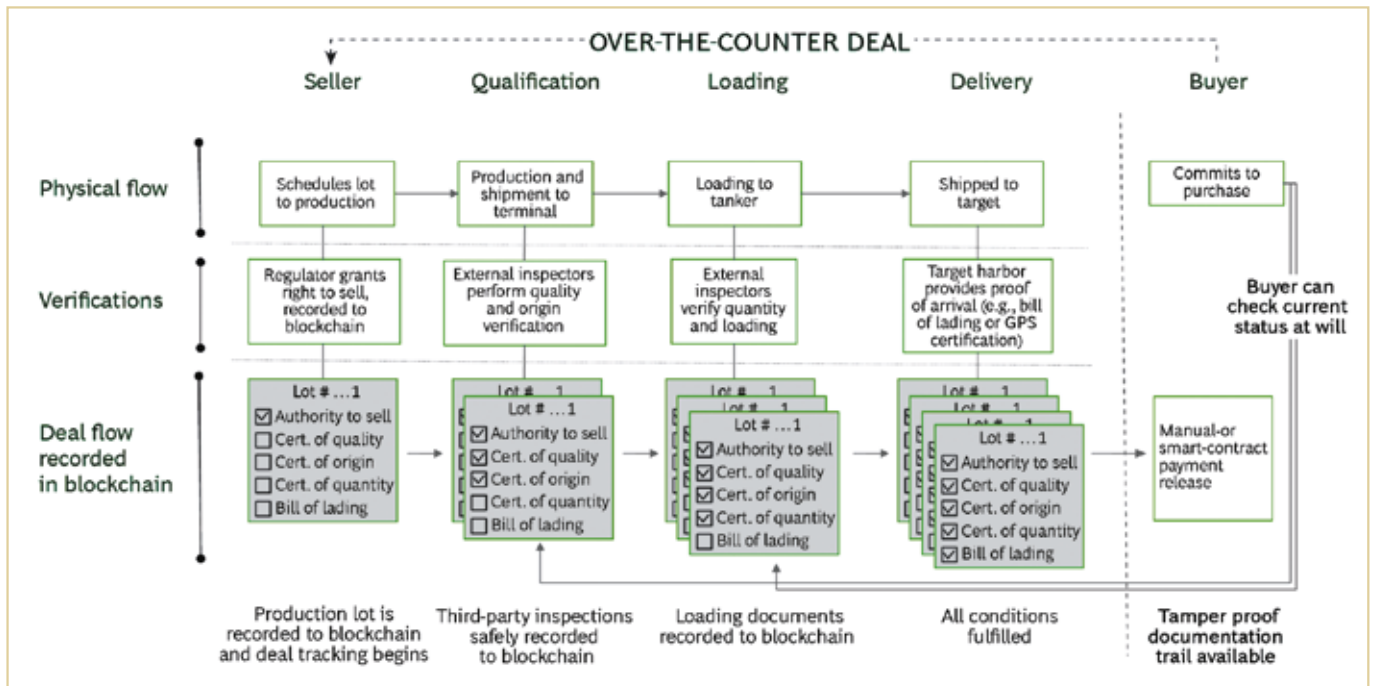


Figure 10. Blockchain's suitability for different commodity markets [33]

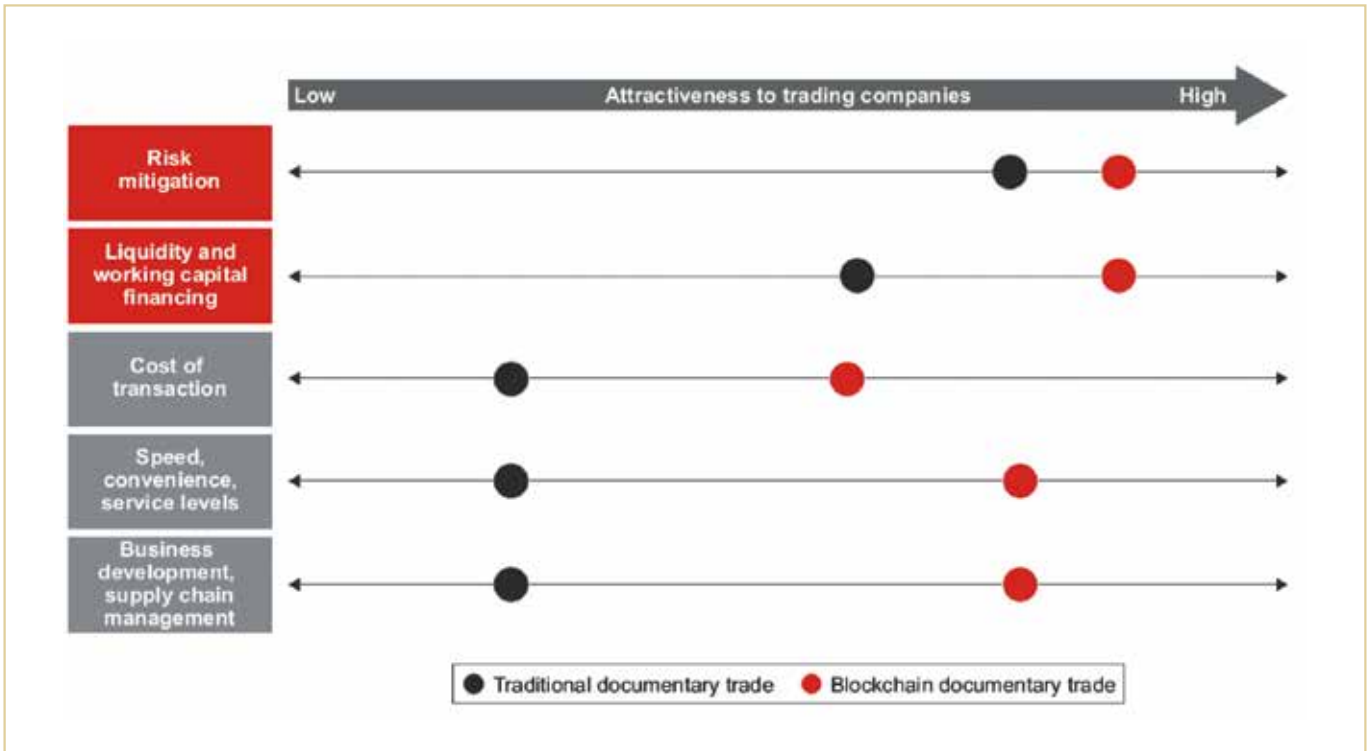
BLOCKCHAIN DRIVER	LOW	MEDIUM			HIGH	
Pricing complexity	Power	Gas	Iron ore	Diamonds	Agricultural	Physical oil
# of transactions	Diamonds	Iron ore	Agricultural	Physical oil	Gas	Power
Requirements for origin certification	Power	Gas	Iron ore	Agricultural	Physical oil	Diamonds
Effort to reach efficient infrastructure	Power	Gas	Iron ore	Physical oil	Agricultural	Diamonds

stream also brings in different elements that could be object of great improvement.

Perhaps, the area that could be most impacted by blockchain is oil and gas trading. In the case of gas, where market standardization, efficiency and transparency are already high, there will be less space for improvement. That does not mean it will be small and such

markets could still rely on blockchain to improve transaction and reconciliation efficiency due to the high volumes of trading operations carried out. In the case of oil however, there is still much place for efficiency and standardization, and the suitability for blockchain application is considerably higher (see figure 10). Although the number of transactions is smaller than in gas or electricity markets, pricing complexity is much greater due to product heterogeneity

Figure 11. Blockchain advantages over traditional trading processes [16]



and bilateral dealing. Oil-trading agreements involve complex terms that determine the final price a customer would pay to its suppliers, including average reference prices, currency exchange values or certified product quality and quantities. All these conditions could be registered using smart contracts that could automatically validate its fulfillment and unleash agreed payments.

There are many theoretical advantages of applying blockchains to such trading scenarios (see figure 11) but many companies are already putting it into practice and, in fact, some real world references show how energy trading is ahead of the curve in blockchain adoption:

- Trafigura trading house and Natixis French bank piloted a blockchain solution together with IBM for deal settling in the US oil market [34].
- BP, Eni, Wien Energy have already completed a blockchain pilot for gas trading [35]. BTL, the blockchain platform provider, is currently working on the live commercial version inviting additional companies, which include Total, Gazprom and Mercuria, among others.
- A consortium grouping oil producers BP, Shell and Equinor, commodity traders Gunvor Group Ltd., Mercuria and Koch Supply & Trading, and lenders ING, ABN Amro Bank and Societe Generale, is currently working to develop an oil-trading blockchain platform [36].

Conclusions

As we have seen within this paper, in a matter of few years blockchain has gone from the fringe to the mainstream in such a way that it reminds us of the Internet revolution. However, although the Internet revolutionized the way we manage information, it did not have the same impact on value exchange. Thanks to blockchain, business opportunities arise for new value creation, ecosystem optimization and risk reduction.

Most probably, we are not capable of understanding and identifying full blockchain potential today. Whereas blockchain applications will focus on cost cutting in the short term, they will unlock completely new models tomorrow. Nevertheless, these benefits will only be reached once we overcome its main adoption barriers. Some of them, such as technical aspects or infrastructure costs, have already been broken down. However, there exists still high uncertainty about standards and regulations that could grant blockchain applications the ability to become commercially viable and scale out. Blockchain is not just a new way of recording data, but it involves a completely new paradigm for value exchange, both among individuals and companies. Hence, regulators must be onboard from the very beginning and industries need to embrace a cooperation mindset, as the more participants, the higher networking effect.

Actually, O&G companies are used to this collaborative competition. Many of them have successfully created joint ventures with one another in the past and now they will be required to do it again in a different context. From upstream to downstream, ecosystem complexity, global scale and high regulatory standards are all common factors where blockchain can clearly add great value as already presented. On top of that, there exists even more scenarios we have not analyzed, such as cybersecurity threat reduction in offshore rigs, where communications can be exposed, or reward programs for end customers, in downstream.

The areas for blockchain application are countless, so its adoption will be natural. There are currently many initiatives being developed by different players for distinct use cases. Industry leaders just need some real proofs to verify its feasibility and realize gains.

References

- [1] Wikipedia. <https://en.wikipedia.org> . [Online; accessed 11th-Nov-2018].
- [2] T. Kim. Warren Buffett says bitcoin is 'probably rat poison squared'. CNBC, May 2018. <https://www.cnbc.com/2018/05/05/warren-buffett-says-bitcoin-is-probably-rat-poison-squared.html> . [Online; accessed 11th-Nov-2018].
- [3] H. Son, H. Levitt, B. Louis. Jamie Dimon Slams Bitcoin as a 'Fraud'. Bloomberg, September 2017. <https://www.bloomberg.com/news/articles/2017-09-12/jpmorgan-s-ceo-says-he-d-fire-traders-who-bet-on-fraud-bitcoin> . [Online; accessed 11th-Nov-2018].
- [4] Bitcoin value. Coindesk. <https://www.coindesk.com/price/> . [Online; accessed 11th-Nov-2018].
- [5] Confirmed Transactions Per Day. Blockchain. <https://www.blockchain.com/charts/n-transactions> . [Online; accessed 11th-Nov-2018].
- [6] Oxford Dictionaries. <https://en.oxforddictionaries.com> . [Online; accessed 11th-Nov-2018].
- [7] Douglass North. (1991). "Institutions." *Journal of Economic Perspectives*, 5(1): 97-112; Abstract
- [8] The trust machine. *The Economist*, October 2015.
- [9] Digital Transformation Initiative, Oil and Gas Industry. World Economic Forum, January 2017.
- [10] Fast forward, Rethinking enterprises, ecosystems and economies with blockchains. IBM Institute for Business Value, June 2016.
- [11] B. Carson, G. Romanelli, P. Walsh, A. Zhumaev. Blockchain beyond the hype: What is the strategic business value? *Digital McKinsey*, June 2018.
- [12] S. Davies, G. McNamara. PwC's Global Blockchain Survey 2018. PWC, 2018.
- [13] Deep Shift, Technology Tipping Points and Societal Impact. World Economic Forum, September 2015.
- [14] Hype Cycle for Emerging Technologies, 2018. Gartner, August 2018.
- [15] J. Lovelock, M. Reynolds, B. Granetto, R. Kandaswamy. Forecast: Blockchain Business Value, Worldwide, 2017-2030. Gartner, March 2017.
- [16] S. Ganesh, T. Olsen, J. Kroeker, Venkatraman P. Rebooting a Digital Solution to Trade Finance. Bain & Company and HSBC, 2018.
- [17] TradeLens. <https://www.tradelens.com/> [Online; accessed 11th-Nov-2018].
- [18] K. Rooney. Walmart is going to use blockchain to stop the spread of E. coli and other diseases in lettuce. CNBC, September 2018. <https://www.cnbc.com/2018/09/24/walmart-is-going-to-use-blockchain-to-stop-the-spread-of-e-coli-in-lettuce.html> . [Online; accessed 11th-Nov-2018].
- [19] Chevron, GE Form Technology Alliance. Chevron press release, February 2014. <https://www.chevron.com/stories/chevron-ge-form-technology-alliance> . [Online; accessed 11th-Nov-2018].
- [20] Total to Develop Artificial Intelligence Solutions with Google Cloud. Total press release, April 2018. <https://www.total.com/en/media/news/press-releases/total-develop-artificial-intelligence-solutions-google-cloud> . [Online; accessed 11th-Nov-2018].
- [21] Woodside, Australia's Largest Independent Oil and Gas Company, Uses IBM Watson to Enhance Decision Making and Increase Efficiencies. IBM press release, May 2015. <https://www-03.ibm.com/press/us/en/pressrelease/47013.wss> . [Online; accessed 11th-Nov-2018].
- [22] O. Evensen, S. Lin, A. Marshall. Extracting digital rewards, Digital Reinvention in petroleum. IBM Institute for Business Value, January 2018.
- [23] P. Thakkar, S. Nathan N, B. Viswanathan. Performance Benchmarking and Optimizing Hyperledger Fabric Blockchain Platform. ArXiv e-Prints, May 2018.
- [24] F. Chesini, A. Pradhan, C. Healey. Toolkit: Blockchain consortium initiatives. Gartner, March 2018.
- [25] R3. <https://www.r3.com/> . [Online; accessed 11th-Nov-2018].
- [26] MOBI: Mobile open blockchain initiative. <https://www.dlt.mobi/> . [Online; accessed 11th-Nov-2018].
- [27] Alastria. <https://alastria.io/> . [Online; accessed 11th-Nov-2018].
- [28] L. Pawczuk, R. Massey, D. Schatsky. Breaking blockchain open, Deloitte's 2018 global blockchain survey. Deloitte, 2018.
- [29] D. Tapscott. 2018 Blockchain regulation roundtable. Blockchain Research Institute, August 2018.
- [30] Hype Cycle for Blockchain Business, 2018. Gartner, July 2018.

- [31] S. Anand. A Pioneer in Real Estate Blockchain Emerges in Europe. Wall Street Journal, March 2018. <https://www.wsj.com/articles/a-pioneer-in-real-estate-blockchain-emerges-in-europe-1520337601> . [Online; accessed 11th-Nov-2018].
- [32] L. Niazi. Blockchain can help transform supply chain networks in the chemicals and petroleum industry. IBM Cross Business Unit, April 2018.
- [33] A. Belt, S. Kok. A Reality Check for Blockchain in Commodity Trading. BCG, August 2018. <https://www.bcg.com/en-es/publications/2018/reality-check-blockchain-commodity-trading.aspx> . [Online; accessed 11th-Nov-2018].
- [34] G. Meyer, N. Hume. Trafigura tests blockchain for settling US oil market deals. Financial Times, March 2017. <https://www.ft.com/content/e088e0b6-131c-11e7-b0c1-37e417ee6c76> . [Online; accessed 11th-Nov-2018].
- [35] S. Elliot. Blockchain service provider BTL readies energy trade platform for commercial use. S&P Global, March 2018. <https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/032718-blockchain-service-provider-btl-readies-energy-trade-platform-for-commercial-use> . [Online; accessed 11th-Nov-2018].
- [36] M. Vinn, L. Blewitt. Oil Buyers Ditch Paper for Blockchain to Track Tanker Sales. Bloomberg, February 2018. <https://www.bloomberg.com/news/articles/2018-02-26/big-oil-buyers-ditch-paper-for-blockchain-to-track-tanker-sales> . [Online; accessed 11th-Nov-2018].

Additional Bibliography

- M. Schwartz. The potential of blockchain. TED@BCG. https://www.ted.com/talks/mike_schwartz_the_potential_of_blockchain . [Online; accessed 11th-Nov-2018].
- M. Koeppen, D. Shrier, M. Bazilian. Is Blockchain's Future in Oil and Gas Transformative or Transient? Deloitte, July 2017.
- Y. Sung Kim. The Blockchain Benefit, Driving freight bill audit and pay savings in oil and gas. Accenture, Consulting, 2018.
- Oil and Gas trends 2018-19, Strategy shaped by volatility. PWC, 2018.
- E. Muzzy. O&G blockchain series of posts. Ondiflo, July-November 2018. [Online; accessed 11th-Nov-2018].
- C. Catalini. How Blockchain and Cryptocurrencies Will Impact the Digital Economy. MIT Digital, June 2017. <https://www.youtube.com/watch?v=ToZG0lj7UcQ> . [Online; accessed 11th-Nov-2018].
- B. Warburg. How the blockchain will radically change the economy. TEDSummit, June 2016. https://www.ted.com/talks/bettina_warburg_how_the_blockchain_will_radically_transform_the_economy?language=en#t-29451 . [Online; accessed 11th-Nov-2018].
- E. Piscini, M. Singhal, D. Andrzejewski, S. Cremins. Taking blockchain live. Deloitte, 2017.
- How smart contracts automate digital business. PWC, March 2016. <http://usblogs.pwc.com/emerging-technology/how-smart-contracts-automate-digital-business/> . [Online; accessed 11th-Nov-2018].
- P. Evans, L. Aré, P. Forth, N. Harlé, M. Portincaso. Thinking outside the blocks. BCG Perspectives, December 2016. ■