TABLE OF CONTENTS

Executive Summary 3
Introduction 4
  History 7
  What Blockchain Is 8
Blockchain vs. Central Database 10
  Advantages of Each Technology 12
Blockchain for Value Chain Management 13
  Value Drivers 13
  Combining Blockchain with IoT and AI for Added Value 14
  Barriers to Adoption 15
  The Role of Standardization 17
Examples of Blockchain Implementations 19
  New Product Development 19
  Material Sourcing 20
  Supply Chain Traceability 22
  Logistics 24
  Shopping Experience 25
  Marketing 27
  Service and Maintenance 27
  Predictive Analytics 29
Keys to Successful Implementation 30
Conclusion 32

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EXECUTIVE SUMMARY

Even after the burst of the Bitcoin bubble at the end of 2017, interest in blockchain, Bitcoin’s underlying technology, remained strong. Is it all hype or does blockchain truly provide a superior alternative to other existing solutions? This paper aims to address this question within the context of value chain management, and identify the types of applications where the technology can potentially offer a real advantage over traditional solutions.

To do that, we first compare blockchain to a central database, which is the alternative solution in most situations. The comparison highlights several compelling advantages of blockchain technology, as well as a number of limitations. Next, we identify the main value drivers and barriers to adoption of blockchain technology for value chain applications. We use those drivers and barriers as the basis for evaluating several blockchain implementations, including programs and solutions related to new product development, material sourcing, supply chain traceability, logistics, sales and marketing, service and maintenance, and predictive analytics. We also explore the added value of combining blockchain with other emerging technologies, including the Internet of Things and artificial intelligence, as well as the role of standardization in helping to bring blockchain to the mainstream.

Our analysis indicates that under the right conditions, blockchain has the potential to improve visibility and traceability, facilitate collaboration, improve process efficiencies, and provide a secure audit trail. The magnitude of some of these benefits can potentially be enhanced by combining blockchain with IoT and AI. To reach its full potential, the technology needs to be further developed, concerns surrounding security and interoperability need to be addressed, additional standards should be developed, and people should become more knowledgeable about the technology and the ways to best utilize it.
INTRODUCTION

Interest in blockchain, the distributed ledger technology that holds the promise of transparency, integrity, and security, remains strong. Worldwide spending on blockchain solutions reached $2.7 billion in 2019, an increase of 80% over 2018 (see Exhibit 1). Even after the slowdown in spending due to the global COVID-19 pandemic, market researcher IDC forecasts worldwide spending of nearly $4.3 billion in 2020 and expects spending to reach $14.4 billion by 2023.¹ Is it all hype, or will blockchain follow the tracks of Bitcoin, its first major application?

EXHIBIT 1: WORLDWIDE SPENDING ON BLOCKCHAIN SOLUTIONS, 2017-2023

Source: IDC.com and Statista.com

Bitcoin, which in its early days was worth a fraction of a U.S. dollar, saw over time a significant increase in its valuation and trading volumes (see Exhibit 2). Its meteoric rise reached its peak in 2017, when the value of Bitcoin rose from about $1,000 at the beginning of the year to a record high of more than $19,000 in December of that year.

EXHIBIT 2

BITCOIN PRICE AND TRADING VOLUME, 2010–2020

Source: Cointelegraph

Even after the bursting of the Bitcoin bubble, enthusiasm for blockchain remained strong. The technology has been hailed as world-changing, the biggest breakthrough since the internet. Don Tapscott, co-founder and executive chairman of the Blockchain Research Institute, described blockchain as “the technology likely to have the greatest impact over the next few decades.”4 And in late 2017, IDC predicted that by 2020, “25% of top global transaction banks, nearly 30% of manufacturers and retailers, and 20% of healthcare organizations will use blockchain networks in production.”5 Such enthusiasm has been one of the key drivers behind the surge in related investments (see Exhibit 3).

EXHIBIT 3
EQUITY FUNDING AND INVESTMENT IN BLOCKCHAIN STARTUP COMPANIES WORLDWIDE, 2012–2018

<table>
<thead>
<tr>
<th>Year</th>
<th>Investment (Millions USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>$1</td>
</tr>
<tr>
<td>2013</td>
<td>$93</td>
</tr>
<tr>
<td>2014</td>
<td>$357</td>
</tr>
<tr>
<td>2015</td>
<td>$524</td>
</tr>
<tr>
<td>2016</td>
<td>$550</td>
</tr>
<tr>
<td>2017</td>
<td>$1,053</td>
</tr>
<tr>
<td>2018</td>
<td>$4,152</td>
</tr>
</tbody>
</table>

Source: CB Insights and Statista.com

While blockchain technology no doubt has some compelling advantages over existing solutions, it also has its limitations. For instance, blockchains may be inefficient, may require a lot of data storage space, may consume large amounts of electricity, and may still be vulnerable to security risks. Our goal in this paper is to provide an objective analysis of blockchain in the context of value chain management and to examine the types of applications where the technology may have a real advantage over traditional solutions. We also discuss the added value of combining blockchain with other emerging technologies, in particular the Internet of Things and artificial intelligence.

The structure of the paper is as follows: We start with a brief history of blockchain and Bitcoin, followed by a quick blockchain primer. In the second section, we

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compare blockchain to a central database and discuss the characteristics and advantages of each of these technologies. We then highlight the main value drivers for adopting blockchain solutions, as well as the added value of combining blockchain with IoT and AI. We also discuss some of the key barriers to adoption, and the role of standardization in helping to bring blockchain to the mainstream. Next, we provide examples of blockchain implementations throughout the value chain and evaluate them in light of the aforementioned value drivers and barriers to adoption. Finally, we provide recommendations for decision makers who are considering adopting blockchain solutions.

HISTORY

BITCOIN - THE FIRST BLOCKCHAIN APPLICATION

The first blockchain implementation took place in 2009, when Bitcoin, which had been invented the prior year, was released as open source software. The Bitcoin protocol is a peer-to-peer (P2P) payment system. Its uniqueness compared to other digital currencies that existed at the time was that it solved the double-spending problem, where the same digital token could be spent more than once.

Bitcoin was introduced shortly after the 2008 financial crisis, which highlighted the shortcomings of financial institutions and eroded people’s confidence in them. The time was ripe for people to become interested in P2P currency, which was not controlled by government or financial regulators and did not require any central authority to manage financial transactions.

At a high level, the way Bitcoin works is that rather than deposit money in a bank account, people create an account, or a Bitcoin Wallet, for storing their Bitcoins. Information about the Bitcoin balance of each account is recorded in the blockchain. Whenever Bitcoins are exchanged between two users, information about the transaction, and the updated account balances, is also recorded in the blockchain.

While the early adopters of Bitcoin were essentially hackers, over time it started attracting interest from mainstream users. The number of daily Bitcoin transactions increased from a few dozen in 2009 to an average of close to 300,000 in the first 6 months of 2020. Thousands of other cryptocurrencies were introduced to the market following Bitcoin.

As Bitcoin and other cryptocurrencies began moving into the mainstream, companies started accepting them as a legitimate form of payment. An HSB survey released in early 2020 found that 36% of U.S. small and midsize businesses accepted cryptocurrency. Several larger retailers, including Starbucks, Nordstrom, and Whole Foods, also began accepting Bitcoin and other cryptocurrencies.

EVOLUTION OF BLOCKCHAIN TECHNOLOGY

In the first few years following the introduction of Bitcoin, blockchain technology was used mostly for cryptocurrency applications.

In 2013, Vitalik Buterin, a programmer involved in Bitcoin, published a white paper in which he proposed a new type of blockchain platform to leverage the technology’s capabilities. He envisioned a platform that would go beyond the financial use cases allowed by Bitcoin and could record other assets such as loans or contracts. The Ethereum platform, launched in 2015, implemented this vision. It enables the development of

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decentralized applications and smart contracts, as well as keeping track of the current state of these contracts. Realizing the potential of blockchain beyond Bitcoin, companies began to explore ways to use blockchain in a variety of applications, and investors followed suit. While current blockchain solutions often focus on efficiency or reengineering of existing processes, Gartner expects enterprise-ready, blockchain-complete solutions to emerge by 2023, offering a path to completely new business models. Those solutions will utilize all five elements of blockchain: distribution, encryption, immutability, tokenization, and decentralization.

WHAT BLOCKCHAIN IS

Blockchain is an immutable, distributed digital ledger that can be used to record transactions and track assets. The information is recorded on digital blocks, which are linked and secured using cryptography. All nodes in a blockchain network keep a copy of the same distributed ledger, meaning that each participant can access the complete database.

Key characteristics of a blockchain network include:

- **Immutability:** A blockchain is a permanent record. No participant can modify the information recorded to a block after it has been validated and added to the ledger.

- **Consensus:** Before a new block is added to the blockchain, a consensus algorithm is used to validate the block and ensure that protocol rules are being followed.

- **Transparency:** In Bitcoin and other similar blockchains, all transactions are public. This brings trust into the system. Other blockchains may use mechanisms that provide a way to verify transactions without revealing sensitive information. (A more detailed discussion of privacy management is included later in this paper.)

- **Peer-to-Peer Network:** This setup eliminates the need for intermediaries and central institutions.

BLOCKCHAIN CONSENSUS MECHANISMS

Since blockchain eliminated the role of a central authority that manages and validates transactions, a different mechanism had to be established to validate the legitimacy of new transactions before their details are recorded to the blockchain, and to ensure that all nodes store the same blockchain. Below is a brief description of a few of the most popular consensus mechanisms in use today.

- **Proof of Work:** This is the original Bitcoin/blockchain consensus mechanism, which has been adopted by multiple cryptocurrencies. Under this consensus mechanism, miners try to solve complex mathematical puzzles. The first miner to solve the puzzle gets to create the next block and is compensated for this effort. Solving the puzzles requires a significant amount of computational power (and electricity), and the time to confirm each new transaction is relatively long. Due to these constraints, PoW is unlikely to be selected in the future for high-volume blockchain applications.

- **Proof of Stake:** Unlike in PoW, where many miners compete to be the one to validate each new block, in PoS an algorithm selects the validators of new blocks based on their stake. The way the process works is as follows: First, users must ‘stake,’ or lock up, some of their tokens to become validators who are eligible to validate new blocks. A randomized process then determines which of the validators gets to produce the next block, with the validators with the highest stake having the highest chance of being selected. Validators are usually compensated by receiving either a fixed amount of coins or a portion of all the transaction fees related to the transactions in the block they created. PoS is much more energy-efficient than PoW and offers greater revenue-

generating capabilities for a broader set of users. Validators in a PoS system also have a much bigger incentive to properly maintain the network, due to their high stake in the blockchain. Ethereum plans to shift to a PoS network sometime in 2020.

• **Delegated Proof of Stake:** DPoS is designed as an implementation of technology-based democracy. Under this system, users vote to elect witnesses, who are in turn responsible for creating and validating blocks. Only the witnesses who have collected the most votes earn the right to validate transactions and collect the associated fees. Elections take place frequently, which provides an incentive for witnesses to avoid malicious behavior, such as trying to censor transactions or double spend, as such behavior will likely cause them to lose their position as witnesses in the next round of voting.\(^\text{13}\)

Energy consumption associated with PoW is extremely high. One estimate puts Bitcoin’s minimum annual electricity consumption at about 50 terawatt-hours per year,\(^\text{14}\) comparable to the annual energy consumption of countries such as Switzerland or the Czech Republic. In contrast, newer consensus mechanisms are much more energy-efficient. Ethereum, for instance, plans to cut its energy consumption by 99% by moving from PoW to a PoS consensus protocol.\(^\text{15}\)

**TYPES OF BLOCKCHAINS**

Blockchains can be classified as public, private, or hybrid, based on who is allowed to participate in the network:

• **Public/Permissionless:** This type of blockchain allows anyone to join and participate in the network, which is fully decentralized. While the openness of public networks is an advantage for some applications, the same attribute, combined with the sheer size of public networks, may make them impractical for other applications. Bitcoin is an example of a public network.

• **Private/Permissioned:** This type of blockchain is controlled by a single central entity that sets read/write privileges for a limited set of participants. These networks are typically smaller and more efficient than public ones, but they may not offer some of the benefits of an open, public network. Use cases for private networks include, for instance, tracking goods along the supply chain, synchronizing data across multiple stakeholders, and facilitating international payments.

• **Hybrid/Consortium:** These blockchains lie in between public and private blockchains. Consortium blockchains are controlled by a group of companies rather than a single one, a setting that is likely to reduce development costs and ensure wider adoption but may make it harder to reach agreements while establishing the blockchain. Other forms of hybrid blockchains may include, for instance, a private part, used by a few big partners for restricted services, combined with a public part for managing settlements among a large number of entities.\(^\text{16}\)

Most enterprises that have tested or implemented blockchain technology to date have chosen to adopt a private blockchain, mainly to ensure data privacy, obtain greater control over network participants, and implement more efficient consensus protocols. Such an approach has also made it easier to test this new technology.

Some commentators argue that the centralized nature of private blockchain networks may be detrimental to wide adoption and future growth. The infrastructure of some private blockchains may also fail to address the

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long-term scaling requirements of global businesses.\textsuperscript{17} Moreover, for most enterprise blockchain projects, transaction costs are expected to be higher in private blockchains compared with public blockchains.\textsuperscript{18}

For these and other reasons, most experts predict a future shift from private to public blockchains. But for that to happen, public-blockchain-related concerns surrounding such issues as user anonymity, infrastructure reliability, security, and data privacy will first need to be addressed. While some companies are already developing solutions to address these and other concerns, until such solutions reach maturity, most enterprises would likely prefer to continue using private or hybrid blockchains.

**MANAGING PRIVACY ON THE BLOCKCHAIN**

While transparency builds trust into the system, companies and individuals alike will often be reluctant to record information onto a blockchain if that information could then be accessible to all, without any restrictions. A private, permissioned network inherently provides more privacy, due to the limitations on who can participate in the network and in what capacity. Still, this level of protection may not be sufficient for most businesses.

Recent technological innovations address this issue and provide a way for participants in either private or public blockchain networks to better protect their sensitive information. For instance, zero-knowledge proofs (ZKP) can be used to verify that a given statement is true without revealing any of the underlying data. ZKPs provide a way for companies to keep their sensitive information behind their firewall, while still maintaining the functionality of the blockchain network. One example of such a solution is Nightfall, released by EY into the public domain in May 2019. Nightfall is a ZKP protocol that allows businesses to transact privately on the public Ethereum blockchain.\textsuperscript{19} Another example is the cryptocurrency Zcash, which uses ZKP to shield information regarding sender and receiver addresses and transaction amounts. The public can verify only that the transaction occurred and that the fees were paid. Another way to control access to data is through the use of smart contracts.\textsuperscript{20} Additional solutions are in development.

**BLOCKCHAIN VS. CENTRAL DATABASE**

Whenever the adoption of a new technology is considered, we must think carefully about its advantages and disadvantages compared with the second-best alternative. In the case of blockchain, the leading alternative in most cases is a central database.

A central database stores all information in a single location, which users can access by connecting to a central server. The database is managed by an administrator, who can create, update, and delete records, and who also creates user accounts and sets privileges for each user.

Table 1 compares the characteristics of central databases to those of public and private blockchains. We use a color code to illustrate which aspects of a private blockchain are similar to a public one (yellow), and which are closer in nature to a central database (blue). Green identifies those characteristics that lie somewhere in between public blockchains and central databases.

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\textsuperscript{18} “Total Cost of Ownership for Blockchain Solutions.” \textit{EY}, April 2019.


<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>CHARACTERISTICS OF PUBLIC / PRIVATE BLOCKCHAIN VS. CENTRALIZED DATABASE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CENTRAL DATABASE</strong></td>
<td><strong>BLOCKCHAIN (PUBLIC)</strong></td>
</tr>
<tr>
<td><strong>DATA STORAGE</strong></td>
<td></td>
</tr>
<tr>
<td>Centralized: Data stored in a central location</td>
<td>Distributed: All nodes store a copy of the blockchain</td>
</tr>
<tr>
<td><strong>CONTROL</strong></td>
<td></td>
</tr>
<tr>
<td>Centralized: A single entity owns and controls the database</td>
<td>Decentralized: Network is governed in a decentralized fashion</td>
</tr>
<tr>
<td><strong>DATA VERIFICATION</strong></td>
<td></td>
</tr>
<tr>
<td>Only a few people are granted writing privileges</td>
<td>With consensus mechanisms such as PoW and PoS, anyone can be a miner/validator, as long as they have sufficient resources</td>
</tr>
<tr>
<td>There may be designated data verifiers</td>
<td></td>
</tr>
<tr>
<td><strong>ACCESS</strong></td>
<td></td>
</tr>
<tr>
<td>Permissioned: Admin creates user accounts and sets read/write privileges</td>
<td>Permissionless: Anyone can join and use the network. All peers are equal in how they access the blockchain</td>
</tr>
<tr>
<td><strong>USER IDENTITY</strong></td>
<td></td>
</tr>
<tr>
<td>Known</td>
<td>Unknown (anonymous users)</td>
</tr>
<tr>
<td><strong>HOW TRUST IS ACHIEVED</strong></td>
<td></td>
</tr>
<tr>
<td>Through centralization, and security features managed by admin</td>
<td>Through transparency and immutability of records</td>
</tr>
<tr>
<td><strong>SIZE OF DATABASE</strong></td>
<td></td>
</tr>
<tr>
<td>Admin can delete obsolete records or move records to a backup database</td>
<td>Permanent records</td>
</tr>
<tr>
<td>Database size can be managed to optimize performance</td>
<td>Blockchain continuously growing</td>
</tr>
<tr>
<td><strong>SPEED</strong></td>
<td></td>
</tr>
<tr>
<td>Fast: Visa claims about 1,700 transactions per second</td>
<td>Slow: Bitcoin can process about 7 transactions per second</td>
</tr>
</tbody>
</table>
ADVANTAGES OF EACH TECHNOLOGY

As can be seen from Table 1, blockchains and central databases differ in many of their characteristics. We highlight below the main advantages of each technology.21

ADVANTAGES OF BLOCKCHAINS

- **Work well in a trustless environment:** There is no need for participants to know or trust each other, or to trust a central admin to properly manage the data and set user permissions. Public blockchains in particular provide a P2P environment where anyone can join the network and view the data and all participants have equal privileges.

- **Fault-tolerant:** If one or more nodes are down, there will be other nodes available that will run the blockchain.

- **Immutability:** Altering the stored data requires changing the data on all nodes. This is extremely complicated and expensive, so there is no incentive to try.

- **Transparency:** A blockchain can provide a publicly visible proof that a transaction occurred. This creates trust and makes the blockchain censorship-resistant.

- **No intermediaries required:** Transactions within the network do not require intermediary institutions such as banks for verification.

ADVANTAGES OF CENTRALIZED DATABASES

- **Customizability:** A database can be customized by the admin depending on business requirements. Applications can be developed to give users a more consistent and user-friendly interface.

- **Speed:** A database system can handle large volumes of data and process a large number of transactions per second. Unlike P2P networks, large centralized systems can optimize their data delivery schemes to ensure fast data transfer. Moreover, the sheer size of blockchains, which grow continuously, can slow them down and make it harder for new participants to join the network. Blockchains are also limited by the time it takes to validate new blocks.

- **Scalability:** Unlike blockchains, where a fixed block size and the time required to validate a new block limit their throughput, scalability is not an issue in a traditional database.

- **Stability:** When needed, the admin can restore a database from a backup.

Due to the limitations of blockchains, they may never fully replace all traditional databases. At the same time, there are a variety of applications where blockchain may provide a superior solution to other existing technologies. One such promising area of adoption is value chain management.

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Nowadays, a typical value chain may comprise dozens or hundreds of entities, including several tiers of suppliers, manufacturing facilities, distribution centers, retail stores, and more. It is often a challenge to successfully coordinate activities across this large network of organizations and to gain sufficient visibility into the extended supply chain. Yet it is critical, since limited visibility can contribute to production delays, higher operating costs, poor customer relations, higher exposure to risk, and more.

VALUE DRIVERS

While improved visibility and information sharing can often be achieved through the use of a central database, there are several settings under which a blockchain solution may be superior. In particular, we believe that blockchain technology is better suited to foster collaboration between competing companies and within large networks. The immutability of data stored on the blockchain may also make this technology a more secure solution when data accuracy and authenticity are critical. Smart contracts can further foster trust and eliminate inefficiencies. We next discuss each of these value drivers in more detail.

COLLABORATION BETWEEN COMPETING COMPANIES

Though not intuitive at first sight, under some circumstances competing companies may benefit from a certain level of information sharing. In some instances, some form of collaboration may be required to comply with government regulations. Other times, information sharing may benefit all involved, for instance by supporting accelerated product development or improved operational efficiencies.

But given the limited trust that is likely to exist between competing organizations, they may be reluctant to share information via a central database that is controlled and managed by one of them. Even if the database is managed by an independent third party, companies may hesitate to lose control over the information stored in that database. A blockchain solution, based on a peer-to-peer network and with mechanisms to protect sensitive information, may be more practical in such situations.

INFORMATION SHARING WITHIN LARGE NETWORKS

As mentioned earlier, a typical value chain often includes several tiers of suppliers. These suppliers may be spread over large geographical areas and may not have any direct business relationship with the brand companies that use their goods and services. Yet the same brand companies are likely to be held accountable for safety and human rights violations at these manufacturing facilities, for counterfeit goods or materials that find their way into the extended supply chain, and for other serious issues that are beyond their direct control.

Using a single blockchain, accessible to all, to increase visibility throughout the value chain may be a more feasible solution in this case compared to a central database, for a number of reasons. First, with a large number of companies that do not have any direct business relationship, trust is likely to be very limited. And as discussed earlier, blockchain is better suited for trustless environments. In addition, a centralized system requires ensuring information connectivity among all participants, which can be a complex task in large networks. It may also be too risky to rely on a single database for storing such a large amount of information, as it may expose the database to cybersecurity threats, to downtime due to hardware failures, and more. And having a large number of users trying to access the database at the same time may create bottlenecks and limit accessibility.

SECURE STORAGE LOCATION FOR CRITICAL INFORMATION

The immutability of data recorded to the blockchain, and the resilience of blockchains compared to central databases, may make them a preferable storage location for critical information, where data accuracy and permanency are paramount, such as information related to intellectual property (IP) rights. Similarly, the technology may offer a superior solution for authenticating such products as medications and luxury goods, or for establishing the provenance of products such as precious stones and metals, which tend to have murky supply chains. When conducting audits, blockchain may be used as a source of verification for reported transactions.

IMPROVED TRUST AND EFFICIENCY THROUGH SMART CONTRACTS

A smart contract is a computer protocol that can be used to establish and manage contracts between different parties. A smart contract will automatically and immediately self-execute when predetermined conditions are met. While regular, legal contracts are still needed to determine the high-level relationships between the parties, smart contracts can be used to manage the operational, day-to-day activities and to streamline the movement of goods and services throughout the value chain.

Since the details of smart contracts are recorded to the blockchain, they cannot be modified, thus giving all parties the confidence that they will be executed properly. A smart contract also ensures that the contract will be executed immediately, without delays and without requiring any intermediaries or human intervention. This in turn fosters trust, in addition to providing accuracy and eliminating the inefficiencies and delays associated with manual verification of the terms of the contract.

One must keep in mind, though, that smart contracts may also pose some challenges. For instance, due to the code’s permanence on the blockchain, it is essential to verify ahead of time its correctness and completeness. It is also critical to ensure that the contract is executed based on correct information. Furthermore, mechanisms should be put in place to manage situations where one of the parties challenges the way the contract has been executed or when there is a need to reverse a transaction.  

COMBINING BLOCKCHAIN WITH IOT AND AI FOR ADDING VALUE

IoT refers to all the physical devices that now have the ability to collect and share data through the internet without requiring any human intervention. The use of IoT is widespread, with the total number of connected IoT devices expected to reach 41.6 billion by 2025.

By coupling blockchain with IoT, the value of both technologies can be enhanced. As discussed earlier, the immutability and decentralization offered by blockchain can foster collaboration and information sharing across the extended value chain. IoT can augment the value of blockchain implementations by providing the means to gather some of this information in a more efficient way. Examples of information that can be collected and/or released through IoT devices to improve value chain operations include: identification of parts and finished goods throughout the value chain; location of in-transit goods; temperature and other environmental conditions of goods during transportation and in storage; and the health of equipment or in-home appliances, for improved maintenance operations.

At the same time, blockchain can provide an added layer of security for IoT networks, which tend to be vulnerable to hacking. And blockchain’s distributed nature means that compromised devices can be

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locked out or shut down without compromising the performance of the network. Moreover, blockchain can streamline the sharing of IoT data among relevant stakeholders, without having to rely on any intermediaries. And companies can promptly act on this data through the use of smart contracts.

Similarly, pairing blockchain with AI can also be beneficial. AI refers to the theory and practice of building smart machines capable of performing tasks that would normally require human intelligence. AI solutions can help companies make the most out of the trove of data stored on the blockchain by providing the means to quickly analyze and interpret it.

At the same time, blockchain can enhance AI applications by providing a highly secure place to store the data that is to be processed by AI systems. Blockchain may also provide network participants faster access to the data and reduce their reliance on central storage for processing. Another advantage of blockchain is that it provides AI solutions with access to shared pools of computing power across the network. Finally, recording the decisions made by AI into a blockchain could make them easier to audit.

BARRIERS TO ADOPTION

While blockchain solutions are becoming more prevalent and a growing number of decision makers are open to exploring this technology and its potential value, key issues still exist that may hinder blockchain implementations, at least in the short term.

According to a 2018 PwC survey of 600 executives, the top barriers to blockchain adoption are regulatory uncertainty (48% of responders ranked it as one of their top three barriers), lack of trust among users (45%), the ability to bring the network together (44%), separate blockchains not working together (41%), IP concerns (30%), and inability to scale (29%).

A 2019 Deloitte survey of 1,386 senior executives in a dozen countries also identified a wide array of barriers to increasing adoption and scale in blockchain technology, many of them similar to those identified by PwC. They include regulatory issues (30%), implementation challenges (30%), potential security threats (29%), lack of in-house capabilities (28%), uncertain return on investment (28%), and concerns over sensitivity of competitive information (25%).

The next few pages include a high-level discussion of several of these key issues.

REGULATORY CONCERNS

Due to the uncertainty around regulatory requirements, regulations are a top concern for those interested in the development or deployment of blockchain solutions. Compounding the issue are the different approaches to blockchain taken by jurisdictions across the world.

For instance, when considering cryptocurrencies, which is what most regulators have focused their attention on so far, the U.S. has taken a “regulation first, business later” approach, restricting the potential mainstream applications of blockchain programs utilizing cryptocurrency. In early 2020, the U.S. Treasury secretary announced plans to introduce even stricter regulations around digital currencies, driven by growing concerns over their use by nefarious entities such as foreign adversaries and terrorist groups. In contrast, East Asian countries have, at least initially, allowed blockchain companies to operate without restrictions. But there, too, the regulatory landscape has evolved. One example: the restrictions on Initial Coin Offerings (ICOs) imposed by South Korea and

China to prevent investors from being defrauded by scammers.\textsuperscript{30}

Regulations related to privacy control are also likely to have an impact on blockchain applications. The General Data Protection Regulation gives every citizen in the European Union the “right to be forgotten.”\textsuperscript{31} Similarly, in the U.S., the Health Insurance Portability and Accountability Act (HIPAA) of 1996 provides data privacy and security provisions for safeguarding medical information.\textsuperscript{32} And the California Consumer Privacy Act, which went into effect on Jan. 1, 2020, requires businesses to provide covered consumers with the ability to access and/or delete personal information collected from or about them.\textsuperscript{33} These and other regulations are likely to clash with the immutability of data stored on blockchain platforms and with the decentralized structure of blockchains.

**SECURITY AND DATA PROTECTION**

Naturally, businesses are concerned about storing sensitive information on a blockchain, if the data could then be viewed by others. This is especially true in public blockchains but is also a source of concern in private networks. It is expected, though, that these concerns will diminish over time, as more solutions are developed to allow network participants to guard their sensitive information while still maintaining the functionality of the network.

Another source of concern: security risks that blockchains are still exposed to, despite the inherent security provided by a distributed ledger, and even though cryptographic proofs make them nearly impossible to hack. Examples of security risks include:\textsuperscript{34}

- **51% Attack:** When a malicious entity controls more than 50% of the network’s mining hash rate (in PoW) or cryptocurrency (in PoS), this allows them to prevent new blocks from being created and to reverse transactions.

- **Social Engineering:** A malicious entity can use phishing to try to trick users into sending over their credentials, which can then be used to access their account.

- **Software Flaws:** While most big-name blockchains are quite secure, the apps built on top of them are still susceptible to bugs, which may lead to security issues.

**LACK OF TRUST AND UNDERSTANDING**

Many executives have only a vague understanding of blockchain and the ways it can impact their business. Many only connect it with Bitcoin and other cryptocurrencies. This, combined with the early stage blockchain technology is still in, results in a lack of confidence in the technology. Some of the other concerns mentioned in this paper may also have a negative impact on the current level of trust in blockchain. Furthermore, limited understanding of the technology may hinder executives’ ability to identify the most promising use cases, which are more likely to have successful deployments and result in a positive return on investment.

**IMPLEMENTATION CHALLENGES**

Once a decision has been made to adopt blockchain technology, moving forward with this decision may prove daunting. One challenge may be internal resistance. With legacy systems that work fairly well and that everyone is familiar with, people may be reluctant to try out new systems unless there is a clear impetus for change.
In addition, as blockchain technology is still in its early stages, many organizations lack sufficient internal knowledge and expertise to determine how best to take advantage of it. Exacerbating the problem is a shortage in people trained and educated to work with blockchain technology, which is likely to make any attempt to recruit the right talent challenging and costly.

Furthermore, being an emerging technology, blockchain doesn’t yet have a clear roadmap for implementation. While many consultants and other organizations provide services to help guide companies through the implementation process, finding the right partner to help identify the best roadmap for the company’s specific needs may not be easy.

### SCALABILITY AND INTEROPERABILITY

Blockchain’s greatest return on investment comes from using it to connect multiple entities, with the level of benefits likely to increase as more companies join the network.

But growing the network may prove to be extremely challenging. Some companies may be reluctant to join due to concerns regarding the technology itself or uncertain expected return on investment. Others may hesitate to trust and join a private network that was created, and is controlled, by a business competitor. Growing the network is likely to be especially daunting in those situations when it must include the vast majority of companies within a specific industry or supply chain in order to realize its intended goals.

Another key obstacle to mainstream adoption is that while blockchain systems proliferate, they remain isolated and do not communicate with each other. Without the ability of blockchain networks to exchange data seamlessly, the usability of the technology may be limited. Experts often compare the current situation to the pre-internet days, when thousands of siloed intranet networks were in use. People could use them to transfer information, messages, or emails within their own intranet network, but were unable to connect to other networks until infrastructure like TCP/IP and web browsers were created. Several technological innovations aim to address the issue of interoperability and allow information sharing across blockchain systems or networks.

### THE ROLE OF STANDARDIZATION

Standards can help address several of the challenges mentioned earlier and foster wider adoption of blockchain technology. By establishing consistent terminology, standards can increase the understanding of the technology. Standards can also play a role in ensuring the interoperability of blockchain networks. Greater trust could be achieved through standards that address security, privacy, and governance concerns, as well as through standards that ensure strong encryption mechanisms.

Multiple organizations, including international and globally recognized standard-setting bodies, as well as platform- and industry-specific alliances, have been working on developing blockchain and distributed ledger technology (DLT) standards. So far, however, only a few of them have been published. More standards are expected to be published either later this year or in the coming years. Following is a brief overview of some of the standard-development initiatives that are currently underway:

- One set of initiatives focuses on developing generic framework standards to provide principles and guidelines. Organizations developing such standards include the IEEE Standards Association, a standard-
setting body within the Institute of Electrical and Electronics Engineers (IEEE); ISO/TC 307, the committee of the International Organization for Standardization (ISO) set up to work on standards around blockchain and DLT; and the International Telecommunication Union’s Telecommunication Standardization Sector. These and other organizations are also working on developing enabling technology standards, which focus on the enabling mechanisms and key building blocks of DLT technologies. Some of these initiatives are driven by platform-specific technology implementations, such as Hyperledger, Corda, and Ethereum. One such example is the Enterprise Ethereum Alliance, which develops open specifications and standards for enterprise blockchain networks, with a focus on those aligned with the broader Ethereum ecosystem.

Other organizations, including a number of blockchain consortia, have been focusing on building customized industry solutions that are based on the generic framework standards. Examples include the Blockchain in Transport Alliance and the Mobility Open Blockchain Initiative (MOBI). IEEE has also been working on industry-specific initiatives, for instance through its Pharma Supply Blockchain Forum.

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44  “IEEE Driving Collaboration on Advancing Blockchain Adoption Within the Pharmaceutical Industry.” IEEE.org, 2017.
EXAMPLES OF BLOCKCHAIN IMPLEMENTATIONS

Over the last few years, companies have been investigating and piloting the use of blockchain technology to improve a variety of processes throughout the value chain. In the following pages we discuss several such programs and solutions (summarized in Figure 1) and evaluate them in light of the value drivers and barriers to adoption discussed above.

FIGURE 1: BLOCKCHAIN PROGRAMS THROUGHOUT THE VALUE CHAIN

NEW PRODUCT DEVELOPMENT
- Research and development
- IP rights protection

MATERIAL SOURCING
- Responsible sourcing
- B2B transactions

SUPPLY CHAIN TRACEABILITY
- Track and trace
- Product recalls
- Cold chain management

LOGISTICS
- Cross-border transactions
- Customer disputes
- Last-mile delivery

SHOPPING EXPERIENCE
- Goods authentication
- P2P marketplaces
- Loyalty programs

MARKETING
- Digital advertising

SERVICE AND MAINTENANCE
- Maintenance records
- Parts history
- Warranty claims management

PREDICTIVE ANALYTICS
- Expected future customer behavior

NEW PRODUCT DEVELOPMENT

While naturally all companies closely guard their product development activities, in some cases limited collaboration with competing companies can actually prove beneficial to all. For instance, the development of autonomous vehicles requires massive amounts of rich data on driving patterns under different conditions. Obtaining data on such a scale is likely to take years if each company attempts to do so independently. To address this issue and accelerate the development of safe autonomous vehicles, in April 2019 MOBI formed the autonomous vehicle data markets working group. The group, chaired by General Motors, is looking into ways to develop a marketplace that would allow companies to exchange and source autonomous vehicle data in a controlled way.\textsuperscript{45} Blockchain can provide the mechanism for establishing such a marketplace, as it can be used by companies to register the information, establish provenance, and agree upfront on the framework within which everyone will operate.\textsuperscript{46} This example demonstrates the power of blockchain technology to foster collaboration between

\textsuperscript{45} “GM, BMW Back Blockchain Data Sharing for Self-Driving Cars,” by Ian Allison, Coindesk, April 8, 2019.
\textsuperscript{46} “How AI will Impact the Automotive Sector,” an interview with Chris Ballinger, CEO and Founder of MOBI, Youtube, October 2018.
competing companies, for the mutual benefit of all involved.

Another promising use case for blockchain during product development is IP rights protection. Given the immutability of blockchain records, the technology can help creators prove ownership of their work and provide a timestamp of when it was created or completed. It could also streamline the process of applying for patents or copyright protection.

In October 2018, the World Intellectual Property Organization (WIPO) created a task force to explore the possibility of using blockchain technology to support IP rights protection, management, and use. The task force identified several potential use cases, such as management of patents and trade secrets, anti-counterfeiting, digital rights management, and more. The task force also investigated the role of standardization in ensuring interoperability between IP blockchain systems and actors.

**MATERIAL SOURCING**

The increased transparency and immutability provided by blockchain can potentially help ensure responsible sourcing of raw materials. One industry that has seen multiple efforts to use blockchain technology for this purpose is the diamond industry. Examples include Everledger, a global digital registry for diamonds, which was founded in 2015 with a stated goal of solving the issue of blood diamonds; Tracr, the blockchain platform launched by De Beers Group in 2018 to improve the transparency of the diamond value chain; and TrustChain, a blockchain initiative launched in 2018 by a consortium of gold and diamond industry leaders with a goal of tracking and authenticating diamonds, precious metals, and jewelry at all stages of the global supply chain.

The diamond value chain is quite complex and opaque, with each step in the mining, processing, and distribution of diamonds potentially taking place in a different part of the world. For instance, more than 50% of gem-quality diamonds are mined in Africa; global trading hubs include Antwerp, Tel Aviv, and Dubai; India is the largest cutting and polishing center; and the U.S. is the leading consumer market, representing close to half of global demand for diamond jewelry. While the lack of transparency may not have been an issue in the past, the growing awareness of the issue of conflict diamonds has increased consumer demand for ethically sourced jewelry. In response, the Kimberley Process Certification Scheme was established in 2003. Yet despite being successful in reducing the flow of conflict diamonds, with time KPCS’ efficiency has been questioned. In recent years the program has been criticized for including loopholes that allow the exploitation of mine workers and their communities and for giving consumers false confidence about where their diamonds come from.

Blockchain can potentially provide a superior mechanism to certifying diamonds by keeping permanent records of all the steps each diamond went through, from the mine to the retail store. To accurately establish provenance, it is necessary to set a mechanism to uniquely and securely identify

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56 Ibid.
the diamonds. Tracr, for example, assigns to each diamond a unique “Global Diamond ID” that records its characteristics (e.g. carat, clarity, and color) to the blockchain. This information is verified at each milestone of the diamond’s journey. Another requirement for such a blockchain solution to be successful is for the technology to be paired with a process to physically evaluate each value chain partner — especially production mines — and certify that they indeed follow established good practices. UL, an independent global safety certification company, is the entity that leads these efforts for the TrustChain initiative. A few additional hurdles that blockchain initiatives in this industry may need to overcome are lack of interoperability between the different blockchain protocols and finding a way to expand the network to include more artisanal and small-scale mines, which together account for 20% of the global diamond supply.

Within the gold industry, the Responsible Gold Supply Chain Application (RG SCA) similarly provides a secure way to track the provenance and custody transfers of conflict-free and responsibly sourced gold from mine to refinery to vault. RG SCA is supported by blockchain, IoT, and an AI-powered imaging technology. A cryptoseal attached to the gold doré is scanned at the mine, again when it reaches the logistics operator, and then at the refiner. After refining, gold kilobars are identified and tracked with GoldID, which is an AI-powered imaging technology that maps and analyzes the unique patterns of the surface of each gold cast bar. All relevant information is recorded to the blockchain, providing the means to establish provenance, enhance trust and transparency, and simplify and automate the settlement and reconciliation processes, while effectively eliminating costly intermediaries.

Another aspect of responsible sourcing that some companies try to address with blockchain is human rights protection. Nearly 25 million people worldwide work in forced-labor conditions, a problem that is especially acute in the Asia-Pacific region. In response, Coca Cola, which sources most of its sugarcane from the Asia-Pacific region, announced in 2018 a joint blockchain initiative with the U.S. Department of State, aimed at increasing the transparency of hiring practices, contracts, and labor agreements. The plan was to create a blockchain-based secure registry for workers, their contracts, and their rights, to reduce the possibility of human rights violations. It is important to keep in mind, though, that such a registry, while increasing visibility, cannot by itself force suppliers to abide by the contracts. To be more effective, an audit mechanism should be put in place to observe suppliers’ actual practices, and workers should be provided with a way to report violations of work agreements. This may not be easy to achieve, since individual workers may not have smartphones or other means to access the system, verify their rights, and report on any cases of abuse.

Beyond responsible sourcing, companies have been using blockchain to support business-to-business transactions. One example is the VAKT platform, launched in November 2018 in partnership with several firms including oil companies BP and Shell. The companies use the blockchain platform to improve post-trade processing, from trade entry to final settlement, a process that is traditionally extremely manual and prone to errors. By sharing relevant information throughout the process, the companies

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57 Based on an interview with Mark Hanna, Chief Marketing Officer, Richline Group. March 25, 2019.
can eliminate reconciliation and paper-based processes, increase efficiencies, and lower costs.\textsuperscript{62}

One of the main reasons the companies chose to use blockchain technology is that it is better suited for competitive, trustless environments. The oil companies perceive information as power — a means to differentiate themselves from the competition during the trading process. At the same time, they realize that some major inefficiencies in the post-trade process could only be improved through collaboration with their trading partners.

Having a decentralized system, where data is not controlled by a single, central authority, combined with the persistence and permanence of data stored to the blockchain, is of much value in this setting. Seamless access to the stored data is also crucial to the participating companies.\textsuperscript{63} Another factor that helped make this initiative successful was the use of an industry consortium to drive it. Experts from all consortium companies contributed their knowledge to the development process, helping to create a more robust solution. And the members of the consortium provided a critical mass of early users, which in turn encouraged faster adoption by others in the industry. Finally, by pooling the required initial investment, each consortium member could lower their exposure to risk while still enjoying all the benefits associated with this initiative.

\section*{Supply Chain Traceability}

A few decades ago, companies were more vertically integrated, and they were held responsible only for the activities that took place within their four walls. Today, in contrast, not only is collaboration with external partners more crucial for business success, but brand companies are also often held accountable for their tier-two suppliers and for outsourced manufacturing operations. Several companies have been turning to blockchain to provide secure track-and-trace capabilities, help establish product provenance, improve supply chain governance, and enhance trust.

One industry that can significantly benefit from higher visibility and better traceability is the food industry. The U.S. food supply chain is a complex network of thousands of producers, processors, manufacturers, and retailers, including roughly 125,000 food facilities and farms located in more than 200 countries or territories, from which the U.S. imports about 15\% of its overall food supply.\textsuperscript{64} Traditional methods offer limited visibility into the path food takes after it is picked or processed. In contrast, the decentralization and permanency offered by a blockchain solution can encourage broader participation, which can then provide the means to keep track of the entire route the food takes on its way to the retail store. IoT devices may make it easier to collect additional information, such as shipping and storage temperatures. The information stored on the blockchain can assist retailers in addressing a broad range of quality issues and increase consumers’ confidence in the quality of the food that they consume. Improved traceability can be especially beneficial in the event of an outbreak of a food-borne disease, as it can help investigators to quickly determine the source of the outbreak and issue a more targeted recall to minimize food waste.

One example of a blockchain initiative in the food industry is the Food Trust platform, launched by IBM in late 2018 to connect retailers, wholesalers, and suppliers across the food ecosystem and provide greater traceability. As of April 2019, more than 80 brands were participating in the Food Trust network, including Walmart, Kroger, Driscoll’s, Nestlé, and others.\textsuperscript{65} Other examples include the food-tracing

\begin{itemize}
\item \textsuperscript{62} “VAKT Launches World First Enterprise Grade Blockchain Platform with BP, Shell," \textit{Unlock}, Nov. 30, 2018.
\item \textsuperscript{64} “FDA Strategy for the Safety of Imported Food,” \textit{fda.org}, February 2019.
\end{itemize}
system introduced by Chinese retail giant Alibaba in April 2018 to provide end-to-end supply chain traceability for imported goods, and the solution used by the Grass Roots Farmers’ Cooperative to boost consumers’ confidence in the quality and origins of the meat they purchase.

These and other examples illustrate the value of an immutable and decentralized database and the additional benefits that can be realized when combining it with IoT solutions. At the same time, there are a number of hurdles that should be addressed for blockchain initiatives in the food industry to fully realize their potential. First is the issue of cost. This is a low-margin industry, so putting in the required investment may be hard for some supply chain participants. Furthermore, any proposed solution should create a win-win situation, where the costs and benefits are shared fairly throughout the supply chain. Another point to keep in mind is that full transparency and traceability from farm to fork requires wide participation in the blockchain network. But some organizations may be reluctant to join. Some may lack the required resources. Others may worry that after joining the network, they will be required to share information that they prefer to keep private. Interoperability and standardization are also important, to allow participants to integrate the blockchain solution with enterprise solutions already in use and to support information sharing between blockchain networks as needed.

The pharmaceutical industry can also significantly benefit from improved traceability. Theft, product diversion, and counterfeits are common and painful issues in this industry. Adding to the pressure for change is the Drug Supply Chain Security Act (DSCSA), which outlines requirements for an electronic, interoperable system to identify and trace certain prescription drugs as they are distributed in the U.S. DSCSA was enacted in 2013, and full compliance must be achieved by 2023.

In response, the MediLedger Network was launched in 2017, with a mission to explore whether blockchain’s innovative capabilities could be utilized to track and trace prescription medicines in a way that would be compliant with DSCSA. Initial participants in this industry-owned permissioned blockchain network included industry leaders Genentech, Pfizer, AmerisourceBergen, AbbVie, and McKesson Corporation, with Chronicled providing the underlying technology. Their first solution, the Product Verification System, was developed in response to DSCSA’s requirement for all prescription medicine returned to distributors to have their unique product identifier verified with the manufacturer before being resold. Additional solutions are in development.

One of the main advantages of the MediLedger Network is its decentralized nature and the data security it provides. None of the participating companies wanted to create a central database that would hold information on all drugs sold in the U.S., as such information is of immense value. MediLedger provided a better alternative, as it allows participants to keep all sensitive information protected behind their firewalls, while using ZKPs and other mechanisms to provide the required functionality. An added layer of security is provided by the cryptographic proofs and hashes used for all information recorded to the blockchain. In addition, the protection of sensitive data and the business rules defined by MediLeger’s initial working group ensure that the solutions created are of value to all network participants. Another benefit is the ability of network participants to communicate via secure P2P messages, which allows wholesalers to verify the identity of returned products within less than a second. The direct interaction also eliminates the need to share highly sensitive data with any external

solution providers. To meet the requirements of DSCSA, the MediLedger Network is interoperable with other solutions in the pharmaceutical industry.

Another use case for blockchain technology is improved visibility into cold chains. This is a critical application for such goods as medical and pharmaceutical products, which must be kept within a certain range of temperatures to remain effective. Modum, a Zurich-based startup founded in 2016, uses IoT sensors to keep track of the temperature of medicines at all stages of transit. Prior to shipment, an IoT sensor is placed inside the package. While in transit, the sensor collects offline data regarding the temperature inside the package. Once the package arrives at its destination, the barcode on the package is scanned, the data stored on the IoT device is read, and a unique checksum of all the data is written to the blockchain. Based on this checksum, a smart contract determines whether to resend the product (if the prespecified conditions have not been met) or issue an invoice. 69

LOGISTICS

Cross-border transactions, where goods often travel great distances and change hands numerous times, are often marked by poor visibility and traceability. Several alliances have formed in the last couple of years to explore ways to reform ocean shipping — often a complex process that is paper-intensive and requires manual document-handling — through blockchain technology.

In early 2018, shipping giant Maersk and IBM formed a joint venture, and later that year they launched TradeLens, a blockchain platform for tracking shipments as they move from one port to another. The platform provides a way for all parties involved in the supply chain, including cargo owners, ocean and inland carriers, freight forwarders and logistics providers, ports and terminals, customs authorities, and financial service providers, to interact more efficiently through real-time access to shipping data and documents. 70 Other examples include freight forwarder Kuehne + Nagel, which handles hundreds of thousands of transactions per month with blockchain through the Verified Gross Mass portal, 71 and the Global Shipping Business Network, which is led by a consortium of nine industry-leading ocean carriers and terminal operators and is still in the process of being officially established. 72 The Blockchain Document Transfer platform by startup CargoX provides the means for transferring documents of title and other documents in a safe way, and it also provides a way to transfer the ownership of those documents. 73 The platform uses the neutral, public blockchain Ethereum network.

A blockchain solution can significantly improve the slow and cumbersome exchange of paper-based documents by providing all parties real-time access to those documents they have permission to view or edit. It can increase transparency and efficiency, reduce friction, and provide a clear and encrypted audit trail. But the value derived from such blockchain platforms would likely depend on the number of network participants. And growing the network is often not an easy feat. TradeLens, for instance, found it challenging early on to bring additional ocean carriers on board. The main issue was the position of Maersk — a competing carrier — as a partner in the joint venture that owns TradeLens. This meant that Maersk stood to profit from any additional carrier that joined the network, which made other ocean carriers reluctant to

join. Only after changes were made to resolve these issues did adoption rates increase significantly. As of July 2019, 15 ocean carrier lines, representing more than half of the world’s ocean container cargo, had committed to the TradeLens platform. Another issue that should be addressed by the different solution providers is interoperability, given the number of blockchain solutions developed for this industry.

Blockchain also has the potential to resolve inefficiencies associated with cross-border payments. For instance, the Bank of Canada and the Monetary Authority of Singapore announced in May 2019 the conclusion of a successful trial of cross-border payments using blockchain technology and central bank digital currency. According to their announcement, the trial showed great potential to increase efficiencies and reduce risks for cross-border payments.

Other companies have been using or testing the technology to improve other aspects of logistics operations. For instance, shipping giant FedEx has tested a blockchain solution that takes advantage of the transparency provided by the technology to settle customer disputes and improve customer service. Vinturas, a European consortium of logistics service providers in the finished vehicle logistics industry, is using blockchain technology to provide real-time supply chain visibility and improve operational efficiencies during the transport and storage of new and used cars. And VOLT aims to improve last-mile delivery through a P2P platform that directly connects customers and messengers, thus providing same-day delivery at lower costs for customers and higher profits for messengers.

SHOPPING EXPERIENCE

In addition to the mostly business-to-business applications described so far, a growing number of companies are moving forward with customer-facing blockchain applications. We discuss here a few examples of such applications, focusing on goods authentication, P2P e-marketplaces, and blockchain-based loyalty programs.

Trade in counterfeit and pirated goods has risen steadily in recent years. The Organization for Economic Cooperation and Development (OECD) estimates the value of imported fake goods worldwide to have reached $509 billion in 2016, while a Research and Markets report estimates global counterfeiting to have reached $1.2 trillion in 2017. Several blockchain initiatives aim to address this issue and restore consumers’ confidence in the authenticity of the goods they buy. Examples include the blockchain solution launched by China’s Alibaba in April 2018 for its Tmall Luxury Pavilion, and AURA, a platform launched in May 2019 by blockchain company ConsenSys and Louis Vuitton owner LVMH. Both platforms allow consumers to access product history and obtain a proof of authenticity for the luxury goods they purchase. These and other similar initiatives take advantage of the immutability of data stored on the blockchain, which enhances consumer trust. An added benefit provided by solutions such as AURA, which is based on
a consortium model, is that it encourages wider participation by other luxury brands.

Another consumer-facing blockchain application is the P2P e-marketplace. Examples include OpenBazaar and Particl. As decentralized, open-source platforms that are not controlled by any single entity, they do not require any intermediaries between buyers and sellers, thus eliminating all fees and restrictions. Furthermore, these marketplaces do not require users to provide any personal information, eliminating the risk of this information being stolen or sold to third parties. Another benefit is the use of cryptocurrencies as a form of payment, which results in lower transaction fees and instantaneous transactions. These are especially valuable for cross-border transactions, which tend to require higher fees and take several days to complete. At the same time, a key disadvantage of cryptocurrencies such as Bitcoin or Ether is their volatility, which may make them less practical for day-to-day payments. This problem can be mitigated by using stablecoins, which are pegged to a currency like the U.S. dollar or to the price of precious metals and are therefore much more stable.

Another potential challenge of a completely decentralized marketplace is that it does not have a centralized support team to manage disputes between buyers and sellers. Various mechanisms have been developed to address this issue. For instance, OpenBazaar offers buyers the option of using a 2-of-3 multi-signature escrow account rather than paying the seller directly. The third party on this account is a moderator, mutually agreed on by the seller and buyer, who offers dispute resolution when needed. Particl uses a dual-deposit escrow system, which requires buyers and sellers to make a security deposit into an escrow account controlled with a smart contract. The security deposits are refunded back only when both parties confirm that the transaction has been completed satisfactorily. This gives them an incentive to reach an agreement with which both parties will be satisfied.

The last example of a customer-facing application is blockchain-based loyalty programs. Examples include Singapore Airlines’ KrisPay program, the mobile app Pei, and the platform provided by Loyyal. KrisPay lets users exchange their accumulated air miles for digital currency which, in turn, can be spent at an extensive list of partners. Pei users can automatically collect cash back, in either crypto or U.S. dollars, when shopping at thousands of retailers. And Loyyal helps businesses expand their partner network and manage their loyalty program more efficiently.

One potential benefit of blockchain-based loyalty programs is the transparency and accuracy they bring. Whenever loyalty points are issued, redeemed, or exchanged, the information is securely recorded to the blockchain. Updates can take place in near real time, due to the elimination of intermediaries. This in turn can help minimize customer disputes and allow businesses to avoid such issues as double spending, fraud, and abuse. Blockchain can also improve the efficiency of managing reward networks, processes which can be time-consuming and expensive in traditional platforms. For instance,

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Loyyal provides a simple process for integrating a new business into the network. And smart contracts can increase the efficiency of managing how reward points are accumulated and redeemed across the network. Such improvements are not only beneficial to the companies that offer the loyalty programs, but they ultimately make these programs more valuable for customers.

**MARKETING**

The world of internet advertising has a myriad of problems. As advertising budgets increase, so does the frustration users feel with the number of distracting ads that pop up on their screens. Many users are also concerned about malvertisements and about a lack of control over the ways their personal information is collected and used. Consequently, a growing number of them employ ad blocking software, leading publishers to face a shrinking ad-block-free market. As for advertisers, not only does more than 40% of their digital advertising budget go to intermediaries, but the current system also makes it harder for them to assess the effectiveness of their advertising campaigns.

Some blockchain solutions aim to improve this situation. One example is the blockchain-based digital advertising platform offered by Brave, which uses a distributed ledger to directly connect internet users, advertisers, and publishers in a way that benefits all parties. The platform lets users choose whether to opt in to receive ads when using the Brave browser. If they opt in, they are compensated in return with Basic Attention Tokens (BATs), which they can use to pay for premium content or to tip the publishers they value the most. A ledger system measures user attention to the ads at the browser level, and the information is used as the basis for determining payments to publishers. The platform uses smart contracts to distribute advertisers' payments among publishers and users. Advertisers pay Brave a fee for their services but avoid payments to other intermediaries. As users are the ones choosing to receive ads, advertisers are likely to enjoy a higher conversion rate. The exclusion of intermediaries gives advertisers direct access to information they can use to assess the effectiveness of their ads. Finally, the use of cryptocurrencies makes it easier to facilitate micropayments to users. Another benefit for users is that their identities are shielded and their browsing data is encrypted and kept on their own devices.

**SERVICE AND MAINTENANCE**

Service and maintenance operations are complex, involving many component suppliers, service organizations, technical experts, and other entities, each using different methods and systems to keep records of preventive maintenance, repairs, part/product failure, and more. A single distributed ledger shared by all these entities can bring about a number of benefits. First, a shared log of usage and service information is likely to make it easier for service providers to ensure parts availability and increase efficiency. A single, shared ledger can also help identify issues with a specific component or supplier and provide a clear and secure audit trail. Finally, a distributed ledger can provide an easier way to verify the authenticity of spare parts and screen out any counterfeits that find their way into the supply chain.

One industry that stands to gain from the increased visibility and traceability provided by blockchain technology is the aviation industry. An airplane can have as many as 2 million parts, and each of them must be tracked and traced. Maintenance records are often stored on paper or within isolated databases. Moreover, these records are likely to be owned by multiple maintenance agencies, which may be

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reluctant to share the information with other interested stakeholders. Blockchain can provide an immutable digital record of all scheduled and unscheduled maintenance activities. The technology can also allow network participants to protect sensitive information, while using ZKPs to verify maintenance activities. In addition, blockchain can be used to connect the supply chain and provide visibility into the entire history of each part. This is critical since for safety reasons, airlines can use a part only if they can fully trace its history, which can be a daunting task with siloed databases and paper-based records. Accessibility of parts history is especially beneficial when trading in used and reconditioned parts on secondary markets. Still, the level of realized benefits is likely to be tied to the number of participating entities, including airlines; maintenance, repair, and overhaul (MRO) organizations; and OEMs. To achieve wider adoption, mechanisms should be put in place to protect data privacy and to ensure that all participants stand to gain from such collaboration. The establishment of standards and interoperability solutions can further increase adoption rates.

GE Aviation, which provides jet engines to around 60% of the global airline industry, is one of the companies looking to increase traceability and efficiency with blockchain technology. In mid-2019 they announced their partnership with MTU Maintenance to use blockchain technology to improve how parts and repairs are tracked and traced over their lifetime. Their plan is to eventually expand the network to include an industrywide consortium of partners, for fuller visibility into the entire history of the engines and the parts that go into them. Another example is the MRO Blockchain Alliance, formed in early 2020. The alliance, which includes leading organizations covering every aspect of the MRO chain, looks into issuing aircraft parts with digital passports to prove their authenticity and provide a “digital thread” for their transport and custody history. The alliance believes that blockchain will simplify and speed up parts tracking while enabling secure sharing of information. The automotive industry has also been experimenting with the use of blockchain technology to improve maintenance operations. One example is the automotive blockchain platform launched by SHIFTMobility in May 2018, which offers connected services to seamlessly integrate data from vehicles, repair shops, parts suppliers, and manufacturers. Among other things, the platform stores vehicle maintenance requirements and service history, information that can be accessed by dealers and service centers. When selling a vehicle, current owners can share the vehicle’s history with potential buyers and then transfer the vehicle’s data to the new owners after the deal is final. Warranty providers have also been considering blockchain technology as a way to protect against fraudulent claims, detect counterfeit products, and determine the status of coverage. One example is the warranty claims management module offered by Verso, which clients can use to report, process, and settle warranty claims. Among other things, the module provides a way for supply chain parties, including

suppliers, distributors, dealers, and retailers, to share accurate information on outstanding warranties.  

**PREDICTIVE ANALYTICS**

A growing number of organizations view predictive analytics — the ability to analyze data to help identify patterns and trends and to predict the likelihood of future events — as critical to their future success. One indication for that is the soaring adoption of big data in enterprises, from 17% in 2015 to 59% in 2018. But gaining access to predictive analytics can be a daunting task, especially for smaller companies that may not have the resources to hire trained specialists and may not have access to the large volume of data required for generating meaningful and accurate predictions.

Blockchain could potentially improve predictive analytics and their accessibility in multiple ways. First, data stored on the blockchain is timestamped and cannot be altered, making it more reliable. Second, a blockchain stores data coming from its entire network, providing each network participant access to a high volume of data, which can be used to make more accurate predictions. Furthermore, a blockchain can potentially use the computational power of hundreds or thousands of computers, offering even small companies the ability to benefit from predictive analytics through a pay-per-use system. The computational power can also be used to determine what data sets to use to best respond to a user query expressed in natural language.

One such example is the Endor Protocol predictive analytics platform, which leverages blockchain infrastructure and the company’s proprietary AI-based Social Physics technology. The platform uses data related to purchases made with cryptocurrencies to make business predictions about expected future customer behavior. The platform offers many of the benefits discussed earlier, such as a valuable service to smaller companies and higher credibility due to the immutability of data stored on the blockchain, which prevents data censorship and ensures unbiased results. Payments are made with Endor Protocol Token coins, and smart contracts ensure that data owners are compensated fairly for any user query that makes use of their data. Moreover, the platform’s unique capability to process fully encrypted data guarantees data security and ensures compliance with GDPR and other data privacy regulations.

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KEYS TO SUCCESSFUL IMPLEMENTATION

The following are several steps that we recommend to decision makers interested in implementing blockchain technology to increase the likelihood of success:

1. GAIN A DEEP UNDERSTANDING OF BLOCKCHAIN

As mentioned during the discussion on barriers to adoption, one of the key challenges is a lack of sufficient understanding of blockchain technology, its benefits and limitations compared with other technologies, and potential enterprise use cases. Therefore, as a first step, decision makers must educate themselves on the technology’s unique characteristics. This knowledge will not only help them determine whether blockchain is the right solution for the challenges the organization is facing, but it should also alleviate concerns and increase comfort levels if a decision is made to move forward with a blockchain implementation. Companies should also invest in training as needed, to minimize talent shortages later on.

2. DETERMINE WHETHER BLOCKCHAIN IS THE RIGHT SOLUTION FOR THE ORGANIZATION’S BUSINESS PROBLEM

The discussion about blockchain vs. central databases highlights the different set of advantages that each of these technologies offers. While blockchain may be a valuable solution in some scenarios, under other circumstances a different technology may prove superior. Therefore, the adoption of blockchain technology should not be set as a business goal in and of itself. Rather, decision makers should first identify the business problem the organization faces and the ways they would like the situation to improve. They should then assess whether blockchain is the right tool to deploy to address those business needs, or whether the business challenges can be mitigated with other, more traditional technologies that may be easier to implement.

3. DETERMINE WHETHER AN EXISTING BLOCKCHAIN NETWORK CAN ADDRESS THE NEEDS OF THE ORGANIZATION

Once it has been determined that blockchain is the best approach to addressing the identified business needs, companies should explore whether a blockchain initiative already exists that is aligned with their business goals. After all, blockchain is best suited for cross-enterprise applications, with the magnitude of realized benefits likely to increase as more companies join the network. Joining an existing blockchain network will therefore make such an initiative more likely to succeed. Furthermore, it will prevent duplication of efforts, as in the case of the diamond industry, where several siloed blockchain networks have been developed, all with a goal of improving the transparency of the diamond supply chain. At the same time, before joining an existing blockchain initiative, companies should carefully examine characteristics such as its structure, governance mechanisms, and information that participants are required to share, to assess whether joining that network is the right move. If no existing blockchain networks can address the business challenges of the company, the next step is to embark on a new blockchain initiative. The following are several important points to consider when taking on such an initiative.

4. IDENTIFY ESSENTIAL PARTICIPANTS AND GET THEIR BUY-IN

Any blockchain initiative is likely to require the participation of other value-chain partners. It is therefore critical to work together with major stakeholders, understand their perspective, and determine together how to set up the blockchain initiative in such a way that will benefit all. Key partners should jointly determine the network's business objectives, the way it will be governed, the information that should be shared for it to function well, how to protect each company's sensitive data, and more.
Obtaining the buy-in of critical partners, as well as ensuring that the costs and benefits are allocated fairly and that everyone stands to benefit from the initiative, will be instrumental to its success. The industry consortium that drove the VAKT initiative is one example that illustrates the value of such an approach. In contrast, the challenges faced by TradeLens early on illustrate the obstacles that an initiative driven by a single organization may face. It is important to note that while essential, reaching an agreement with other stakeholders may be one of the biggest obstacles to overcome, especially when it involves competing companies.

5. DETERMINE WHAT TYPE OF BLOCKCHAIN TO IMPLEMENT

Private, public, and hybrid blockchains have different characteristics. When starting a new blockchain initiative, companies should carefully consider which type of blockchain to use, since once set up, a blockchain cannot be easily converted or significantly modified. So far, most enterprise applications have been based on private blockchains, which made it easier to test this new technology in a controlled environment. But as explained earlier, most experts predict a future shift from private to public blockchains.

It is also important to consider the interoperability of the selected solution with other blockchain networks, to allow seamless data exchange across blockchain systems for added functionality.

More broadly, companies should carefully vet blockchain solution providers to verify their trustworthiness. The solution provider should not only be able to provide the desired functionality but should also be able to construct a solution that, among other things, addresses security concerns, protects sensitive information, and encourages wide adoption.

6. CONSIDER INTEGRATING BLOCKCHAIN WITH OTHER TECHNOLOGIES FOR ADDED VALUE

Pairing blockchain with other advanced technologies, including IoT and AI, can potentially augment the value that each of these technologies can provide on its own. This was illustrated by the examples of Modum, which combines blockchain and IoT technology for cold chain management, and Endor, which uses AI to derive predictive analytics from information stored on the blockchain. Companies should then explore whether integrating blockchain with one or more of these technologies may be the right approach for their organization or network, given the specific characteristics of their value chain and the issues they are facing.

7. TAKE ADDITIONAL STEPS TO ACCELERATE BLOCKCHAIN ADOPTION

Beyond the adoption of blockchain within their own network, companies may want to take additional steps to advance the development and adoption of blockchain technology. One way to do that is by joining a standard-development body and providing input to help accelerate the development of standards and ensure that they address the needs of their industry. Another potential way to get involved is by engaging with regulators to impact how the regulatory framework surrounding blockchain technology evolves.
CONCLUSION

While blockchain technology is not a panacea for all business problems, its special characteristics make it potentially superior to other technologies for a variety of business applications. Within the context of value chain management, blockchain technology can potentially improve visibility and traceability, facilitate collaboration, improve process efficiencies, and provide a secure audit trail. It can be particularly valuable for sharing information within large networks or among competing companies, where trust is likely to be an issue. Integrating blockchain with other technologies such as IoT and AI may further elevate the associated business benefits.

At present, companies face many hurdles to unlocking the potential value of blockchain. The technology itself is immature and quite complex, the regulatory landscape is unclear, security concerns exist, and standards are in an early stage of development. Some companies struggle to identify strong use cases, while others find it hard to expand their blockchain initiatives beyond small-scale pilots.

We do believe that in the long run, as the technology matures, concerns surrounding security and interoperability are resolved, standards are developed, and people become more knowledgeable about the technology and the ways to best utilize it, adoption rates will likely grow and blockchain networks will expand, providing more companies with the opportunity to realize a positive return on their investment.