From Buzzword to Biz World

Realizing Blockchain's Potential in the International Business Context

Du, Juan; Nielsen, Bo Bernhard; Welch, Catherine

Document Version
Final published version

Published in:
California Management Review

DOI:
10.1177/00081256231202266

Publication date:
2023

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Citation for published version (APA):
Du, J., Nielsen, B. B., & Welch, C. (2023). From Buzzword to Biz World: Realizing Blockchain's Potential in the International Business Context. *California Management Review*, *66*(1), 124-148. https://doi.org/10.1177/00081256231202266

BerkeleyHaas
Haas School of Business
University of California Berkeley

International Business

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California Management Review
2023, Vol. 66(1) 124–148

DOI: 10.1177/00081256231202266
journals.sagepub.com/home/cmr
Sage

Juan Du[1], Bo Bernhard Nielsen[2], and Catherine Welch[3]

SUMMARY

Initially making its name as the backbone technology of Bitcoin, blockchain has been referred to as a distributed ledger, public database, Internet of value, digital infrastructure, network, and platform. Compared with fluctuating cryptocurrency and non-fungible token (NFT) markets, applications of blockchain technology in more diverse business scenarios have received less attention. By analyzing 16 international business use cases under eight categories of blockchain-based solutions, this article offers a contextualized understanding of the potential for blockchain to become a general-purpose technology (GPT). It discusses how the extensiveness, evolvability, and enabling (3Es) aspects of blockchain influence the value, vision, and viability (3Vs) required for successful real-world applications. The article discusses how firms can draw on lessons from failed cases and good practices of existing cases to enhance the 3Vs for blockchain adoption.

KEYWORDS: blockchain, international business, inter-organizational collaboration, innovation, technology management, adoption

Blockchain has become a buzzword associated with the promise of secure and transparent transactions without intermediaries.[1] Blockchain-based smart contracts are expected to automate exchanges of information and ownerships regardless of geographical location or institutional environment.[2] Blockchain-based applications are proposed to eliminate various transaction costs associated with paper-based

[1]The University of Sydney Business School, Sydney, NSW, Australia
[2]University of Sydney Business School, Australia and the Copenhagen Business School, Denmark
[3]Trinity Business School, Trinity College Dublin, Dublin, Ireland

administrative work, intermediating and monitoring, and dispute resolution.[3] Blockchain breeds new generations of buzzwords, such as DeFi (decentralized finance), DAO (decentralized autonomous organization), dApp (decentralized application), NFT (non-fungible token), Web 3.0, and the Metaverse.[4]

Yet, when blockchain meets the real business world, promises often fade and problems arise. Although hailed as the "trust machine," blockchain has been mistrusted by potential adopters due to a lack of understanding of its seemingly contradictory features (e.g., transparency vs. anonymity) and the negative headlines associated with cryptocurrency theft and speculative moves in NFT markets.[5] Use cases and business models have served as proofs of concept to improve the understanding of blockchain.[6] Notwithstanding, there is a need to dial down the buzz and go back to the basics of blockchain-based solutions used in broader business contexts.

To provide a more practical view of how blockchain can be applied in the business world, we go beyond the hype of blockchain 1.0 (cryptocurrency) and 2.0 (contract) and focus on use cases from blockchains 3.0 (dApps) and 4.0 (blockchain + AI).[7] We present the extensiveness, evolvability, and enabling characteristics of blockchain as a potential general-purpose technology (GPT). We explain how blockchain can make a difference to the business processes and managerial practices of organizations, especially those operating in lengthy value chains, dispersed geographical locations, and diverse institutional environments: in other words, international business contexts in which the need for trustworthy data transfer is particularly acute.

Method

This article provides a holistic view of *how* the attributes of blockchain as a potential GPT influence its adoption in real-world business settings. We consider a technology to be socially shaped, and thus, it is critical to observe the development of a technology in real-life situations.[8] To this end, we selected a set of international business use cases to delineate the practical solutions (as well as the challenges) enabled by blockchain at a global level. Compared with a dedicated technology, such as beer brewing technology, a GPT requires worldwide standardization and interoperability.

The process we took to select the use cases in this study involved multiple steps. First, we undertook a thorough review of self-reported use cases by multinational organizations, such as blockchain adopters and service providers. Second, we conducted further analysis of those use cases on which detailed information was publicly available. This analysis yielded a spectrum of use cases in terms of the problems that the companies were addressing (their pain points).

Our third step was then to select case examples that in sum covered the diversity of use cases that we had identified. We developed case profiles through secondary data, such as media coverage, newsletters, and public speeches. We

then contacted relevant organizations for feedback, verification, and clarification of our written cases. We retained only those use cases in our study on which feedback was forthcoming. In total, we obtained 16 use cases on common pain points faced by managers in international business contexts that can be addressed by eight types of blockchain-based solutions.

The round of feedback that we conducted allowed us to obtain insights from relevant industry experts with first-hand experience in blockchain-enabled solutions, such as founders, executive directors, CTOs, and business leads. We then analyzed blockchain in real-life applications to understand why and how the extensiveness, evolvability, and enabling (3Es) attributes of this technology matter to managers. Finally, based on these analyses, we build a framework for decision makers to assess and develop the value, vision, and viability (3Vs) needed for blockchain adoption.

Blockchain as a Potential GPT: Technological Capabilities

A GPT is usually characterized by its pervasive "input in many downstream sectors" (*extensiveness*), "inherent potential for technical improvements" (*evolvability*), and "innovational complementarities" (*enabling*).[9] As a GPT evolves, it brings about productivity spillovers to the economy.[10] The label of a GPT can only be applied ex-post.[11] It took about a century for electricity and several decades for information technology (IT) to be widely adopted by businesses and households. However, blockchain has shown potential as a generic technology that is enhancing efficiency via pervasive applications. It has been swiftly enabling and evolving with complementary technologies in the past decade.[12]

Extensiveness

Blockchain has the potential for applications in a broad range of industry sectors.[13] In a digital society, software and hardware are highly interconnected across many sectors. Blockchain can serve as a distributed ledger connecting data islands. As credible data form a basic factor of production in a digital economy, data integrity is critical for addressing trust barriers to efficient transactions. Blockchain can offer a trust mechanism by recording timestamped and tamper-proof data.[14] The enhanced trust in data brings greater efficiency to the exchange of information and value.[15]

Together with technical solutions such as asymmetric cryptography and consensus algorithms, blockchain can offer secure management of data and privacy.[16] It confirms and records the ownership of data throughout their entire lifecycle. It ensures that the transaction of certain data happens without unintended exposure of related data or transfer of data ownership. By addressing privacy and security concerns, blockchain enhances the scope of data sharing and frequency in data exchanges. Blockchain has been adopted in areas where the transaction of information and ownership without physical contact requires high

trust in data from each party. Its applications in industrial networks accelerate digitalization and integration among equipment and firms.

Although their attitudes toward cryptocurrencies vary, governments have introduced measures to encourage the development of blockchain technology to serve the real economy.[17] Blockchain applications are increasingly realized in both public and private sectors.[18] Despite the wide applications of blockchain-based solutions, there has been much trial and error in real-world applications due to the novelty of the technology.

Evolvability

Blockchain is adaptable and expandable with potential for further improvement.[19] The origin of blockchain dates back to the 1970s when underlying concepts and technologies were being developed by computer scientists.[20] Since its implementation as a decentralized public ledger to transact bitcoins in 2009, blockchain has gone through rapid evolution and inspired applications beyond cryptocurrency.

It was hard to predict which technology stack was going to form a new generation of blockchain and how long it would take. Based on new capabilities enabled and new markets created, practitioners and scholars propose four generations of blockchain technologies. Blockchain 1.0 mostly focuses on cryptocurrencies.[21] Blockchain 2.0 involves "privacy, smart contract, non-native asset blockchain tokens and capabilities."[22] Blockchain 3.0 extends capabilities further to decentralized applications (dApps). Blockchain 4.0 incorporates AI and blockchain to inform and automate decision-making.[23]

Blockchain applications are growing in speed, scale, and security thanks to advances in technological solutions, such as scalable consensus, high-speed smart contract execution engines, and privacy-preserving computation.[24] Cross-chain interoperability is improving among permissioned blockchains and permissionless ones, owing to technical improvements such as enhanced cross-chain data processing capabilities.[25] As tools and tutorials for developers to participate in open-source blockchain projects continue to grow, blockchain technology is maturing for wider real-world applications. As a potential GPT, blockchain co-evolves with complementary technologies.

Enabling

Blockchain can lead to new solutions by complementing and enabling other innovations.[26] Blockchain empowers complementary technologies. The fusion of blockchain and cloud computing offers secure data migration and distributed cloud computing solutions for firms to outsource computing needs.[27] When aggregated with 3D modeling and augmented reality, blockchain helps create virtual interaction with digital recreations of valuable artifacts or remote settings.[28] When paired with artificial intelligence, blockchain unlocks the value in data for automated business processes and decision-making.[29]

The combination of blockchain and IoT propels digital transformation from individual organizations to an industrial supply chain level. IoT generates digital twins as virtual representations of physical entities or systems over their entire lifecycles. Digital twins have been used in asset-intensive industries (such as aviation and automotive industries) to pinpoint conditions and run virtual tests offsite.[30] Blockchain can provide a secure environment for organizations to exchange and validate data on digital twins and foster more coordinated inter-organizational workflows. Blockchain also constitutes a digital infrastructure enabling organizations to share digital twin resources of physical assets for examination, rental, or (re)sale.

New business processes and models flourish thanks to the efficient circulation of assets on blockchain. Apart from digital twins, blockchain also secures and spurs the exchange of other digital assets, such as NFTs. NFTs are non-fungible tokens representing ownership of items with certain intrinsic value to the owners. NFTs are created through a minting process on blockchain. A creator or owner outlines the fundamental details of an item, broadcasts the information on a blockchain, triggers a smart contract function, and creates a token with a unique identifier minted to it. The identifier makes the token non-fungible and indelibly attaches it to its owner. NFTs can represent ownership of intangible goods such as digital artworks, electronic tickets, IP, ID, or health records. Physical goods from fashion collectibles to real estate can also be tokenized. Unlike cryptocurrencies, NFTs are not mutually interchangeable with one another. Like other assets, NFTs may be traded or hypothecated. Like other technological capabilities of blockchain, their application to business contexts is being actively explored.

From Technological Capabilities to Real-World Applications

Practitioners adopt blockchain by finding value in solutions, setting a long-term vision, and building viability (i.e., utilizing the 3Es of blockchain to achieve the 3Vs necessary for adoption). Blockchain's technological capabilities can be translated into real-world use cases despite the uncertainties that currently surround its potential.

Extensive Use Cases and Value Creation

Adopters of blockchain should not aim to be trendsetters but troubleshooters. Successful blockchain applications will offer workable solutions to real-world problems.[31] Blockchain's potential to be applied extensively in multiple sectors means that it is not appropriate to have a universal approach to the value proposition for diverse use cases. Blockchain is not a panacea for all business issues, despite its potential as a GPT. To date, it has been found to be mostly useful to recurring problems related to inter-organizational data sharing. To offer a contextualized understanding of how blockchain adds value in addressing certain problem patterns, we illustrate the eight types of valuable solutions that we found: controllable and confidential data transactions; immutable data and timestamped records; integrated data flow and workflows; distributed data

management and multi-party coordination; automated processing and settlement; automated data analysis and decision-making; secure exchange of digital twin information; and creation and exchange of NFTs (see Table 1).

As illustrated by the 16 use cases in our study, the value provided by blockchain-based solutions varies case by case, sector by sector. The value proposition in some use cases overshadows the others. For instance, multimillion-dollar sales of NFT artifacts often grab the limelight, albeit in the form of negative headlines relating to Ponzi schemes. In contrast, enterprise use of blockchain often remains a back-end story, with adopters sometimes shying away from news exposure.[32]

Although blockchain can serve as a valuable solution in many sectors, a successful use case starts from a pain point: a business problem, not a technology or a solution. In general, blockchain helps address pain points at the ecosystem level and requires intra- and inter-organizational collaboration. Blockchain enhances connectivity among organizations and facilitates the optimization of inter-organizational collaboration. It enables systemic innovation when there is a need for automation in decentralized, end-to-end processes, and multi-party coordination. It offers a distributed architecture for organizations to participate in data sharing and processing. It provides technical solutions for organizations to retain control of data to be shared for a specific purpose. Specifically, competing organizations within an industry find it easier to share their valuable data for a common purpose. By consolidating data from individual organizations, blockchain helps improve inter-organizational workflows and creates synergy at an industry level.

As the use cases in Table 1 show, real-world applications are diverse and tackle the problems of uncontrollable data sharing, incomplete audit trails, fragmented information flow, multi-party coordination, paper-centric manual work, information asymmetry, insecure data transactions, and centralization. What these use cases have in common is that they all address the inefficiencies and vulnerabilities of sharing data across organizational and national boundaries. Because blockchain is still an emerging technology with evolving capabilities that are yet to be fully understood, the eight types of solutions outlined in Table 1 are not meant to serve as a collectively exhaustive taxonomy.

Evolving Technology and Vision for Adoption

As a nascent technology, blockchain's capabilities are still being explored and improved. Decentralization, an inherent trait of blockchain, means that, at least in its current stage of maturity, the technology is suited to being developed via an open-source approach rather than being controlled by a single or a few entities. The open-source approach has three main advantages at this point in blockchain's evolution: adaptation, supporting ecosystems, and interoperability:

> "Unlike private technologies, Ethereum has been a public project and community. No one entity develops or controls public Ethereum—not us, not the Ethereum Foundation, not anyone. This is important. It is the broader decentralized community that does that." (Executive Director of Enterprise Ethereum Alliance)

TABLE 1. Blockchain-Based Solutions and Use Cases.

Solutions	Use Cases
Controllable and confidential data transaction	1. International transport and logistics To enable the digital transformation of the Shipping Industry, the Global Shipping Business Network (GSBN) built a blockchain platform harnessing technology from Oracle, Microsoft, Ant Group, and Alibaba Group. The platform allows GSBN members to retain the control and ownership of data while enabling encrypted data exchange.
	2. Carbon management and trading To support auditing and verification of carbon emission data, the Ant Group set up a blockchain-based software-as-a-service (SaaS) product named Carbon Matrix for firms, carbon certifier, and carbon exchanges. The platform helps the stakeholders manage carbon impact, audit carbon emission record, and exchange carbon assets by aggregating carbon data without disclosing unauthorized information.[a]
Immutable data and timestamped record	3. Traceability and provenance To trace the provenance of possible conflict-zone cobalt for electronic vehicle (EV) battery production, EV manufacturers such as Volvo launched a blockchain platform with Oracle and Circulor for ethical sourcing.[b] The timestamped and immutable data on blockchain provides an audit trail of who mined the raw material, under what working conditions, and how it was transported to prevent human rights violations in the supply chain.
	4. Authentication and anti-counterfeiting To provide authentic information on details of a product, its ownership, and repair history, Breitling rolled out a blockchain-based digital passport for its new watches.[c] The digital passport allows customers or traders to validate information and avoid fraudulent products during purchase and resale.
Integrated data flow and workflow	5. Cross-border payment and trade financing To ease access to financial services for small and medium-sized enterprises (SMEs), multinational banks and Ant Group launched the blockchain-based Trusple platform by integrating cross-border payment and trade financing services.[d] The platform provides SMEs, banks, and customers with real-time data on import-export operations. It automates settlements among buyers and sellers to alleviate the risk of delayed payment and cashflow issues. It generates reliable data on transaction records that can replace physical collaterals for resource-constrained SMEs to receive financing on the platform.
	6. Cooperation among competing industry players To reduce cost and improve visibility for car delivery from manufacturers to customers, leading European automotive logistics service providers initiated a blockchain network called Vinturas.[e] The blockchain serves as an infrastructure for competing logistic service providers to share their data in a secure environment and controllable way. It uses an integrated interface with standardized templates for service providers and terminals to log real-time data on each stage of car delivery. The tamper-proof data in the blockchain serve as legal documents for payments to be processed seamlessly throughout the collaborative network of manufacturers, logistics service providers, terminals, and dealers.
Distributed data management and multi-party coordination	7. Multi-country regulatory compliance To meet increasing European regulatory requirements, Renault, IBM, and automotive suppliers launched one of the first automotive blockchain-based platforms at scale (XCEED). The platform tracks and certifies compliance of vehicle components manufactured in several European countries.[f] Almost real-time information about each component in a vehicle is shared on the network by multi-tiered suppliers. This allows every member of the supply chain, but also, in the future, customers and regulators, to have access to a consolidated record of compliance information throughout the lifetime of a vehicle.

(continued)

TABLE 1. (continued)

Solutions	Use Cases
	8. Cross-border supply chain management To reduce data discrepancies in invoices and business processes, Walmart Canada launched the DL Freight with DLT Labs for its 70 third-party freight carriers.[g] The platform consolidates information systems for invoices and payment among Walmart and carriers to provide a single source of truth for all stakeholders. By automating invoice and payment management, disputes over invoices have been reduced from 70% to less than 1% and payments can be made on time.
Automated processing and settlement	9. Cross-border insurance claim settlement To streamline workflows in cross-border auto insurance claims, Allianz set up a blockchain-based platform as a single source of record of each claim.[h] The platform synchronizes information on auto insurance claims across Europe to reduce inefficiencies from back-and-forth email exchanges. Blockchain-based smart contract helps automate the claim settlement process, such as task validation and settlement, cost splitting, VAT, and billing calculations.
	10. Cross-border remittance To accelerate cross-border remittance, the Ant Group launched a blockchain-enabled cross-border remittance service with Standard Chartered, AlipayHK, and GCash Philippines.[i] The blockchain smart contracts pick up predefined data from each party and automatically execute steps to process a remittance in nearly real time. Users of the service no longer need to accommodate bank hours in different time zones and face unexpected exchange rates.
Automated data analysis and decision-making	11. Supply chain optimization To advance data analysis and speed up decision-making, IBM pairs blockchain and AI solutions for its Food Trust users.[j] Blockchain pools real-time data, such as inventory, suppliers, and shipment, from extensive members in the food supply chain. AI analyzes critical information and offers actionable insights to automate business decisions, including re-filling inventories or choosing a most cost-effective shipping solution.
	12. Intellectual property (IP) protection and retailing To reduce the cost of IP certification and protection, Ant Group integrates blockchain, AI, and cloud computing-based solutions on its Digital Copyrights Service Platform.[k] The platform can verify the originality of a digitized work, including articles, music scores, pictures, and videos, and produce a notarized digital certificate for content creators. This can be automated by AI and cloud computing within a minute and save up to 95% of the related cost. The platform also provides one stop services of IP exporting, such as data-driven matchmaking, for both individual and institutional content creators. Its combined technological solutions help IP exporters actively monitor and identify IP infringement at a low cost.
Secure exchange of digital twin information	13. Carbon footprint monitoring in value chain To monitor carbon footprint of materials used in the complex vehicle manufacturing process, Circularise, Porsche, and innovative material suppliers set up a digital twin thread for transparency in the value chain.[l] The blockchain-based process records lifecycle data on each batch of raw materials making up thousands of vehicles components. Blockchain provides a controllable and secure environment for suppliers to share confidential proprietary information, such as the composition of innovative materials, without fear for losing their competitive advantage. Porsche and its customers can easily access information from sourcing to recycling, and the environmental impact of each step for materials used in a car via mobile phone apps.

(continued)

TABLE 1. (continued)

Solutions	Use Cases
	14. Warehouse receipt financing in commodity trade To establish trust and simplify procedures in warehouse receipt financing, the Ant Group offers commodity traders a blockchain and IoT-based solution.[m] IoT pegs digital twins of commodities and establishes credibility to warehouse receipts. The lifecycle data of digital twins are logged on blockchain as a timestamped and immutable record. The blockchain-based and digital twin-pegged warehouse receipts reduce the time of due diligence and risk of fraudulence for financial institutes. Those receipts can serve as pledges for commodity traders to access financial services more efficiently. The technological solution breeds a new financing model by attaching trust to goods instead of an organization. It benefits specifically young firms or SMEs with high-value assets but low credit as an organization.
Creation and exchange of NFTs	15. IP licensing and trading To facilitate the licensing and commercializing of patents, IPwe teamed up with IBM and created a blockchain-based platform for digitizing patents as NFTs.[n] On the platform, AI replaces inefficient manual work to process vast amount of data on patents. Blockchain tokenizes patent assets based on the data of their historical and current records. Tokenization and the transparent records make patent assets easier to analyze, value, transact, monetize, and pool for joint licensing. Blockchain also provide auditable transaction records and execute smart contract during trading. The new models of IP licensing and ownership trading bring higher liquidity for patent asset holders, especially for SMEs and individual inventors.
	16. Distributed transaction of digital works To get rid of the disadvantageous revenue sharing models with centralized intermediaries, musicians, artists, writers, and content creators are turning to blockchain marketplaces for direct distribution and sale of works to global users.[o] Creators can release works as predefined numbers of NFTs by minting fundamental information of the works together with attribution information. Blockchain executes smart contract for creators to receive royalties based on the attribution directly from sale and resale. The transaction information will be kept in blockchain as a tamper-proof record of ownership. The transparency in transaction history and attribution allows creators to get the payments they deserve. It is also easy for buyers to verify the authenticity of products at a low cost.

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> "[Hyperledger has a] global community supporting all its open-source projects (currently 16) including one of the most adopted permissioned DLTs." (Executive Director of Hyperledger Foundation)

First, open-source communities allow for a high level of adaptability, given the number of participants and innovations they facilitate. Open-source projects, such as Ethereum and Hyperledger, have been co-developed by global contributors, including top tech companies. They can adapt to different product and geographical markets and adoption needs in the course of their evolution, thus facing fewer applicability trade-offs.[33] Despite the trade-offs between scalability, security, and decentralization, or the so-called "blockchain trilemma," variations of underlying blockchain reference architectures allow adopters to make a choice about which benefit to prioritize. The open-source nature of blockchain technology also attracts a large number of service providers to join its commercial ecosystem. They have been contributing solutions at Layer 2 and/or Layer 3 networks to enhance capabilities, such as performance or permission, on top of an underlying blockchain infrastructure.[34] Open-source communities also facilitate knowledge sharing, which is an advantage for an emerging technology that lacks precedents.

Second, the open-source approach allows blockchains to develop in open-governed, participative, and maturing ecosystems. For instance, contributors to Ethereum and Hyperledger are often competitors. This kind of competition is key to maintaining a healthy and growing ecosystem for blockchain development. Contributors need to abide by institutions agreed upon by the community, such as working group guidelines and anti-trust policies. Project development is all done in the open to ensure fairness to big and small participants alike. Compared with technologies proprietarily held by a few companies, open-source technologies offer transparency, an essential ingredient in generating trust:

> "The Ethereum ecosystem is by far the largest and most active blockchain ecosystem in the world. The standards that we create are whatever our members think they need. This is really important. The EEA does not set out a priori to try to define the world and how it should be. Instead, when members come to us and bring issues that they have, we then determine whether a standards effort would be appropriate, and we create that. But we are only one small part of an amazing and vibrant ecosystem." (Executive Director of Enterprise Ethereum Alliance)

> "In an open-source community like ours, we have very strict antitrust policy guidelines. And when companies want to work together, yet compete against each other, antitrust policies and rules and regulations really help that conversation. So, when they are in our community, every single meeting that they have, every single discussion that is done in the open, is under those antitrust policies, and that's very important for large companies (obviously in small companies as well) to make sure that the market is fair." (Executive Director of Hyperledger Foundation)

Third, because blockchain technology is being developed by decentralized communities, there is no one blockchain to rule them all. Interoperability has become a key consideration during the development of blockchain for business use. Unlike centralized platforms, it is hard for any single player to orchestrate a blockchain platform across different segments of a value chain. Therefore, it is important to have interoperability between different blockchain networks. For instance, interpretability between blockchain networks of mineral, chemical, and automotive industries will be critical to providing cradle-to-gate information on the carbon footprint of a car component along the value chain. In other words, the adoption of a blockchain does not stop at the launch of a single blockchain network but requires successful connections among networks of networks:

> "Ethereum is the most-bridged-to network in the world. The Ethereum Virtual Machine (EVM) is so foundational that many chains proudly work towards being 'EVM-compatible', reducing the learning curve for their developers by copying parts of Ethereum's design. However, we rightly live in a multi-chain world, with new chains for new niches popping up all the time." (Executive Director of Enterprise Ethereum Alliance)

> "Interoperability across blockchains also becomes an important requirement as public and private enterprises need convergence and assets need to be safely and securely moved from one blockchain to another . . . One example is Hyperledger Fabric that is designed to be interoperable with other technologies and systems, allowing it to be easily integrated into existing IT infrastructure." (Executive Director of Hyperledger Foundation)

Blockchain is still an emerging technology. Its real-world applications are new to the world, too. Therefore, managers need to adopt a long-term vision. This vision needs to be shared by multiple organizations, given the need for cooperation at the ecosystem level. Long-termism and cooperation are difficult to achieve in a traditional corporation, in which quarterly results and market share are key performance criteria. That's why some managers choose cooperation within broader open-source communities.[35] By demonstrating use cases and exchanging experiences, managers contribute to broader communities by allowing blockchain to co-evolve with real-world use cases. In return, managers benefit from educating potential adopters and aligning visions. Potential adopters can learn from extant use cases about how blockchain enables new solutions to build viable use cases.

Enabling Technology and Viable Solutions

Blockchain is an enabling technology in two ways: it needs to be integrated with other solutions to function in the real world; and in doing so, it provides the potential for new innovations. Turning to the first point, like most GPTs, blockchain requires combining with existing solutions used in business settings. For example, it cannot completely replace physical inspections by humans, but it can facilitate due diligence and certification by providing a shared ledger

of immutable data with a full audit trail. It cannot work without traditional IT systems, but it can add an additional layer of transaction records and provide a "single source of truth." It also needs to be integrated with user applications to function as an enabling infrastructure that allows secure and tamper-proof data transactions:

> "We are working with ISCC (International Sustainability and Carbon Certification) and also with other certification bodies to see how some of the data points that they require (in order to be compliant with those schemes) can essentially be digitized and monitored on blockchain to make it easier for supply chain actors to share information with each other, and also with auditors, third parties, and certifiers, in order to make that process more seamless, to have that transparency for certification, traceability, etc." (Lead Business Developer & Strategy for North America, Circularise)

> "The Hyperledger Fabric layer, with its three smart contracts, probably accounts for about 20% of the application, and then the rest is the database underneath . . . just traditional technology. So, a good UI [user interface] front end gives it a satisfactory user experience." (Global Head of Blockchain, Allianz)

> "What we found is that the blockchain platform as an infrastructure, by itself, is good at providing a basic enabling environment for custom development. But to speed up the adoption, you need to have pre-built application capability on top . . . . So, we are not only bringing technology, but we are also helping with the applications, with low-code development tools to help build them from scratch, industry applications from partners, and also to help users with existing applications to integrate with the blockchain." (Senior Director of Blockchain Product Management, Oracle)

Managers can benefit from the symbiotic relationships between blockchain and other technologies and discover new opportunities in bi-directional or convergence use cases. The use cases in our study showed that companies are combining it with a range of technologies beyond conventional IT. When used for AI, blockchain can feed large-scale longitudinal datasets to train machine learning models. AI can read and analyze data on blockchain to provide actionable insights. When built on IoT devices, blockchain provides a trustworthy way of data transmission across industry networks. IoT helps address the last-mile issue by linking the blockchain digital record to the physical asset or item to ensure that data logged into the blockchain are true from the origin:

> "The IoT technology is like tentacles of the network of value reaching out to tangible assets in the physical world. It helps realize the real-time, reliable trust anchors and links to digitize assets in the physical world, thus serving as a starting point for the digitization of assets." (Ant Group)

As an enabling technology, blockchain can unlock new business models and opportunities. For instance, a manufacturer can create NFTs for its products

so that owners of the NFTs can access full historical information about the product. By bringing transparency of the product and traceability of product components, NFT serves as a trustworthy medium to transfer ownership of the physical product. The manufacturer can further build an online marketplace for owners to trade their products and transfer ownership. In this way, the manufacturer can create value from more frequent engagement with extant customers after purchase.

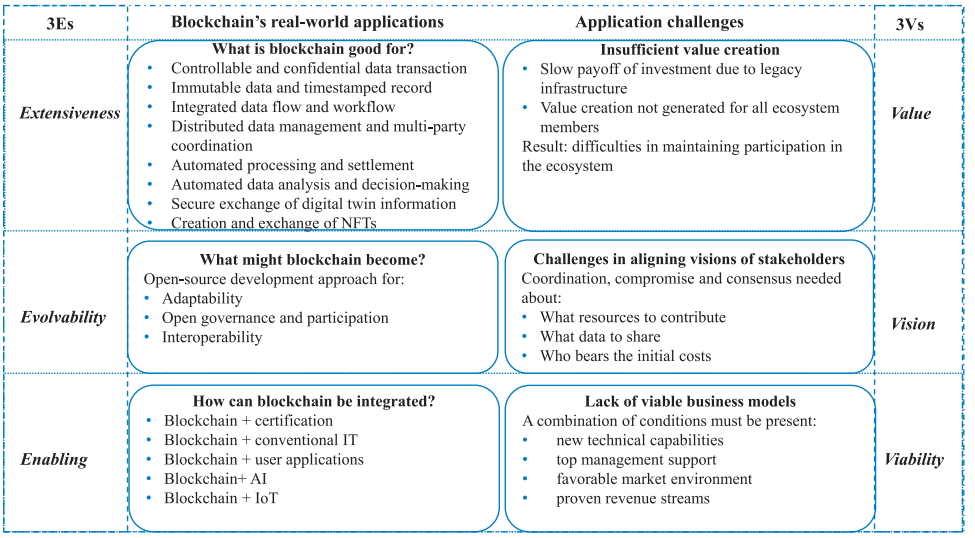
Blockchain can generate new business insights through accumulated transaction data over time. Serving as a shared ledger that records and tracks transactions in chronological order, blockchain offers managers large amounts of structured data that are ready for real-time analysis. Blockchain can also create value from integrated information flows. Managers can consider using data differently, given that blockchain offers credible data exchanged among multiple parties. They can leverage blockchain to connect different sources of data and create value from integrated information flow. Blockchain harmonizes business processes. Managers can promote further automation by building on standardized practices at an industry level to remove duplicated and non-value-added activities:

> "...we are working on the trade, trade in trade out, a lot... So, we are going to build a platform where Breitling owners can join the platform using the NFTs, so (an) anonymous club, to exchange watches, or resale watches among themselves. So, you really want to bring a level of support to a decentralized community of Breitling owners where the NFT is the key to answer..." (Chief Digital & Technology Officer, Breitling)

> "The question is what would be the benefit of collaboration? And if you take the place of a supplier, who faces several OEMs, you will see that he needs to adapt each time its own process to provide some specific documents requested by each OEM, which is always different. This is a non-value-added activity, and who do you think pays for it? Of course, the OEM pays! But if you think only about your company's silo, you don't see that spending a few more resources will give you huge benefits, not only for your own company, but for your suppliers' company. And if your suppliers have performance, you have performance. And if your supplier makes 30% of productivity, you will be sure to get a minimum of 15% of this productivity. It's a question of perspective. Of course, you can look at your own company, but if you could look wider, you can make more benefits." (Former Blockchain Vice President, Renault)

The process of exploring new viable solutions enabled by blockchain is summarized in Figure 1. But at the same time, the limits of blockchain technology need to be kept in mind. Blockchain does not offer a complete solution by itself but facilitates new ways of problem solving. Even though a blockchain-based solution may stand out against alternative ones, there is a need to consider what it can and cannot do (see Figure 1).

FIGURE 1. From 3Es to 3Vs.



Challenges of Translating 3Es into 3Vs

The *extensiveness, evolvability, and enabling* (3Es) attributes of blockchain technology do not always end up with *value, vision, and viability* (3Vs) in blockchain use cases. On the one hand, blockchain will go through a long adoption cycle like most innovative technologies. There will be trial and error. One telling truth about the difficulty in translating the technological capabilities of blockchain into business use cases is that even high-profile blockchain projects run by top tech companies and big industry players fail. It is often not due to the technology itself, but rather various business issues.

Lessons Learned from Failed Use Cases

We found that failure relates to the 3Vs, so it stems from insufficient value creation, challenges in aligning the visions of stakeholders, and a lack of viable business models. These all relate to the difficulties in achieving and maintaining co-opetition in an ecosystem in which risks and uncertainties are high.

Insufficient value creation. The speed of value creation matters. The integration of blockchain to legacy infrastructures takes time and resources, especially when there is a large number of participating organizations. There may be little immediate value created during the initial phase of a blockchain project. This may be prolonged in industries that are highly paper-centric, which take time and capital to digitalize.[36] The scale of value creation is also important. As blockchain is by nature an ecosystem-level solution, it is essential to create value for all ecosystem members. This can be difficult because not all ecosystem members find enough value in adopting an emerging technology:

> "I think some of the projects you have seen that have shut down is probably because they did not create sufficient business value for the participants to justify sharing the data . . . What is the value that is going to come for each participant to justify joining the blockchain network? . . . And even for those who've already joined, you might have participants at some point saying, 'We are not seeing enough value.' . . . It can arise from a stressed business environment, inflation, and geopolitical concerns. People are evaluating constantly, which could create additional stress that may not have existed before." (Senior Director of Blockchain Product Management, Oracle)

Challenges in aligning the visions of stakeholders. An enterprise blockchain network usually hosts diverse stakeholders with different sizes, strategies, and willingness to pay for a new technological solution. It can be difficult to agree on issues such as what resources to contribute, what data to share, and who bears the initial cost.[37] Therefore, it is important to understand the bottom line of every stakeholder and find a way to compromise and reach a consensus:

> "Sometimes we see that the participants cannot come to terms or agree on the basic principles. I think that's very important from the early days to focus on governance and ensure that the network is also operated in a way that allows everybody to have their voice heard, though in a business network there may be a different weight that each participant's vote carries. As to the failing consortiums we've heard about, I think there is a reason for that. You might have . . . disagreement in the approach among the leaders of the blockchain who were driving it." (Senior Director of Blockchain Product Management, Oracle)

> "It's very hard. Some of the projects are profit driven. If one invests so much money to develop a platform, they will need to monetize the users at some point, and there will be disagreements on the approach. The public blockchain protocols or cryptocurrencies have the same issue. When the protocol focuses so much on the price of the token, instead of the value creation for the ecosystem, it is very hard to align the vision." (CEO of GSBN)

Lack of viability in business models. A viable business model is sustained by a combination of conditions, such as technology, business, and regulatory factors. The adoption of an emerging technology requires new technological capabilities, top management support, a favorable market environment, and proven revenue streams. It is difficult to ensure that all these conditions are in place at the same time:

> "It isn't about the technology, but rather the business models and the teams put together to address the new business models that need a combination of regulation, legal, business model, and technology to succeed . . . Consortiums are a real business with a need for a sustainable business model as its foundation. Just like startups (which about 90% of startups fail), they don't fail because they don't have a 'product' that works, they fail because they lack customers and proven financial models, sales channels that create customer demand, don't have the right team, have regulatory and legal challenges that might take too long to overcome, and more." (Executive Director of Hyperledger Foundation)

> "I think if you look at blockchain networks, there must be two to three failures this year . . . In both cases, the reason why they failed is that there is no clear business model. If you don't have a clear reason to use blockchain, it's very hard to sustain it for more than two to three years. Because the investment will stop at some point, people will eventually ask, 'Why should I give you more money?' So, the more important thing, to me, is not to have the most members for the sake of membership fees. What is important is having compelling use cases." (CEO of GSBN)

Tech Logic versus Business Logic

Managers need to account for these business realities while translating attractive features from a tech logic into a business logic for real-world applications. Because of this, the same term relating to a technological feature may have a different meaning in a business context. We contrast the meanings of key terminologies—including consortium, decentralization, trust, and anonymity and privacy—in tech and business logics, respectively. This contrast draws out the different considerations in a technological as opposed to a business context.

Consortium. A consortium or federated blockchain is often the choice made by enterprises for business use. Nonetheless, some adopters tend to avoid this label for their blockchain network. To maintain the neutrality of the blockchain network among competing members, many blockchain-based entities choose to be set up as a non-profit organization. Some refer to themselves as an "initiative" or a "data utility" instead of consortium to avoid being related to a concentration of market players. The avoidance of the consortium label by business users shows the need for differentiation from centralized platforms. It also reflects the difficulty in governing network members who are in competition with each other, especially big industry players who do not want to be led by others:

> "We decided that it is better to be a not-for-profit. If you are for profit, there is a risk that the platform would be using its market power to capture value from the shipping lines and the terminals. People would just refuse to share their data. For instance, there are lots of debates in the United States right now, and the Federal Maritime Commission is assessing whether container lines are extracting too much value from the shippers with unreasonable fees because of supply chain disruption. The same thing can happen if a for-profit platform has all the data of the shipping industry and is perceived as having rent-seeking behaviors." (CEO of GSBN)

Decentralization. As a distributed network, blockchain is expected to delegate decision-making to peers in the network and disintermediate third parties in a transaction. However, in real-world applications, it is almost impossible to remove middlemen due to regulatory requirements. For instance, in the financial sector, intermediary banks are needed for anti-money laundering compliance. Moreover, not all members of the blockchain network are equal peers. In business networks, large multinationals often have a higher weight in decision-making than small and medium-sized enterprises (SMEs). These power

differentials mean that disintermediation and decentralization often cannot be fully realized in blockchain use cases:

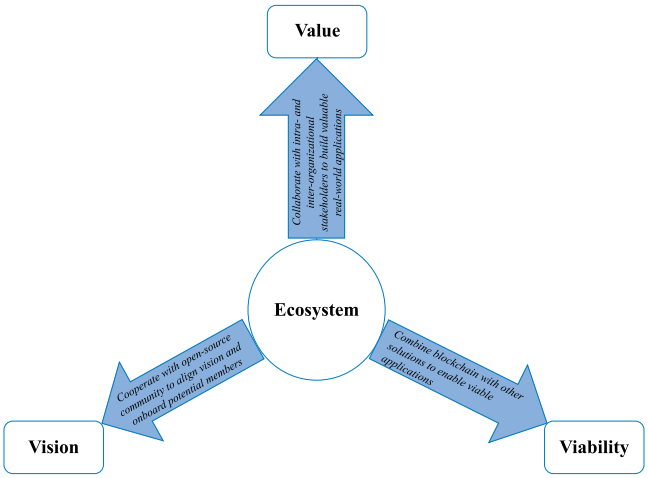
> "Basically, you cannot take decentralization to extremes. We get everything decentralized . . . It's a peer-to-peer network. And we kept it that way. But it's super hard to keep it that way. Because everybody is thinking centralized. You have to think peer to peer; everybody is equal. Not everybody is equal in the real world or in the digital space. But from the designer perspective, everything is equal." (Product Owner of Vinturas)

Trust. Blockchain has been hailed as the trust machine. It automates transactions through smart contracts and reduces reliance on human trust for regular business processes agreed between organizations.[38] However, trust-less inter-organizational transactions depend on the quality of data in blockchains.[39] Apart from applying technological solutions to tackle first or last-mile issues, managers also need to follow agreed standards, terminologies, and templates while sharing data on blockchains. They need to be aligned for the data scope and make sure all data are relevant and useful.[40] Moreover, blockchain cannot replace the trust needed for decision-making in inter-organizational relationships. Automating day-to-day inter-organizational business routines takes a high level of trusted business relationships in the first place:

> "When we talk about trust, there are many fine-grained elements to it at different levels. You could have general trust between companies, partners, and suppliers . . . there must be some level of trust between companies to get them to work together . . . Where blockchain can help is the level of ensuring that whatever policies are agreed upon between companies are enforced at individual transactions, they are essentially captured to the extent possible in the smart contract coding, implementations of business logic, and they can be automatically verified based on signatures and validity of input parameters. In the business logic and with reference to existing on-chain data, there are a lot of ways to validate updates or reconciliations automatically at the transaction level. That's what we mean when talking about algorithmic perspectives . . . There's a very different concept of trust at the business level." (Senior Director of Blockchain Product Management, Oracle)

Anonymity and privacy. One of the technological capacities of blockchain is allowing users to retain anonymity and privacy during transactions. While data can be encrypted on blockchain, it is not enough to meet regulatory requirements for privacy protection. In reality, organizations need to be selective about what data to store on blockchain. In general, personal data are kept off chain. Users can be anonymous on a blockchain, but they cannot escape national regulations. Real-world regulations on data sovereignty imply virtual-world data spaces scattered in different countries. Organizations may need to operate in individual national data spaces, such as hosting cloud and data centers within the physical borders of a country. These real-world constraints need to be kept in mind when considering the future:

FIGURE 2. A 3Vs framework.



> "The transactions do not collect private data. And, or if they do, it's a reference to data stored on an underlying database, so we can have that connection and achieve that GDPR (General Data Protection Regulation) requirement . . . and it's just the decision that is stored, not the actual underlying claims data, for example. So, at the very beginning of the design phase, we took advice from one of the biggest legal firms in Germany to ensure that we've built an appropriate GDPR-compliant solution right from the start. We wanted to be squeaky clean, so to speak, in terms of adhering to European regulations . . . Number One Recommendation is always having the lawyers in the room from the first day." (Global Head of Blockchain, Allianz)

Discussion: The Way Forward

There is no universal formula to design and implement successful blockchain projects, but we can learn some good practices from extant use cases. Based on comments from industry experts, we draw particular attention to the social aspects that determine the adoption of blockchain. Specifically, managers need to take an ecosystem approach to create value, align the visions of stakeholders, and build viable business models (Figure 2).

Realize Value Creation

Successful blockchain use cases take an ecosystem approach to value creation. Managers need to look beyond their individual organizations and explore ways to co-create tangible benefits for everyone in an ecosystem. For instance, managers can leverage blockchain as a shared ledger for several organizations to exchange and analyze data, improve operations, meet regulatory requirements, and create value for an entire supply chain. They can also use blockchain to realize cost savings by digitizing inter-organizational business processes, such

as automating validation, verification, and settlement of transactions, thus bringing efficiency to complex business operations requiring multi-party coordination.

Align the Visions of Stakeholders

It is always easier to onboard members for a blockchain network by starting from existing business relationships or ecosystems. There are several ways to bring different organizations together. For instance, demonstrating value created from successful projects with hard numbers on savings or showing benefits from collaboration at the ecosystem level (such as access to information shared by other players, and optimization of resources at the supply chain level):

> "Technology is actually not very hard. Aligning the visions of the different entities is probably the hardest part . . . all have different business goals, different strategies, and different [degrees of] willingness to invest in technology. One of the reasons that this job is interesting, but also very challenging, is to figure out the middle path that will be acceptable to the majority. You need to understand where the red lines are for everyone. You need to figure out the compromise to get things done." (CEO of GSBN)

There is also a certain order when onboarding participants of different sizes. In the initial phase, it may be wise to bring on relatively bigger organizations because they can be supportive with their business expertise and knowledge. With their higher influence in a market, they can help reach a critical mass for adoption faster. Medium and small-sized organizations usually lack the resources to adopt a new system or digitize, but they serve as important links in a business network. Managers need to provide practical options for the smaller players to join the network; for instance, let them use smartphones to capture and upload data (e.g., a picture) if they cannot afford IoT systems.

The adoption of blockchain requires aligning the vision of both internal and external stakeholders. It is always difficult to ask people to do things in a different way. When working with an emerging technology, the trials and errors can test people's patience. During the designing and implementation phases of a blockchain project, managers need to plan big, start small, collect feedback from stakeholders, and adapt along the way.[41] To onboard industry players, managers can work through existing common relationships, for instance, collaborating with an industry association. To connect to participants from other industries, managers need to work on the interoperability of blockchain networks so that they can communicate with those participants through networks of networks.

Managers also need to constantly educate potential participants and change mindsets, not just about the technology, but how blockchain can solve real-world problems through robust use cases. It's not just about digitizing, but also about how blockchain can change an entire underlying process and solve problems in a different way:

> "It's not just a technology product or a project that is highlighting the technology, you are solving a real business problem . . . We're in a constant state of education, changing mindsets around. You have to rethink problems when you use this technology. It's not just about digitizing the process." (Global Head of Blockchain, Allianz)

Enhance Viability in Business Models

It is essential to build a business model by tackling common business issues faced by network participants, specifically, a business model that makes collaboration among network participants attractive. A viable business model based on blockchain is often co-innovated or co-created by ecosystem members. It is a learning-by-doing process. While blockchain can be a disruptive technology, blockchain-enabled business models should stay close to common practice or what people are accustomed to, so that they are easily understood and adopted[42]:

> "The most important thing for a blockchain network to be successful, in my experience, is to look at what has been built before and what has not worked. The fundamental issue is never the technology. One needs to understand the challenges of the network participants. Through that lens, you will find the right business cases. You also need a business model that enables collaboration between a wide array of parties. You will never be able to solve all the problems by yourself, regardless of your size. A lot of blockchain consortiums underestimate the need for collaboration." (CEO of GSBN)

In some use cases, a blockchain network serves as an infrastructure that needs to be integrated by user applications. The pricing of services provided based on the blockchain infrastructure is critical to the adoption and long-term sustainability of a business model. The initial return on investment can be low. The early phase of operation may be less about profit-making and more about cost recovery. By attracting more users and increasing transactions, managers can amortize fixed costs and make higher margins.[43] Managers can also gradually build on extant solutions and offer more blockchain-enabled services by using data accumulated on blockchain differently and integrating business processes:

> "That's the beauty of digital . . . and the beauty of collaboration as well. Because you have more ideas in several heads than in one. And what we have seen is that each day we find new use cases, new opportunities, and also depending on the context; we really need to become agile and adaptable." (Former Blockchain Vice President, Renault)

Future Considerations

> "One thing I would suggest is to not blindly believe in every one-year or two-year old story you find online. Always make sure to check out the latest because it's a rapidly changing space. If you are reading something from a few years [ago] about blockchain, chances are it may not be accurate or at least not showing the whole story. The evolution in adoption in specific industries, the technology capabilities

> and limitations, and the line between public and permissioned networks—many of these have changed in the last couple of years. Stay current with the materials you are looking at and the sources you go to. It's a very rapidly evolving world." (Senior Director of Blockchain Product Management, Oracle)

Being a potential GPT, blockchain is still an *emerging* technology. The nascency and uncertainty about blockchain have both academic and managerial implications. We highlight the key considerations emerging from our study.

First, for this study, our analysis is only as good as the current information available. It would be useful to take a longitudinal approach when studying the real-world impact of blockchain. The primary data we collected from industry experts on blockchain infrastructure, service provision, and adoption helped update our knowledge gained from extant literature. For instance, we discovered that the cost of blockchain, compared with conventional execution and storage infrastructure, goes beyond business processes. There is an ecosystem cost that is much more of a concern to managers than software system costs. Apart from kick-off costs and operating costs, organizations need to bear the ecosystem costs, which include (but are not limited to) the time needed to adopt blockchain, change business routines by ecosystem members, hire new staff, and dedicate a team or department to blockchain adoption.[44]

We also highlight the technological dynamism of blockchain and the need for a more nuanced understanding of its practical implications. While publicly accessible and permission-only blockchains are maturing, scholars need to be careful about generalizing one blockchain's capability to another's. For instance, the "probabilistic guarantees about the recording of a transaction" found in public blockchains can be an issue for transactions for some organizations.[45] Organizations in the financial sector often turn to private blockchains to have a deterministic finality on transaction settlement because they need to know who owns the contract and the money.

Finally, there are still many uncertainties about blockchain's future development. Managers need to take an agnostic approach to choosing blockchain infrastructures and service providers. They need to keep an eye on technological improvements addressing issues faced by blockchain infrastructures, such as energy consumption, speed of transaction, and interoperability. They need to be flexible in choosing underlying blockchain infrastructures by prioritizing interoperability because if some blockchain shuts down in the future, they can still migrate to surviving ones. They also need to be pragmatic about service providers for data centers and hosting clouds due to changing national regulations on data sovereignty and cross-border data transactions.[46]

Conclusion

Unlike existing research on GPTs, which is mostly based on patent analysis, our study offers a holistic view on blockchain's characteristics as a potential

GPT (3Es) and discusses why they matter to managers (3Vs) in international business contexts.[47] We also point out the implication of blockchain as an emerging—rather than mature—GPT on business research and practices. We hope that the GPT perspective can help managers from the public and private sectors consider how blockchain can play a role in systemic innovation and tackling real-world challenges, such as Sustainable Development Goals. Albeit its potential to be a GPT, blockchain is just a technology: the business and social contexts should be prioritized. One should always start with the business problems, not the technological solutions.

Author Biographies

Juan Du is a Business School Research Scholar and PhD candidate in International Business at the University of Sydney (email: juan.du@sydney.edu.au).

Bo Bernhard Nielsen is a Professor of Business Strategy at the University of Sydney and an Adjunct Professor at Copenhagen Business School (email: bo.nielsen@sydney.edu.au).

Catherine Welch is Chair of Strategic Management at Trinity College Dublin in Ireland, a Distinguished Visiting Professor at Aalto University in Finland, and an Honorary Professor at the University of Sydney in Australia (email: welchc@tcd.ie).

Author's Note

Bo Bernhard Nielsen is also affiliated with Copenhagen Business School, Denmark.

Notes

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34. Layer 2 refers to a layer of separate framework or protocol built on top of Layer 1 chains, or main chains such as Ethereum, to improve transaction speed and enhance scalability. Layer 3 often refers to the layer of protocol that hosts decentralized Apps.
35. This information is based on observations of member organizations of the Enterprise Ethereum Alliance and the Hyperledger Foundation.
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37. *Ibid*.
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