# Blockchain for Intelligent Grids Management: A Case Study for Various Projects and Initiatives

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## Abstract:

This article aims to integrate emergent blockchain technology with Intelligent Energy Management. The goal of this survey is to discuss the necessity of applying blockchain in different components of smart grids as well as Intelligent Energy Management, identify the challenges encountered by current solutions, and highlight the frameworks and techniques used to integrate blockchain with Intelligent Energy Management. The study is primarily based upon the secondary data. For this extant literature related to the topic from different databases, websites and other available sources were collected. To answer the research questions, a literature review was conducted. The articles were selected from evidence-based scientific databases such as Emerald, Sage Premier, ScienceDirect, Springer Open, and Google Scholar. we searched relevant literature using specific keywords, e.g., “Blockchain Technology,” “smart grids,” “Intelligent Energy Management,” “Electricity Distribution”. seventeen scholarly articles were selected by using exclusion and inclusion criteria and screening the relevant articles.

**Keywords: Blockchain Technology; smart grids; Intelligent Energy Management; Electricity Distribution.**

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## 1. Introduction:

Over the years, the use of emergent digital innovative technologies, through telebanking, online and mobile banking and fintech, has contributed towards offering new experiences. In this regard, convenience, availability, speed, efficiency, effectiveness and transparency of banking and financial processes have enabled the sector to tackle some of the common challenges associated with facilitating transactions across various sectors (Peters and Panyi, 2016). The emergence of blockchain technology has been heralded as the next revolution that will transform the shape and size of the banking and finance industry and the way business transactions are conducted (Ceremeno, 2016). Blockchain technology is focused on having an open, universally accessible decentralized ledger for establishing trust in an unsecured environment without relying on a third party. The ledger contains the shared and agreed-upon state of the blockchain, including a list of all past transactions that are immutable. Moreover, it can also be utilized along with other technologies, such as encryption, business rules and identity management, in order to make such technology fit for the challenges at hand (van Engelenburg et al., 2018).

Blockchain technology offers the opportunity to help in enhancing issues surrounding transparency, trust and privacy for relevant stakeholders. Nonetheless, as much as blockchain has brought opportunities for organizations, it is pivotal to realize that there will be several challenges and complexities across technical, regulatory and adoption-related areas. Recent events such as digital currency theft and cybersecurity breaches have demonstrated the high-level of risks related to the use of blockchain technologies in banking and finance.

## 2. Research questions:

This article focuses to answer the following questions:

- What is the meaning of the blockchain technology and how it works?
- What are the main characteristics and benefits of the blockchain technology?
- What is the meaning of the smart grids?
- How do blockchain technology applications work especially for Intelligent Energy Management and why is it important?

## 3. Research objectives:

This paper focus to:

- contribute to facilitating the successful adoption and application of the blockchain technology.
- outline blockchain's concept, benefits as well as challenges of the technology in the context of Intelligent Energy Management.

## 4. Methodology:

The study is primarily based upon the secondary data. For this extant literature related to the topic from different databases, websites and other available sources were collected. A systematic review of the collected literature was done in detail.

## Literature Review:

### 1. Blockchain Concept:

The blockchain concept can be defined as "shared, distributed ledger that facilitates the process of recording transactions and tracking assets in a business network. An asset can be tangible a house, a car, cash, land or intangible like intellectual property, such as patents, copyrights, or branding." (Gupta,2017). This ledger information operates with encrypted data to implement identification, authentication, and authorization of access to information. Integrity and trust on data, which is in the information systems, is the main objective of blockchain technology. Blockchain is a technological tool to comply with data integrity, in terms of its completeness, correctness, and free of contradiction, in distributed software systems. Distributed software systems are a number of independent computers that cooperate with each other in numerous informational transactions, without having a centralised computer to control or monitor those transactions. In a centralized system, only one computer can control all the information occurred in a specific context or network. In our everyday life economy, we know that transactions should not be on only one computer to prevent fraud risk, but rather in multiple computers. For this reason, companies use decentralised information systems. Within this decentralised system, ownership of information must be authenticated, the ownership proof has three elements: (1) the identification of the owner, (2) the identification of the object being owned, and (3) mapping the owner with the correspondent object. This object and the mapping to its owner is

maintained in a ledger, corresponding to a proof of ownership. Next figure represents the ownership concepts used to certify and proof property.
Blockchain means different things to different background people (Gupta,2017). For some authors blockchain is defined as a data structure, for others is an algorithm, for others can be defined as a suite of technology, and even for others blockchain can be a group of systems that communicate peer-to-peer within a common application area (Drescher ,2017). Drescher (2017) defines blockchain as a distributed ledgers system, which uses an algorithm for computers to communicate with each other with cryptographic and security technologies to achieve and maintain data integrity.

In October 2008, Satoshi Nakamoto published a paper where he introduced the concept of a decentralised trustless peer-to-peer digital currency called Bitcoin, the first cryptocurrency, that was not issued and backed by a central authority, but by automated consensus among networked users (Nakamoto,2008). The backbone of Bitcoin is the blockchain technology, a distributed ledger which contains the details for every record processed since the very first one. The validity and authenticity of each transaction are protected by digital signatures resorting to cryptography, thus the denomination cryptocurrency. To understand better, it is necessary to comprehend how the cryptography on the bitcoin blockchain works. Digital signatures are produced by using hash functions and encrypted resorting to a private key. This key is used to authenticate and authorize transactions in the bitcoin network, confirming the ownership of the bitcoins in each address, which identifies senders and receivers of transactions. The public key is used in the creation of bitcoin addresses by a digital application known as wallet (Martins,2018). From a user perspective, in a transaction, the sender must know the address of the receiver and inputs merely the desired amount to transfer.

## 1.2. How Blockchain Works:

Here are five basic principles underlying the technology.

### 1.2.1 Distributed Database:

Each party on a blockchain has access to the entire database and its complete history. No single party controls the data or the information. Every party can verify the records of its transaction partners directly, without an intermediary.

### 1.2.2 Peer-to-Peer Transmission:

Communication occurs directly between peers instead of through a central node. Each node stores and forwards information to all other nodes.

### 1.2.3 Transparency with Pseudosymmetry:

Every transaction and its associated value are visible to anyone with access to the system. Each node, or user, on a blockchain has a unique 30-plus-character alphanumeric address that identifies it. Users can choose to remain anonymous or provide proof of their identity to others.

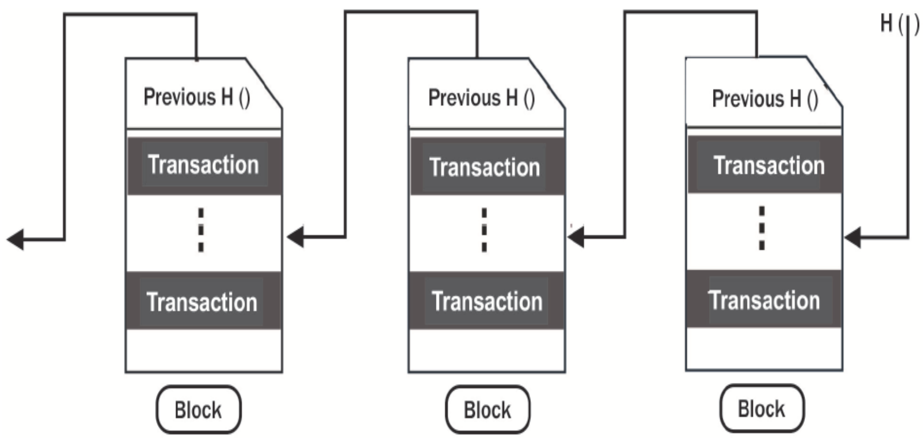
### 1.2.4 Irreversibility of Records:

Once a transaction is entered in the database and the accounts are updated, the records cannot be altered, because they're linked to every transaction record that came before them (hence the term "chain"). Various computational algorithms and approaches are deployed to ensure that the recording on the database is permanent, chronologically ordered, and available to all others on the network.

### 1.2.5 Computational Logic:

The digital nature of the ledger means that blockchain transactions can be tied to computational logic and in essence programmed. So, users can set up algorithms and rules that automatically trigger transactions between nodes (Tapscott,2017).

**Ficure01. The formation of the blockchain**




**Source: (Tapscott,2017)**

### 1.3 Characteristics of Blockchain:

A blockchain is characterized by censorship resistance, immutability and global usability, and has a global network of validators called miners, who maintain it through block rewards, named crypto tokens.

the creator of Ethereum, states that decentralization assures fault tolerance, attack resistance and collusion resistance. Also, that blockchain is decentralized on two of the three possible axes in software decentralization (Holotescu,2018):

- politically decentralized - meaning that no one controls it;
- architecturally decentralized - no infrastructural central point of failure exists;
- logically centralized - there is one commonly agreed state and the system behaves like a single computer.

Anyone has the autonomy to access a blockchain, to download a copy and play a role in maintaining the blockchain, thus that computer becoming a node. The copy will be actively updated along with every copy on every other node, edits can only be made to the blockchain with general consensus among the individuals running a node.

The process of adding a new block (containing thousands of transactions) to a blockchain, by hash verification procedures, is named mining. The new block is linked to the last one in blockchain. Each blockchain starts with the genesis block, containing its settings.

The advantages of the blockchain technology are the following (Holotescu,2018):

- self-sovereignty - users identify themselves and maintain control over the storage and management of personal data;
- trust - the technical infrastructure offers secure operations (payments or issue of certificates);
- transparency and provenance - to perform transactions in knowledge that each party has the capacity to enter into that transaction;
- immutability - records are written and stored permanently, without the possibility of modification;
- disintermediation - no need for a central controlling authority to manage transactions or keep records;
- collaboration - ability of parties to transact directly with each other without the need for third-parties.

The main drawbacks are the high consume of hardware, energy and time needed for the mining process, also the fact that the technology is complex and difficult to understand. Moreover, the plethora of development platforms in continuous release and the novelty of associated languages still keep the blockchain implementations as appanage of geeks, similar with sending e-mails using line commands at the beginning of web (Holotescu,2018).

Thus more friendly GUIs and tools are needed in order blockchain to enter in mainstream. blockchain needs to overcome its usability problem in order to impact on the everyday lives of people. The usability and understanding issues make blockchain be the one least heard about, as concluded by the "Trust in Technology" study.

Greenspan (2015) listed specific conditions to be met in order to implement a decentralized solution, thus avoiding "pointless blockchain projects": needing shared databases with multiple writers, having interactions between transactions, operating with an absence of trust, and without the need of a trusted intermediary; for the other cases a regular database (Oracle, SQL Server, MySQL, Postgres or NoSQL) should be used (Holotescu,2018).

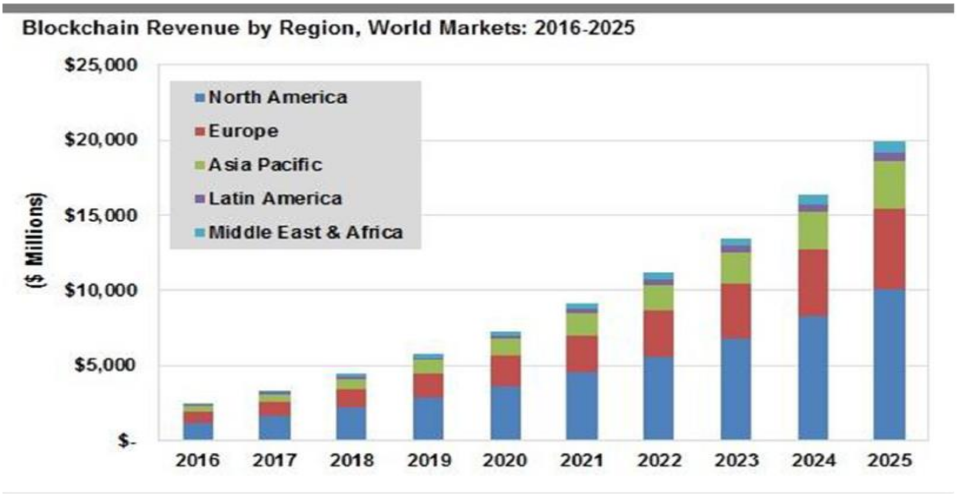
Some aspects to be considered when designing blockchain products are (Atchley, 2018):

- engaging target users in interviews, surveys and usability testing, designing for trust: transparent product's information architecture, which is critical to acquisition, retention and building trust;
- visual consistency: clear visual style, familiar terms, flow and functions for product interface;
- constant and consistent feedback, active guidance to users because of the long duration of validation and confirmation transactions on a blockchain network (Holotescu,2018).

### 1.4 Benefits from Blockchain:

Blockchain, as discussed in the above section by virtue of its design and architecture, offers some inherent benefits which the industry has been looking for quite some time now. The distributed nature of Blockchain brings in a lot of transparency in processing and thereby reduces the need for manual verification and authorization. The key features of the Blockchain include following (Shah & Jani ,2018):

**Figure 02. blockchain revenue by region, world market :2016-2025**




**Source:** (Niranjanamurthy et al,2019).

**1.4.1 Near real time:** Blockchain enables the near real-time settlement of recorded transactions, removing friction, and reducing risk.

**1.4.2 No intermediary:** Blockchain technology is based on cryptographic proof instead of trust, allowing any two parties to transact directly with each other without the need for a trusted third party.

**1.4.3 Distributed ledger:** The peer-to-peer distributed network records a public history of transactions. The blockchain is distributed and highly available. The blockchain does not typically preserve the identities of the parties or the transaction data, only the proof of the transaction existence.

**1.4.4 Irreversibility & Immutability:** The blockchain contains a certain and verifiable record of every single transaction ever made. This prevents past blocks from being altered and in turn stops double spending, fraud, abuse, and manipulation of transactions.

**1.4.5 Smart Contracts:** Stored procedures executed in a Blockchain to process pre-defined business steps and execute a commercially/legally enforceable transaction without involvement of an intermediary.

### 1.5 Advantages of Blockchain Technology:

• **Disintermediation and trustless trade:**

Two social affairs can make an exchange without the oversight or intermediation of an outcast, solidly decreasing or despite massacring counterparty possibility.

• **Empowered clients:**

Customers are accountable of every one of their information and trades.

• **High quality information:**

Blockchain information is finished, reliable, convenient, exact, and generally accessible.

• **Process respectability:**

Clients can assume that exchanges will be executed precisely as the convention summons expelling the requirement for a trusted outsider.

• **Transparency and changelessness:**

Any sort of transactions whether modify or reversal can be shown to customers as all the transactions are permanent, which means they can't be adjusted or erased.

• **Faster Transactions:**

Interbank Transactions can possibly take days for clearing the cheques and demand drafts, particularly outside of working hours. With the use of Blockchain all interbank transactions are carried out within short span of time. Customers can use E-Banking, M-Banking and UPI etc for any sort of transactions even at home.

• **Lower exchange costs:**

By taking out outsider middle people and overhead expenses for trading resources, blockchains can possibly extraordinarily diminish exchange charges (Akram,2017).

## 2. Blockchain for Intelligent Energy Management:

### 2.1. Current Issues in Intelligent Energy Management:

Energy management is the general term for scientific planning, organization, inspection, control and supervision of the entire process of energy production, distribution, conversion and consumption. It can be roughly divided into supplier energy management and demand side energy management. In order to achieve intelligent smart grid management, a number of schemes have been proposed to analyze consumption data for building models. However, existing methods have poor scalability and require expensive computation for realtime and dynamic smart grids. In addition, traditional energy management has problems with centralized

storage, and hence is prone to single-point failures, which is easy to cause excessive waste of energy resources.
It turns out that solutions based on blockchain can implement effective management of electrical energy. They not only improve security of smart grids, reduce energy consumption and manpower, but also achieve higher scalability and decentralized design. These solutions can be further divided into two groups: effective electricity distribution and demand side management. For these two specific groups, we elaborate on the problems and technical characteristics of each solution. Finally, we conduct a comparative analysis on these solutions (Guo. et al,2022).

## 2.2. Effective Electricity Distribution:

The goal of energy distribution is to meet electricity demand, so as to achieve reasonable energy management. Tsolakis et al. (2018) establish a secure demand response platform based on OpenADR and blockchain. In this platform, OpenADR can make the equipment respond to peaks and troughs of electricity consumption, thereby reducing power consumption and realizing a reasonable energy distribution. In order to enhance robustness and realize supervision of the system, an information collection center is established in this system. a design an energy management platform for smart buildings, aiming to meet the user’s demand for renewable energy. At the same time, the authors conduct an experimental test based on Ethereum and employ smart contracts for automatic management and monitoring. The results show that this scheme is suitable in a distributed environment with high power consumption. Edmonds et al. propose an energy management platform for smart homes to address demand response. They make use of smart contracts and propose a privacy protection mechanism based on a private blockchain.
In addition to meeting demand response, effective energy distribution can optimize the entire energy system. In, AlSkaif et al. apply a distributed optimal power flow model to manage the local distribution network based on a private blockchain. On this basis, the authors propose an optimization algorithm based on ADMM (alternating direction method of multipliers), achieving more reasonable and efficient energy distribution. Similarly, to achieve cost minimization modeling, which is especially suitable for flexible appliance scheduling.
Many researchers utilize reasonable energy distribution to achieve load optimization in virtual power plants. Moreover, research works aim to realize

optimal management of energy costs. uses smart contracts to implement economic scheduling among the prosumers and protect the interests of each prosumer. Yahaya et al. propose a model based on smart contracts and the demurrage technology to optimize consumers' energy consumption as well as achieve a reasonable distribution of energy.

Blockchain also shows a great potential in managing renewable resources to uses smart contracts to achieve automation and transparent design. Lazaroiu et al. propose a price prediction algorithm to improve the accuracy of energy allocation. Experiments show that this scheme is particularly suitable for smart cities and prosumers. In addition, the main purpose of the scheme is to ensure the security and privacy of renewable energy in the energy management process. Kim et al. summarize the potential security risks when renewable energy sources join the traditional power grid distribution management, and propose to use blockchain to improve the management of the smart grid (Guo. et al,2022).

## 3. Current Projects and Initiatives:

For completeness of this research, we summarize current projects and initiatives that apply blockchain to smart grids.

**3.1 Russian Carbon Market (R.C.M)**. In response to the call for green energy, Russian company DAO IPCI employs blockchain technology to facilitate the business of local carbon industry companies. This platform is safe and open, and all nodes can monitor the data on the blockchain. In the implementation process, Hinprom takes the lead in experimental studies.

**3.2 Tanzania X-Solar.** The X-Solar project is provided by M-PAYG with the corresponding technical support. The purpose of X-Solar is to solve the power shortage problem in developing countries of Africa such as Tanzania. It can provide solar power monitoring, as well as transaction and payment functions based on the blockchain.

**3.3 Brooklyn Microgrid (B.M)**. In Brooklyn, the local power grid company (LO3) proposes to combine Ethereum with the smart grid and implement it locally. It allows residents to use solar energy to generate electricity and trade to obtain token rewards.

**3.4 Global Grid (G.G)**. Global Grid cooperates with a local Mexican developer to build a solar blockchain platform and a large photovoltaic grid. It is understood that this project also intends to expand to other renewable resource areas such as geothermal.

**3.5 De La Salle University Microgrid (D.L.S.U.M)**. This is a microgrid system constructed inside the De La Salle University. This system uses photovoltaic power generation, combined with the Qtum blockchain system for P2P transactions. The actual effect shows that the system can effectively realize the optimization of cost, environment, and safety.

**3.6 Solar Bankers (S.B)**. Solar Bankers is a distributed solar trading platform proposed by Singapore. In Solar Bankers, blockchain is adopted to guarantee the security and transparency of solar energy production and transaction processes. Users can obtain the digital currency SunCoin by trading energy.

**3.7 Rotterdam Heat Network (R.H.N)**. CGI & Eneco designs a heat energy trading platform based on Tendermint and conducts a field test in Rotterdam.

**3.8 Austria Grid Project (A.G.P)**. Grid Singularity is an Austrian energy trading platform. It has conducted experiments on the smart grid locally. It is implementing an open and secure distributed smart grid system.

## III. Conclusion:

We summarize the design goals, targets, and other blockchain related attributes of existing works discussed in this section. After reviewing the aforementioned blockchain-based solutions for smart grids, we obtain the following findings:

• The decentralized nature of blockchain facilitates efficient energy management in smart grids, including energy distribution and demand side management. Many solutions use blockchain to carry out distributed transformation of the smart grid so that it can adapt to the management of new distributed energy sources. Distributed management can realize the decentralization of management rights and solve the centralized management problems of traditional power grids, which can facilitate the conversion of consumers to prosumers.

• Most management solutions that combine blockchain and smart grids can realize effective demand response balance, entire system optimization, distributed storage management of resources, and overall market balance control.

• Some solutions are suitable for various application scenarios and have good universality. There are also solutions that target specific scenarios, such as smart home, prosumer, and outsourcing fields. Blockchain has played an important role in all these schemes.

• The multiple combinations of blockchain platforms and consensus algorithms provide a huge number of choices for various application scenarios. At the same time, some solutions even innovatively propose new blockchain platforms and consensus algorithms to perfectly adapt to their needs.

• Smart contracts and incentive mechanisms closely integrated with blockchain can effectively realize automated operations of a system, eliminate the intervention of third parties, and attract more users to join. Especially in the management of smart grids, smart contracts can give full play to their greatest advantages, eliminate hidden human hazards, increase system security, and reduce required costs.

• However, the biggest problem with most solutions is that they all ignore user privacy protection. They simply mention that their solutions can protect privacy, but do not provide technical details on privacy protection.

## IV. REFERENCES:

1. Akram, W. (2017). Blockchain technology: Challenges and future prospects. *International Journal of Advanced Research in Computer Science*, *8*(9), 642-644.
2. Antonopoulos, A. M. (2017). Mastering Bitcoin: Programming the open blockchain. " O'Reilly Media, Inc.".
3. Atchley, D. (2018). UX Design for Blockchain is still UX Design. tandem.ly Blog post. Online at https://medium.com/tandemly/ux-design-for-blockchain-is-still-ux-design-2a3e1dd15a99.
4. Bech, M., & Garratt, R. (2017). Central bank cryptocurrencies. BIS Quarterly Review, 55–70.
5. Bertani, T., Butkute, K., & Canessa, F. (2017). Smart flight insurance-InsurETH. Retrieved from http://mkvd.s3.amazonaws.com/apps/InsurEth.pdf
6. Caplen, B. (2018). Blockchain: Where it works, where it doesn’t. Retrieved from https://www.thebanker.com/Comment-Profiles/Editor-s-Blog/Blockchain-where-it-works-where-it-doesn-t
7. Casey, M. (2015). Nasdaq to provide trading technology for Bitcoin market place. *The Wall Street Journal*, 12 October. Accessed at http://www.wsj.com/articles/nasdaq-to-provide-trading-technology-for-bitcoin-marketplace-1427140006.
8. Cerme~no, J.S. (2016), “Blockchain in financial services: regulatory landscape and future challenges for its commercial application”, BBVA

Research, Madrid, Spain, available at: http://www.smallake.kr/wp-content/uploads/2017/01/WP_16-20.pdf.

9. Collomb, A., & Sok, K. (2016). Blockchain/distributed ledger technology (DLT): What impact on the financial sector? Digi world Economic Journal, (103).
10. Corradino, S. (2018). Stronghold launches first venture-backed USD token on stellar network. Retrieved from https://www.businesswire.com/news/home/20180717005365/en/Stronghold- Launches-Venture-Backed-USD-Token-Stellar-Network
11. Drescher, D. (2017). *Blockchain basics* (Vol. 276). Berkeley, CA: Apress.
12. Gatteschi, V., Lamberti, F., Demartini, C., Pranteda, C.,& Santamaría, V. (2018). Blockchain and smart contracts for insurance: Is the technology mature enough?. Future Internet, 10(2), 20.
13. Greenspan, G. (2015). Avoiding the pointless blockchain project. Online at https://www.multichain.com/blog/2015/11/avoiding-pointless-blockchain-project.
14. Guo, H., & Yu, X. (2022). A Survey on Blockchain Technology and its security. Blockchain: Research and Applications, 100067.
15. Guo, Y., & Liang, C. (2016). Blockchain application and outlook in the banking industry. Financial Innovation, 2(1), 24.
16. Gupta, M. (2017). Blockchain for DUMMIES.[Sl]: John Wi-ley & Sons.
17. Harsono, H. (2018). Bank-based blockchain projects are going to transform the financial services industry. Retrieved from https://techcrunch.com/2018/01/28/bank-based-blockchainprojects- are-going-to-transform-the-financial-services-industry/
18. Hassani, H., Huang, X., & Silva, E. (2018). Banking with blockchain-ed big data. *Journal of Management Analytics*, *5*(4), 256-275.
19. Hillsberg, A. (2018). Can blockchain technology impact banking? We analyse this important trend. Retrieved from https://www.comparethecloud.net/articles/can-blockchaintechnology-impact-banking-we-analyse-this-important-trend/
20. Ho, F. (2016).What blockchain actually means for the future of banking. Retrieved from https:// decentralize.today/what-blockchain-actually-means-for-the-future-of-banking- 4dd868d020cf
21. Holotescu, C. (2018). Understanding blockchain technology and how to get involved. *The 14thInternational Scientific ConferenceeLearning and Software for EducationBucharest*, *April*, *19*, 20.

22. Hughes, A., Park, A., Kietzmann, J., & Archer-Brown, C. (2019). Beyond Bitcoin: What blockchain and distributed ledger technologies mean for firms. *Business Horizons*, *62*(3), 273-281.
23. Iansiti, M., & Lakhani, K. R. (2017). The truth about blockchain. Harvard Business Review, 95 (1), 118–127.
24. Kawasmi, Z., Gyasi, E. A., & Dadd, D. (2020). Blockchain Adoption Model for the Global Banking Industry. *Journal of International Technology and Information Management*, *28*(4), 112-154.
25. Kovach, S. (2021). Tesla buys $1.5 billion in bitcoin, plans to accept it as payment. CNBC, February.
26. Lang, J. (2017). Three uses for blockchain in banking. Retrieved from https://www.ibm.com/ blogs/blockchain/2017/10/three-uses-for-blockchain-in-banking/
27. Lemieux, V. L. (2016). Trusting records: Is blockchain technology the answer? Records Management Journal, 26(2), 110—139.
28. Lund, J. (2018). Stable coins: Enabling payments on blockchain through alternative digital currencies. Retrieved from https://www.ibm.com/blogs/blockchain/2018/07/stable-coinsenabling-payments-on-blockchain-through-alternative-digital-currencies/
29. Luu, L. (2017). With blockchain, knowing your customer is more important than ever. Retrieved from https://www.forbes.com/sites/luuloi/2018/05/17/with-blockchain-knowingyour- customer-is-more-important-than-ever/#4da8e968559c
30. MacDonald, T. J., Allen, D.W., & Potts, J. (2016). Blockchains and the boundaries of self-organized economies: Predictions for the future of banking. In Banking beyond banks and money, edited by Paulo Tasca, Tomaso Aste, Loriana Pelizzon, and Nicolas Perony (pp. 279–296). Cham: Springer.
31. Maiya, R. (2017). How to be a truly digital bank. Journal of Digital Banking, 1(4), 338–348.
32. Marr, B. (2017). Practical examples of how blockchains are used in banking and the financial services sector. Retrieved from https://www.forbes.com/sites/bernardmarr/2017/08/10/ practical-examples-of-how-blockchains-are-used-in-banking-and-the-financial-servicessector/# f1b33831a116
33. Martins, P. (2018). Introdução à Blockchain. *FCA-Editora de Informática, Lda*.

34. Min, H. (2019). Blockchain technology for enhancing supply chain resilience. Business Horizons, 62(1), 35-45.
35. Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system.
36. Nasdaq.com (2015). Nasdaq launches enterprise-wide blockchain technology initiative. *GlobeNewsWire*, 11 October. Accessed at http://www.nasdaq.com/press-release/nasdaq-launches-enterprisewide-blockchain-technology-initiative-20150511-00485#ixzz3fkl5TZUa.
37. Niranjanamurthy, M., Nithya, B. N., & Jagannatha, S. (2019). Analysis of Blockchain technology: pros, cons and SWOT. Cluster Computing, 22(6), 14743-14757.
38. Patel, B. (2018). How can blockchain help with AML KYC. Retrieved from https://www. finextra.com/blogposting/15022/how-can-blockchain-help-with-aml-kyc
39. Peters, G.W. and Panayi, E. (2016), "Understanding modern banking ledgers through blockchain technologies: future of transaction processing and smart contracts on the internet of money", Banking beyond Banks and Money, Springer International Publishing, Cham, Switzerland, pp. 239-278.
40. Peterson, J., & Krug, J. (2015). Augur: a decentralized, open-source platform for prediction markets. *arXiv preprint arXiv:1501.01042*.
41. Pilkington, M. (2016). Blockchain technology: principles and applications. In *Research handbook on digital transformations*. Edward Elgar Publishing.
42. Sarnitz, A., & Maier, R. (2017). Blockchain in retail banking. Retrieved from https://www. bankinghub.eu/innovation-digital/blockchain-retail-banking.
43. Schou-Zibell, L., & Phair, N. (2018). How secure is blockchain? Retrieved from https://www.weforum.org/agenda/2018/04/how-secure-is-blockchain/
44. Shah, T., & Jani, S. (2018). Applications of blockchain technology in banking & finance. *Parul CUniversity, Vadodara, India*.
45. Shubber, K. (2015). Banks put aside suspicion and explore shared database that drives bitcoin. *Financial Times*, 14 October. Accessed at http://www.ft.com/intl/cms/s/0/51c07a78-61cb- 11e5- 9846-de406ccb37f2.html.
46. Tapscott, A., & Tapscott, D. (2017). How blockchain is changing finance. Harvard Business Review, 1(9), 2-5.
47. Tapscott, A., & Tapscott, D. (2017). How blockchain is changing finance. Harvard Business Review, 1, 2–5.

48. Tapscott, D., & Tapscott, A. (2016). Blockchain revolution: How the technology behind bitcoin is changing money, business, and the world. Portfolio: Penguin Random House.
49. Thomson Reuters. (2016). Thomson Reuters 2016 know your customer surveys reveal escalating costs and complexity. Retrieved from https://www.thomsonreuters.com/en/press-releases/ 2016/may/thomson-reuters-2016-know-your-customer-surveys.html
50. van Engelenburg, S., Janssen, M. and Klievink, B. (2018), "A blockchain architecture for reducing the bullwhip effect", International Symposium on Business Modeling and Software Design, Springer, Cham, pp. 69-82.
51. Walker, G. (2018). Is KYC using blockchain the answer for banks? Retrieved from https://blogs. thomsonreuters.com/financial-risk/financial-crime/kyc-using-blockchain-answer-banks/
52. WEF (2015) *Deep Shift: Technology Tipping Points and Societal Impact* [online] available from <http://www3.weforum.org/docs/WEF_GAC15_Technological_Tipping_ Points_r eport_2015.pdf> [13/05/2022].
53. Guo, Y., Wan, Z., & Cheng, X. (2022). When Blockchain Meets Smart Grids: A Comprehensive Survey. High-Confidence Computing, 100059.