Cryptocurrencies, Blockchain Technology and Sustainability

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Abstract

Satoshi Nakamoto is the name used by the presumed pseudonymous person or persons believed to be the inventor of cryptocurrency Bitcoin, came up with the concept of blockchain as a core component of it when published a white paper on "BitCoin: A peer to peer electronic cash system" in 2008, blockchain technology made its public debut. Bitcoin is generally considered the first decentralized cryptocurrency and since the release of it, over 6,000 altcoins have been created. Cryptocurrencies use decentralized control as opposed to well-known, traditional centralized digital currency and also central banking systems. The decentralized control of each cryptocurrency works through distributed ledger technology, typically a blockchain. Blockchain is a system that in which a record of transactions made in cryptocurrencies are maintained across several computers/servers that are linked in a peer-to-peer network. Blockchain based applications provides many opportunities to create a more sustainable world. This paper contribute to the discussion on future avenues for sustainability especially in terms of cryptocurrencies and blockchain based platforms and services.

1 Introduction

The global economy is not all sunshine and rainbows. Throughout the world, there are alarming warning signs that consumers and especially some countries are being overburdened with debt. In the financial crisis of 2008, the available alternative assets were gold, silver, and real estate but it is strange that bitcoin was born out of the financial crisis. Bitcoin offers an alternative to fiat currency. Bitcoin is not controlled by any person or any government, capital controls cannot be imposed, and it can be freely used across borders. 2008 Financial crisis has revealed the inadequacies of some of big institutions which were believed too big to fail, and has energized a loose coalition of entrepreneurs and information technology companies and startup companies try to reform and reinvent the current financial system (Olleros & Zhegu, 2016).

Virtual currencies namely cryptocurrencies are online payment systems that are not issued or backed by central governments like fiat money are one of the hottest topics in financial world. They are transferable digital assets, secured by cryptography. Almost all of them have been created by private individuals, academics, organizations or firms. Cryptocurrencies are digital alternatives to traditional paper monies. Bitcoin has emerged as the most successful cryptographic currency in history. Current cryptocurrencies, starting with Bitcoin in 2009, build a decentralized blockchain based transaction ledger, maintained through proof of work that also generate a monetary supply. Such decentralization structure has benefits, such as independence from national political control, but also significant limitations in terms of scalability and computational cost (Danezis, Meiklejohn, 2015).

The blockchain, the ledger technology that underlies Bitcoin, has huge implications for many industries. Blockchain consist of distributed database of records, or public ledger of all transactions or digital events that have been executed and shared among participating parties. Each transaction in the public ledger is verified via consensus of a majority of the participants in the network. Once entered, information can not be deleted, only insert operation is permitted. Blockchain architecture is similar to a distributed ledger that is consensually kept, saved, updated, protected, validated and can not deleted by any party involved in all the transactions within a public, hybrid or private network (Risius, Shoprere, 2017).

Blockchain technology has paved the way for disrupting different business industries over the world. It is known as one of the most significant technical innovations in digitalization of asset ownership. One of the important points is, the most impactful blockchain applications require tight collaboration between developers, incumbents, innovators, and regulators, adding complexity and delaying implementation (Wef, 2016).The decentralized nature of the blockchain makes cryptocurrencies theoretically immune to the old ways of government control and also it eliminates need for mediation (Rosic, 2016). Additionally, it is kind a financial tool that plays an important role in the sustainable development of the global economy. That's why this paper focuses on the emerging landscape for blockchain technology in terms of sustainability.

2 Rise of Cryptocurrencies

Cryptocurrencies, predominantly spearheaded by the Bitcoin, are unique instruments in the investing and finance world. It's obvious that cryptocurrencies are an important and rising element in today's digital economy. All digital currencies and Bitcoin are based on the idea of a distributed ledger trust mechanism called the "blockchain", a way of keeping track of trusted transactions in a decentralized way (Wef, 2015). Virtual assets such as Bitcoin are powerful financial tools which can transfer wealth immutably. Starting with Bitcoin, the blockchain technology has developed beyond a global payments system and started to also impact other areas, i.e access to finance, supply chain management, digital identities, smart contracts, health care, land registries or aid, through decentralized

applications. Unlike traditional banks, blockchain uses a distributed network of volunteer users (miners) from around the world to produce, record, monitor, and verify Bitcoin.

Cryptocurrency is an umbrella term used for all digital mediums of exchange that implement a cryptographic framework and security features. They have become the new business opportunities for investors across the globe. Cryptos are protected by technology that makes it impossible to expand the money supply by more than a predetermined algorithmic rate that is already known to the public. The cryptocurrency phenomenon traces its roots back to 1998. Nick Szabo has been involved in the crypto sector since the 90s, pioneering, among other ideas, the notion of “smart contracts” as well as designing BitGold. He proposed a system for a financial system that combines different elements of cryptography and mining to accomplish decentralization. These elements include timestamped blocks (information) that are stored in a title registry and are generated using "proof of work" strings. In 2008, an individual (or a group) published a paper under the name of Satoshi Nakamoto entitled “Bitcoin: A Peer-To-Peer Electronic Cash System” and this became the birth of cryptocurrency systems. It wasn’t until 2009 that developer Satoshi Nakamoto implemented the first blockchain. Bitcoin uses blockchain technology on a peer-to-peer network as a de-centralized ledger for all transactions (Url-1, 2019).

Cryptocurrency properties are listed below (Rosic, 2016).

- Irreversible: Transactions can not be reversed after confirmation.
- Pseudonymous: Neither transactions nor accounts are connected to real-world identities.
- Fast and Global: Transactions are propagated almost instantly in the network and are confirmed in a couple of minutes.
- Secure: A public key cryptography system keeps cryptocurrency funds. Only the owner of the private key can send cryptocurrency.
- Permissionless: There is no gatekeeper. It‘s just a software that everybody can download for free.
- Controlled Supply: All cryptocurrencies control the supply of the token by a schedule written in the code. Most cryptocurrencies limit the supply of the tokens. In Bitcoin, the supply decreases in time and will reach its final number sometime around the year 2140.
- No debt but bearer: Cryptocurrencies don‘t represent debts, they just represent themselves.

Version 0.1 of the cryptocurrency Bitcoin is released and includes a generation system intended to create 21 million bitcoins through 2040 (Zimmermani, 2016).The name of unknown inventor of Bitcoin is Satoshi Nakamoto. According to him, strict peer-to-peer version of electronic cash can allow online payments to be sent directly from one person to another without mediation that eliminates transactions going through a financial institution. The cost of mediation increases transaction costs high. Bitcoin does not have a mediation mechanism. Blockchain is one of a kind decentralized technology and distributed decentralized ledger that implements bitcoin architecture. Blockchain technology presents an innovative way of conducting all manner of transactions over the Internet. Introducing the blockchain environment will actually enhance the economics. Blockchain architecture enables all the transaction are recorded right from the manufacturer to the buyer.

In 2002, a Turkish academician Mr. Emin Gün Sirer in US at Cornell University implemented a peer-to-peer system protocol called “Karma”. It was a digital currency for peer-to-peer distributed systems. So, Satoshi is not the first one who held peer to peer system distributed concept and virtual currency. Starting in 2002, Emin Gün Sirer and his two students aim was to build one global currency, with no inherent monetary value, which could be used to download digital things by creating the first distributed mint based proof of work. The main problem in decentralization is getting consensus and difficulty of cooperation between different parties. They described three important characteristics that a system needs to have facilitating peer-to-peer networks (Mahler, 2018):

- **Distribution:** It must be completely distributed with no centralized functionality or trust;
- **Replication:** Account data needs to be replicated to insure against loss and tampering;
- **Coordination:** Coordination among the different replicas must be kept to a minimum.

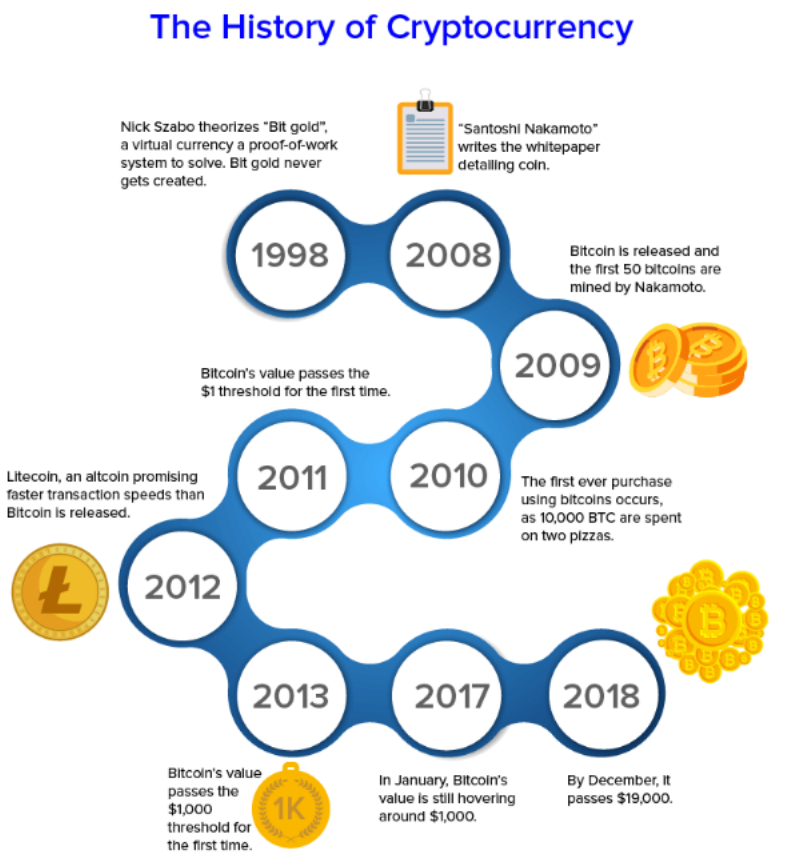

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Figure 1. *The History of Cryptocurrency Technology* ***Source: (****Url-2, 2018)*

Actually even known as 2009 is the year that Blockchain concept revealed, Blockchain was invented in 1991. It's history back to early 1990's by two researchers: Stuart Haber and W. Scott Stornetta who are co-inventors of the blockchain technology. Several aspects of the Bitcoin blockchain architecture are based on Stornetta's work. Haber and Stornetta worked on a cryptographically secured chain of blocks whereby nobody can tamper with timestamps of documents. Afterwards they upgraded block chain system to incorporate with Merkle trees that enhanced efficiency and performance thereby enabling the collection of more documents on a single block in 1992 (Url-3, 2019).

There are a lot of digital moneys developed since 2008. Cryptocurrencies have attained much attention from the financial and tech sectors and academics. According to coinmarketcap web site, total market capitulation is more than $247 billion. This is the list of most popular ones among 5403 coins are shown in Table 1:

Name	Symbol	Market Cap
Bitcoin	BTC	$160,451,968,735
Ethereum	ETH	$24,027,240,150
XRP	XRP	$9,972,159,875
Tether	USDT	$6,412,543,756
Bitcoin Cash	BCH	$4,727,872,384
Bitcoin SV	BSV	$3,842,732,871
Litecoin	LTC	$3,161,201,935
EOS	EOS	$2,764,461,241
Binance Coin	BNB	$2,064,696,186
Tezos	XTZ	$2,064,696,186

Table 1 : *Top 10 Cryptocurrencies by Market Cap* ***Source:*** *(Url-4,2020)*

Cryptocurrencies are challenging the traditional pillars of the financial system by seeking to provide a secure, fast, and frictionless means to store, spend, and move value. By the end of the decade, most tech startups will have a crypto component, just like most tech startup companies use increasingly the internet and take the advantage of artificial intelligence, machine learning and deep learning technologies today. Also more than a decade cryptocurrencies, bitcoin and blockchain has attracted extensive attentions from both industry and academia. By

shifting cryptocurrency from being primarily about trading and speculation to being about real world utility, the 2020s will see a huge increase in the number of people using cryptocurrency.

3 Development of Blockchain

Ever since January of 2009, blockchain technology has still been growing and evolving. It is widely accepted that the computational architecture of blockchain technology which is a distributed ledger technology creates a wide range of potential uses. A blockchain is a decentralized digital ledger that saves transactions on thousands of computers around the globe. In 2015, World Economic Forum Report states that around 10 percent of GDP by 2027 will be stored on blockchain and similar technologies (Wef, 2015). There is a wide spectrum of blockchain applications ranging from cryptocurrency, financial services, risk management, internet of things to healthcare, identity, insurance, real estate, supply chain, contracts, public, government and social services. The economic, political, health care, humanitarian, intellectual property and legal system benefits of blockchain start to make it clear that it is a potentially disruptive technology. Blockchain revolution can broke down into 3 categories shown in Table 3 (Swan, 2015).

Year	Blockchain Revolution Explanation
Blockchain 1.0	Currency (deployment of cryptocurrencies in application related to cash, i.e currency transfer, remittance, digital payments)
Blockchain 2.0	Contracts (entire state of economic, market, financial applications)
Blockchain 3.0	Applications (beyond currency, finance and markets- especially for government, healthcare, science, literacy, art and culture)

Table 2: *Blockchain Revolution Summary* ***Source:*** *(Swan, 2015)*

Also Swan (2015) lists 7 technical properties, challenges and limitations for the adaption of blockchain technology:

- **Throughput:** The potential throughput of issues in the Bitcoin network is currently maximized to 7 transactions per second. When the frequency of transactions in blockchain increases to similar levels, the throughput of the blockchain network needs to be improved.
- **Latency:** To create sufficient security for a bitcoin transaction block, it takes currently roughly 10 minutes to complete one transaction. To achieve effective security mechanism, more time has to be spent on a block, because it has to outweigh the cost of double spending attacks.
- **Size and Bandwidth:** There is a limitation in the number of transactions that can be handled (on average 500 transaction in one block). If the blockchain needs to control more transactions, the size and bandwidth issues have to be solved.
- **Security:** The current blockchain has a possibility of a 51% attack . If this occurs, a single entity would have full control of the majority of the network's mining hash-rate and would be able to manipulate blockchain. To solve this issue, more research on security is necessary.
- **Versioning, hard forks, multiple chains:** A small chain that consists of a small number of nodes has a higher possibility of a 51% attack. Another issue emerges when chains are split for administrative or versioning purposes.
- **Usability:** The Bitcoin API is difficult to use. There is a need to develop a more developer and use friendly API for Blockchain.
- **Wasted resources:** Unfortunately bitcoin mining wastes huge amounts of energy. The waste in bitcoin mining is caused by the "Proof-of-Work (PoW)" effort. There are some alternatives in industry fields, such as "Proof-of-Stake (PoS)". With PoW, the probability of mining a block depends on the work done by the miner. However with PoS, the resource that is compared is the amount of Bitcoin a miner holds. The issue with wasted resources needs to be solved to have more efficient mining in Blockchain (Swan, 2015).

Blockchain technology differs from most existing information systems designs by including four key characteristics; decentralization, security, auditability and smart execution (Steiner and Baker 2015). In blockchain, an agent creates a new transaction. New transaction is broadcast to the network for verification and auditing by all parties in the system. Once the majority of nodes in the chain approve this transaction according to prespecified approved rules, this new transaction is added to the chain as a new block. A record of that transaction is saved in several distributed nodes for security. Meanwhile, the smart contract, as a critical feature of blockchain technology allows the performance of credible transactions without third parties' involvement (Saberi et al, 2018).

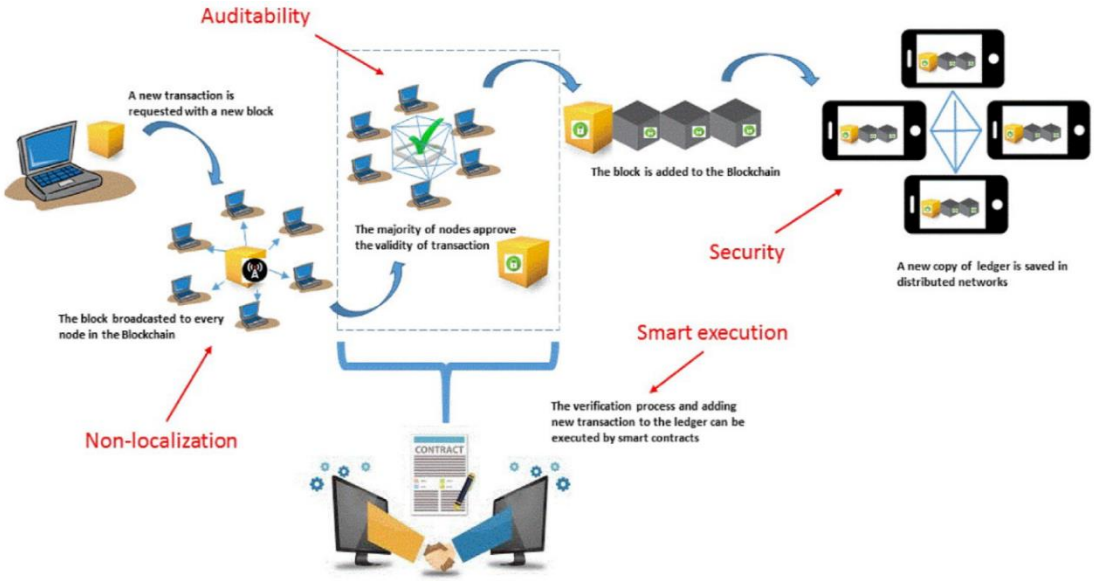

Figure 2. *Steps in Blockchain Information and Transactions.* ***Source:*** *(Saberi et al, 2018)*

Blockchain's distributed, decentralized system should turn out to be a more robust, trusted and reliable solution than is usually provided by a centralized authority to its stakeholders (Collomb, Sok, 2016). Blockchain technology is not limited to processing cryptocurrency transactions. Besides finance, from a supply chain perspective, such visibility will help ensure efficient transactions, while promoting food safety, efficient recalls, the elimination of counterfeits, and the assurance of ethical trading partners (Leblanc, 2019). Sustainability has been defined by the triple-bottom-line concept that includes a balance of environmental, social, and business dimensions when managing the supply chain (Seuring et al. 2008).

According to a research by PwC, it is listed that most effected sectors by blockchain's distributed ledger technology in 2018 (PwC, 2018).

Industry	Blockchain Involvement
Financial Services	46%
Industrial products and manufacturing	12%
Energy and Utilities	12%
Healthcare	11%
Government	8%
Retail and Consumer	4%
Entertainment and Media	1%

Table 3. *Industries Seen as Leaders in Blockchain,* ***Source:*** *(PwC, 2018.)*

4 Blockchain and Sustainability

Even if there are a lot of advantages of disruptive new blockchain technology, there are some issues such as energy consumption of Bitcoin mining need to be solved. In 2018, Bitcoin miners and other cryptocurrencies could require up to 140 terawatt-hours of electricity, about 0.6 percent of the global total which is more than expected power demand from electric vehicles in 2025 (Tomesco, Loh, 2018). Governance is another issue for Blockchain. Even if a blockchain can be permissionless, the core developers are making daily decisions on behalf of the other blockchain users. That′s why it is appropriate to understand that Bitcoin is actually decentralized (Gervais et al., 2014). Under the perspective of its being a driver of social change, bitcoins and related blockchain technologies might overcome the problems highlighted by numerous detractors.

Bitcoin has inherent scalability limit that tradeoff between throughput and latency (Eyal, et al., Sirer & van Renesse., 2016). Despite criticisms about illegal uses and social consequences, it is attracting the interest of the scientific community. Blockchain protocols face a significant scalability barrier and sustainability issues. Because of inefficiencies and protocol based problems, developers continue to implement new crypto coins and protocols such as Avalanche. For example, Emin Gün Sirer and his team developed 3 protocols called Snowflake, Snowball and Avalanche recently. They combine the best of Bitcoin's consensus with the best of classical. These are fast, efficient and less energy consuming ones compared to Bitcoin. They aim to solve non-sustainable proof-of-work mining problems of Bitcoin. Bitcoin itself is technically very hard and has some issues. It's incredibly limited in its scale and its performance and when the network is congested, throughput and latency will increase. With these new systems called autonomous blockchains, where two party can engage in secure communications and secure

data sharing without recourse to a public blockchain — without having to make any of the information public and without a private blockchain, either, without having to designate third-parties to hold their data (Casado et al., 2018).

Blockchain technology is not limited to cryptocurrencies transactions. There is a pilot project planned and initiated in Turkey, İzmir. Solar Bankers, an USA renewable energy company, wants to apply an energy efficient form of blockchain technology and elaborate solutions for off-grid electricity networks with the aim of helping developing countries expand rural electrification. Solar Bankers' de-centralized ledger system may enable individuals to trade energy amongst themselves without a utility company. Their system uses the highly scalable and efficient blockchain platform to create a virtual currency system for effective, high performance and secure electricity trading. The model is currently being tested in a pilot project in Izmir, Turkey and tested by Turkish company named Enerclever (Jost, 2018). The new system could allow remote areas in developing countries to better participate in the global economy in a sustainable way.

It is seen that, there are obvious efforts has been made by some companies such as IBM to prevent time-consuming activities. Last year in 2019, IBM developed a blockchain based supply chain verification network, named "Trust Your Supplier". IBM said that Trust Your Supplier is "designed to eliminate manual time-consuming processes and help reducing the risk of frauds and errors, creating frictionless connectivity across supply chains and designed to improve supplier qualification, validation, onboarding and life cycle information management." (Chitkara, 2019). Also there are promising outcomes of blockchain applications i.e sustainability, decreased environmental impact and better assurance of human rights and fair work practices. For human rights and fair work case, product history clear reports may help product buyers to be confident that goods being purchased are coming only from sources that have been recognized, trusted. Additionally, there has been a proliferation of internet of things and artificial intelligence applications that can automate big data collection and processing for use in blockchain platforms (Wef, 2018).

5 Conclusion

Blockchain, which is the base for a distributed and public ledger of the transactions, could foster new and challenging opportunities. Not only for cryptocurrencies, but also sharing the framework of medical data, energy generation and distribution in micro grids at the citizen level, may benefit from blockchain based transactions. The security of the blockchain depends on an algorithm which is compute intensive for bitcoin mining, that prevents double spending of bitcoins and tampering with confirmed transactions. Hence, more research is required to evaluate the adoption of blockchain technology for different business purposes. The important thing is that blockchain can be programmed to record not only financial transactions, but anything of value.

Blockchain technology has been hailed as the next disruptive leap forward in data sciences. Most legal scholarship related to the topic has mentioned its applications on finance, but it could revolutionize business supply chains. Especially, solutions implemented blockchains are expected to improve the reliability of data related to supply chains and to help businesses eliminate waste and harms to people and the environment. Moreover, experts trying to build new protocols, applications and more efficient cryptocurrencies especially in terms of processing power, electricity and energy consumption. Understanding the full implications of blockchain technology in the supply chain will require transdisciplinary efforts. System related issues of blockchain requires more focus in future research and effective technical solutions to address the scalability issues need to be more studied. The opportunities that blockchain offers need to be developed and governed wisely, with upfront and continual management of unintended consequences and downside risks. It is obvious that there is a substantial amount of work in this area for future research direction.

References

- Casado Vara R., Prieto J., De La Prieta F., Corchado J. M., 2018. "How blockchain improves the supply chain: case study alimentary supply chain", Procedia Computer Science Volume 134, Pages 393-398
- Chitkara, H., 2019. "IBM has introduced a blockchain-based supply chain verification network", https://www.businessinsider.com/ibm-cuts-costs-with-new-blockchain-network-2019-8?utm_source=twitter&utm_medium=referral&utm_content=topbar&utm_term=desktop&referrer=twitter
- Collomb A., Sok K. (2016). "Blockchain / Distributed Ledger Technology (DLT) What Impact On Financial Sector? ", Digiworld Economic Journal, No:103, third quarter, 93.
- Danezis G., Meiklejohn S., 2015. "Centrally Banked Cryptocurrencies", Cornell University Computer Science Cryptography and Security, https://arxiv.org/abs/1505.06895
- Eyal, I., Gencer, A. E., Sirer, E. G & van Renesse, Robbert, 2016. "Bitcoin-NG: A Scalable Blockchain Protoco". Proceedings of the 13th USENIX Symposium on Networked Systems Design and Implementation (NSDI '16), 45-59.

- Gervais, A., Karame, O. G., Capkun, S., & Capkun, V. , 2014. "Is Bitcoin a Decentralized Currency? ", IEEE S&P Magazine.
- Jost, A., 2018. "Renewable Energy Company Solar Bankers Uses Blockchain for Solutions in Sustainable Development", https://www.prnewswire.com/news-releases/renewable-energy-company-solar-bankers-uses-blockchain-for-solutions-in-sustainable-development-680338483.html
- Leblanc, R., 2019. "How Blockchain Will Transform Supply Chain Sustainability", https://www.thebalancesmb.com/blockchain-and-supply-chain-sustainability-4129740
- Mahler, T. A., 2018. "It's Karma", https://medium.com/blockwhat/03-it-s-karma-484fdc2d8657
- Olleros, F. X. & Zhegu, M. (Ed.), 2016. "Research Handbook on Digital Transformations", Edward Elgar Publishing.
- PwC, 2018. "Blockchain is here. What is your next move?", https://www.pwc.com/gx/en/issues/blockchain/blockchain-in-business.html
- Risius M., Shoprere K., 2017. "A Blockchain Research Framework: What We (don't) Know, Where We Go from Here, and How We Will Get There", Business & Information Systems Engineering, 59(6), 385-409.
- Rosic, A., 2016. "What is Cryptocurrency? [Everything You Need To Know!].", https://blockgeeks.com/guides/what-is-cryptocurrency/
- Saberi S., Kouhizadeh M., Sarkis J., 2018. "Blockchain technology and its relationships to sustainable supply chain management", International Journal Of Production Research, Volume 57- Issue 7.
- Seuring, S., J. Sarkis, M. Müller, and P. Rao., 2008. "Sustainability and Supply Chain Management – An Introduction to the Special Issue.", Journal of Cleaner Production 16 (15): 1545–1551.
- Steiner, J., and J. Baker., 2015. "Blockchain: The Solution for Transparency in Product Supply Chains.", https://www.provenance.org/whitepaper.
- Swan M., 2015. **Blockchain: Blueprint For New Economy**, O'reilly Media Inc.
- Tomesco, F., & Loh, T., 2018. "Bitcoin Could End Up Using More Power Than Electric Cars", https://www.bloomberg.com/news/articles/2018-01-10/bitcoin-outshines-electric-cars-as-driver-of-global-power-use
- Url-1, https://www.worldcryptoindex.com/blockchain/, Alıntı Tarihi: 05.04.2020
- Url-2, https://101blockchains.com/history-of-blockchain-timeline/#prettyPhoto, Alıntı Tarihi: 03.04.2019
- Url-3, https://appinventiv.com/blog/cryptocurrencies-market-trends/, Alıntı Tarihi: 20.04.2020
- Url-4, https://www.coinbase.com/, Alıntı Tarihi: 29.04.2020
- World Economic Forum (Wef), 2015. "Deep Shift Technology Tipping Points and Societal Impact.", http://www3.weforum.org/docs/WEF_GAC15_Technological_Tipping_Points_report_2015.pdf#page=24
- World Economic Forum (Wef), 2016. "The Future Of Financial Infrastructure An ambitious Look At How Blockchain Can Reshape Financial Services" https://www.weforum.org/reports/the-future-of-financial-infrastructure-an-ambitious-look-at-how-blockchain-can-reshape-financial-services
- World Economic Forum (Wef), 2018. "Building Block (chains) For A Better Planet"
- Zimmermani 2016. **The Evolution of Fintech** , The New York Times, https://www.nytimes.com/2016/04/07/business/dealbook/the-evolution-of-fintech.html.