# BLOCKCHAIN FOR DIGITAL TRANSFORMATION: A SYSTEMATIC LITERATURE REVIEW

Lappeenranta-Lahti University Of Technology LUT

LUT School of Engineering Science

Master's Degree Programme in Software Engineering and Digital Transformation

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ABSTRACT

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**Blockchain for Digital Transformation: a systematic literature review**

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Digital Transformation is an inevitable trend that covers all spheres of modern life and the deeper investigation of this phenomenon is relevant worldwide. The transition from old-fashioned strategies to new models increases business freedom, operational revenue and affects society living standards. Blockchain is one of the emerging technologies that have an incredible potential to transform the business.

Despite the technology dynamic development in all areas, its possibilities, advantages, and disadvantages have not been sufficiently explored. The study aims to conduct a systematic literature review on the Blockchain impact on Digital Transformation and synthesize all findings. Through a review of 39 empirical articles, some summaries are made relating to challenges and barriers from adoption, technological benefits, and the most promising spheres of digitalization. The number of successful use cases is limited, and this situation gives a broader perspective for conducting new experiments.

Meanwhile, sustainable development is not a plain trend but a strict requirement. The main capabilities of the Digital transformation and the impact on five sustainability dimensions (Economic, Social, Individual, Environmental and Technical) are concluded in a chart. As a result, open issues are identified which can be handled in future research. Based on the articles review, the theoretical framework is developed for academia and industries that want to learn more about Blockchain. The real-world example can help to adopt the technology considering possible limitations.

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I thank my parents for supporting me with every crazy idea and always believing in me. Any attempt cannot be satisfactorily completed without all people I've ever met. They guided, taught and helped me to become the exact person I am now. Life is not about being right. It is about making mistakes, falling down, being disappointed but regardless of all these factors always move forward.

Last but not the least, I would like to thank me for being me all the time. For being a learner and challenger, for being open to new possibilities and for never quitting. Because at the end we only regret the chances we did not take.

*Anastasiia Gurzhii*

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# 1 Introduction

Blockchain is a breakthrough technology, early adopters are sure about its indisputable advantages and claim that it can be implemented broadly (Getteschi et al., 2018). As an immature solution, all adopters should take into consideration if they can solve their problems with Blockchain, do they really need it as a panacea and finally to answer the question: "To Blockchain or not to Blockchain" (Getteschi et al., 2018). This research is aimed to answer this question. This chapter first discusses the background. Then it presents the research gaps and research questions. As a conclusion the structure of the thesis is presented.

## 1.1 Background overview

Digital Transformation is causing the evolution in our world and this process is ongoing (Parvianen et al., 2017). It is a current trend that affects various fields and industries. Companies are looking for innovative solutions and ideas on how to stay competitive and grab a market share. The transition to digital society includes a modification of the business processes, industrial enterprises activities, service providers, government agencies and financial institutions (Kraus et al., 2021). Several problems can be solved, and digitalization is no more just an opportunity, but a crucial requirement for all companies to meet all demands and expectations in the world with a continuously growing population (Kraus et al., 2021). Modern technologies contribute to more efficient work with data, processes improvement and the emergence of new governance approaches. To stay on track and run the business successfully, companies should interact with each other, collect data and learn from failed cases. Eventually, those changes will have a tremendous impact not simply on the business itself and companies, but on society (Teichert, 2019).

Companies adopt modern technologies and adjust them according to their operational targets and Blockchain or, in other words, distributed ledger technology is considered as a promising one and can be implemented in various spheres (Massaro, 2021). Despite the technology dynamic development in all areas, its possibilities, advantages and disadvantages have not been sufficiently studied. Some authors have tried to overcome those issues (e.g. Greenspan,

2015, Seppälä, 2016) and analyse criteria that make Blockchain more attractive to businesses. Meanwhile, all organizational changes lead to several difficulties (Deline, 2018) and not every amendment can be met with approval. Statistic data shows that 70% of technological initiatives fail (Barrett and Stephens, 2016) and it is almost impossible to predict the future of such changes.

## 1.2 Research gap and research questions

Blockchain has been around since 2008, but, to the author's knowledge, there are no studies that synthesize the role of Blockchain in relation to Digital Transformation and contain empirical data. While academia is focusing on the theoretical frameworks (e.g., L'Hermitte and Nair, 2020; Du et al., 2021; Ebinger and Omondi, 2020) and finding areas of Blockchain adoption, companies resolve local problems and propose solutions that cannot be implemented broadly (Mattila, 2016). Theoretically, Blockchain can be adopted in different spheres and it gains more attention worldwide (Bektenova, 2018), but the experts' opinions from industries should be studied as well. This can help to provide a better collaboration and fulfil the gap between academia and the real business world. To make Blockchain more attractive, technological awareness should be increased and different opinions should be discovered, whereas it could become a strong competitor to traditional systems in various fields.

Digital Transformation via Blockchain is possible when the proper data from different industries and successful real cases are collected, technological concepts are considered and Blockchain promising spheres, types, and consensus algorithms are determined. The practical significance of this work is the possibility to identify the most promising sectors, current situation, summarize challenges, barriers and perceived benefits mentioned by members of various industries and job positions or highlighted in reports.

Sustainability is regarded as the most important and valuable direction in every sphere of business environment establishment (Carter and Easton, 2011). While many researchers (Varriale et al., 2021; Alazab et al., 2021; Queiroz and Wamba, 2019; Lohmer and Lasch, 2020; Thiruchelvam and Bamiah, 2018) are focusing on one-three dimensions' maximum, the complete chart contains 5 dimensions which should be considered (Penzenstadler and Femmer, 2013). Consequently, there is a lack of proper knowledge about all sustainability

dimensions in one work, how the technology can evolve over time, what criteria have an impact and what requirements should be taken into consideration during Blockchain development.

The study does not contain Blockchain implementation steps from the technical point of view or frameworks on how to design the universal system that can fit every industry. Instead, this research is aimed to provide a systematic literature review (SLR) and to explain the main aspects of Digital Transformation via Blockchain, then collect empirical articles (methods of data collection are interviews, questionnaires, case studies, observations, surveys, audits, and experiments) with data regarding the mentioned gaps to answer 3 research questions:

Q1. What is the current Blockchain position in different spheres?

Q2. What are challenges and the current vision in the implementation of Blockchain technology?

Q3. How can Blockchain relate to sustainability dimensions during digital transformation?

## 1.3 Thesis structure

The thesis structure is represented in Figure 2. The need to conduct the SLR of the Digital Transformation and Blockchain is caused by the need to summarize empirical evidence from various fields and make conclusions about the current situation and future of the technology from the various fields' specialists' point of view or reports data. While the majority of SLRs are focusing on one direction (e.g., Konstantinidis et al., 2018; Shen and Pena-Mora, 2018; Tandon et al., 2020), this study contains evidences from different industries and Blockchain system reports, organized authors summaries, their limitations, recommendations and future improvements. Based on the articles review, the theoretical framework is developed for academia and industries that want to learn more about Blockchain. The real-world example can help to adopt the technology considering possible limitations.

The research begins with a description of the Digital Transformation and Blockchain technology itself, principles of operation, the main advantages and disadvantages in comparison with other emerging technologies. Results are systemized and contained empirical evidence. Finally, limitations with future research directions are identified.

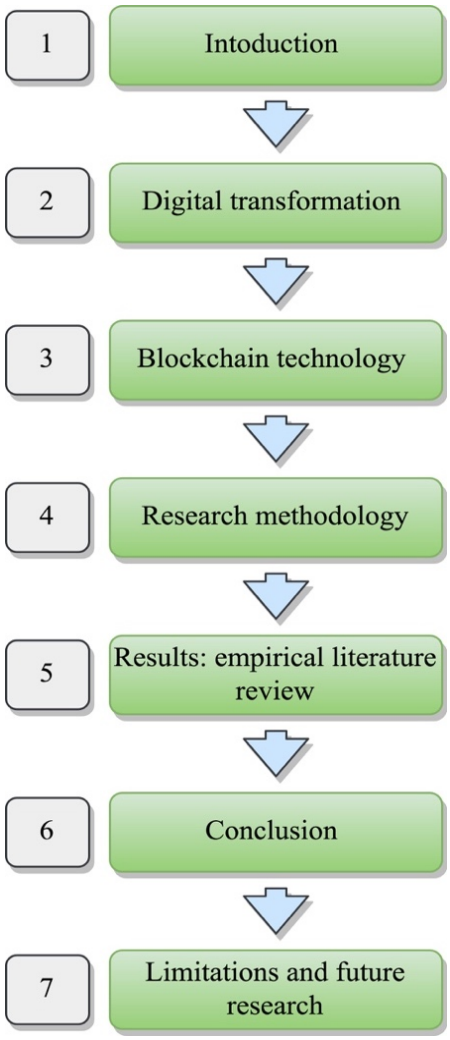


Figure 1. Thesis structure.

# 2 Digital Transformation

The main goal of this part is to describe the Digital Transformation concept, analyse different definitions and provide their explanation. It is important to understand not only a simple vision but to dig deeper into systems and technologies, that make digitalization possible. Moreover, theoretical aspects of the impact and sustainability dimensions in the developing world were defined.

## 2.1 What is Digital Transformation?

Even though we hear about Digital Transformation from everywhere, the definition is not clearly agreed upon by the researchers. Looking back to the 20th century, the ideas of technological perspective was defined in the 1990s and 2000s (Schallmo and Williams, 2018). Availability of computing systems for everyone was one of the prerequisites to transform not only business but also society.

Humanity has been through 3 industrial revolutions and the 4th one is ongoing. It is totally associated with Digital Transformation and characterized as fully automated processes, where all processes are controlled in real-time and in response to changing external conditions. The modern industrial revolution manifests itself in a growing symbiosis of industrial and technological innovation (Kurt R. 2019).

Gregory Vial in his research (Vial, 2019) analysed 23 exclusive definitions of Digital Transformation. Most of them are linked with business and organizational changes, but as a whole, they should relate to every sphere of personal and professional life. Some of them are listed below in Table 1.

Table 1. Digital transformation definitions

| Author | Definition |
|---|---|
| Matt et al. (2015) | Digital transformation strategy is a blueprint that supports companies in governing the transformations that arise owing to the integration of digital technologies, as well as in their operations after a transformation. |

| | |
|---|---|
| Nwankpa and Roumani (2016) | Changes and transformations that are driven and built on a foundation of digital technologies. Within an enterprise, digital transformation is defined as an organizational shift to big data, analytics, cloud, mobile and social media platform. |
| Kane (2017c) Kane et al. (2017) | The best understanding of digital transformation is adopting business processes and practices to help the organization compete effectively in an increasingly digital world. |

Sometimes people confuse the terms of Digital Transformation and Business processes reengineering (BPR) (Schallmo and Williams, 2018). The authors compared those 2 dimensions and stated, that BPR focuses on rule-based processes (fits for processes, where there is no need of human decision or it is minimized), while digital transformation focuses on creation a business value for customer and sustainability for society.

To conclude, it is possible to make a Digital Transformation definition as follows: it is a process that makes different functions optimization that previously seemed impossible to improve; expands scaling possibilities, increases work and production effectiveness without labour force magnification, regardless of the nature of business or production operations.

## 2.2 Enabling technologies of Digital Transformation

Digital transformation implies fundamentally the latest trends both in production and in realizing opportunities for customers. These advantages make it possible to solve many recent problems that place high demands on the reliability and manufacturability of production. Additionally, Digital Transformation affects businesses main activities, such as processes planning, modernization, planning tools, etc. (Venkateswaran, 2020).

There are a considerable number of emerging technologies implementation use cases and most of them are related to manufacturing and factories upgrade (Gundu et al., 2022; Weche and Wagner, 2021; Guo et al., 2021) or address primary features how to connect people with a machine using modern technologies and how to make a company more sustainable in the digital world (Venkateswaran, 2020). Besides, some authors point to the impact of Digital Transformation on the individual or society. Emerging technologies can surely change peoples' life and the technological summary is presented in Table 2 (Adapted from Woensel and Archer, 2015).

Table 2. Enabling technologies of Digital transformation

| **Technology** | **Explanation** |
|---|---|
| Big data | A common name for information flow, technologies, methods of its processing and analysis systems. Definition can be referred to the huge amount of data available to organizations, which, due to their size and complexity cannot be easily analysed. |
| Artificial intelligence | A computer systems ability to execute creative and intellectual functions that are considered to being processed by humans. This technology can be implemented in different spheres of everyday life. Year by year all AI becomes more complex and able to perform in a better, more intricate way. |
| Robotics | Technological solution that has a certain autonomy level and performs assigned tasks. Robots are quite promising branch of digitalization that can offer solution for big companies (manufacturing) or for individual usage (like vacuum cleaner). |
| Addictive manufacturing or 3D printing | A technology that allows you to create layer-by-layer physical objects based on a digital 3D model. It is worth noting that the possibilities of 3D printing are almost endless, the possibility to make anything. Nowadays this technology is popular in manufacturing in creating not too complex models due to the high price of the technology, but in the re, it may become commonly used in all spheres. |
| Augmented reality | This is a new term that denotes all kinds of options for introducing imaginary (virtual) objects into real space (for example adding virtual objects to the video image in real time). |
| Simulation and Virtual/ reality | It is an immersion in three-dimensional space created with the help of modern technologies. All computer games are created using this technology. |
| Cyber-physical systems | An integrated system that is created to receive data from the open environment and uses it to further control processes optimization (like smart cities concept, where the system contains computational and physical elements). |
| IoT | The technological concept of all things in the world to the Internet for remote control via software and data in real time (using a server or directly). |
| 5G & Multi-access Edge Computing | New generation of mobile connection, with a higher transmission speed. |
| Cybersecurity | It is an activity aimed at protecting systems, networks, and programs from digital attacks. During the current age, a lot of personal information is stored in clouds, so the main goal is to prevent cyber-crimes and provide data safety. |

| | |
|---|---|
| Digital twins | A digital (interactive) copy of a physical object, that is created to optimize business effectiveness. For example, a digital twin of a factory can simulate equipment layout, employee movements, workflows, and contingencies. |
| Virtual currencies | When the Internet emerged there were a lot of attempts to create an online payment system with an official rate, which can be equal to physical money. For now, this system becomes popular but still too expansive and complex to make it commonly available. |
| Cloud technologies | this is a service through which a user receives computing resources via the Internet (processor time, RAM, disk space, network connections), services or programs through the network and can use them for IT (Information Technology) solutions. |
| Machine learning | The technique when an information system solves a number of common problems independently of the human. |
| Blockchain | It is a continuous chain of blocks. Unlike standard databases, the information inside the system cannot be changed or deleted. About this technology, we will talk a bit later. |

## 2.3 Impacts of Digital Transformation

All technologies, that are mentioned in Table 2 are enablers of Digital Transformation and completely change the situation in the world (Ismail et al, 2017). It is shaping new markets and products, as well as influencing approaches to customer value creation. As an aftermath of Digital Transformation can be noted a growing interaction and digital transaction of businesses that include a various number of stakeholders (like clients, vendors, rivals, partners, etc.) and ecosystems formation (Farouk et al., 2020).

Digital Transformation affects three primary business dimensions: external (customer experience and interaction lifecycle improvement), internal (business processes, decision-making, and organizational structure), and an organizational (business segments and functions) (Ismail et al, 2017). Consequently, transformation is not an independent process, but an inseparable part of a corporate strategy, shaped with the help of classical strategic analysis tools and measurable goals. The decision to select and implement a technology should be based on the chosen solution deep analysis of conformity with main companies' objectives, commercial maturity, infrastructure and interested parties' preparedness (Tsenzhsrik et al., 2020).

At the same time, in another study the author defined 2 main levels that are affected by Digital Transformation (Vial, 2019): 1) organizational (operational efficiency and performance) and 2) higher level (societal & well-being and security & privacy). In this case, the Digital Transformation process relies on the quality of business enhancement strategy and current trends.

1) A lot of attention is paid to different systems implementation (Table 2) and their impact on the business (e.g., Jacobides et al, 2018; Cusumano et al., 2019). While some studies (Woensel and Archer, 2015) aimed to create a theory, an effective operating model of a particular company is still the principal element of successful strategy execution at the highest level (Morakanyane et al., 2017). It is the key to business growth and scalability, a guarantee of improved customer service and operational productivity and, in addition, it ensures sustainable development. As a result, it helps in improving operational capabilities and corporate flexibility.
2) The digitalization process affects all spheres of human lives and can cause both positive and negative impacts on society. Emerging technologies can induce a number of improvements, when they are implemented in everyday activities (Pramanik et al., 2016). Modern society got used to the majority of systems and take them for granted. At the same time, there is a considerable risk of related problems, among which is the lack of skills, security and trust, as well as resources constraints to manage and implement innovations (Bazarhanova et al., 2018). For example, in 2021 there is no doubt that almost every company is concerned about both their own and users' data privacy and pays a lot of attention to cybersecurity when conducting digitalization programs.

## 2.4 Digital Transformation Challenges

Digital Transformation does not happen without problems, false starts, and, sometimes, failures. Organizations that succeed in their Digital Transformation strategy lead the process iteratively. Changes take place in an evolutionary way, there is no obvious leap, just every year technological sphere is forced to change to meet the market and customer expectations (Mattila et al., 2016).

There are 10 main Digital Transformation challenges (Figure 2) (Gebhart et al., 2016). Nowadays, a lot of companies orient on customer needs and propose their own technological solutions. According to current trends, one of them can be program reusage, instead of creating something new from the scratch (Ochs, 2014). Regardless of the sphere, business owners want to adapt exciting solutions in compliance with their strategic goals and financial condition. That is why they are seeking for providers that can be flexible and are following new emerging disciplines or technological breakthroughs. Additionally, modern customers have more requirements for the final system, tend to be immersed in the development process, complete the implementation as soon as possible, but are not always completely aware of the reasons and system objectives.

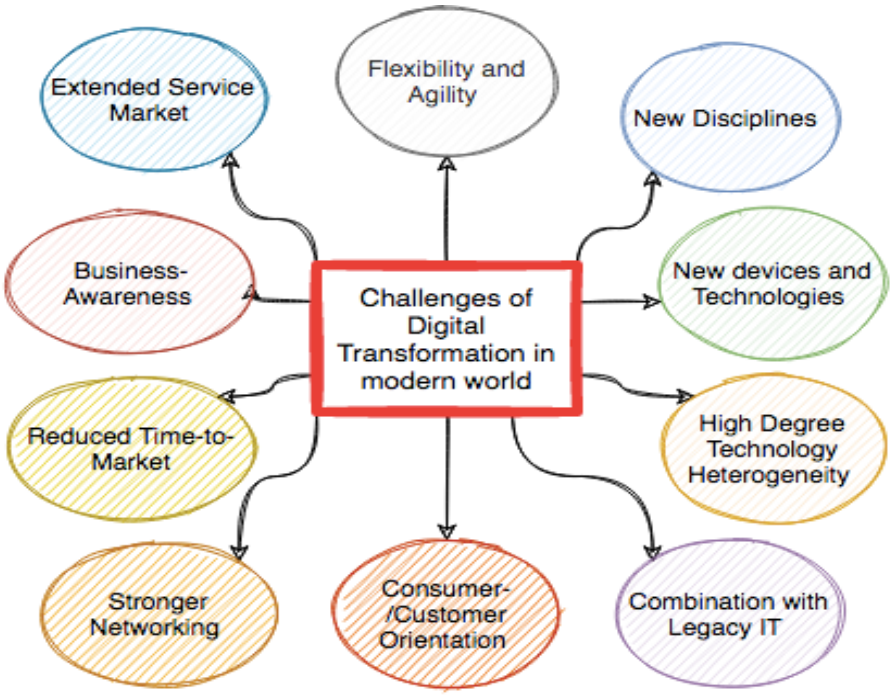


Figure 2. Challenges of Digital Transformation (Adapted from Gebhart et al., 2016).

At the same time, if changes happen too fast, there is a need to merge novel solutions with legacy IT and more powerful networks. Especially they are noticeable in big companies, where changes cannot be implemented rapidly (Berman, 2012). All solutions are aimed at satisfying society needs and improving their life. Frequently, new solutions should be in continuous development and the data is highly protected. Because of the new tools, environments, approaches it becomes more difficult to track whether a new product is used in an authorized way or not. To detect the actions of intruders in time and to prevent the

recovery of an expensive system after a cyber-threat, it is essential to think about a clear strategy and tools for continuous process monitor (Li, X et al., 2020).

Finally, lack of support and coordination from management, the absence of a single management body or lack of clear Digital Transformation concept management, leads to weak cross-functional interaction of units and low level of reformation (Gebhart et al., 2016). This jeopardizes the effectiveness of the entire Digital Transformation program, leads to delays in the project's timing and increases the cost of their implementation (Garther, 2021). At the same time, excessive planning slows down the process of change and reduces flexibility. Lean thinking, where some of the strict planning procedures are replaced by short experiments in the Agile-approach style, can help to combat this.

## 2.5 Dimensions of sustainability

Our world changes rapidly and sustainable development is not a plain trend but a strict requirement. A company develops steadily when it creates the business environment around itself, carefully treating resources, attracting investments, raising reputation, and changing the quality of people lives for the better.

The word "sustainable" is extremely common in different spheres, like business, everyday life activities, home, cities, economy and so on (Scoones, 2007). So, nowadays every business unit wants to produce products that can refer to this description. The most common sustainability definition is when it is connected with business processes (Schoorman et al., 2019). Meanwhile, it can be linked with IT investments, innovation payoffs and development plan proposals (Abraham Mohan, 2015). The transformation of a company should be proceeded by adapting its business models according to emerging technologies and remain competitive to stay on the market (El Hilali and El Manouar, 2019).

To proceed with those changes, dimensions of sustainability should be considered. There are 4 of them (Goodland, 2002): individual, social, economic, and environmental. However, Digital Transformation is a process that is inextricably connected with systems and technologies, so the fifth one, technological should be added (Penzenstadler and Femmer, 2013). Figure 3 shows the 5 dimensions of sustainability and levels of impact.

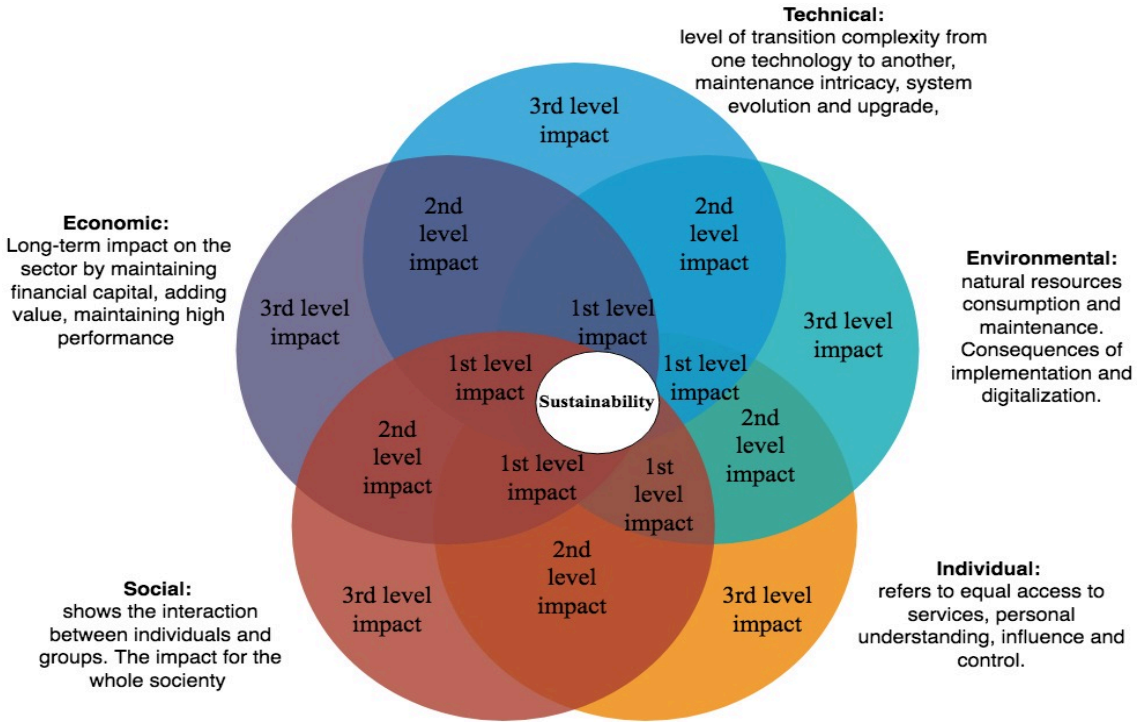


Figure 3. Dimensions of sustainability (Adapted from Goodland, 2002 and Penzenstadler and Femmer, 2013).

There are 3 levels of impact (Berkhout and Hertin, 2001): 1st level or immediate are direct effects of the technology and its usage. 2nd level or enabling are indirect effects of using the system in its application domain. 3rd level or structural effects that are linked with long-term predictions and future improvements over time.

The implementation of sustainable development strategies is no longer possible without the participation of transnational companies because they control about half of the world's industrial production. However, this does not mean that small companies should not be involved in this process. Representatives of small and medium-sized businesses can share their examples of gaining competitive advantage through the implementation of global goals in their activities via Digital Transformation.

# 3 Blockchain technology

In this part, major features of Blockchain are described. Some attention is paid to the technology definitions, key features, types, consensus algorithms, as well as pros and cons.

## 3.1 What is Blockchain?

Blockchain is a distributed database of records or a public registry of all transactions that have ever been made and transferred to authorized users. Every transaction should be verified by a major part of participants and once entered data cannot be erased (Crosby et al, 2016). In simple words, Blockchain contains a definite record of all digital activities have ever made. In general, the main prerequisite for the introduction of such technology is the lack of trust among the parties interacting in the process. This approach eliminates the forgery of documents and other fraudulent activities.

Blockchain is a kind of database that provides durable and tamper-proof data tracking and storing. All stored data are shared, replicated, synchronized, and stored by participants of the decentralized system, where each member has the data copy that can be checked and updated at the same time (Chang, Iakovou and Shi, 2020). Moreover, data protection and validation do not rely on third-party actors, and data blocks are organized through appropriate software, which allows data to be sent, processed, stored and displayed appropriately for all network participants (Kamilaris, Fonts and Prenafeta-Boldú, 2019).

Gartner is a company that gives an overview of different modern technologies and how will they evolve over time. According to the company's new curve for Blockchain, most cases will begin to have a meaningful effect on business development in 5-10 years. CIOs survey shows (the Gartner CIO Agenda Survey 2020) that about 60% of CIOs are planning to adopt Blockchain projects in the next 3 years, even though the effect on companies' business remains questionable.

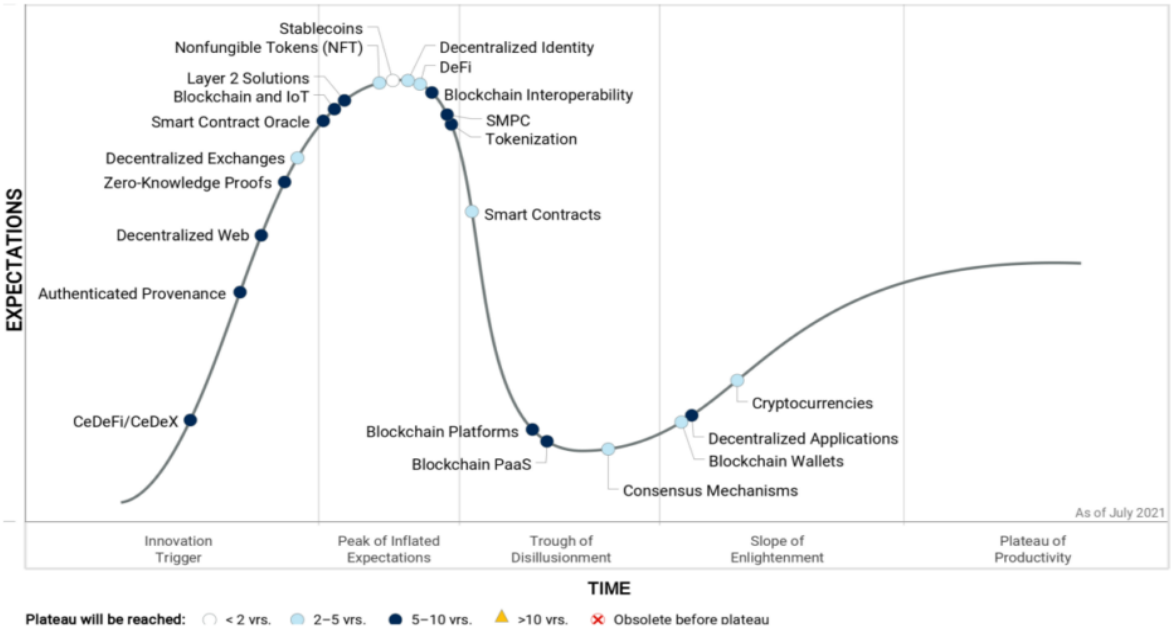


Figure 4. Hype cycle of Blockchain (Gartner, 2021).

The report shows that a lot of attention is paid to smart contracts and cryptocurrencies. Decentralized Blockchain applications are flourishing, but there are a few successful authorized corporate Blockchain projects. Users need to understand how new developments help to integrate corporate requirements with Blockchain innovations.

## 3.2 Blockchain types

There are 3 types of Blockchain, the characteristics of which are presented in Table 3 (adapted from Zheng et al, 2017). The described aspects are based on access to data in the system, viewing, downloading and supplementing them.

Table 3 – Blockchains types overview

| Aspect | Public | Consortium | Private |
|---|---|---|---|
| Consensus algorithm | All miners | Selected number of users | A single company |
| Permission to read | Everyone | Only allowed users | Only allowed users |
| Immutability | Almost impossible | Can be tampered | Can be tampered |
| Effectiveness | Low | High | High |
| Level of centralization | Decentralized | Partly decentralized | Centralized |
| Consensus | Permissionless | Permissioned | Permissioned |

- *Public Blockchain:* Any user can join a public Blockchain network (e.g., Bitcoin) and become a rightful system member. The disadvantages include high computing power requirements, low confidentiality of transactions and trust-related issues. These criteria are important when using Blockchain in corporate environments.
- *Consortium Blockchain:* several organizations may be responsible for such network administration. These pre-selected organizations establish access rights to perform transactions or access data. Blockchain consortium is an ideal solution for companies when all participants are authorized and collectively responsible for the system.
- *Private Blockchain:* The system is created for one company and is controlled by it. A private Blockchain network can reside behind a corporate firewall or even in a local environment. A new user can be added only through a direct invitation and the corresponding permission from the company. There are different levels of access to a private blockchain and information must be encrypted in order to protect privacy.

## 3.3 How does Blockchain work?

According to the name, the Blockchain is a chain of blocks that contain the data. Each block holds some input information and hashes of the current block with the hash of a previous one. The Blockchain objective determines what type of information will be stored inside the block (Salah et al, 2017). Figure 5 shows a typical Blockchain structure, where each block has its own unique number that is in order.

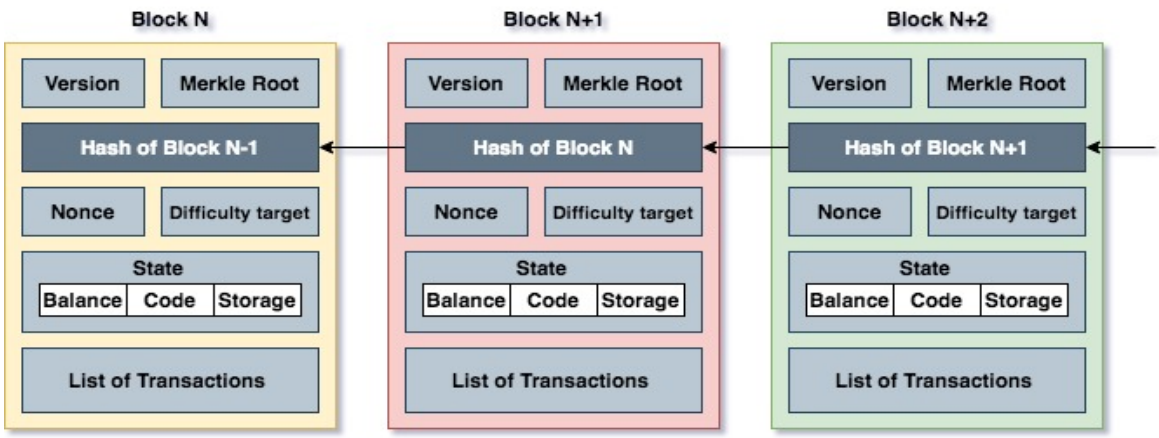


Figure 5. Blockchain design structure (Adapted from Salah et al, 2017).

Merkle root or Merkle tree is a complete binary tree, whose leaf nodes contain hashes from data blocks, and its inner nodes contain the sum of values in child nodes hashes. The root node of the tree contains hashes from the whole data set and is used to store transactions efficiently (Andrea, 2014). Changing the root, and therefore the hash of the block, will cause the system to consider it a completely changed block, and therefore it will not be validated (Buterin, 2014).

A hash identifies the block, all stored data and it is always unique. The hash is calculated at the time of block creation. A hash changes when any modifications are made inside the block. The third element inside each block is the hash of the previous block. All these features help to make Blockchain technology protected through the effectively created chain of blocks (Salah et al, 2017). Each member of the network tries to generate a hash value of the block header according to a given complexity, and to do this, the nonce number must change randomly and continuously until the header hash is equal to or less than the target hash (Zheng et al., 2017). The nonce, how it was described above, relied more on Bitcoin Blockchain. It may be used or not in other Blockchains or its usage may differ.

Difficulty target determines the complexity of the target hash, which means that the header hash must be smaller than this target (Lee et al., 2016). Shortly, it shows how difficult it is for the current goal to find a block, compared to how difficult it would be to achieve the highest possible goal (highest goal = lowest difficulty).

All transactions records are stored in the ever-growing chain, copies are available on multiple computers and the synchronization occurs according to formal Blockchain rules (Satoshi, 2008). Figure 6 shows an example of how transactions are added and validated by miners using the PoW consensus algorithm.

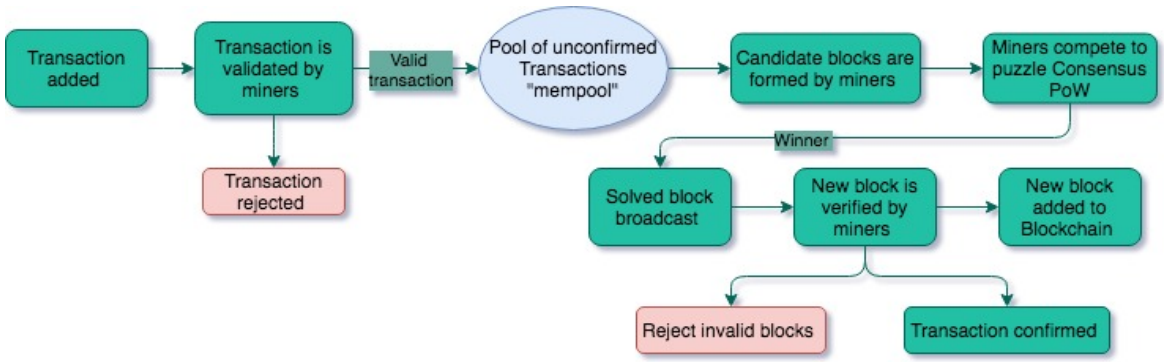


Figure 5. Block creation process.

## 3.4 Consensus algorithm in Blockchain

According to the whole concept, transactions are considered fully secure and validated on the Blockchain, while there is no central authority. It is possible because of the consensus algorithm that is the core component of a Blockchain system. It directly determines how the system behaves and what performance it can achieve. A consensus algorithm is a mechanism that helps to reach an agreement on a single value of data in the distributed system (Bano et al, 2019). There are some algorithms presented and Proof-of-Work and Proof-of-Stake are the most popular:

*Proof-of-Work (PoW):* In PoW, the miners must solve complex mathematical problems (hash functions) to confirm transactions and prevent others from spending the same coins twice. The miner that finds the solution first is rewarded with new network coins. At the same time, the complexity of mining protects the network from possible threats in the form of DDoS attacks. At least 51% of nodes should be controlled by users, who manipulate the data in the network. If the tasks were too easy, attackers could hack the network without any challenges (Gatteschi et al., 2018).

In PoW, mining is too energy intensive. Many nodes in the network compete, constantly performing complex calculations. According to Cambridge Bitcoin Electricity Consumption Index (CBECI), Bitcoin mining consumes more energy than countries such as Finland or Greece.

*Proof-of-Stake (PoS):* There is no mining in the PoS. Instead of solving mathematical problems, new coins are mined through stacking, a mechanism that allows new blocks to be added by proving ownership of the cryptocurrency of that network, which used to also be called foraging. In this way, the system can be compared to a bank deposit. The more coins frozen in the network, the higher the reward. For validators, this is an opportunity to earn passive income. The main disadvantage of the PoS algorithm is the threat of centralization. The validators with the most coins will end up controlling most of the network (Binance Academy, 2020d).

*Proof-of-Authority (PoA):* PoA is a consensus algorithm that considers "merit" and validator ratings. It is considered an efficient mechanism for private Blockchains, was first conceptualized in 2014 by Ethereum co-creator Gavin Wood and has been used for several

years in the Microsoft Azure cloud platform, which includes over 200 products and services. Thus, a fixed number of validators, which were selected by the network participants or the project developers, are responsible for the network performance. This approach guarantees high transaction processing speed and good scalability. However, validators have a vested interest in ensuring that their work is honest and transparent, otherwise, they will lose their status and reputation as a reliable network participant (Samuel et al., 2021).

## 3.5 Smart Contracts

To connect different parties in Blockchain "Smart contracts" were created. Smart contacts ensure the reliable execution of agreements formalized in software code between several actors involved (Kannengiesser et al., 2021). Unlike physical, smart contracts are completely digital. Such contracts once developed and deployed, are capable of self-execution and self-verification without human intervention. Some advantages in comparison with traditional contracts are reduced transaction risk, lower management and maintenance costs or more efficient business processes, as they are usually deployed on and protected by Blockchains (Yongshun Xu et al., 2021). This can allow any type of contract to be settled faster. The concept is new, has no duplicate and can simplify the interaction between business actors. This is one of the best advantages of Blockchain to this day because when there are no third parties, people can send money with minimal fees.

## 3.6 Key Features of Blockchain Technology

Unlike centralized repositories, distributed ledgers are inherently much better protected, because instead of a single database, they are multiple copies of the same data. Used methods to protect and update information mean that participants can share data and be always sure that all copies of the registry match with each other. Possibilities to run a business transparently through transactions, which can be identified as decentralized, anonymous, immutable, transparent and traceable (Lin and Liao, 2017). In detail, main Blockchain properties are:

- **Decentralization.** It refers to the processes of data handlings on the Blockchain (Cheng et al, 2018). Trust between users is built using not centralized organization

structure, but mathematical methods. In other words, all data manipulations occur in a distributed way without a third party involvement.

- **Anonymity.** Trust problem is a great issue in the business world, so every action, like transaction or data transfer, can be anonymous. Only a person's Blockchain address should be known (Lin and Liao, 2017). Thus, each party can have an address to interact with the network, and even different addresses can be used to hide their identity. Consequently, a central body does not contain private information.
- **Tamper proof.** The data is created and verified in a distributed way, and it is a key strength of Blockchain technology. Being decentralized by nature, it runs on different servers or nodes scattered around the world**.** When a miner generates a block, it should be confirmed by other users in the network. Additionally, all transactions are digitally signed, and a hacker needs a private key. That is why all manipulations and data falsification will be detected (Monrat et al., 2019).
- **Transparency and traceability**. The information is transparent because the transaction information is visible for every user, but at the same time, this data cannot be changed (Lin and Liao, 2017). All blocks are linked with each other, chronologically connected in the existing chain and each block relates to two adjacent blocks according to a cryptographic hash function.
- **Immutability**. All interfering's with transactions will result in different hash values and this activity will be noticed by all nodes that perform the same verification algorithm (Lin and Liao, 2017). Consequently, the unchanged data structure and clean function provide a transparent reference.

## 3.7 Blockchain Advantages and Disadvantages

The advantages are as follows (Cheng et al, 2018):

- All data will always be stored in the system, since they cannot be deleted from there, which is a big plus since often outdated archived data is lost. Each participant in the chain can access the data.
- All participants can trust each other.
- Absence of a supervisory authority. All participants in the chain are on a par with each other.

- Potentially, the technology will be able to unite all entities in one country / region / associations, etc., for more convenient access to data.
- Smart contracts and digital signatures for faster and more secure transactions.

But at the same time some barriers of adoption and disadvantages should be considered (Gatteschi et al.,2018):

- Currently, centralized structure is prevalent in various spheres with a lot of different platforms to integrate, infrastructure, that can't be controlled by all actors involved (or lack of partners agreed to connect).
- Scalability. The idea is to connect all citizens, but there is a great risk of system overload. For now, it is impossible to store a great amount of data. Slow mining process and data adding.
- It is not fully protected from cyber-attacks. There are cases of cryptocurrency theft, which can happen to user data. More serious methods of protection are required. Some use artificial intelligence for security purposes.
- Data replication requires space. Local copies of the Blockchain are stored on each node of the network. Therefore, performance is not yet comparable to databases.
- No regulatory base from the government and lack of engagement among citizens.
- Blockchain is energy consuming system, so realization is quite expensive.

Despite all the advantages that Blockchain can provide in comparison with a standard database, there are many obstacles to its implementation. At the very beginning, it is essential to accurately determine whether the system can solve the set of tasks and problems, as well as provide high ROI (return of investment).

# 4 Methodology

The aim of this part is to provide the understanding of the main concept of the research method used and its brief explanation. Then the used methodology, including goals, search key words, steps of data collection, evaluation, analysis and synthesis is presented.

## 4.1 Study design

The chosen research method for the current thesis is a systematic literature review. Such reviews are required to summarize the information to the efficient and productive Digital Transformation. However, the openness and availability of such reports are far from ideal. The utility of systematic reviews is diminished when they are poorly reported to industry specialists, Blockchain developers, policy makers and other possible potential users (Liberati et al., 2009).

For this thesis, a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method was chosen to carry out the research (Moher et al. 2009). A 27-item checklist and a four-phase flow diagram (Figure 7) make up the PRISMA statement. The checklist comprises things deemed necessary for transparent systematic review reporting. The aim of creating such a statement was the situation, where a work did not have a clear and succinct visual research design scheme. That is why the importance to establish a type of quality standard is vivid: unclear research logic cannot be shown as a scheme.

Firstly, in the current research articles were chosen using key words (section 4.2) and the papers were evaluated for relevancy after the records were pooled. After filtering through the research titles and abstracts, any publications that were not related to the subject of this study were deleted. The remaining pieces were fully reviewed to eliminate articles that were not essential for further evaluation. The data from the chosen articles were combined in a qualitative synthesis. To answer the research questions indicated in 1.2, the synthesis was completed by combining general article data, article findings, limitations and future study areas.

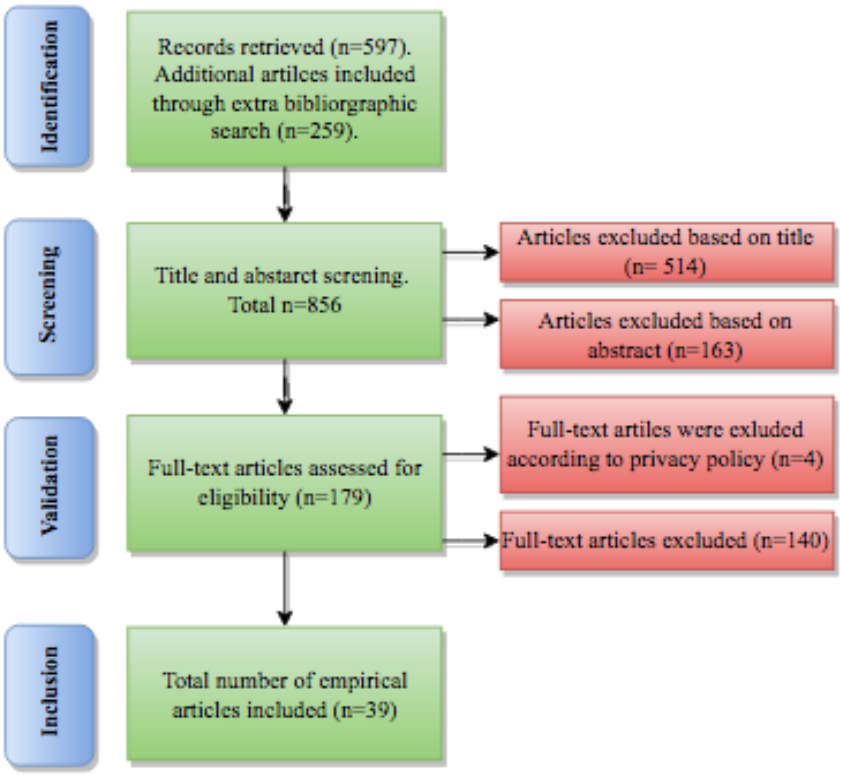


Figure 7. Scientific database search.

## 4.2 Goals and steps

The goal of this literature review is to provide a deep understanding of Blockchain, its impact on Digital Transformation in different industries and to generate a detailed summary of the current state along with problem's treatment in prior publications. The overall methodological plan includes the following steps (Adapted from Moher et al. 2009):

1. Provide the short review of the already known information relating to the topic. Identify the goal of the research, formulate research questions and develop the review time frames.
2. Identify the main points of the research, collect data through articles, take notes with key ideas of collected articles, synthesize the data and correlate to main dimensions of the research.
3. Analyse the data, compile the collected information into a single report, finalize the paper with conclusions, limitations and future research identification.

## 4.3 Search Keywords and conducting the search

Scopus was chosen as the main scientific database with key words (and substitutes) “BLOCKCHAIN”, “DISTRIBUTED LEDGER TECHNOLOGY”, “DIGITAL TRANSFORMATION”, “DIGITALIZATION” and “BUSINESS TRANSFORMATION” in article titles, abstracts and key words. Additional searches were also conducted with key words “EMPIRICAL”, “DATA ANALYSIS” and “CASE STUDIES”. Additionally, some Scopus refinement features were used: search for related documents for the main search and multiple article refinements. All proposed articles with titles, key words and abstracts were collected in a single document for further evaluation.

## 4.4 Data collection and evaluation

After the articles extraction inclusion and exclusion parameters were used to eliminate irrelevant papers (Table 4). Some criteria were used before the articles search to limit all results to scope (document type, access, language). The total number of articles found is 856 (Figure 7), including backward snowball sampling, which implies the process of screening the bibliographies of the papers in a review (Wohlin 2014). Then all articles titles were examined attentively. As a result, 514 articles were excluded based on title and 163 based on the article. The remaining 179 articles were fully read, only 39 met all criteria and were included in the review.

All articles contain empirical data: research design qualitative or quantitative; authors conducted interviews, questionnaires, analysed companies reports or collected data through observations according to a case study.

Table 4. Inclusion and exclusion criteria

| Selection Criteria | Description |
|---|---|
| Inclusion | Articles (including articles in press); conference papers; no time-frame limitations; open access; English/German/Russian language; empirical (qualitative or quantitative data); without industry limitations. |
| Exclusion | Book chapters; literature reviews; conference reviews; articles with missing abstracts/notes; partly available; articles with theoretical background or proposed frameworks without real interaction with industries. |

## 4.5 Data analysis and synthesis

In the thesis, an exploratory and qualitative approach was used to analyse the collected data. All selected articles, that are meeting established inclusion criteria, are grouped by industry, type of data and research design method. Main points, such as methods used, impact (positive or negative), value creation, observed conclusions and relation to research questions are briefly outlined.

The synthesis process began with the articles familiarizing by reading them several times and making notes. All the publications were read by the author of this thesis; no other researchers were involved in the reading process. The descriptive data was obtained, such as methods used, impact from Blockchain adoption (positive or negative), value creation, sphere, research design, observed conclusions and theoretical knowledge were combined in a single table for further evaluation.

Then the research was divided into three groups: barriers with challenges, benefits and sustainability dimensions. The essential findings from each article were gathered and categorized based on the groups that were mentioned before. The goal was to determine what topics the items mentioned, how the discussed themes differed between various spheres, countries and industries, and whether there are any parallels in the results to create a united framework for all possible Blockchain users.

# 5 Results

The results part contains the main findings from empirical articles, such as challenges and barriers, benefits, impact on the sustainability dimensions and a summarized framework, how to provide digital transformation by means of Blockchain.

## 5.1 Spheres of Digital Transformation and data analysis

The current analysis is based on the 39 empirical articles, which contain collected data from expert interviews, questionnaires, online surveys, observations, experiments, case studies, report analysis and company audits. Spheres and main research directions are presented in the figure 8. Some articles are linked with each other since they cover multiple aspects of Blockchain adoption.

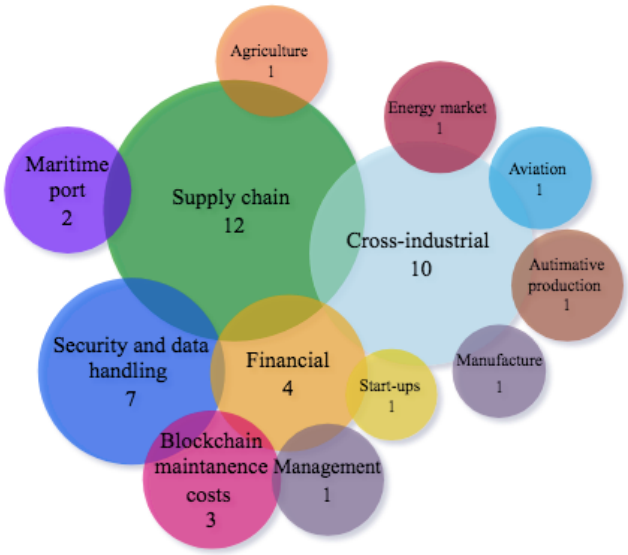


Figure 8. Selected articles research direction.

One of the most attractive spheres is the supply chain and logistics processes, as most cases are related to this direction. Additionally, the supply chain connects all industries together and various stakeholders are inextricably connected with each other. At the same time, researchers focus on cross-industrial studies to determine and compare challenges, fears and

society readiness to implement Blockchain technology, or at least, consider it as a promising one. The word cloud relationship represents the most familiar words that are used in the chosen papers (Figure 9).

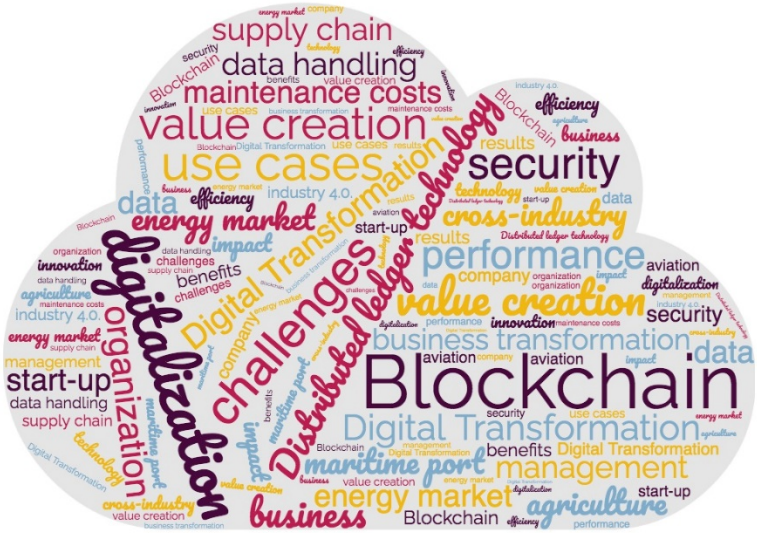


Figure 9. Main authors keywords.

Digitalization through Blockchain technology is at the very beginning and Figure 10 shows in which countries the authors conducted research. The current situation gives a broader perspective to academia and industries that work with Blockchain. The number of successful use cases is limited, and this situation gives a broader perspective for conducting new experiments.

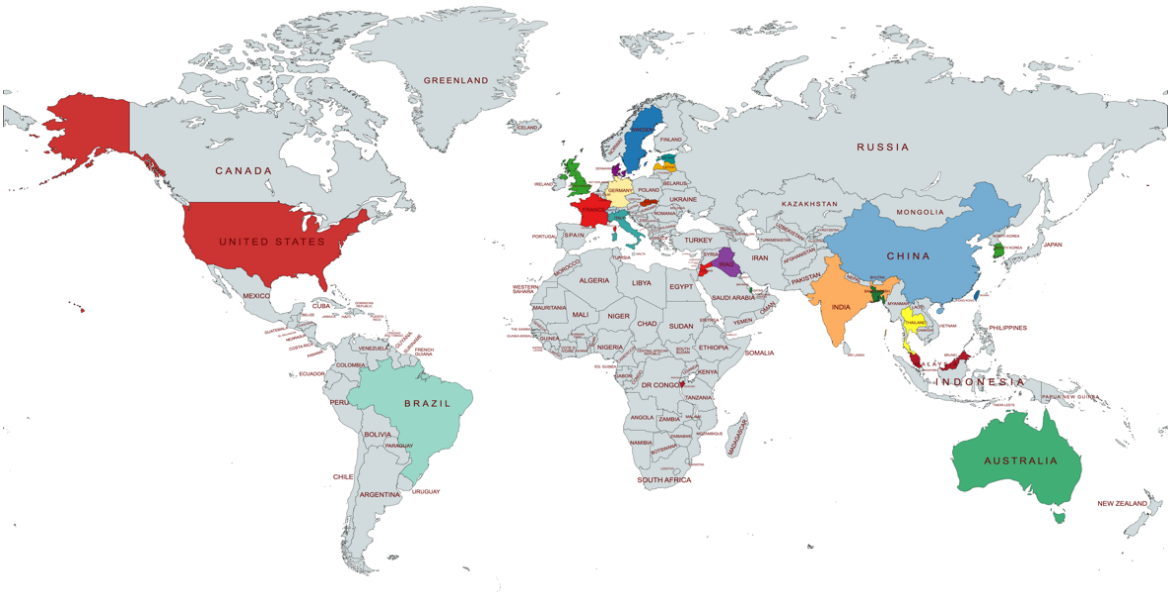


Figure 10. Authors contribution by countries.

To analyse the collected data, the authors used various theories. Table 5 contains basic information about concepts with brief descriptions and limitations. In practice, people can use several theories to consider numerous factors that have an influence on technology acceptance not only by companies but by regular users as well.

Table 5. Relevant theories to analyze intentions to adopt Blockchain

| Used theory | Description | Limitations |
|---|---|---|
| TOE (Technology-Organization-Environment) (Tornatzky et al, 1990) | Contain factors that have a direct influence on the modern technologies' adoption. | No information how those factors collaborate with each other. |
| Unified Theory of Acceptance and use of Technology (UTAUT) (Venkatesh et al., 2003) | Describes the desire to adopt and use the system and prediction of future user behaviour. | Perceived weakness in the organization matter. |
| Innovation Diffusion Theory (IDT) (Agag and El-Masry, 2016) | Models to explain and forecast the innovation spreading in the society. | Shortage of the interaction effects. |
| Task-Technology Fit (TTF) (Goodhue and Thompson, 1995) | The system relationships between tasks and features effectiveness assessment | Absence of supporting factors, such as environment or business preparedness. |
| Value-Based model (VBM) (Kim et al., 2007) | Overall value and reasonable costs choice | Absence of supporting factors, such as environment |

## 5.2 Challenges and barriers

There are a number of challenges and barriers that are outlined in this section. 7 main groups were defined that have a huge impact and are most common in various spheres.

### 5.2.1 Legal regulations

Governmental support and legal regulations are essential when referring to the Digital Transformation and new technologies implementation. Different regulatory constraints are instrumental and, according to experts' opinion will remain for more than 5 years (Arefjevs

et al. 2020). This happens because authorities understand that they should take part in technological development but do not endeavour to amend the current situation (Kend and Nguyen, 2020). Currently, there is no wide legal recognition for documentation in the global trade, which retards Blockchain smart contracts implementation (Gruchmann and Bischoff, 2021). The digital version of the document can be stated as a legal one only when a physical signature is transferred to a digital level. When unexpected situations occur (e.g., damage or valuable changes) third parties should re-sign the contract that may take time.

Concerning the global framework for Blockchain adoption, especially in the supply chain, experts' opinions were divided (Kopyto et al., 2020). The most common opinion was regarding the national restrictions and laws that are linked with cultural specificities and economic systems. The easiest and most possible solution in the nearest future relates to private and consortium Blockchains, where the number of users is limited. If there are participants from different countries, authorities will be able to manage the system by themselves according to the local policy (Kopyto et al., 2020). But all experts are sure that such regulations will emerge in the future. Even existing solutions, such as TrendLens from IMB, are centralized by governments and do not support the standardization process (Lohmer and Lasch, 2020). It can be explained in a way that the technology market can be overflowed with information, which relevance for legislature should be discovered in a deeper way and the benefits to be proven (Veerpalu, 2019).

Another challenge for all industries is data management and confidentiality. Governments are seeking to control industries and all innovative solutions should comply with legal privacy requirements (e.g., European Union General Data Protection Regulation (GDPR)) and it can be a barrier for completely decentralized platforms (Andoni et al., 2019). Thus, companies will choose more proven data services that are accepted by governments. Legal authorities always will have an influence on emerging technologies, and they can take part in development, data quality assurance or solve conflicts (Zavolokina et al., 2017).

At the same time, some countries, such as Germany, are too dependent on legal circumstances that in order to circumvent international communicability constraints, they should remove gaps in laws, such as Data Protection Law or Contract Law (Knauer and Mann, 2019). Another country to consider is India and the research was conducted among specialists in the mining industry (Bhattacharyya and Shah, 2021). The industry had been defined by the cheap labour force but strict rules and regulations, that along with other

factors, neglected a number of Digital Transformation possibilities. Hence, all problems will remain unsolved so long as various industry authorities ignore Blockchain acceptance and standardization on a legal level (Malik et al., 2021). Such uncertainty deters companies from system development and deployment (Lohmer and Lasch, 2020). However, regulations absence or gaps in industry standards cannot be claimed as a foremost reason not to use Blockchain (Li et al., 2021).

### 5.2.2 Technological maturity

While the speed of most common technologies, such as ERP or cloud solutions, grab the market share and evolve so fast, Blockchain is nowhere near that (Kend and Nguyen, 2020). The technology is good for narrow problems and a special application is required. But still, there is no specificity about Blockchain sustainability in a long term. There is no unified ecosystem with clearly written rules, standards and regulations (Lakshmi and Sricharan, 2019). Regardless of the number of industries that implemented Blockchain, continuous development and more experiments are required to unleash its whole potential (Yang, 2020). Additionally, the risks related to early development stages and lack of experience with such large-scale solutions should be discovered more (Andoni et al., 2019). Consequently, there is some time needed to improve the resilience to the security risks and gain public confidence.

For example, in the study (Dabbagh et al., 2020) eight Blockchain platforms were analysed in order to evaluate the performance characteristics using the comparative framework. Consensus algorithms, number of transactions and peers were investigated and, as a result, existing Blockchain platforms are not ready to fully replace traditional databases or other more reliable systems.

Blockchain cannot be defined as a common technology in industries and technological readiness is a factor that can unite different participants to make the system more attractive for every sphere (Gruchmann and Bischoff, 2021). Authors point as well, that the system implementation requires the infrastructure transformation that cannot happen instantly, and this challenge liked with investment constraints. Even Blockchain is a type of database, it still cannot be used just for effective data storage because of slow block creation (Norström and Lindman, 2020).

Although smart contracts have an enormous potential, there is still no secure and legally sound framework (Lohmer and Lasch, 2020). The accurate smart contract setup requires proper training and skilled professionals, which can be a problem nowadays. At the same time, while companies use permissioned Blockchains (mostly in a consortium) the system setup is plain, while the network setup remains challengeable (Lohmer and Lasch, 2020). Even the uncertainty still remains, this approach may be dominant in the nearest future.

Another problem is linked with cryptocurrencies (Lohmer and Lasch, 2020). It can be noted that the market is too volatile, and the media has an enormous influence on crashes (e.g., in 2017 – early 2018). That is why they are not assumed as reliable or even controllable and the time is required to see live successful cases in industries.

Talking about public Blockchains, theoretically, the security is extremely high, and the attack probability is relying on the balance of the computing power between fair miners and the potential attackers (Ciaian et al., 2021). But authors provided empirical evidence by collecting daily data from the crypto market starting from 2014 to 2021 and proved that the security is highly dependable on the mining reward. Consequently, the market is too volatile, the PoW consensus algorithm is imperfect and may cause several equilibriums with high and low levels of security. Usually, companies intend to choose technologies that are more predictable and immaturity may be one of the main reasons for unacceptance (Lakshmi and Sricharan, 2019).

### 5.2.3 Data management issues

There is a lot of data that should be stored and processed but as usual, companies are not ready to meet a number of standards, because nowadays all decisions are made individually by development teams (Gruchmann and Bischoff, 2021). For example, it is essential to check the validity of data before it is input into the system and consistency according to set standards.

At the same time, data archiving may be an issue as well (Gruchmann and Bischoff, 2021). A permanently increasing amount of data may cause pressure on the existing infrastructure as well as information findability. This closely relates to auditing processes and experts from this industry are too sceptical about the technology usage (Kend and Nguyen, 2020). They

see the potential loss of the important audit trail information that is stored outside the company, as well as on system processes.

In the comparative study (Queiroz and Wamba, 2019) both countries experts were reluctant about data exchange with their business partners. It is an enormous challenge to agree on what amount of information each actor may share with another and the majority of them are not ready to give full access to the data. Reputation and experience are the most common sources of trust in industries (Xiaoning and Papadonikolaki, 2020) and in the begging a lot of effort is needed to overcome all issues.

### 5.2.4 Security and trust

Security is a valuable factor that has an influence on Blockchain adoption/acceptance by industries or regular citizens and can be a mediator to the technology benefits, such as cost savings, automation, etc (Fleischmann and Ivens, 2019). When a lot of stakeholders, especially the third parties, are involved in the process there is a significant risk of losing personal information and market control. When a big player runs a platform (e.g., TredeLens from IBM with a large logistician "Maersk" venture), no one wants to share the information with a leading competitor and pay him additional fees for the platform usage (Gruchmann and Bischoff, 2021). That is why Blockchain's transparency is the barrier to a wide implementation. Experts are leaning toward private solutions because fears are connected not only with private data security but also with the input information authenticity. If anyone can join the network, the tracking of further data movements for stakeholders and filtering becomes more complex (Gruchmann and Bischoff, 2021).

Talking about smart contracts, their inherent features make them more attractive to cyber-attacks than typical software solutions (Wan et al., 2021). 40% of experts, that are working with Blockchain-based smart contracts, claimed that their solutions have security issues and additional breaches. This can be linked not only with an inability to permanently check the validity of created documents and the absence of formal standardization but with optimistic behaviour as well (Rhee et al., 2012). Sometimes people are too confident and human factors can have a negative impact on the entire system.

The survey that was taken among regular customers and aimed to reveal their desire to share their personal information on the Internet (Frey et al., 2017) disclosed the following: the

privacy concerns had a considerable impact and members of a control group with strong security requirements have higher expectations; additionally, users do not willingly share their personal data if they are not aware of the privacy policy or another option of risks reduction. In the same situations with users, that want to use "the right to be forgotten" (Norström and Lindman, 2020), Blockchain stores all the data, and it cannot be deleted instantly. To overcome this issue, labels can be created (Zavolokina et al., 2019). When a potential user sees that Blockchain is supported by the network of various companies, it helps to increase trust. But at the same time, governmental initiatives and labels should be used with caution. If citizens do not trust authorities, their references may cause the opposite effect and repulse potential users (Zavolokina et al., 2019). Blockchain developers and providers should think about how to overcome trust issues and convince customers that their information is protected (Fleischmann and Ivens, 2019).

The security issues are linked with the inability to completely trust new participants in public or private networks (Lakshmi and Sricharan, 2019). Data correctness cannot be proven if participants do not trust each other (Sternberg et al., 2020), so reliable methods should be established. While the system contains the whole transaction trails and history, companies are not ready to share their personal information with unscrupulous users (Lakshmi and Sricharan, 2019). Consequently, it is essential to create a good collaborative network where all participants could trust each other, consider needs and the possibility of existing informational system integration (Supranee and Rotchanakitumnuai, 2017).

### 5.2.5 Implementation issues

Although there are a lot of potential for Blockchain users, the majority of them are still struggling not only regarding how to use the technology and when, but also about the basic technological concepts (Gruchmann and Bischoff, 2021). The technology itself can completely transform the business and differs from other most common solutions (some of them are mentioned in Table 2). But there is still a lack of experience in system development and integration. A haulage constructor expert (Gruchmann and Bischoff, 2021) is certain that Blockchain providers should have deep knowledge of the technology, have various software interfaces be able to adapt the solution according to the customer maturity level

and needs. But still, perceived complexity results in low acceptance and adoption level in various fields (Malik et al., 2021).

Top managers in the number of companies were sure that before the innovative technologies adoption, the whole benefit should be extracted from the already existing ones (Bhattacharyya and Shah, 2021). This situation may create a huge gap where the business transformation via emerging technologies and the permanent opportunities rejection will require more skills and investment costs in the future. ReLog case (Sternberg et al., 2020) is a notable example, how technical human mistakes may create a wrong reflection of processes in the real world. That is why standards are essential, as well as proper training with a prominent level of trust between all stakeholders.

Facilitating conditions (organisational and technological conditions existence) is another challenge companies main face, especially undeveloped ones (Quiroz and Wamba, 2021). High development costs are another prominent issue along with an inability to provide any competitive advantages against existing solutions, such as relational databases that are cheaper and more mature (Andoni et al., 2019). Developed countries have more power and possibilities to implement Blockchain, but at the same time, infrastructural maturity may discourage the technology acceptance (Quiroz and Wamba, 2021). When the benefit can be gained from the existing technologies, there is no need to look for immature alternatives. Additionally, because of Blockchain immutability, a lot of data requires space that may cause extra expenses for system maintenance and its latency because of the huge data amount (Gruchmann and Bischoff, 2021).

### 5.2.6 Investment constraints

To implement any technology potential benefits from adoption should be defined and operational costs should be linked with all business advantages (Gruchmann and Bischoff, 2021). Cost calculations may vary according to the Blockchain type. Public Blockchains usage price is too volatile (e.g., Ethereum with great security) and depends on the system workload, while logisticians may pay a couple of cents for notary authentications with CMR (Gruchmann and Bischoff, 2021). System maintenance from a development perspective along with marketing costs are important as well.

An organization cannot implement such technology without their main partners, while the idea is to link all stakeholders together. Decisions that are not supported by other actors may cause negative consequences (Malik et al., 2021), as a system cannot exist if there are not enough participants. That is why the business transformational option via Blockchain have mostly big companies, while smaller practitioners are struggling from implementation cost constraints (Kend and Nguyen, 2020). Larger firms are more likely open new positions and hires, invest internally, carry out global research and be ready to invest in new technologies (Hopkins, 2021).

Among other important adoption factors is the enterprise's total asset scale (Pan et al., 2020). When authors analysed the same companies, the ones with a larger scale were more positive about Blockchain implementation and the intention of the system adoption should be considered at an appropriate time. Rapid company's growth and partnership strengthening lead managers to consider Blockchain and when the cash flow increases, it supports the smooth implementation (Pan et al., 2020). But another quantitative cross-industrial research (Raihanul Hasan et al., 2021) showed a different tendency: coefficients "firms' age" and "firms' size" were substantial and negative. Therefore, big and old companies have a less positive impact from Blockchain adoption. The situation may vary in various spheres or the complexity of the inner process. The number of stakeholders involved may be crucial as well. Conclusions cannot be named as universal and require additional empirical testing.

### 5.2.7 Readiness level. Overall mistrust and scepticism from potential users

While adopting any new technology, there always will be an uncertainty element where the result is not completely known and around Blockchain there are too many doubts (Kend and Nguyen, 2020). A lot of information about the benefits and advantages of the system can be found, but eventually, the majority of people still do not fully understand the solution. To overcome those issues, a few real cases with empirical evidence are needed to prove the theoretical efficiency, while industrial experts do not see the material influence on the current processes (Kend and Nguyen, 2020). Every single situation should be analysed individually and the proper option to be determined. Some companies can leapfrog and move directly from physical to Blockchain, but it can be unreasonable (Lohmer and Lasch, 2020).

Potential Blockchain customers miss opportunities that the system can give them because of the perceived technological complexity (Knauer and Mann, 2020). Several experts during interviews (Lohmer and Lasch, 2020) claim, that Blockchain is not a panacea for all companies and with this rush they can neglect other existing possibilities that suit better for their case. Experts with higher managing positions support Blockchain less and are claimed to be more sceptical about new technologies benefits (Yang 2020). As usual senior positions are taken by older people, that are less perceptive to technological changes in the company (Yang 2020). They are ready to adopt it only when benefits and effectiveness are vivid (Liang et al., 2021). At the same, the audit of some industries (e.g., medium-sized port communities) revealed, that there is a lack of knowledge not only about Blockchain but about informational technologies as a whole (Meyer et al., 2020).

Every new technology adoption is guided by top managers and when they are not aware of all opportunities they can miss a possible increase in efficiency through digitalization, but the opposite conviction that the Blockchain is the solution for every case may cause dire consequences as well (Lohmer and Lasch, 2020). The technology has enormous potential only when it is used properly, but again, authors point that the majority of users will not even notice it in the next 5-10 years. Some are convinced that the technology will not be valuable enough to justify all the necessary efforts to create standardization and international law (Kopyto et al., 2020).

Even if Blockchain adoption and its major features (e.g., transparency, disintermediation, compatibility, etc.) are consistent with the company's strategic goals, business owners are reluctant to accept the technology because of perceived risks from adoption (Malik et al., 2021). Comparative analysis in India and the USA (Queiroz and Wamba, 2019) revealed that data transparency as a factor that has a different influence on adoption and was supported in the USA, presumably because of a diverse awareness level among specialists in those countries. For example, the study among smart-contracts developers supported the inconsistency between the security issues understanding and the reason for those issues emergence in the real world (Wan et al., 2021).

In general, digital services are seen more as an additional expense and the fear of the long-term partners and social contacts loss are barriers from Blockchain implementation (Linsner et al., 2019). But eventually, the proportion of industry experts that want to try the technology outweighed those who refuse.

## 5.3 Benefits from adoption

Perceived benefits are the most common topic in academic research. To conclude, 6 groups were mentioned that can be linked together and motivate businesses to invest in Blockchain.

### 5.3.1 New products and business models creation

Digital Transformation affects all industries and, as a result, new and cost-effective products emerge (Arefjevs, et al., 2020). Authors point as well, that the financial sector is a "backbone" of the economy and a lot of changes occur there. In addition to technologies that are mentioned in Table 2, ancillary processes support innovations: payment systems with cryptocurrencies or Blockchain-based smart contracts for a better monitor of all deals (Arefjevs, et al., 2020). The connection is direct – all payments are linked with smart contacts not only in the industry but available for regular users (Fleischmann and Ivens, 2019). The spheres may be different, such as real estate deals where a smart contract can be a right of ownership confirmation (Fleischmann and Ivens, 2019).

The competition level increases every year and to keep a market share, companies are focused on innovations and learning capabilities growth (Malik et al., 2021). The competition is high nowadays and the concept is to switch the competition from business against business to network against network (Lohmer and Lasch, 2020). When companies gain a number of benefits, such as cost reduction or processes optimization, they can arrange better planning and share gained benefits. Additionally, the collaborative network may create a new business opportunity, when direct competitors are not fighting against each other, but making a single working environment and strengthening the interaction.

Blockchain is a technology that may change the way organizations function on the market and create new industrial strategies (Liang et al., 2021). The research (Malik et al., 2021) shows that the ability to take risks may be a driver to adopt Blockchain. Forward-looking companies should arrange a learning mechanism of world sensations that can make a sufficient difference to their current state. At the same time, the competition can become a driver to adopt Blockchain (Norström and Lindman, 2020). A good example of such collaboration may be the "vertical" consortium (Zavolokina et al., 2017). It might be useful at the initial stage of adoption because in this type of the majority of users do not compete

and unnecessary conflicts are eliminated. Consortium helps to unite all participants and provide a deep understanding of all processes. It is an another possibility to make success in the long run and stakeholders should be ready to transform the consortium to “horizontal”, where companies involved start to compete with each other (Zavolokina et al., 2017).

Choosing the right consensus algorithm and creating the right architecture are essential in Blockchain-based systems development. While PoW is proven as secure and more mature, it is too energy-consuming and slow (Andoni et al., 2019). Hence, in new initiatives developers and moving forward with more energy-intensive, faster and adjustable algorithms, such as PoS and PoA. Those concepts have already been tested and proved their efficiency, but still, further development is required to achieve sustainability (Andoni et al., 2019). Additionally, Blockchain’s connection possibility with IoT encourages the new and considered business model – asset tokenization (Lohmer and Lasch, 2020). In simple terms, it is a process when physical or legal assets are replaced by Blockchain’s tokens. It may benefit companies who want to be among pioneers in this field, for instance, all physical goods may be paid and shared by the system participants. The IoT area is still open and is well suited for innovative ideas, such as Blockchain with different scenarios testing since there is no standardization (Lohmer and Lasch, 2020).

Talking about Blockchain initiatives, a number of well-known companies are involved in the development (e.g., IBM, Hyperledger, BlockLab with Rotterdam Port, etc.) and 140 projects that show the potential value were analysed (Andoni et al., 2019). But the long-term benefits are still must be proved because most cases are in the early development stage or have been tested only in small-scale projects. So it is hard to say if the system is suitable broadly. Meanwhile, the environmental factors play a vital role and are among others that encourage companies to consider Blockchain as a promising technology (Liang et al., 2021). Such changes can raise the business status and reputation in a global market, and, as a result, gain social approval.

### 5.3.2 Processes optimization and automation

The COVID-19 pandemic revealed structural imperfections and highlighted the importance of digitalization (Li, 2021). The transformation can help to reduce epidemic spreading risks without the productivity sacrifice (e.g., faster operational speed and less crucial human

errors). The main target of all companies is to increase operational efficiency and awareness about data sharing is a factor that has a tremendous effort of a long-term steady development (Pan et al., 2020). When all stakeholders are linked together with a single platform there is no need to create their own solutions and request the data from other participants, as it is always available (Gruchmann and Bischoff, 2021). Digitally available data reduces time-consuming, saves effort, and increases productivity. Smart contracts provide more clear communication in case of paper-based processes absence. Digital confirmation reduces queries concerning process flows, eliminates downtimes and prevents documents from missing (Gruchmann and Bischoff, 2021). Additionally, an organization meets the transaction costs reduction by eliminating manual work data changing and sharing (Raihanul Hasan et al., 2020).

The pilot Blockchain initiative of the middle-size municipality in Northern Europe (Norström and Lindman, 2020) was taken to decrease costs by reducing the number of manual work by employees and preventing double-spending. Clear transactions overview and their tacking are essential for every business. In the mentioned case people seed their vouchers and registered various times, while only paper check was established. With Blockchain, such chaos was eliminated, and the technology can be applied to other areas that deal with documents (Norström and Lindman, 2020). New possibilities for redefining data work are opening up and digitization will no longer be an inevitability, but an opportunity to create value (Linsner et al., 2019).

When 2 scenarios in the supply chain are compared: traditional and with emerging systems usage, such as Blockchain (Varriale et al., 2021), the second one shows more time-consuming potential. For example, a smart contract provides automation and standardization of an order receipt, while the connection with other services (such as virtual warehouse, IoT and RFID sensors) allows to track products over all stages. In case of emergencies, the management inefficiencies are reduced at least by 3,2%. The responsibilities are shared between stakeholders, every step is monitored and controlled (Varriale et al., 2021).

There are three main applications that can be employed in logistics (Xiaoning and Papadonikolaki, 2020): tracking (especially valuable in after-sales cost savings), smart contracts formation (help to avoid inspections and save time) and transferring (better control of all financial flows). A good real case is the MediLedger project (Mattke et al.,2019) that was created to establish a unique ecosystem with the whole pharmaceutical lifecycle

governance, product tracking and verification, monitoring the property rights and preventing the counterfeit possibilities. Such innovation can give a deeper insight and prove Blockchain's efficiency. Even though the system was created for the medical industry, the findings can be adapted broadly.

Claims management can be optimized as well. In the supply chain some processes may take up to 8 weeks just because of papers and confirmation work (Gruchmann and Bischoff, 2021). When a certain deal may be closed earlier, a final customer becomes more satisfied, as a result a company levels up a marketing position and increases its reputation (Varriale et al., 2021). Smart contracts may be used in highly standardized processes and are identical in the whole industry (Lohmer and Lasch, 2020). Authors mentioned that a lot of companies are concerned about smart contracts usage that even created the term "Fear of Missing Out" because they are afraid of being left behind. Consequently, when a real case emerges with proven benefits, other companies strive for the same result.

When business owners realize the possibility to run the business without intermediaries' involvement, they are mostly tending to adopt Blockchain (Malik et al., 2021). Disintermediation can accelerate all processes by transaction costs reduction, advance payment procedures and provide a closer interaction between a service provider and a customer (Norström and Lindman, 2020). It is like a "technological glue" (Seebacher et al., 2019) that connects all participants and reinforces the position of every single actor involved. Nowadays, several decentralized platforms without a mediator exist, e,g., Uber or Airbnb, and new cases that are focused on the customer may be a great solution (Lohmer and Lasch, 2020). There is the possibility to collect and share data not only from people but from machines as well (e.g., cars or high-valued equipment) (Fleischmann and Ivens, 2019). It is a great possibility to gain customers' trust and strengthen the link between a service or product provider with their clients by sharing insights into their interaction lifecycle (Sternberg et al., 2020).

### 5.3.3 Data management improvement

Perceived data transparency is the driving factor for the technology adoption (Malik et al., 2021). Data availability for every participant in the system increases trust between all stakeholders and helps to share required information with complete certainty. Meanwhile,

transmission bugs are eliminated as well (Gruchmann and Bischoff, 2021). It causes a lot of processes automation without manipulative fears. Sometimes the internal departments are not linked with each other properly and data sharing may be violated. When a problem of informational asymmetry occurs, the Blockchain can be a solution since it rebuilds mechanisms based on technological trust (Pan et al., 2020) and data transparency. Blockchain is a decentralized database with a high level of trust, thus, a platform connects alliances effectively, builds a trusting ecosystem and peer-to-peer cooperation can be achieved with less effort (Xiaoning and Papadonikolaki, 2020). As an outcome, trustworthy information can be shared inside and outside the company.

Data administration in Blockchain is processed by a number of a predetermined set of rules. The more complex and advanced they are, the more automated procedures become (Varriale et al., 2021). The exchange platform is secure, and all interactions are produced by technology and required equipment, instead of individuals (Alazab et al. 2020). Users highly depend on themselves while carrying out transactions or participating in the consensus process. When they are completely aware of the system and how to use it correctly, possible data-related risks are minimized or even eliminated.

### 5.3.4 Integration with another systems and technologies

There are a substantial number of Digital Transformations enabling technologies and the possibility to gain the maximum effectiveness from Blockchain is possible when it is combined with other solutions (Kopyto et al., 2020). To implement Blockchain, facilitating conditions are required and business environment in developed countries has an adequate level of infrastructure, both technological and organizational (Alazab et al. 2020). Every company, especially big ones, have their own platforms and Blockchain's possibility to integrate with the existing solutions is a technological advantage and a progressive business model in case of long-term investments (Gruchmann and Bischoff, 2021). Such combination increases trust between stakeholders involved and decreases opportunistic behaviour (Varriale et al., 2021).

Integration with additional services provides automation, especially when a lot of data input is required, but still, some standardization should be established to allow seamless synchronization (Sternberg et al., 2020). There are several promising applications and

examples that can link Blockchain with IoT (Lohmer and Lasch, 2020) or other technologies, such as NFC, Bluetooth, RFID and cameras (Sternberg et al., 2020), which are essential for future data collection and analysis. Physical elements (such as machines or equipment) can operate autonomously, predict next actions and move from reactive maintenance strategy to prescriptive when the capacity of a machine is known for several months ahead (Lohmer and Lasch, 2020). Every product has its own lifecycle and Blockchain can be the technology that may support it from the integration stage till disposal.

Another (Lohmer and Lasch, 2020) is the possibility for regular consumers to use cryptocurrencies and the platform for secure payments (e.g., charging autonomous vehicles or a parking slot booking). Blockchain technology is a solution when it is critical to maintain the independent IoT systems operations and their connection with other systems without critical data sharing. With Blockchain adoption systems may interact together with no fears of data manipulations and without dependence on a provider of cloud services (Lohmer and Lasch, 2020).

Digital ID systems and Blockchain can be implemented collaboratively to improve the quality of e-services (Al-Musawi, 2020). The author points that one-stop services are very popular on the governmental level and without an ID system there is a considerable risk with authorization credentials and data management if there is a desire to provide decentralized control. The recent initiative from the Energy Web Blockchain can provide about a thousand transactions per second and similar initiatives can attract Blockchain adoption in several applications, where fast data transmission is required (Andoni et al., 2019).

### 5.3.5 Data protection and security

Fears regarding data sharing is a barrier for implementation, but at the same time, Blockchain reinforces data immutability, and this feature increases trust (Gruchmann and Bischoff, 2021). Technological and inter-organizational trust are among the major features that have a positive effect on the implementation intention (Alazab et al., 2020). Only when all stakeholders agree that the chosen technology is reliable and trustworthy, it can be adopted.

As it was mentioned before, Blockchain is a high-trust database, which is distributed, has characteristics of traceability and the data is tampering resistant (Pan et al., 2020).

Consequently, data safety is a top priority while it is stored in the system and all stakeholders can be sure, that the existing ecosystem is effective and eliminates the trust crisis. Data immutability is a good feature in municipal cases (e.g., voting) when everyone can be sure that the data will not be changed or somehow deleted from the system (Norström and Lindman, 2020). This can increase trust among citizens that do not believe their government and the interaction between authorities and society can be levelled.

In order to increase the security some strategies can be used (Wan et al., 2021): detailed and permanent code review, following the coding style or the code itself from reliable sources, looking into the failure cases to identify common mistakes, continuous development and specialists from the industry involvement. MediLedger project (Mattke et al.,2019) is implemented in pharmaceutical supply chains and with a zero-knowledge proofs combination, Blockchain-based applications provide immutability of the transactions and stored data, but additionally, protects time and does not reveal sensitive personal data. Thus, competing organizations can use the single platform and be completely sure about data safety, while smart contacts ensure that all products delivery meets all business rules and quality requirements.

A good option is “on-chain” and “off-chain” principles: personal data is stored outside the Blockchain (“off-chain”) and only the hash associated with the data (“on-chain”). When the information is removed from off-chain the hash does not refer to anything (Linsner et al., 2019).

### 5.3.6 Globalization and network expansion

Since Blockchain adoption in different countries and spheres is at the early stage, models existence that provides a deep insight for industries about the acceptance behaviour at an individual level along with various fields study is essential (Alazab et al. 2020). Those models can support a firm to determine key factors and a deep understanding of the adoption challenges. Successful domestic solutions can be a guide for others. The most promising area is supply chain collaboration and transparency (Hopkins, 2021). The global trading industry is rapidly growing and delays may undermine customers’ credibility. Blockchain adoption might contain only actors that provide high-quality certified products, establish fair direct distribution and sustainable business development (Thiruchelvam and Bamiah, 2018).

COVID-19 pandemic turned the world upside-down and solutions should be adaptable for such rapid changes.

Borders for services (e.g., financial) tend to disappear as a lot of products are developed globally (Arefjevs, et al., 2020). Cross-border transactions take a lot of time and are costly (Fleischmann and Ivens, 2019). If Blockchain will be implemented globally using cryptocurrency, the expensive exchange offices can disappear, and this influence may cause tremendous changes on the whole financial market. All boundaries between payment networks are created artificially and Blockchain can erase them (Fleischmann and Ivens, 2019). There are several companies that are open to new ideas and risk-seeking and "Early Adopters" are people or businesses that might stimulate Blockchain spreading by their own initiative (Knauer and Mann, 2020). They have a profound influence on the "Early Majority" which actions are critical to gain the critical mass trust.

At the same time, Blockchain adoption is defined by boundaries fading between stakeholders involved and presence of both internal and external cooperation (Beck and Mueller-Bloch, 2017). This means that decentralization requires more attention from various fields specialists, such as information technologies and legal authorities. A lot of companies are aware of the technology, consider its benefits and are thinking about its implementation, but have not entered the adoption phase (Beck and Mueller-Bloch, 2017). The more developed and diverse the network, the greater the potential benefit from the system (Seebacher et al., 2020). Every participant can add their individual ideas to increase productivity and create valuable updates that can be applied broadly.

Blockchain can be a solution for a municipality and the industry unification (Norström and Lindman, 2020). When the legal authorities support local businesses and they are all connected by a single platform, great collaboration and expansion opportunities emerge. In a continuously growing network when one participant lefts it will not be a heavy load on the system (Seebacher et al., 2020). Therefore, the impact on an individual entity is minimized with the expanding ecosystem and a new one can be easily added.

Potential long-term impact cannot be predicted with full confidence because even despite the possible strategic value of Blockchain, the awareness in the field is too limited (Kopyto et al., 2020). But the research shows that the technology will be strongly implemented by 2035 in various fields and the most promising one is the supply chain.

Companies can provide their goods or services remotely with a minimum life interaction and Blockchain can be is one of the systems that support cross-border businesses (Arefjevs, et al., 2020). Additionally, it may help to improve performance or maintenance, along with sustainability goals achievement (Bhattacharyya and Shah, 2021).

Even the number of empirical evidences are limited, predictions of Digital Transformation via Blockchain are positive in the long-term. To make it successful, main barriers and challenges should be eliminated. Figure 11 (Source: Author) shows the main findings and how they can fit into integrated business management, which aim is to gain loyal customers and increase the corporate performance according to the strategic planning (Yang, 2009).

The main objective of every company is to make a financial profit, which can be a result of sustainable previous activities development. Negative factors, that were mentioned by authors can become barriers, but the overall mistrust and scepticism not only from companies and potential customers but from legal authorities can be removed. This can help to achieve Blockchain's maturity, trustworthy network expansion and globalization with best established practices.

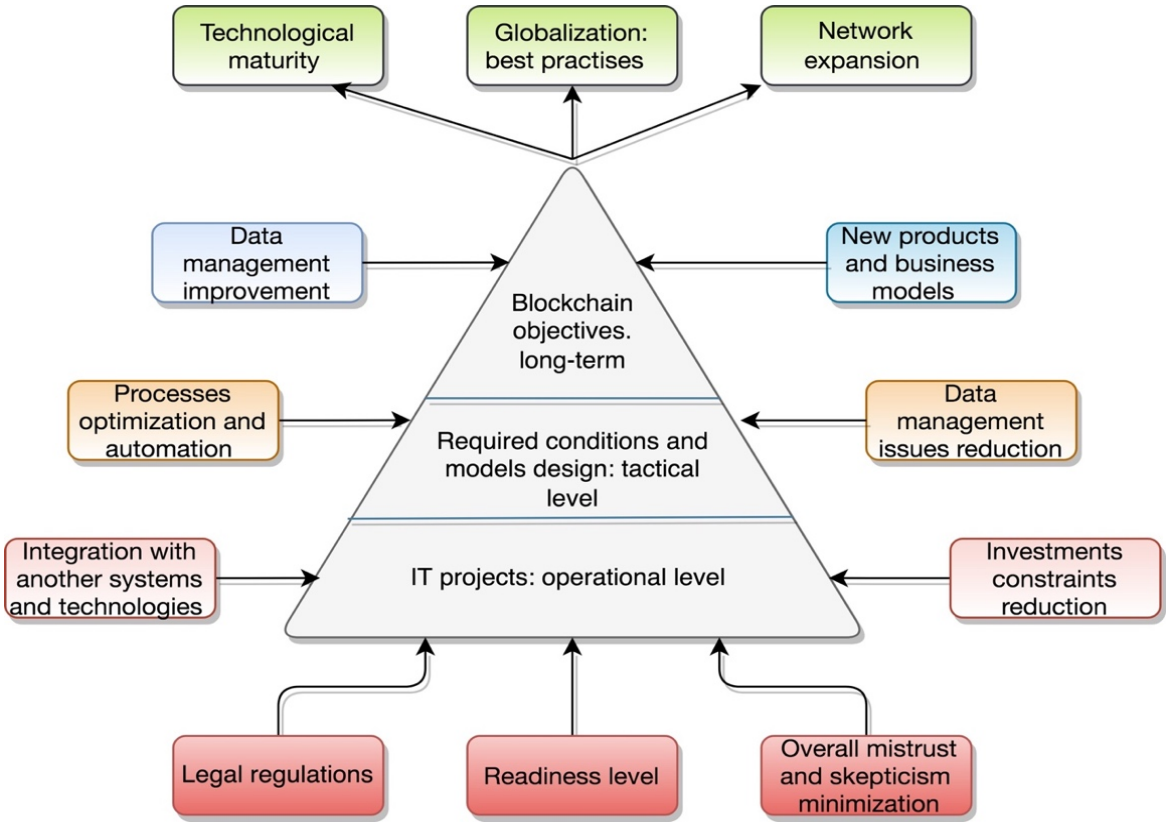


Figure 11. Elements of effective Digital transformation and Blockchain.

## 5.4 Blockchain effects on Sustainability dimensions during Digital Transformation

Changes in the 21st century occur too fast, and the COVID-19 pandemic had a profound influence on Digital Transformation. According to the productivity report (de Vries et al., 2021) information-driven Digital Transformation can be the foundation of a sustainable future for everyone. From the very beginning of the pandemic, companies had to accelerate the adoption of modern technologies to keep on track and adjust to the new conditions.

At the same time, it also opened new opportunities for an intellectual revolution and played a catalyst for digital change that will help to solve global problems. According to the Digital Transformation Initiative report (World Economic Forum, 2021), the modern technology wide implementation can accelerate the achievement of at least 10 out of 17 sustainable development goals formulated by the United Nations (UN Department of Economic and Social Affairs, 2015). However, in other circumstances, businesses may have overlooked technologies that actually may help to achieve new economic, social, and environmental goals. That is why actions that humanity takes in the next ten years will be decisive.

Blockchain is one of those technologies that can help to achieve world sustainability. A key aspect in sustainable development is to determine main instruments or indicators, that will have an influence on the business objectives establishment (Ebrahimi and Rahmani, 2019). The main capabilities and the impact that are mentioned by authors are concluded below and summarized in Table 5:

### 5.4.1 Technical

The dimension links with the future technological development, systems maintenance, evolution over time and the possibility to integrate it with other existing systems. Additionally, it shows the system adaptability to changes in the future (Ebrahimi and Rahmani, 2019). In the reviewed papers the main attention is paid to the new technological models' creation, collaboration possibilities of processes automation via Blockchain and how to achieve system independence. Sustainability can be explained as the Blockchain flexibility in the digital age and its ability to adapt over time in accordance with the company’s management requirements.

### 5.4.2 Economic

The system adoption should be economically viable and comply with the company's operational targets. New business models, network expansion and globalization are among other aspects that have an influence on sustainability. When the business goal is to stay competitive and make profit, any additional investments are supported only when the Return of Investments is guaranteed (Panigrahi et al., 2019). Blockchain's perceived benefits (e.g., secure transactions, product transparency, lover transaction costs, smart contracts, time/money/effort saving) are attractive to business owners and coerce them to consider the technology as an economic driver.

### 5.4.3 Social

Interaction between individuals and groups becomes closer. To adopt any system people should accept the technology and awareness is crucial to provide more loyalty. "Healthy society" is the reason companies are looking for new models' creation and involve customers in processes (Panigrahi et al., 2019). Social influence may have both positive and negative influences on technology adoption because in the product lifecycle there are several stakeholders involved. Consequently, the system adoption should level up the quality of life and support human rights.

### 5.4.4 Environmental

Ecological concerns becoming more and more vivid. That is why there is a peak of intensive discussions about the industrial world influence on the surrounding environment and how those issues can be fulfilled (Zailani et al., 2012). The main target is to reduce the pollution amount, non-recyclable waste, emissions and natural resources consumption (Valinejad and Rahmani, 2018). Developed countries are trying to create new business models and emerging technologies are among main instruments. In simple words, this dimension is linked with natural resources and the idea is to minimize the system impact on the environment. In the Blockchain case, examples might be the reduction of paperwork or collective problem awareness.

### 5.4.5 Individual

This dimension is linked only with individuals and reflects the influence of the system adoption on every person. Additionally, some aspects are covered by equality and free access to the system, rights and barriers absence. The system should give broader perspectives and improve the quality of life (e.g., better service and products quality, the possibility to control operations, trusted providers, the possibility for start-ups). As a result, every single resident can become a driver of the Digital Transformation.

### 5.4.6 Criteria for sustainability radar chart evaluation

Blockchain implementation may be a challenge and to achieve sustainable Digital Transformation through the technology some criteria should be taken into consideration. Each criterion gives profit and has an influence on all sustainability dimensions. There are 3 levels of impact and they are sequentially linked with each other. Table 5 summarizes the main finding and reflects the author's opinions and Figure 12 illustrates the sustainability analysis radar chart for Digital Transformation via Blockchain technology.

Table 5. Summarized dimensions' criteria

| Criteria | Author's opinion |
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| ***Technological sustainability*** | |
| Integration with existing systems | (Gruchmann and Bischoff, 2021), (Varriale et al., 2021), (Lohmer and Lash, 2020), (Mattke et al., 2018), (Meyer et al., 2020), (Hopkins, 2021), (Al-Musawi, 2020), (Linsner et al., 2019), (Andoni et al., 2019), (Thiruchelvam and Bamiah, 2018), (Li et. Al., 2021), (Sternberg et al., 2020), (Liang et al., 2021), (Bhattacharyya and Shah, 2021), (Kopyto et al., 2020), (Seebacher et al., 2020). |
| Future development, system evolution and reliability | (Gruchmann and Bischoff, 2021), (Kend and Nguyen, 2020), (Raihanul Hasan et al., 2020), (Azalab et al., 2020), (Queiroz and Wamba, 2019), (Norström and Lindman, 2020), (Mattke et al., 2018), (Zavolokina et al., 2018), (Zavolokina et al., 2019), (Meyer et al., 2020), (Xiaoning and Papadonikolaki, 2020), (Hopkins, 2021), (Al-Musawi, 2020), (Yang, 2020), (Linsner et al., 2019), (Andoni et al., 2019), (Thiruchelvam and Bamiah, 2018), |

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| | (Supranee and Rotchanakitumnuai, 2017), (Sternberg et al., 2020), (Liang et al., 2021), (Bhattacharyya and Shah, 2021), (Dabbagh et al., 2020), (Wan et al., 2021), (Kopyto et al., 2020), (Seebacher et al., 2020). |
| Processes automation | (Gruchmann and Bischoff, 2021), (Arefievs et al., 2020), (Kend and Nguyen, 2020), (Azalab et al., 2020), (Norström and Lindman, 2020), (Mattke et al., 2018), (Zavolokina et al., 2018), (Zavolokina et al., 2019), (Meyer et al., 2020), (Xiaoning and Papadonikolaki, 2020), (Hopkins, 2021), (Al-Musawi, 2020), (Linsner et al., 2019), (Andoni et al., 2019), (Thiruchelvam and Bamiah, 2018), (Supranee and Rotchanakitumnuai, 2017), (Li et. Al., 2021), (Sternberg et al., 2020), (Liang et al., 2021), (Bhattacharyya and Shah, 2021), (Kopyto et al., 2020), (Seebacher et al., 2020), |
| System safety | (Azalab et al., 2020), (Queiroz and Wamba, 2019), (Lohmer and Lash, 2020), (Frey et al., 2017), (Ciaian et al., 2021), (Lakshmi and Sricharan, 2019), (Mattke et al., 2018), (Zavolokina et al., 2018), (Fleischmann and Ivens, 2019), (Meyer et al., 2020), (Al-Musawi, 2020), (Yang, 2020), (Andoni et al., 2019), (Knauer and Mann, 2019), (Sternberg et al., 2020), (Liang et al., 2021), (Bhattacharyya and Shah, 2021), (Dabbagh et al., 2020), (Wan et al., 2021), (Seebacher et al., 2020). |
| ***Economical sustainability*** | |
| Operational efficiency increase | (Gruchmann and Bischoff, 2021), (Kend and Nguyen, 2020), (Raihanul Hasan et al., 2020), (Pan et al., 2020), (Lohmer and Lash, 2020), (Norström and Lindman, 2020), (Mattke et al., 2018), (Meyer et al., 2020), (Xiaoning and Papadonikolaki, 2020), (Hopkins, 2021), (Al-Musawi, 2020), (Linsner et al., 2019), (Andoni et al., 2019), (Thiruchelvam and Bamiah, 2018), (Supranee and Rotchanakitumnuai, 2017), (Li et. al., 2021), (Sternberg et al., 2020), (Liang et al., 2021), (Bhattacharyya and Shah, 2021), (Kopyto et al., 2020), (Seebacher et al., 2020). |
| Cost benefits for stakeholders | (Gruchmann and Bischoff, 2021), (Varriale et al., 2021), (Arefievs et al., 2020), (Malik et al., 2021), (Mattke et al., 2018), (Zavolokina et al., 2018), (Zavolokina et al., 2019), (Meyer et al., 2020), (Xiaoning and Papadonikolaki, 2020), (Hopkins, 2021), (Linsner et al., 2019), (Andoni et al., 2019), (Thiruchelvam and Bamiah, 2018), (Knauer and Mann, 2019), (Supranee and Rotchanakitumnuai, 2017), (Li et. Al., 2021), (Liang et al., 2021), |

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| | (Bhattacharyya and Shah, 2021), (Kopyto et al., 2020), (Seebacher et al., 2020), |
| Network expansion | (Varriale et al., 2021), (Arefievs et al., 2020), (Raihanul Hasan et al., 2020), (Lohmer and Lash, 2020), (Mattke et al., 2018), (Zavolokina et al., 2018), (Meyer et al., 2020), (Xiaoning and Papadonikolaki, 2020), (Linsner et al., 2019), (Andoni et al., 2019), (Thiruchelvam and Bamiah, 2018), (Li et. Al., 2021), (Sternberg et al., 2020), (Liang et al., 2021), (Bhattacharyya and Shah, 2021), (Kopyto et al., 2020), (Seebacher et al., 2020). |
| New business models creation | (Varriale et al., 2021), (Arefievs et al., 2020), (Kend and Nguyen, 2020), (Raihanul Hasan et al., 2020), (Queiroz and Wamba, 2019), (Pan et al., 2020), (Norström and Lindman, 2020), (Mattke et al., 2018), (Zavolokina et al., 2018), (Zavolokina et al., 2019), (Holotiuk and Moormann, 2017), (Meyer et al., 2020), (Xiaoning and Papadonikolaki, 2020), (Linsner et al., 2019), (Andoni et al., 2019), (Thiruchelvam and Bamiah, 2018), (Supranee and Rotchanakitumnuai, 2017), (Sternberg et al., 2020), (Bhattacharyya and Shah, 2021), (Kopyto et al., 2020), (Seebacher et al., 2020), (Veerpalu., 2019). |
| System governance by all actors involved | (Gruchmann and Bischoff, 2021), (Raihanul Hasan et al., 2020), (Queiroz and Wamba, 2019), (Lohmer and Lash, 2020), (Zavolokina et al., 2018), (Zavolokina et al., 2019), (Xiaoning and Papadonikolaki, 2020), (Linsner et al., 2019), (Thiruchelvam and Bamiah, 2018), (Li et. Al., 2021), (Kopyto et al., 2020). |
| Solve trust issues and provide transparent reporting | (Varriale et al., 2021), (Kend and Nguyen, 2020), (Raihanul Hasan et al., 2020), (Azalab et al., 2020), (Queiroz and Wamba, 2019), (Lohmer and Lash, 2020), (Frey et al., 2017), (Lakshmi and Sricharan, 2019), (Beck and Mueller-Bloch, 2017), (Norström and Lindman, 2020), (Mattke et al., 2018), (Zavolokina et al., 2018), (Zavolokina et al., 2019), (Fleischmann and Ivens, 2019), (Meyer et al., 2020), (Hopkins, 2021), (Al-Musawi, 2020), (Yang, 2020), (Linsner et al., 2019), (Andoni et al., 2019), (Thiruchelvam and Bamiah, 2018), (Bhattacharyya and Shah, 2021), (Kopyto et al., 2020), (Seebacher et al., 2020), (Veerpalu., 2019). |
| ***Environmental sustainability*** | |
| Provides paperless interaction | (Varriale et al., 2021), (Arefievs et al., 2020), (Lohmer and Lash, 2020), (Norström and Lindman, 2020), (Mattke et al., 2018), (Hopkins, 2021), (Yang, 2020), (Linsner et al., 2019), |

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| | (Thiruchelvam and Bamiah, 2018), (Sternberg et al., 2020), (Liang et al., 2021), (Seebacher et al., 2020), (Veerpalu., 2019). |
| Environmental problems awareness and providing possible solutions | (Varriale et al., 2021), (Ciaian et al., 2021), (Meyer et al., 2020), (Yang, 2020), (Linsner et al., 2019), (Andoni et al., 2019), (Bhattacharyya and Shah, 2021). |
| Collective activities to prevent the impact on the environment | (Varriale et al., 2021), (Kend and Nguyen, 2020), (Malik et al., 2021), (Queiroz and Wamba, 2019), (Yang, 2020), (Linsner et al., 2019), (Andoni et al., 2019), (Bhattacharyya and Shah, 2021). |
| Combine environmental protection and control activities | (Varriale et al., 2021), (Malik et al., 2021), (Norström and Lindman, 2020), (Meyer et al., 2020), (Andoni et al., 2019), (Thiruchelvam and Bamiah, 2018), (Bhattacharyya and Shah, 2021), (Kopyto et al., 2020), (Seebacher et al., 2020). |
| ***Sociological sustainability*** | |
| Social acceptance | (Arefievs et al., 2020), (Azalab et al., 2020), (Queiroz and Wamba, 2019), (Lohmer and Lash, 2020), (Frey et al., 2017), (Beck and Mueller-Bloch, 2017), (Norström and Lindman, 2020), (Zavolokina et al., 2018), (Zavolokina et al., 2019), (Fleischmann and Ivens, 2019), (Hopkins, 2021), (Supranee and Rotchanakitumnuai, 2017), (Sternberg et al., 2020), (Bhattacharyya and Shah, 2021), (Kopyto et al., 2020). |
| Understanding customers' needs | (Varriale et al., 2021), (Queiroz and Wamba, 2019), (Pan et al., 2020), (Lohmer and Lash, 2020), (Norström and Lindman, 2020), (Mattke et al., 2018), (Zavolokina et al., 2019), (Fleischmann and Ivens, 2019), (Holotiuk and Moormann, 2017), (Hopkins, 2021), (Yang, 2020), (Linsner et al., 2019), (Andoni et al., 2019), (Thiruchelvam and Bamiah, 2018), (Kopyto et al., 2020), (Seebacher et al., 2020). |
| Collaboration with government and all legal authorities | (Arefjevs et al. 2020), (Kend and Nguyen, 2020), (Lohmer and Lasch, 2020), (Li et al., 2021), (Gruchmann and Bischoff, 2021), (Kopyto et al., 2020), (Andoni et al., 2019), (Zavolokina et al., 2017), (Knauer and Mann, 2019), (Bhattacharyya and Shah, 2021), (Malik et al., 2021), (Veerpalu., 2019). |
| Various spheres digitalization | (Varriale et al., 2021), (Kend and Nguyen, 2020), (Malik et al., 2021), (Raihanul Hasan et al., 2020), (Azalab et al., 2020), (Lohmer and Lash, 2020), (Zavolokina et al., 2018), (Xiaoning and |

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| | Papadonikolaki, 2020), (Hopkins, 2021), (Al-Musawi, 2020), (Sternberg et al., 2020), (Liang et al., 2021), (Bhattacharyya and Shah, 2021), (Wan et al., 2021), (Kopyto et al., 2020), (Seebacher et al., 2020), |
| System understanding and availability for everybody | (Kend and Nguyen, 2020), (Malik et al., 2021), (Azalab et al., 2020), (Lohmer and Lash, 2020), (Frey et al., 2017), (Beck and Mueller-Bloch, 2017), (Zavolokina et al., 2019), (Fleischmann and Ivens, 2019), (Xiaoning and Papadonikolaki, 2020), (Yang, 2020), (Linsner et al., 2019), (Andoni et al., 2019), (Thiruchelvam and Bamiah, 2018), (Knauer and Mann, 2019), (Supranee and Rotchanakitumnuai, 2017), (Sternberg et al., 2020), (Liang et al., 2021), (Kopyto et al., 2020), (Seebacher et al., 2020). |
| Increase the quality of life | (Varriale et al., 2021), (Raihanul Hasan et al., 2020), (Azalab et al., 2020), (Queiroz and Wamba, 2019), (Mattke et al., 2018), (Zavolokina et al., 2019), (Fleischmann and Ivens, 2019), (Andoni et al., 2019), (Thiruchelvam and Bamiah, 2018), (Supranee and Rotchanakitumnuai, 2017), (Liang et al., 2021), (Kopyto et al., 2020), (Seebacher et al., 2020). |
| ***Individual sustainability*** | |
| Closer interaction between a customer and product owner | (Varriale et al., 2021), (Arefievs et al., 2020), (Raihanul Hasan et al., 2020), (Queiroz and Wamba, 2019), (Frey et al., 2017), (Norström and Lindman, 2020), (Mattke et al., 2018), (Zavolokina et al., 2019), (Fleischmann and Ivens, 2019), (Xiaoning and Papadonikolaki, 2020), (Yang, 2020), (Linsner et al., 2019), (Thiruchelvam and Bamiah, 2018), (Supranee and Rotchanakitumnuai, 2017), (Sternberg et al., 2020). |
| Better quality of services and products | (Varriale et al., 2021), (Raihanul Hasan et al., 2020), (Norström and Lindman, 2020), (Mattke et al., 2018), (Zavolokina et al., 2019), (Fleischmann and Ivens, 2019), (Holotiuk and Moormann, 2017), (Xiaoning and Papadonikolaki, 2020), (Linsner et al., 2019), (Andoni et al., 2019), (Thiruchelvam and Bamiah, 2018), (Supranee and Rotchanakitumnuai, 2017), (Sternberg et al., 2020), (Kopyto et al., 2020). |
| Increased trust in all emerging systems | (Gruchmann and Bischoff, 2021), (Kend and Nguyen, 2020), (Azalab et al., 2020), (Queiroz and Wamba, 2019), (Pan et al., 2020), (Lohmer and Lash, 2020), (Frey et al., 2017), (Lakshmi and Sricharan, 2019), (Beck and Mueller-Bloch, 2017), (Norström and Lindman, 2020), (Mattke et al., 2018), (Zavolokina et al., 2019), (Fleischmann and Ivens, 2019), (Andoni et al., 2019), |

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| | (Thiruchelvam and Bamiah, 2018), (Knauer and Mann, 2019), (Supranee and Rotchanakitumnuai, 2017), (Li et. Al., 2021), (Sternberg et al., 2020), (Liang et al., 2021), (Wan et al., 2021). |

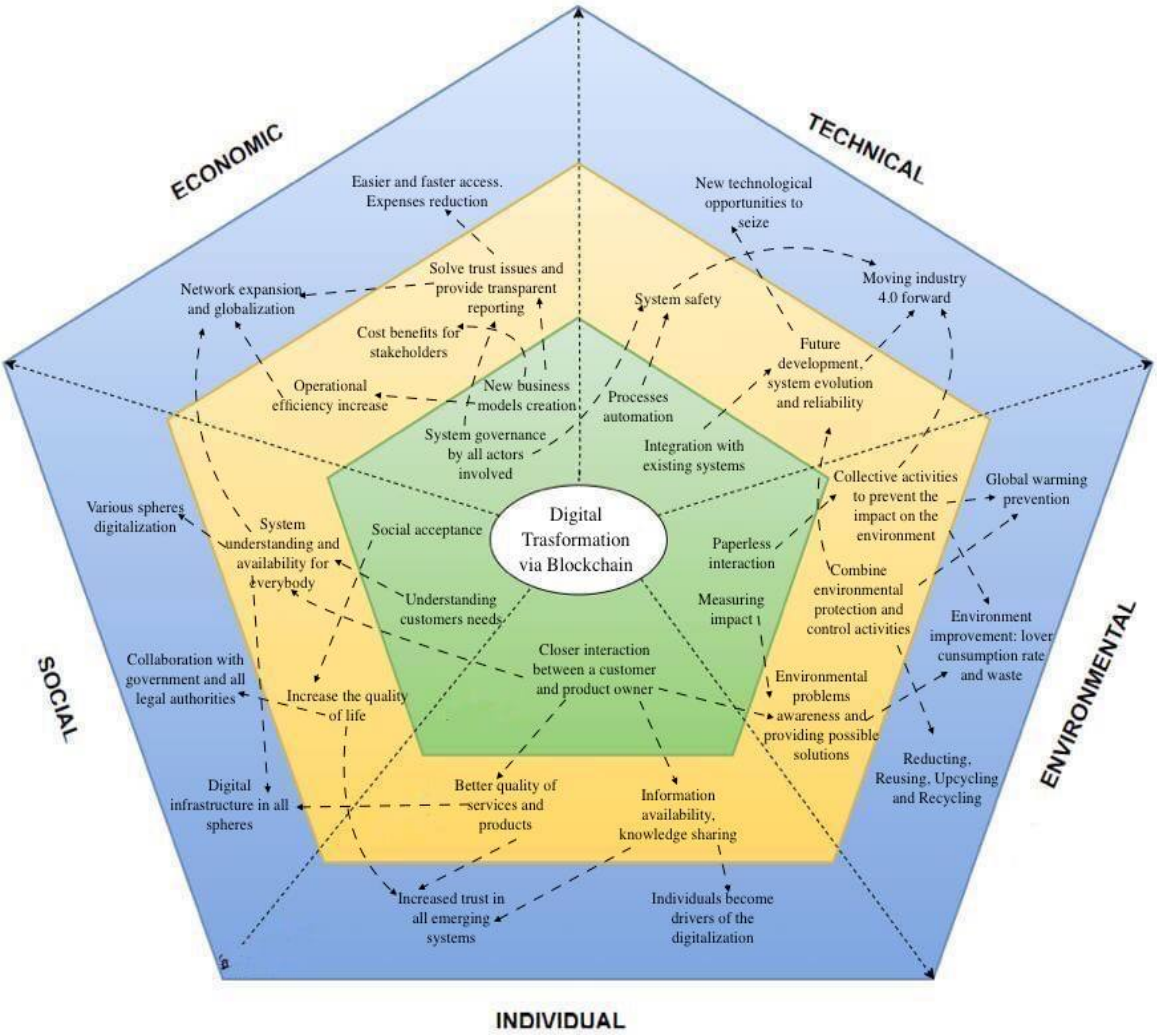


Figure 12. Sustainability dimensions and influencing criteria.

Sustainability Analysis Radar Chart expresses the effects and impacts of the technology considering the five sustainability dimensions. The effects and impacts are divided into three categories depending on how fast the impact is: immediate effect (direct influence), enabling effect (appear when the technology is used in its application domain), and structural impacts (system evolution over time) (Penzenstadler and Femmer, 2013). Structural effects are mostly not presented in Table 5 and are added by the author as vivid conclusions.

Specific conditions associated with Digital Transformation, including the chaotic development of new technologies, investor pressure, lack of understanding, and overall mistrust, must be noted as an obstacle, but also as a challenge at the same time. The

Blockchain adoption process is still a long way off in undeveloped countries. As a result, it scatters the implementation approach in terms of sustainability at the start (different specialities and stakeholders may treat differently these issues).

To conclude, sustainable Blockchain technology should include the following parts (Figure 13. Source: Author). The following elements are grouped and divided by colours: green – the development in an appropriate level the awareness is high; yellow – the situation is acceptable, the progress is noticeable, but still at the low level; red – the situation needs the involvement extension.

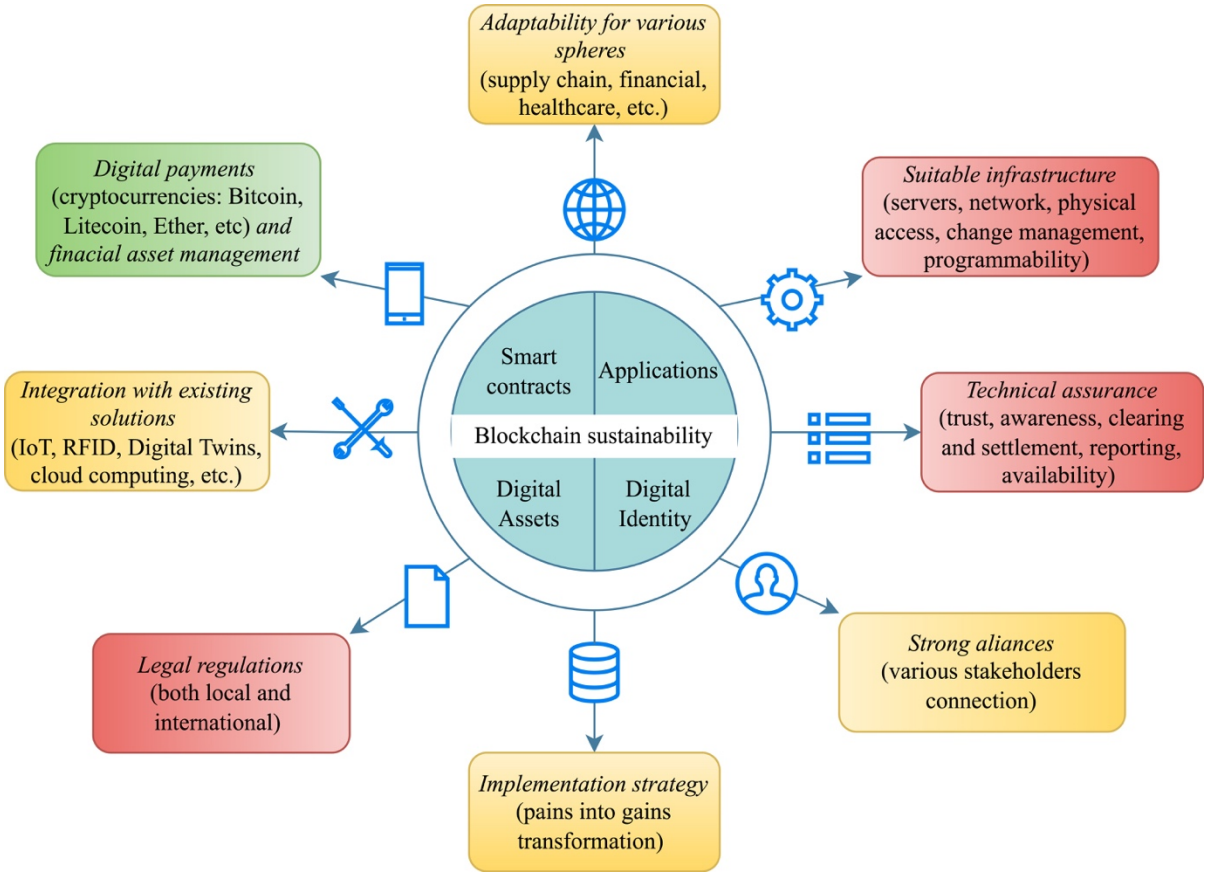


Figure 13. Blockchain sustainability.

# 6 Discussions & Concluding remarks

To summarize, Blockchain is not just a way to exchange financial transactions. In a broader sense, it is a distributed, secure database in which information cannot be tampered, deleted or changed retroactively. Because of these properties, Blockchain brings a range of capabilities and services where the reliability and integrity of data are important, as well as speed and availability. The last section contains information about key findings, contributions, limitations and future research prospects.

## 6.1 Key findings

Blockchain is a young technology. The technology is at an early stage of implementation, and best practices have not been established. Some countries and companies are successfully implementing this solution in their activities, but only touching individual structural units and the technological relevance in various industries still must be proven. Analysed articles contained only empirical data and reflections from industry specialists, Blockchain developers, potential users (companies and customers) or the system productivity reports were taken into consideration. Technological awareness is the most frequent problem that can be a barrier to implementation. Perceived system complexity and trust issues result in overall mistrust and scepticism among potential users. It is necessary to improve the technology from the side of its security, as well as to contribute to changing people's consciousness and their attitude to modern technologies by building trusting relationships.

Nowadays, people try to "pull" Blockchain technology on anything, and often its importance is too exaggerated. Experts and market participants caution against the overuse of the technology remind them of the likely problems that could arise if Blockchain is actively used in every market sphere. The technology is not sufficiently mature, so it is necessary to solve several problems before implementation, such as economic, organizational, and technological.

Empirical results show that the technology implementation has a positive impact on the companies' operational capabilities as well as business transformation. A number of

Blockchain's features, such as traceability, transparency, decentralisation, etc, attract users and encourage them to discover more about the technology, which usage in different spheres may be a competitive advantage. But at the same time, it can weaken the position because of full traceability and data transparency. The situation when benefits are transformed into disadvantages is linked with technological immaturity and lack of proper successful use cases. Future research can fill this gap, provide a deeper understanding of the technology, and unleash full Blockchain's potential.

## 6.2 Contributions

The questions that this research aimed to answer are:

Q1. What is the current Blockchain position in the different spheres?

Q2. What are challenges and the current vision in the implementation of Blockchain technology?

Q3. How can Blockchain relate to sustainability dimensions during digital transformation?

To answer those questions articles, empirical articles from various spheres were collected and summarized and challenges, barriers along with benefits from Blockchain adoption, were identified. Based on the collected evidence, a theoretical framework is proposed on how to transform business via Blockchain, what elements are essential to make the adoption successful and what elements are essential to make the technology sustainable.

Firstly, given the high aspirations put in Blockchain and its growth and it is evident that the findings of this thesis will be of interest to a diverse group of the technology stakeholders from various spheres. According to research, some Blockchain solutions are being used but are not yet available to the majority. Secondly, five sustainability dimensions are combined in a single chart and evidence from prior studies are taken into consideration. The findings are applicable to every sphere and are not limited to one industry.

## 6.3 Limitations of prior studies and future research opportunities

One of the study's major limitation is that just one individual, the thesis's author, was responsible for including and excluding papers from the final sample. The current analysis is based on the collected empirical articles and the observed literature shows that there is

still a lack of evidence from the industry. Even though the technology is popular and there is a lot of information, it is mostly theoretical, and the emphasis is more on creating a problem that Blockchain can solve, rather than the other way around. This leaves a certain imprint and suggests that more research should be done among those who use the technology and preferably over a longer period so that more logical conclusions can be drawn. A lot of tensions relate to Blockchain adoption and paradoxes when system benefits become implementation barriers. While academia is trying to find solutions for a market, real implementation cases are extremely limited.

Additionally, there is a lack of comprehensive evidence from different countries (Figure 10) and the unified barriers and challenges cannot be defined. Every single country has its own culture, economic development level, infrastructure readiness, openness to innovations, lifestyle, etc. There is only one research that predicts Blockchain adoption over time (Kopyto et al., 2020) but still, the research was conducted among experts in the supply chain and the validity for other industries is not completely vivid, as well as the number of problems companies may encounter when implementing Blockchain.

The biggest problem in developed countries is information sharing, while undeveloped ones remain conservative about the digital transformation of big sectors. To make loud statements, a lot of quantitative empirical data should be collected on that matter and as well as observation of real cases implementation on the national level. The short and limited data collection period of time and the number of industries can be another problem. When a solution appears (e.g., pharmaceutical supply chain) the versatility to other industries is still questionable.

If we look at industries, only barriers and the willingness to implement the technology was mentioned by specialists, such as airport workers, seaports, suppliers, or consumers in the supply chain. But virtually no research affect the governing bodies (government and legal authorities) and how the technology can change the ability to share data to improve operational costs or reduce expenses in the long term. The international transfer also depends on research within each country. For example, even if we consider the European Union, each country has its own culture and the intention of a critical mass of people to adopt the technology will depend on many socio-cultural aspects, as well as the level of infrastructure development in that country. Consequently, cross-validation of the majority of research is needed. More deep analysis of the various stakeholders and countries: EU is interested, and

the research might be conducted with the number of countries and legal authorities. Additionally, the research linked with comparative analysis and operational efficiency can be compared.

Additionally, the awareness level is not remarkably high and the lower the level of awareness, the lower the return possibility of a valid and complete survey (Kamble et al., 2018). The experts opinions that were taken into account in writing the papers may be purely personal in nature and as a result, should be double-checked. Also, the intention to adopt the technology, rather than its actual cases, was analysed.

Future research can be linked with:

- Cross-industrial data analysis, along with expert's opinions collection.
- Some findings should be double-checked because those papers were the first on this matter.
- Provide a comparative analysis, how the operational efficiency increased after Blockchain adoption and compare it with other existing technologies on practice (if applicable).
- Discover, how various actors influence on the technology and how the overall efficiency can be increased.
- The empirical evidence can be collected in countries, that are not mentioned in the current SLR, to enhance the generalizability of results.
- Create a model that can predict organizations' intention to adopt the Blockchain technology over time.
- Provide more comprehensive study about Smart contracts, the intention to use them and how to overcome perceived barriers.
- Implementation costs and other indicators calculation (such as ROI, EBITDA, ROIC, etc.) to compare the economic efficiency of Blockchain implementation and other technologies.
- Framework modelling how to combine Blockchain development and adoption with existing legal regulations.
- Build trust in the community and provide a solution to overcome overall skepticism and mistrust of Blockchain.

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Appendix 1. Empirical articles overview

| Article | Methods | Sphere | Research design | Observed Conclusions |
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| Gruchmann, T., & Bischoff, O. (2021). Blockchain-driven handling of digital freight information: a tensions perspective. | Interview | Supply chain | Qualitative | Responding to calls on empirical research on tensions about Blockchain adoption in the logistic sector. Current challenges, pros and cons of the technology are mentioned by specialists from the sphere. What key features attract users and what makes them avoid the implementation. |
| Varriale, V., Cammarano, A., Michelino, F., & Caputo, M. (2021). Sustainable Supply Chains with Blockchain, IoT and RFID: A Simulation on Order Management | Exploratory, based on simulation | Supply chains | Quantitative | The study covers 2 different scenarios in the supply chain when emerging technologies are used: 1. "as is" without technologies and "to be" with the implementation of IoT and Blockchain. The results show how such changes affect sustainability and increase efficiency. |
| Arefjevs, I., Spilbergs, A., Natrins, A., Verdenhofs, A., Mavlutova, I., & Volkova, T. (2020). Financial sector evolution and competencies development in the context of information and communication technologies. | Interviews and statistics analysis | Banking (financial) | Quantitative | The financial sector is an important part of the growing economy and Blockchain adoption started from it. ICT development has a tremendous impact on the sector and the aim of the study is to review the sector statistic and factors that are developing drivers. Results are applicable worldwide. |
| Kend, M., & Nguyen, L. A. (2020). Big Data Analytics and Other Emerging Technologies: The Impact on the Australian Audit and Assurance Profession. | Interviews, observations | Accounting, audit | Qualitative | Blockchain implementation is arguable in many spheres and in audit the majority of specialists are not even familiar with the technology. The possible impact is studied, as well as implementation prospects in comparison with other existing solutions. |

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| Malik, S., Chadhar, M., Vatanasakdakul, S., & Chetty, M. (2021). Factors Affecting the Organizational Adoption of Blockchain Technology: Extending the Technology–Organization–Environment (TOE) Framework in the Australian Context. | Interviews, observations. | Cross-industrial research | Qualitative | The role of different sustainability dimensions in the organizational adoption of BCT. The study aims to find reasons for blockchain ignoring in the market, focus on numerous factors that have an impact on technology acceptance and propose a research model. |
| Hasan, M. R., Shiming, D., Islam, M. A., & Hossain, M. Z. (2020). Operational efficiency effects of blockchain technology implementation in firms. | Panel data for blockchain-based companies | Cross-industrial research (audit) | Quantitative | Companies' operational efficiency increased after Blockchain implementation. While companies with higher financial leverage and return of assets gain more benefits from the technology adoption, big and ones are struggling in implementing it in complex processes. |
| Alazab, M., Alhyari, S., Awajan, A., & Abdallah, A. B. (2020). Blockchain technology in supply chain management: an empirical study of the factors affecting user adoption/acceptance. | Cross-sectoral survey | Supply chains | Quantitative | There are a number of factors that have an impact on Blockchain adoption. Using the UTAUT model authors revealed what factors are sufficient. To collect the data 449 industries were chosen and suggestions how to overcome tensions were suggested. |
| Queiroz, M. M., & Fosso Wamba, S. (2019). Blockchain adoption challenges in supply chain: An empirical investigation of the main drivers in India and the USA. | Questionnaire | Cross-industrial | Quantitative | Blockchain adoption is at the very beginning worldwide and understanding individual behaviour in various countries is essential. The study aims to compare 2 countries: the USA and India. The results were eventually |

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| | | | | supported and the contribution to both scientific world and industries. |
| Pan, X., Pan, X., Song, M., Ai, B., & Ming, Y. (2020). Blockchain technology and enterprise operational capabilities: An empirical test. | Reports collections and analysis | Cross-industrial | Quantitative | While the majority of researchers are focusing on the processes modelling, the study objective is to reveal the connection between Blockchain adoption and the enterprise operational capabilities. 50 companies' analysis showed that the asset scale is a sufficient aspect. |
| Lohmer, J., & Lasch, R. (2020). Blockchain in operations management and manufacturing: Potential and barriers. | Interviews | Manufacturing and management | Qualitative | Defined barriers, fundamental issues, practical solutions, effects on DT. Barriers include human resource constraints, legal uncertainties, lack of infrastructure and standardization, and no legal regulations. Improving the security of smart contracts and the interoperability of private and public protocols will allow the technology to spread further. |
| R. M. Frey, P. Bühler, A. Gerdes, T. Hardjono, K. L. Fuchs and A. Ilic, "The effect of a blockchain-supported, privacy-preserving system on disclosure of personal data," | Online survey | Security, personal data sharing | Quantitative | Security and trust issues are essential factors when adopting innovative technology. The experiment was conducted with 420 participants to reveal their desire to share their personal data and results were dived in 3 categories: technical affinity, Blockchain affinity and privacy concerns. |
| Ciaian P., Kancs D., Rajcaniova M. Interdependencies between mining costs, mining rewards and blockchain security | Reports collection and analysis | Blockchain mining costs, security outcomes, network, and government | Quantitative | Suggest that the price of the cryptocurrency, mining fees and the costs of mining are intricately linked to the security of Blockchain technology. The data was collected from 2014-2021. |

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| Naga Lakshmi, M. V. N., & Sai Sricharan, Y. V. N. (2019). Blockchain: Single Source of truth in Shared Services? An Empirical Paper on the Relevance of Blockchain for Shared Services. | Survey | Finance, Accounting and Supply chain Management | Quantitative | Clear leadership of the finance and accounting department, followed by the supply. Supply chains in organizations to consider Blockchain technology deployment; growth in pre-cash orders, reconciliation and pre-payment purchasing as the most preferred candidates for Blockchain-based transformation |
| Beck, R., & Müller-Bloch, C. (2017). Blockchain as Radical Innovation: A Framework for Engaging with Distributed Ledgers as Incumbent Organization. | Case study, interview | Cross-industrial, management and organizations | Qualitative | The number of real cases with Blockchain implementation is limited and this study shows how the real bank deals with such innovation. To gain maximum profit from the technology, inter- and inner-organizational cooperation is required. Additionally, challenges for companies are mentioned. |
| Norström L., Lindman J. Exploring blockchain municipal use cases | Interview, case study, discussion | Municipality and citizens | Qualitative | Benefits and challenges for governmental structures during Blockchain implementation. 3 dimensions are covered: municipality organization - internal organizational efficiency, Citizens - social welfare and democracy, Industry - a collaboration with firms and entrepreneurs. |
| Mattke, Jens & Maier, Christian & Hund, Axel & Weitzel, Tim. (2019). How an Enterprise Blockchain Application in the U.S. Pharmaceuticals Supply Chain is Saving Lives. | Interview and discussion, case study | Pharmaceuticals Supply Chain | Qualitative | The MediLedger project is an American initiative for the pharmaceutical supply chain. The aim of the system is to avoid counterfeit, connect various actors involved, establish secure transactions and products verification. |

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| Zavolokina, Liudmila & Ziolkowski, Rafael & Bauer, Ingrid & Schwabe, Gerhard. (2020). Management, Governance and Value Creation in a Blockchain Consortium. | Interviews, observations. | Inter-Organizational Collaboration | Qualitative | Blockchain technology is not only a tool to facilitate inter-organizational collaboration. It also makes it easier for businesses to transact and creates a new type of organizational collaboration (Blockchain consortium) that has its own peculiar characteristics. Additionally, authors were involved in such platform creation. |
| Zavolokina, Liudmila & Zani, Noah & Schwabe, Gerhard. (2019). Why Should I Trust a Blockchain Platform? Designing for Trust in the Digital Car Dossier. | Survey, observation, system design | Digital dossier (car industry) | Qualitative | Trust is essential in all transactions, so the question "How to establish trust between participants and secure transactions" is still open. Authors suggested the set of design elements for platform developers to encourage them create more secure and trustworthy systems. |
| Fleischmann, M., & Ivens, B. (2019). Exploring the Role of Trust in Blockchain Adoption: An Inductive Approach. | Observations, interviews, data analysis | Cross-industrial | Qualitative | Trust aspects are key drivers for Blockchain acceptance, and the study covers both functional and economic benefits from the user/customer perspective. |
| Holotiuk F, Pisani F, Moormann J. (2017). The Impact of Blockchain Technology on Business Models in the Payment industry. | Questionnaire | Financial sector | Qualitative | Business models in the financial sector change incredibly fast so it is important to take into consideration emerging technologies. blockchain was presented in the financial sector as a major, so the idea of how to move this industry forward is an open question |
| Meyer, Christopher & Gerlitz, Laima & Henesey, Lawrence. (2020). Cross-border capacity buidling for port ecosystems in small and medium-sized baltic ports. | Audits, case studies, desk research | Marine (Baltic) Ports | Qualitative | The audits carried out within the European Connect2SmallPorts project showed an exceptionally low technology assurance level in small and medium-sized BSR seaports, although port representatives praised digital learning opportunities. Audits revealed the potential of changes and should be covered in training for ports |

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| Qian, X. A., & Papadonikolaki, E. (2020). Shifting trust in construction supply chains through blockchain technology. | Interviews | Supply chain | Qualitative | Trust between stakeholders is essential to adopt Blockchain technology, so authors focused on inter-organizational issues, but the collected data from experts can be subjective. |
| Hopkins, J. L. (2021). An investigation into emerging industry 4.0 technologies as drivers of supply chain innovation in Australia. | Interviews | Supply chains | Qualitative | COVID-19 pandemic revealed the digitalization is essential in the modern world and companies are moving forward emerging technologies as a source of innovation. The author named the most popular ones and provided the level of potential customer awareness and readiness. |
| Al-Musawi, M. M. (2020). Transforming One-Stop E-Services in Iraq: Focusing on perception of Blockchain Technology in Digital Identity System. | Survey | E-government. Security (identification) | Quantitative | E-government can be effective with the use of Blockchain technology and ID system. Some benefits along with challenges are mentioned. The results show that Blockchain can be more effective than traditional ICT. |
| Yang C.-S. (2019) Maritime shipping digitalization: Blockchain-based technology applications, future improvements, and intention to use | Questionnaire | Maritime shipping supply chain | Quantitative | Authors tested the challenges and benefits of Blockchain technology in the maritime shipping supply chain. Perceived benefits, such as automation and paperwork reduction have a positive impact on the technology adoption. |
| Linsner, S., Kuntke, F., Schmidbauer-Wolf, G. M., & Reuter, C. (2019). Blockchain in Agriculture 4.0 - An Empirical Study on Farmers Expectations towards Distributed Services based on Distributed Ledger Technology. | Interview | Agriculture | Qualitative | The majority of respondents were open to the possibility of direct marketing via decentralized platforms. However, the concept of joint management of several farms was perceived as unattractive. In general, digital services tended to be seen as an additional expense. When designing DLT-based services, care should be taken to ensure that the concerns of those affected should be |

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| | | | | addressed to improve the acceptance of the new services. of the new services. |
| Andoni, M., Robu, V., Flynn, D., Abram, S., Geach, D., Jenkins, D., McCallum, P., & Peacock, A. (2019). Blockchain technology in the energy sector: A systematic review of challenges and opportunities. | Case study | Energy market | Qualitative | The paper reveals the main literature that is related to blockchain and use cases from the industry. Many research and Blockchain innovation cases are currently being applied to the energy sector. There is a summarized table with platform, companies, and their location for easier search. |
| Thiruchelvam, Vinesh & Mughisha, Alexandre & Shahpasand, Maryam & Bamiah, Mervat. (2018). Blockchain-based Technology in the Coffee Supply Chain Trade: Case of Burundi Coffee. | Case study, Questionnaire | Supply chains (coffee) | Quantitative | The coffee supply chain has a substantial number of intermediaries and that is why Blockchain can help to automate main processes, provide secure transactions, while using smart contracts the reduction of paperwork and costly delays take place. Using TAM, the authors suggested implementation hints. |
| Knauer, F., Mann, A. (2020). What is in it for me? Identifying drivers of blockchain acceptance among German consumers | Case study, online survey | Customer behaviour, feedback | Quantitative | The customer's perspective is especially important in studies, and it has 2 sides. From one side, they are sure about benefits, like decrease transaction costs and increase security. But on the other, the majority of them do not even know how to get access to the platform. Results can help researchers and developers to create strategies of technology acceptance. |
| Supranee, S., Rotchanakitumnuai, S. The acceptance of the application of Blockchain technology in the supply chain process of the Thai Automotive Industry | Questionnaire , case study | Automotive industry | Quantitative | The authors mentioned main factors that have positive or negative influence on the technology adoption/acceptance by users. Results are useful for as an implementation guidance in the industry. |

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| Li, X., Lai, P.-L., Yang, C.-C., & Yuen, K. F. (2021). Determinants of blockchain adoption in the aviation industry: Empirical evidence from Korea. | Case study, questionnaire | Aviation | Quantitative | Future regulatory improvements management and industry standards, as well as technological improvements and efficiency optimizations, digital and air traffic control. Respondents are open to new novel changes and think positively on Blockchain implementation in the industry |
| Sternberg, H. S., Hofmann, E., & Roeck, D. (2020). The Struggle is Real: Insights from a Supply Chain Blockchain Case. | Case study, observation | Supply chains | Qualitative | The study supported previous conceptual research, revealed some paradoxes and tensions for/against adoption. It is essential to consider both positive and negative factors. The proposed model relates to the vertical context. Additionally, it was mentioned that the integration decision of one actor may have an impact on the other stakeholders. |
| Liang, T.-P., Kohli, R., Huang, H.-C., Li, Z.-L. What Drives the Adoption of the Blockchain Technology? A Fit-Viability Perspective | Survey, case study | Cross-industrial | Quantitative | The authors used 7 theories to analyse experts opinions regarding Blockchain adoption/implementations and revealed factors that have an impact. |
| Bhattacharyya, S. S., & Shah, Y. (2021). Emerging technologies in Indian mining industry: an exploratory empirical investigation regarding the adoption challenges. | Interview | Mining | Qualitative | Despite the study was conducted in the mining industry, results are applicable in various spheres. Emerging technologies are popular and are used in some processes, but there are barriers that hamper companies from adoption, such as lack of awareness, no legal regulations, culture, and no clear benefits in the short term. |
| Dabbagh, M., Choo, K.-K. R., Beheshti, A., Tahir, M., & Safa, N. S. (2020). A Survey of Empirical Performance Evaluation of | Experiment | Blockchain Platforms | Quantitative | The authors proposed a comparative analysis of the most popular Blockchain-based platforms using 10 criteria. The accent is made on the performance evaluation, while the |

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| Permissioned Blockchain Platforms: Challenges and Opportunities. | | | | majority of studies are focused on trust, costs, and security issues. |
| Wan, Z., Xia, X., Lo, D., (...), Luo, X., Yang, X. Smart Contract Security: A Practitioners' Perspective. | Interviews, survey | Security | Quantitative | Smart contracts attract more and more attention. That is why the main research question was how developers overcome security issues in practice and how the trust can be increased. |
| Kopyto, M., Lechler, S., von der Gracht, H. A., & Hartmann, E. (2020). Potentials of blockchain technology in supply chain management: Long-term judgments of an international expert panel. | Survey | Supply chain | Quantitative | Blockchain's future is still unclear, so in the study authors collected information with predictions up to 2035. The results reveal that the technology will be actively used in the supply chain and give the perspective for practitioners. |
| Seebacher, S., Schüritz, R., & Satzger, G. (2020). Towards an understanding of technology fit and appropriation in business networks: evidence from blockchain implementations. | Interview | Cross-industrial | Qualitative, inductive | The main accent is made on the connection between technological and social dimensions of business network. Additionally, factors that have an influence and further consequences are mentioned. |
| Veerpalu, A. (2019) Shareholder ledger using distributed ledger technology: The Estonian perspective | Case study, observations | Government | Qualitative | The Estonian case of distributed ledger technology is observed. The technology-neutrality principle can be applied according to the current regulations and shortcomings with possible suggestions are mentioned. |