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Blockchain: the relation with accounting and its application to Smart Cities

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Contents

Abstract

In this thesis, we defined a study based on blockchain technology and the opportunities which it offers applied to various sectors. We have underlined the main facets of a blockchain, comparing its decentral feature to the traditional ledger in which the management was handled by a single authority, such as in banks and / or public administration, and its role in financial transactions indicating the main advantages and disadvantages in the accounting sector, especially as regards the credit risk management.

In this research we have not sought to directly expand the theoretical framework or to develop new general ideas about technological improvement, but rather to test existing hypotheses within the deductive research approach aimed at filling the lack of empirical evidence of such technological improvements.

Subsequently, we explored the legislative field, taking into account the Italian regulations, where even today this technology is little used or is still seen as a possible threat due to the implementation problems that make its applicability and adaptability for different sectors difficult. This is contrary to what happens in the US, Japan, or United Arab Emirates, where we can find more regulation.

Finally, to give a more realistic view of the theoretical framework given initially, a case study will be presented, relating to a smart city, more specifically the Smart Dubai City. This term refers to an intelligent city but above all to a sustainable, efficient, and innovative city. A city capable of guaranteeing a high quality of life to its inhabitants thanks to the use of connected and integrated technological solutions and systems.

Dubai will be a pioneer in this sense, as the government's intentions are to make it the first city organized entirely with blockchain systems in the near future.

In summary, after outlining the situation at a general level and verifying the results obtained, we were able to see how, despite the great interest shown in this technology, which certainly plays a positive and important role in the management of commercial relationships, there are some aspects that make its implementation difficult.

Introduction

The interaction between human and machine in economic, health and financial management has always fascinated me. This theme has been taken into consideration because in recent decades everything that concerns technological evolution, in the broadest sense of the term, has been changing our way of life.

My generation has lived in this sense, an important passage of change compared to the generation of my parents.

The problem that has found by documenting for the drafting of the thesis is that we are not very effective, in the sense that we do not always apply our technological knowledge in a productive way.

This research was conducted to identify the current theoretical framework for the development of blockchain solutions applied to the banking and business management sectors, this allowed me not only to understand the current state of academic research on the subject but also to determine what advantages would be gained by companies using this technology, as well as what is the impact of the concept and application of blockchain technology on the management of transactions and relationships that affect millions of companies every day.

Despite the initial enthusiasm shown towards this technology, on the one hand, it highlights advancement in the management of disputes among users, but on the other hand, it emerged that the system robustness was not yet fully tested and difficult to implement.

I conducted the bibliographic research by drawing on the information mainly in the articles written by the Deloitte data banks, or report by ResearchGate a community of researcher and scientists, from case studies taken from Emerald Insight, a research tool of the Cà Foscari University library which gave me the possibility to investigate the current situation of blockchain technology, to distinguish a systematic review of blockchain applications across several fields as well as helping to identify the main features that can transform business practices. In addition, I examined some economic reports taken from ICAEW or Bird & Bird which highlighted the strengths, objectives and results achieved with the use of this technology.

The keywords I used in my literature search include blockchain, double-spending, real-time accounting, credit risk, distributed ledger. In the literature search procedure, I distinguished the focal academic and economical profiles engaged in blockchain-based accounting research and those who designed the theoretical framework for the financial and accounting use of the technology.

CHAPTER 1 – A theoretical perspective on blockchain

1 Literature review

The idea of blockchain technology concerning the transferring valuable digital assets such as currency without any third-party intermediary. Assuming that the role of the intermediary has great importance in transaction of digital assets in order to guarantee to avoid the obstacle known as double-spending[1].

The digital transfer of assets, however, could not occur without the existence of a regulatory body, which could be the guarantor of the authenticity and security of the transaction. The initial point to consider is what banks work: if you want to carry out an online transaction, for example a bank transfer, the operation can solely take place using the digital platform of your credit institution and generally the operation is concluded within a period of time temporal which on average goes from 24 to 48 hours later.

As a result, the regulator's goal, in this case the bank's, is to approve the transaction by verifying that the amount of money transferred from one user to another is consistent with the availability of the payer's current account, and then reducing the payer's deposit by an amount equal to the amount transferred, while raising the beneficiaries by the same volume.

This innovative technology is a solution to remove the need for a trusted third-party in many fields of accounting and financial relationships. Specifically, in the 2021 report by Adriana Tiron-Tudor, Cluj-Napoca, Delia Deliu, Nicoleta Farcane and Adelina Dontu argued that through the use of this new technology, accounting data becomes less opaque and more verifiable, which are facilitated by decentralization, immutability, consensus protocols, and programmability of technology. However, this tool outlines some unfavourable peculiarities that must be reviewed and calibrated in order to implement the operating systems, that is, ordinaries organizational not yet fully mature to act in conjunction with blockchain, uncertain legal framework,

[1] *Usman W. Chohan*, *Social Science Research Network. UNSW Business School; Critical Blockchain Research Initiative (CBRI); Centre for Aerospace & Security Studies (CASS). (January 6, 2021* "*The Double Spending Problem and Cryptocurrencies".*

technological barriers, and high energy consumption requirements necessary to conserve the network[2].

Besides, most accounting firms' industrial reports extensively cover blockchain accounting as a platform for conventional corporations. As a result, the industry is a step ahead of academia in developing a comprehensive theoretical framework as a basis for implementing the technology. Furthermore, the Deloitte study *"Blockchain technology a game-changer in accounting?"* voiced the same viewpoint as stated above, in which that technology has the ability to reframe the character of today's accounting and simplify the procedures for validating the authenticity of accounting data[3].

Additionally, Tim Weingärtner, Danielle Batista, and Gilles Voutat in their article "*Prototyping a Smart Contract Based Public Procurement to Fight Corruption*" argue that blockchain-based smart contracts can be used to prevent frauds in public procurement and to diminish the concentration of power among a few public officials.

The use of smart contracts and other innovative technologies in public procurement are under investigation as a way to mitigate fraud. Notably, Hardwick, Akram, and Markantonakis ' 2018 report on the use of smart contracts supported by the government shows that it can significantly improve user trust thanks to their integrity, verifiability, and transparency, especially with regard to the peculiar aspect of payments between the parties[4].

Through a high-level overview of legal and practical challenges that may make the adoption of blockchain-based platforms difficult, a case in South Africa analyses how blockchain-based platforms might be a viable solution for combating corruption in

[2]*Adriana Tiron-Tudor Babes-Bolyai University, Cluj-Napoca, Romania Delia Deliu and Nicoleta Farcane West University of Timisoara, Timisoara, Romania, and Adelina Dontu Babes-Bolyai University, Cluj-Napoca, Romania. Journal (2021). "Managing change with and through blockchain in accountancy organizations: a systematic literature review", Available on Emerald Insight at: https://www.emerald.com/insight/0953-4814.htm*
[3]*Deloitte (2016*) "*Blockchain technology a game-changer in accounting".*
[4]*Hardwick, Freya Sheer; Akram, Raja Naeem; Markantonakis, Konstantinos (2018), "Fair and Transparent Blockchain based Tendering Framework – A Step Towards Open Governance".*

public procurement. According to the authors, blockchain technology and smart contracts have the capacity to introduce fairness, transparency, and accountability[5].

In line with this idea the World Economic Forum (WEF) is advocating the use of blockchain as part of the public procurement process at some stages, considering it to be one of the best methods for keeping and sharing records, ensuring transparency, and enforcing security.

As regard the security of transaction using blockchain technology are covered by a high level of authenticity designed to protect any type of information.

The concept of security, as supported by is also given by transparency, i.e., the information provided is correct, truthful and complete and is accessible to all participants[6].

According to the document published in 2020 by Deutsche Bank Research finds that the blockchain used by large organizations helps to increase transparency, quality control of products, creating trust with consumers and reducing the risk of defective product[7].

In particular, writing about security, the blockchain technology has the goal to prevent the double spending, since duplicating a digital asset is much simpler than duplicating a paper banknote, many hackers are encouraged to attack and engage in real scams to damage honest miners.

In this paper we will verify the reasons why it was possible to attack a blockchain and the solutions adopted to solve the problem through cryptography or the consensus mechanisms used by it[8].

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[5] *Sope Williams-Elegbe, (2019) "Public Procurement, Corruption and Blockchain Technology in South Africa: A preliminary legal inquiry. In regulating public procurement in Africa for development in uncertain times".*

[6] *Teppo Felin and Karim Lakhani, (2018), "What problems will you solve with blockchain? Before jumping on the bandwagon, companies need to carefully consider how ledger technologies fit into their overall strategy".*

[7] *Corporate Bank Research (October 2020) Blockchain and Corporates.*

[8] *Ansgar Fehnker, Vishal Chand, Kaylash Chaudhary, Completed Research Paper (2020) "Double-Spending Analysis of Bitcoin".*

1.2 The transition from Centralized Ledger to Decentralized Ledger

Before getting to the heart of the topic, we have to discuss about the cluster of technologies classified under the name of Distributed Ledger, that operate as distributed archives (registers).

Firstly, a brief mention on the Ledger should be made. The Ledger in accounting, concerns to a series of data containing the records of transactions related to a company's assets, liabilities, owners' equity, revenue, and expenses. Anything in the world which has a financial value needs a ledger, for this reason it can be consider as the pillar of any accounting system which has financial and non-financial data for an organization.

Traditional Ledgers, i.e., those through which public administrations and banks manage the accounting and data recording are centralized (Centralized Ledger).

Technologies that rely on Centralized Ledger are the representation of the centralized logic, where everything is managed by referring to a structure or centralized authority, which represents the trusted body, guarantor of the reliability of the transaction.

With each data change contained in the archives, the Ledger is changed by an authority central office responsible for its management. In this way banks and other entities can verify that actually information regarding a specification transaction and the parties involved are correct and, therefore, approve it.

At the base of this technology there is the trust that everyone must have in the manager of the Central Ledger which then acts as a third party which it guarantees for all parties to the transaction. In addition, the Ledger manager checks that access to information is allowed only to certain users; think for example to a bank that has the power to decide who can access and control the balance of a current account.

Conversely, the empirical reality in which the bank has all this power in some cases could be harmful since if the entity-in-charge has malicious intent, it can do significant damage to its clients.

An example could be that the central body can close transactions without notice and they will no longer be carried on. Giving this kind of authority to someone will result in error, whether it be accidental or not.

The emergence of digitalization has definitely changed this approach management, however in the first phase the changes focused in particular, on one acceleration of the storage and modification system of the data contained in Ledgers that have become progressively more performing and faster to use.

Nevertheless, the considerable transition starts several years later with Blockchain and Distributed Ledger (DLT).

When we mention Distributed Ledger technology, we refer to a decentralized ledger with multiple nodes and actors, in which the same copy of database can be read or modified in independent manner by each individual participant.

The characteristic that makes this approach more reliable and efficient than the traditional one is decentralized and distributed nature. The records in the ledger are not passed from a specific authority to multiple nodes; indeed, the latter are independently constructed and held by every single node in the network. Each executed transactions are proceeded by every distinct user. Furthermore, each user has the task of validating the authenticity of each transaction with the aim of ensuring that the necessary percentage (50%) of the nodes on the network are agree with the conclusions[9].

The voting is called the consensus and once it is reached, the distributed ledger is updated and all nodes on the network will have the same and immutable copy of the ledger.

This is a disruptive architecture since the logic it is distributed among the various components of the network and there is no longer any centre, but each subject becomes himself guarantor of the transaction between any other participant in the network. This means that no one prevails over others and the decision-making process passes strictly through a previous process of acquiring consent to which all nodes of the network take part.

The question in this case arises spontaneously "How can the legitimacy of a transaction be verified if there is not one central authority who acts as guarantor?" The answer lies in the decentralization of the Ledger that, with the blockchain, passes

[9] *Claudia Antal, Tudor Cioara, Ionut Anghel, Marcel Antal and Ioan Salomie, future internet article (2021), "Distributed Ledger Technology review and decentralized applications development guidelines".*

from being uniquely owned by a central authority to belong to all. The ledger therefore belongs to all members of the network, each has a copy and can view and control it.

Anyone can implement a transaction or modify an existing one since the request for modification or implementation will be accepted by all network participants only after they have agreed on its legitimacy. The centrality therefore lies in the rule of consent. The autonomy of each node is subject to the achievement of a consensus on the operations, as mentioned above.

At this point, we could understand the characteristic of immutability of the blockchain, as it is possible to destroy or at least damage a Centralized Ledger by directly attacking its central authority, vice versa in the case of the blockchain it is practically impossible, they should simultaneously damage all copies of the ledger owned by all participants[10].

From here it emerges that DLT is a new way of manage relationships between people and information.

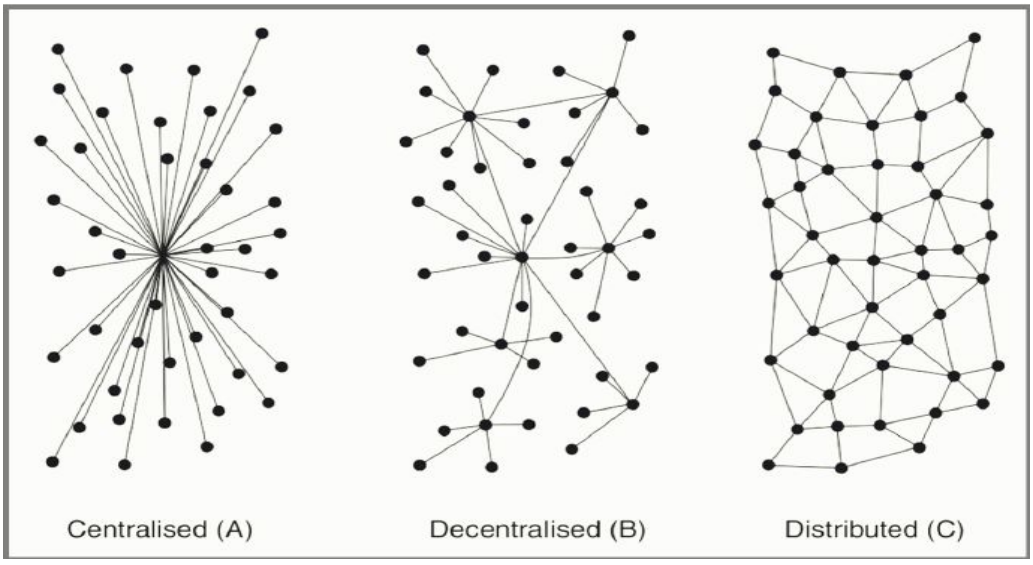

Figure 1: How work the centralised, decentralised and distributed ledger.

[10] *Kevin FK Low and Ernie GS Teo, Journal Law, Innovation and Technology (2017), "Bitcoin and other cryptocurrencies as property?".*

1.3 The history of Blockchain thanks to Bitcoin

Blockchain can be defined as a technology that allows the creation and management of a set of transactions through a block database.

It is a significant shift in the way financial records are generated, maintained, and updated. Blockchain records are shared between all of their members rather than having a single owner. The power of this technology is in its ability to apply a complicated system of agreement and verification to ensure that, despite the absence of a central authority and time gaps between users, a single, agreed-upon version of the truth is distributed to all participants as part of a permanent record. As a result, a type of "universal entry bookkeeping" emerges, in which a single entry is distributed uniformly and permanently with all participants.[11].

Given the great importance that the concept is gaining on the global stage, it is necessary to explain the peculiarity that makes it so tempting and how it could be a solution of considerable interest in various areas, especially in the field of accounting and finance.

Firstly, the history of blockchain idea begins in 1999 when the technological solution was suggested to solve the obstacle of time-stamping easily modified digital assets such as pictures, text documents and audio files to track when a file was originated and when it was changed. This solution was argued in a 1991 article titled "*How to time stamp a digital document*"[12].

Nevertheless, the first practical implementation of the technology was presented in the winter of 2008 by its creator, Satoshi Nakamoto and its team, who made public the White Paper entitled "*Bitcoin: A Peer-to -Peer Electronic Cash System*", explaining their idea of peer-to-peer cryptographic virtual currency without third-parties, governed by algorithms. The proposed idea is a real declaration of war on the banking world, which in that period was overwhelmed by a profound crisis. In 2009 the Bitcoin network begins to function; the community starts to grow and bitcoin is used for the first time for the purchase of a good in the physical world: a pizza.

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[11] *Icawe thought leadership, IT faculty*, "*Blockchain and the future of accountancy".*
[12] *Haber, S. and Stornetta, W. (1991). "How to time-stamp a digital document. Journal of Cryptology", [online]. Available at: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.103.5300&rep=rep1&type=pdf.*

Specifically, the aim of the Paper is to clarify how the Bitcoin system allows the digital transfer of money between two subjects, without resorting to a third-party with the function of intermediary, but basically with the application of a network of users who make up the chain of blocks. The speed of the transaction and the immediacy of the payment that is made in this way, however, would fail, according to Nakamoto, when it is not guaranteed that the transaction is authentic and protected. In fact, when the blockchain system was introduced, digitization had already largely taken over in various areas, including payments.

This feature of the blockchain can be described as the ability to create and maintain unique digital assets and is this innovative property that has made it successful. From this point, derives the concept of Token, which expresses any digital asset that can be exchanged between two parties without the intermediaries but through the blockchain[13].

This asset is marketed on the basis of its actual value, that is, the issuer guarantees to be able to provide a service that can be purchased thanks to the Token, therefore the buyers will be subjects who believe in the value of that service to the point of purchasing it through Token to use themselves of that service or to sell it to others who can then use it in turn. One of the first examples of tokens is Bitcoin, and later other models have been developed, even different ones, such as those created through the Ethereum blockchain.

The blockchain technology in addition to being vital for Bitcoin, has a number of properties that can be applied to other activities to solve various complications.

It is projected to provide the most value to organizations by resolving issues such as preserving record integrity across various entities, preserving information for verification in time of need, promptly regulating and supervising value exchanges, and finally validating user identification.

It's also worth noting that blockchain is still at the embryonic or proof-of-concept stage in various application fields. There are essentially two fields in which it finds potential for application: payments and supply chain management.

[13] *Yan Chen, Business Horizons (2018), "Blockchain tokens and the potential democratization of entrepreneurship and innovation".*

With the recent increase in trade and in particular in international trade, financial institutions are constantly aiming to moderate the slowness and inadequacy of cross-border payment methods. In addition to compliant banking relationships, recent standards also require the presence of an intermediary, thus affecting the timing and commissions associated with the operation. If used to manage such payments, the blockchain can allow for faster, cheaper transfers, unlike current systems.

As regards the supply chain process, the blockchain can overcome some problems. This process being more and more complex as it is very often end consumers and companies are unaware of the history of different products, from the raw material to the moment they arrive final consumer[14].

Establishing provenance is often a challenge, as the complexity of supply chains translate into the fact that products travel through vast networks of operators often beyond national borders. Traceability requires a system I specify that it follows the products throughout their life cycle, from the initial procurement of raw materials to production, distribution and consumption.

Typically, product information comes stored in isolated systems belonging to the companies located in the different stages of the supply chain and are accessible only to certain supply partners' chain; this does not allow to have a transparency on what happens all along the supply chain.

To overcome this limitation, blockchain technology can be implemented by each actor in the supply chain to memorize the path of products along the supply chain and provide that information to consumers improving their purchasing decisions[15].

Also, it can improve the visibility of the actors of the supply chain about the work of upstream and downstream companies, a factor that plays support of their decision making.

[14] *Rohith P. George, Brad L. Peterson, Oliver Yaros, David L. Beam, Julian M. Dibbell and Riley C. Moore, Journal of investment compliance (March 2019). "Blockchain for business".*
[15] *Joon-Seok Kim and Nina Shin, Sustainability article (2019), "The Impact of Blockchain Technology Application on Supply Chain Partnership and Performance".*

1.4 The main typologies of blockchain

Blockchain technology, as we mention above, is a type of DLT running on a network of nodes that can function as a public and private blockchain.

The substantial different of these two typologies concern the authorisation scheme which identifies which participant can enter into the platform.

A public blockchain or also called permissionless are qualified in this way those in which no authorization is required to access the network, to perform transactions or to participate in the verification and creation of a new block[16].

The most popular are Bitcoin and Ethereum, where there are no requisite or boundaries of access. Anyone can take part in it. It is an entirely decentralized structure, as there is no central body that supervises the access authorizations. The data are distributed among all nodes uniformly. The principal features of it are that no user of the network has privileges over others, no one can control the information stored on it, modify or delete it, and no one can manipulate the protocol that defines the operation of this technology.

Even though the data recorded on these Blockchains are public, they are encrypted to conserve an adequate level of privacy. For instance, all Bitcoin nodes recognise the wallet addresses of other participants and the transactions that have taken place between them. In principle, these addresses are pseudonyms and, except if they are traced to the identity of the real-world person who owns them, a sufficient level of privacy is assured.

The main concern related to public Blockchains is the obstacle of scalability, or the capacity of a system to enhance as the number of participants increases. This typology of network is not a scalable technology since even if the number of nodes increases, the speed of transactions remains unchanged but the stability of the system arises, thus becoming more secure.

The other major type of blockchain is Permissioned or private Blockchain. In contrast to public blockchains, in which anyone can download the software, create a node,

[16] *Veronica Valsecchi (June 2018) "La classificazione delle Blockchain: Pubbliche, autorizzate e private".*

vision the ledger and interact with the blockchain, a permissioned blockchain has a central body that defines who can access them.

In addition to specifying who is authorized to be part of the network, this authority fixes the roles that a user can cover within it, also defining rules on the visibility of recorded data. The permissioned Blockchains therefore introduce the notion of centralization and governance in a network where the pillars are decentralized and distributed nature. Only the entities participating in a transaction will have knowledge about it and the other third parties or stakeholders will not be able to access it. Two well-known examples of private blockchain could be the Hipper or Hyperledger, through which a person that want to enter in that blockchain need the permission about the central authority.

As we noted above, private blockchain also rely on the presence of a trusted intermediary, this raises the question of "What are the differences between this model and a traditional database controlled by a central authority?" Although this is a good question, it ignores some of the characteristics of blockchain technology that, in some cases, make private blockchain more desirable than traditional database[17]. Taking the following examples:

- **Immutability,** which means that once data has been recorded in a blockchain it is very difficult to make change without becoming instantly apparent to all participants, and thus being rejected.
- **Digital signatures**: digital signatures allow parties who are not familiar whit or trusting each other to approve and record transaction data on to the blockchain without the involvement of an intermediary. In this way, input from various sources can be coordinated more easily.

Exist situation in which organizations will want the best of both, in this case we speak about hybrid blockchain, which combines the features of both public and private blockchain. It lets organizations set up a private, permission-based system alongside a public permissionless system, allowing them to control who can access specific data stored in the blockchain, and what data will be opened up publicly.

[17] *Jonathan Emmanuel and Gavin Punia, article "Bird & Bird & private Blockchain".*

Exist a situation in which organizations will want the best of both, in this case, we speak about hybrid blockchain, which combines the features of both public and private blockchain. Using it, organizations can set up a private, permission-based system alongside a public, permissionless system, so they can control which data is publicly available, as well as who can access it.

A hybrid blockchain typically does not make transactions and records public, but they can be checked when needed, for example, through smart contracts. It is possible to verify the confidentiality of information within the network, but the private organizations cannot alter transactions.

A member of a hybrid blockchain has the maximum access to the network. Unless other users engage in a transaction, the identity of the user is protected. Only then is their identity revealed to others.

The key advantage of hybrid blockchains is that, as they operate within closed ecosystems, outside hackers cannot take over the network through a 51% attack. Furthermore, hybrid blockchains protect privacy while enabling third-party interaction. In particular, this type of blockchain has better scalability and cheaper transactions than a public blockchain network.

Due to its ability to shield information, hybrid blockchain isn't completely transparent. The network is also difficult to upgrade, and users have no incentive to help out.

Hybrid blockchain is however useful in real estate, among other fields. By using it, companies can run their systems privately while also displaying certain information to the public, such as listings.

Federated blockchains, also called consortium blockchains, are similar to hybrid blockchains since they combine private and public blockchain features. Essentially, a consortium blockchain is a private blockchain between authorized groups, eliminating the risks of leaving the task of controlling the network to a single entity as on a private blockchain.

The consensus methods in a consortium blockchain are governed by the current nodes. It has a validator node, which is responsible for initiating, receiving, and validating transactions. Transactions can be received or initiated by member nodes.

This sort of blockchain can be used for banking and financial. Different banks, for instance, can join forces to establish a consortium, determining which nodes will authenticate the transactions. Groups who want to monitor food, as well as research organizations, can construct a comparable model. It's great, also, for supply networks or medicinal applications.

1.5 Benefits of blockchain and more

Blockchain, as we noted, is a brilliant and innovative technology that led a lot of advantages in our lives and in the way in which companies work.

Some of its peculiarities could be the following[18]:

- **Truth:** By using blockchain, trust can be created between entities that lack or cannot be proven. Consequently, these entities are willing to engage in transactions and data sharing that they may not otherwise have been able to do or would have required an intermediary in order to accomplish. A key feature of blockchain, Bitcoin specifically, is that it allows participants who are unfamiliar with one another to trust each other.
- **Immutability:** It is already impossible to change or modify the information block once it has been added to the chain unless a subsequent block is added to modify it since everything on the blockchain is timestamped and data-stamped, creating a permanent record.
- **Privacy and security:** With end-to-end encryption, blockchain creates an unalterable record of transactions, which prevents fraud and unauthorized transactions. As a result of anonymizing data and requiring permissions to access it, blockchain can address privacy concerns better than traditional computer systems.
- **Individual control:** According to Michela Menting, research director of ABI Research "*In a world where data is a very valuable commodity, the technology inherently protects the data that belongs to you while allowing you to control it*". Due to this, blockchain-enabled smart contracts allow individuals and

[18] *Geraldo Vasquez, CPA Journal (June/July 2021), "An introduction to blockchain: What does it mean for the accounting profession?".*

organizations to decide what digital data they want to share with whom and for how long, while enforcing limits in accordance with their preferences.

- **Costs reduced:** By eliminating the presence of middlemen, the process can be sped up and the costs incurred by companies can be reduced.
- **Transparency:** A blockchain would remove the requirement of separate databases for each organization. Since blockchain uses a distributed ledger, transactions and data are recorded in multiple places simultaneously, in fact the same information is seen by all network participants. This ensures complete transparency.

Nevertheless, these benefits should be estimated taking into account the negative aspects that may loom.

From security point of view, it should be remembered that the settlement mechanisms within a blockchain network require each actor to have not only a public key visible to other users, but also a private key intended to remain confidential. In the event that a private key is lost, there will be no possibility of recovering it, just as it will no longer be possible to access the managed funds.

Instead from an energy point view, can we highlight how blockchain is not a very environmentally friendly technology. As an example, blockchain implementations currently have negative impacts related to the use of energy and the consequential effects on the environment. In order to create blockchains, computers need a lot of processing power, which in turn needs a lot of electricity and cooling power. In particular, it was deducted that the energy expenditure of Bitcoin alone will be equal that of Denmark by 2022[19].

The existing blockchain structure is expensive in terms of energy usage and scale. The core issue is that all blockchain transactions must be performed by almost everyone, and everyone must have a copy of the global ledger. As the blockchain expands in size, more processing power and bandwidth are necessary, and there is a

[19] *Jon Huang, Claire O'Neill and Hiroko Tabuchi, New York Times article (2021), "Bitcoin uses more electricity than many countries. How is that possible?" Available at: https://www.nytimes.com/interactive/2021/09/03/climate/bitcoin-carbon-footprint-electricity.html"*

danger of the blockchain being centralized in terms of decision-making and validating power, as just a few people wish to contribute their time to keeping it functioning.

Along with scaling issues, blockchain governance is an obstacle that has yet to be overcome. There must be well-defined approaches to resolving disagreements as there is no central player[20].

The last critical issue exposed allows us to introduce another aspect concerning the implications related to the processing of information in the blockchain. Pending to expose a reason in favour of traditional technologies, one could refer to the fact that computational processes in a centralized infrastructure have a lower redundancy than the use of DLTs.

This depends on the fact that when a register is modified, the update must involve all the nodes associated with it. This is not a design flaw, but a determining factor for the certification mechanism of a distributed architecture: each node must keep a copy of the ledger, a constraint that can only be satisfied through operations intended to be repeated constantly.

Finally, it is necessary to refer to the cultural resistance that often welcomes the entry of disruptive technologies on the market. The competitive advantage deriving from the abandonment of legacy solutions, often used for decades, may not be immediately perceived as such by all operators in a sector. In finance, this phenomenon is accompanied by a substantial difficulty in integrating the pre-existing solutions with the blockchain networks that are born instead to replace traditional generally centralized architectures.

The lack of a clear and shared regulation regarding the adoption of distributed technologies could help fuel scepticism and support the permanence of intermediation processes, but it is probable that critical issues of this type are destined to find solution in the medium term also thanks to the growing interest in DLT by central banks[21].

[20] *Jonathan Emmanuel, Bird&Bird (January 2020) "Blockchains uncut: risks, rewards & regulation".*
[21] *Iyolita Islam, Kazi MD. Munim, Shahrima Jannat Oishwee, A. K. M. Najmul Islam, and Muhammad Nazrul Islam, Article (2020), "A Critical Review of Concepts, Benefits, and Pitfalls of Blockchain Technology Using Concept Map".*

1.6 The essential components

To understand how a blockchain works, it is useful to highlight which are the main components of it. Essentially, we have five important components of this technology ecosystem and are the following:

- the nodes,
- the consensus algorithm,
- the block,
- the hash,
- the ledger.

Firstly, the node consists of each server connected to the Internet, which must install a specific computer application for the ecosystem in which it wishes to participate. Then we have the consensus algorithm which is a mechanism that allows users or devices to coordinate in a distributed context. It must ensure that all agents in the system can agree on a single source of truth. In particular, among the consensus algorithms we can find are the proof of work and the proof of stake, which will be explained in more detail in the next paragraph. As regard the block consists of a set of transactions that are verified and approved together by each participant, instead the hash is defined, in literature, as a non-invertible operation that allows you to map a text or numeric string to a unique string of a given length. Identify securely each block. Once a string has been encoded via Hash it is impossible to trace the general string that originated it, finally, we have the logical component, the ledger, that is a data structure managed within the node application. Finally, the ledger, which is a data structure handled within the node program, is the logical component. You can view the contents of the associated ledger for that ecosystem once the node program is operating[22].

[22] Geroni Diego, Article 101Blockchain (August 2021) "Blockchain ecosystem, know the core components".

1.7 Proof of work vs Proof of stake

As we anticipated in the previous paragraph, it is useful to focus on what proof of work and proof of stake are in a blockchain.

For this reason, it is important to highlight that every cryptocurrency is centred on a network of computers that helps protect the software from attackers and is responsible for regulating the issuance of new units of its supply. This system is called a consensus mechanism.

The main consensus mechanisms are:

- Proof of work (PoW)
- Proof of stake (PoS)

Both the Proof of work and the Proof of stake require the use of computer algorithms responsible for the great success of cryptocurrencies such as Bitcoin and Ethereum. These algorithms are used to arrive at what is referred to in the cryptocurrency world as "distributed consensus".

Firstly, the proof of work algorithm helps all nodes of a blockchain find the solution to the so-called cryptographic puzzle, which require a great effort in terms of processing capacity of the server of all users. This approach is called mining and is solved by miners.

Specifically, miners try to solve this complex mathematical dilemma in order to be able to find a solution (the connection hash between one block and another) and receive a reward for the work done. The greater the computing power used, the greater the chances of solving the puzzle as the number of attempts per second made will be greater. The proposed mathematical problem, in fact, can only be solved by trial and error and the first miner who finds the solution wins the reward[23].

[23] *Amitai Porat, Avneesh Pratap, Parth Shah, and Vinit Adkar. Article "Blockchain Consensus: An analysis of Proof-of-Work and its applications".*

However, once the operation is resolving a new block will be added to the blockchain only if all the other nodes in the network agree with the provided solution, as can be seen in the picture below.

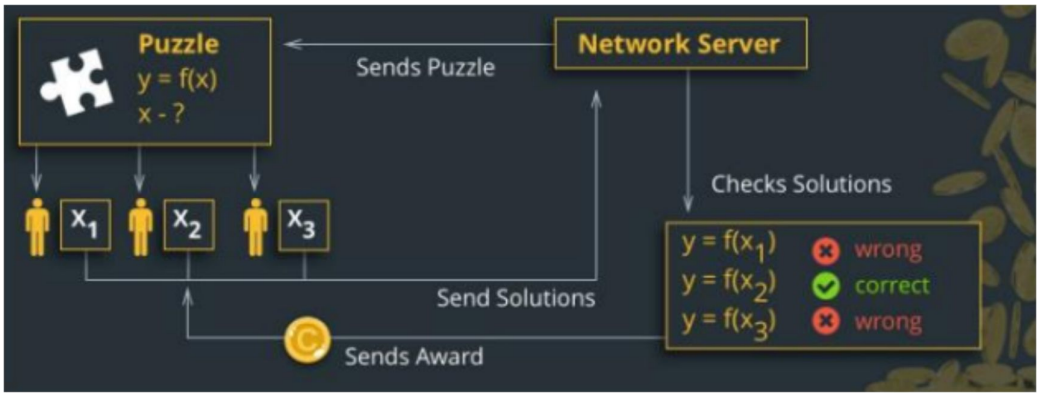

Figure 2: to solve the cryptographic puzzle.

Moreover, according to Digiconomistic, Bitcoin miners alone use about 54 TWh of electricity, enough to power 5 million households in the US or even power the entire country of New Zealand or Hungary, suggesting that this method has significant environmental impacts.

In addition, proof of work penalizes users with basic equipment, as they have less chance of finding an optimal solution of the mathematical problem and receiving a reward.

All this leads to the creation of the so-called “mining pools”, that means a space in which different miners work cooperatively to mine cryptocurrency blocks. In order to increase the possibility of obtaining a reward, they integrate their hashing power and distribute the reward evenly across everyone in the pool. In other words, PoW is causing miners to use massive amounts of energy and it persuades participants to collaborate with each other, forming the mining pools which makes the blockchain more centralized as opposed to decentralized.

In 2011, among other suggested improvements, Bitcoin Talk user Quantomechanic proposed the idea that he called “Proof-of-stake “as a solution to the issue associated

with the huge demand for electricity and energy required for the use of Proof of Work[24].

The basic idea of PoS is to use an election process in which 1 node is randomly chosen to validate the next block. In this case there is no miner, but rather a validator. The latter is not chosen completely at random, in fact to become a validator it is necessary that a node deposit a sum of money into the network as deposit.

Specifically, the automatic selection process takes into consideration a number of different factors to ensure that not only the nodes with the largest dimensions, but also the nodes with the lowest but equally reliable dimensions are selected. The factors taken into account in the selection phase may be different depending on the system considered; however, generally, the amount of the deposited share, the longevity of the stake (so-called coin age, i.e., how long the deposit has been made) and a randomization factor are taken into consideration. It is obvious that the higher the amount deposited as a deposit and the older the deposited cryptocurrencies are, the higher the probability of being selected as validators.

For example, if Alex deposits $100 dollars into the network while Emma deposits $1000, Emma has a 10 times higher chance of being chosen to forge the net block. This might not seem fair because it favours the rich but, as we mentioned above, the PoS process also considers other factors.

Moreover, in this situation, validators "coin" or "forge" new blocks, they do not "mine" blocks like in the Proof of Work. Once a node is selected as the validator of the next block, it will have to check if the transactions it contains are valid, sign the block and add it to the blockchain. Unlike PoW systems, in which the work of miners is rewarded with the creation of new currency unit, in Proof of Stake systems the reward for validators consists of a fee withheld on the validated transaction. Before being able to withdraw your deposited share and collect your reward, the network verifies the validator's work, checking that no fraudulent blocks have been added.

Therefore, the difference between these two important consensus algorithms is quite significant. While in PoW systems, as aforementioned, the security of operations lies

[24] *Development & Technical Discussion*, *Bitcoin Forum (2011) "proof of stake instead proof of work".*

in the huge resources - economic and energy - necessary to complete the validation of a block, in PoS systems it is the stake that discourages validators from validating fraudulent operations. In fact, if the network detects a fraudulent transaction, the validator node loses part of its stake, as well as the right to be selected as a validator in the future. The only way to be able to circumvent the network controls and approve fraudulent transactions would be to own 51% of the cryptocurrencies in circulation, an almost impractical hypothesis, as in such a context the costs incurred to obtain the share of absolute majority would not find in the fees a satisfactory profit margin because the market, in correspondence of such an attack, would attribute to the purchased cryptocurrency an economically much lower value than that of the purchase price.

In other words, even if the Proof of Stake to date is not yet particularly widespread and is not used by the main existing blockchains, it is establishing itself as a preferential method, highlighting the abuses and shortcoming of the now outdated PoW method.

Indeed, the Ethereum blockchain which, much like Bitcoin, only works using a PoW consensus system, is working on the development of a new update called Casper, which will convert Ethereum into a PoS blockchain.

The transition from a PoW blockchain to a PoS could give Ethereum a significant competitive advantage over Bitcoin. Similarly, using a greener technology will allow it to enjoy greater appreciation at the national and supranational level, as well as allowing it to introduce the use of smart contracts in the daily life of citizens for the execution of transactions in real life.

1.8 Operating principle

In the previous paragraphs we have provided an explanation on the structure of a blockchain and its evolution, so we can clarify its areas of application.

To illustrate how blockchain technology works, we will take Bitcoin's public blockchain as a reference. It is essential, however, to underline how the principles

applied to this blockchain are easily adaptable to other types of blockchains, which use tokens other than bitcoin. As noted earlier, the elementary infrastructure of a blockchain concerning to:

- Distributed database;
- Consensus mechanism;
- Reward defined as token.

The term alone makes its operation understandable, in fact "blockchain" is nothing more than a chain of blocks and corresponds to a software application which uses the Internet as a method of connection between a distributed network of nodes (Peer-to-Peer network).

It stores the transactions that occur on the network itself in a distributed manner. In a blockchain, each block contains a certain number of transactions, each involving digital assets[25].

Supporters of Blockchain technology argue that its development is comparable, in importance, to the introduction of double entry accounting. It is seen as the revolutionary method of accounting for assets and liabilities and which, according to some historians, laid the foundations of capitalism, allowing entrepreneurs and investors to collaborate in companies.
In this analogy, the Blockchain is a kind of three-way accounting, the third of which is a verifiable cryptographic receipt issued when a transaction is concluded. Using public/private key cryptography, participants of the blockchain and transactions involving a change of ownership are registered within the block, ensuring security and authenticity. Therefore, each block has a distinctive hash value.

The hashing process makes it possible to uniquely and safely identify each block. The hash is structured in such a way as to prevent the recall of the text or the numeric string from which it was generated. It should be emphasized that each block in addition to having its own identifying hash also contains the hash of the block of the previous one.

[25] *Svein Ølnes, Marijn Janssen. (May 2017) "Blockchain in government: Benefits and implications of distributed ledger technology for information sharing".*

In this way, when a new block is added to the blockchain, it maintains a shared and agreed view of the current state of the blockchain.

The ledger contains the shared and agreed status of the block chain and the list of all the transactions that have taken place. In fact, the blockchain preserves the entire history of all the transactions that have taken place, from their origin to their conclusion; therefore, there remains a perpetual traceability based on the temporal order in which they occurred. In this way, all nodes participating in the network will have a copy of the entire block chain that is continuously updated and synchronized between all nodes.

This aspect is fundamental for blockchain technology, because there is no central point of vulnerability that allows hackers to sabotage or alter the information contained in the various blocks as happens for centralized databases.

In case in which someone intends to alter some transaction within a block, this would modify the identifying hash value. For this reason, the only solution to ensure that the attack is successful, the modification must in turn be replicated on all the nodes of the network. This operation would require enormous computing power which, with currently existing technologies, would be impossible.

After being created, the transaction and its hash are submitted to the other nodes of the network to be verified. In this case, each node performs the procedure independently, as it is an independent procedure. As soon as a node receives a transaction, it starts building a block, which is called mining, which involves competing with other nodes for solving cryptographic puzzles, that takes a fair amount of energy and time to solve.

Once the algorithm has been solved, as already clarified in paragraph 1.8, the validator or miner signals to the other nodes of the network that the block has been validated so that they can verify its actual correctness. After successful verification the block is added to the chain as can we noted in the figure above.

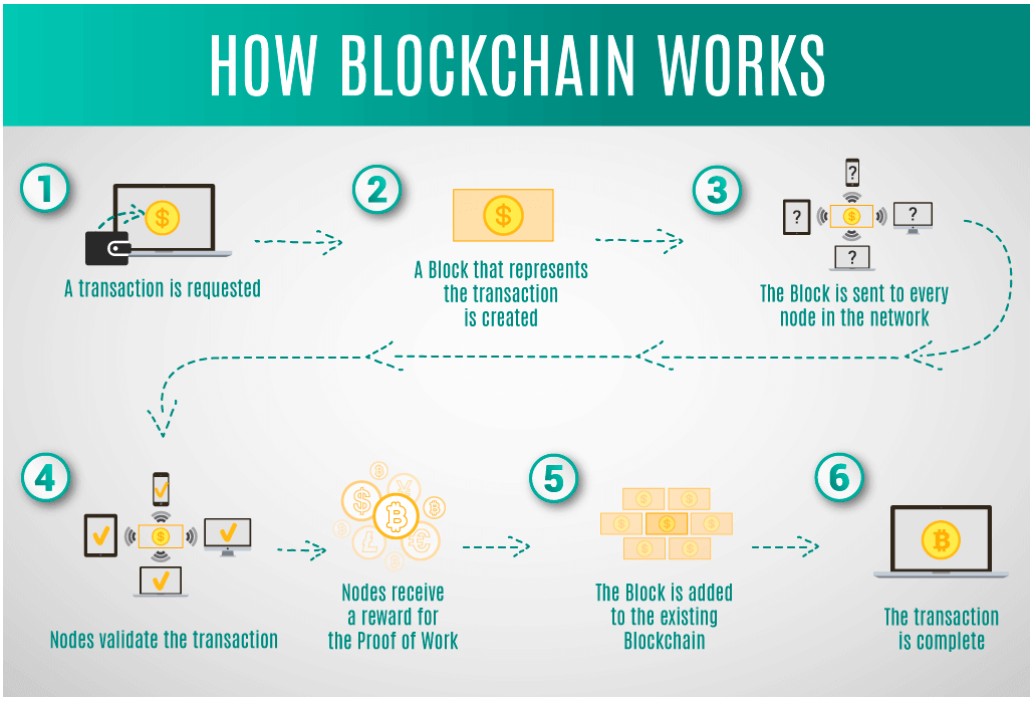

Figure 3: How blockchain works, the various steps.

Furthermore, we discussed cryptographic keys initially: let's now see how they relate to the Bitcoin blockchain.

Specifically, the Bitcoin system is set on two cryptographic technologies: public-private key cryptography and cryptography for network transactions. As previously discussed, each transaction is correlated with a digital signature which is different for each transaction. The technology that allows all this is public-private key cryptography, which allows you, with private key, to create a "signature" associated with a public key.

The public key is shared across the network, while the other key is personal and is used to decrypt data. Also of fundamental importance is the "Elliptical cryptography" which essentially allows you to calculate the public key given the private key but does not allow the opposite[26].

With this system, all users participating in the network are identifiable only through their public key which does not allow access to any personal data within the network.

[26]Joppe W. Bos, J. Alex Halderman, Nadia Heninger, Jonathan Moore, Michael Naehrig, and Eric Wustrow, article titled “Elliptic Curve Cryptography in Practice”.

All this allows users to be anonymous or better, as some authors argue, allows transactions to be defined as "pseudo anonymous".

1.9 Double- spending

One of the most interesting aspects of blockchain technology is to prevent the occurrence of Double-Spending, which is the ability to avoid the same digital asset from being duplicated and therefore used several times by the same people.

Let's imagine being able to duplicate a physical banknote before spending it, in order to be able to spend it a second time, and maybe a third or even a fourth time, we would be faced with a crime situation called counterfeiting of money.

With the tools available today, a fake banknote is easily recognizable as paper duplication is never a perfectly identical copy to the original, but when it comes to digital currency it becomes much easier to create identical copies, it is like duplicating a file, it is a practice that is applied every day in any working environment, a sort of back-up of digital banknotes.

Precisely to avoid the occurrence of this somewhat dangerous situation, Satoshi Nakamoto and other authors had anticipated this situation by creating a unique and recognizable identity for virtual currencies[27].

In particular, the Bitcoin protocol provides that to avoid the double spending of tokens every time they are sent, it is necessary to verify that they have not already been sent previously. In fact, each different transaction involving the related cryptocurrency is sent to the blockchain, verifying it separately and protected by a confirmation process. In this way, the bitcoin blockchain keeps track of timestamped transactions dating back to its founding of the cryptocurrency in 2009.

The cryptography that accompanies bitcoin and in general the different declinations of the blockchain, allow you to manage the identity of the cryptocurrency, with its

[27] *Usman W. Chohan, MBA, PhD, Paper (6th January 2021), "The Double Spending Problem and Cryptocurrencies".*

specific ID code, its name and surname and its history in order to carry out a transaction from a subject to another in a clear and unalterable way[28].

Even though cryptocurrency transactions are protected by important filters, it is possible for there to be cases of double spending, for example, a corrupt miner who uses his computing skills to make his chain larger than the real chain.

Imagine that someone who is corrupt spends all their bitcoins to buy an item from a vendor, the unethical miner adds this transaction to his block and propagates it to the real blockchain, if the other miners authenticate this transaction as correct, they validate and add it to the real blockchain. The duplication occurs precisely at this moment due to the corrupt miner not adding the transaction to its isolated chain. As a result, the corrupt miner can spend all the currencies he had previously spent on the real blockchain now that the owner of the isolated chain block is in the dark about the transaction[29].

In the case of conflicting block paths, the miners decide which chain is valid by continue addition of blocks to it. Generally, the block chain with the longest length is deemed the most valid since it is assumed that most network computations are not generated by malicious users. In the case where a user control most of the computing power, they can manipulate the network to their advantage by establishing two divergent chains: one from which all money goes directly to their wallet and one from which all money goes to a seller[30].

This problem occurred in the Bitcoin platform in March 2013, caused by a conflict between two different versions of bitcoin. The ledgers of two different versions of bitcoin were divergent, allowing the currency to be spent twice in each chain. This caused a rapid devaluation of the value of bitcoins, creating a lot of confusion among participants who obviously felt unsecured in the privacy of their investments.

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[28] *John P. Podolanko, Jiang Ming, Matthew Wright, paper "Countering Double-Spend Attacks on Bitcoin Fast-Pay Transactions".*

[29] *A. Begum, A. H. Tareq, M. Sultana, M. K. Sohel, T. Rahman, and A. H. Sarwar, (February 2020), "Blockchain Attacks, Analysis and a Model to Solve Double Spending Attack".*

[30] *D. K. Toshi, S. Shetty, X. Liang, C. A. Khamhua, K. A. Kwiat and L. Nijilla, IEEE Press Piscataway, USA, (2017) "Security implications of blockchain cloud with analysis of block withholding attack".*

Since the valid chain was determined by a majority vote in the previous version, the chain from the previous version was rapidly re-established as a primary chain, thus resolving the dangerous situation.

Another type of double-spending attack is referred to as a "race attack". When transactions occur quickly, it is difficult to verify their validity. An exchange may be completed before a lockout is verified, as proof of work and proof of stake take time to verify. An attempted race attack involves sending two transaction logs simultaneously: one to a seller and another to the rest of the bitcoin network, where the currency is returned to its original owner. When the seller realizes the fork in the blockchain is invalid, he may have already executed the transaction[31].

Despite the criticisms that accompanied the first phase of the use of the Blockchain Bitcoin platform, which for the situations described above was discriminated against and almost defined as a platform that favoured illegal payments or financing, users continued in its use, especially as long as it was solved the fundamental question of the identity of the Blockchain participants, in fact, thanks to this peculiarity, the Blockchain Bitcoin and other similar cryptocurrencies, today guarantee a very high level of traceability and security.

[31] Muhammad Saad, Jeffrey Spaulding, Laurent Njilla, Charles Kamhoua, Sachin Shetty, DaeHun Nyang, and Aziz Mohaisen, article (2019), “Exploring the Attack Surface of Blockchain: A Systematic Overview”.

CHAPTER 2 – How blockchain and smart contracts will affect accounting

2. The evolution of accounting system

The concept of triple-entry accounting was introduced in a paper of Ian Grigg and Todd Boyle and it adds to the classical two entries, an extra entry.

Prior to discussing triple-entry accounting, it would be worthwhile to examine how accounting has evolved over time. The first single-entry books were written around 5000 years ago in Babylon. These are the most effortless and standard forms of accounting. Single-entry accounting involves creating a list of assets or debts, adding assets or debts as they are acquired, and removing assets or debts as they are sold or repaid[32].

These types of systems are suitable for the most basic requirements but are ineffective for anything more complex. Single entry is a problem for a number of reasons, including the possibility of errors occurring without being noticed until much later, as well as it is easy to manipulate. Specifically, this accounting system is inclined to human error due to some deficits present in its structure, as it is a normal list. Moreover, there is no real authentication if assets and liabilities are in equilibrium if the latter are simply listed. The situation can become quite severe when it is not clear if there is an error, or if fraud is being committed.

Prior the novelty of double-entry accounting, this model accounting has been utilized for approximately 4400 years.

The metamorphosis of the accounting tool does not derive from a simple refinement of the technical, but responds to specific internal and external needs of the firm, which affect the company and logically its accounting data system.

The advent of double-entry pushes us to find a standard reason for each movement of value, that is, a representation of values which is not postponed to the end of the period, but is contemporary to the movement written in the annual report.

The notion of double-entry accounting was supposedly invented by a Venetian friar named Luca Pacioli in the 15th century. According to popular belief, the novelty

[32] *Ian Grigg Systemics, Inc., (2005), "Triple Entry Accounting".*

concept of this accounting system was what made the Venetian merchants prosperous, influential and allowed them to control world trade[33].

Double-entry accounting, eventually, spread around the world becoming the only and most popular method of completing accounting transactions. It concerns debt and credit situations produced by a single operation. For instance, if an individual paid for an item, there would be a debt in the inventory account, and vice versa a credit transaction in the bank account. In particular this approach has the major benefit that each transaction produces two events which cancel each other out, for this reason when credit and debit eliminate each other, the balance sheet will be in equilibrium[34].

Due to the method of single-entry accounting, the error can be found quickly and easily if there is no longer a balance for some reason, in fact, errors are easier to find, and manipulation, as well as fraud, is harder to execute.

However, as great as double-entry accounting is, it still has flaws. Specifically, some of the inadequacies and shortcomings of double-entry accounting have caused indirect and direct accounting scandals in the past decades. In most cases, fraudulent transactions are allowed to pass unnoticed through internal controls due to fabricated transactions. In particular, these inadequacies can often be corrected through regular audits. However, sometimes the same errors are likely to occur, so it is equally appropriate to take steps to prevent them.

2.1 The origin of triple-entry accounting

The double- entry method is universally recognized as perfect, in terms of its economic logic and its internal controls. The favourable conditions for new development in the accounting methodology to be applied in the company are offered by the availability of IT tools which can now manage a large amount of data and information at reduced costs and by the evolution of the business culture. The addition of the third dimension of accounting takes place with the same methodology that

[33] *Massimo Ciambotti, (2019), "Luca Pacioli, la partita doppia e la storia della contabilità e della società".*
[34] *Moise Cîndea, Iuliana Marina Cîndea, Gabriela Ciurariu, Alexandru Trifu and Corneliu Durdureanu, (2011), "History of accountancy. A chronological approach".*

governs the functioning of the first two. It is therefore a work of extending the method which links the first two series to the third, without creating a different method.

Vice versa according to Ian Grigg's estimation, the transition from paper to computers for double-entry accounting has been less than ideal.

Accounting systems that are computerized still rely on double-entry accounting, which was originally meant to be done on paper. According to him, we are not maximizing the benefits of accounting on computers since computers do not offer enough power. We should focus on creating a new type of accounting for computer use instead of trying to adapt double-entry accounting. This would use computer science to make it more secure and efficient. For this reason, the concept of triple-entry accounting born, which is characterized by the presence of three entries: a debit, a credit, and a receipt[35].
These three separate parties are involved in three entries, the payer, issuer, and payee. The payer initiates the payment, the issuer verifies and signs it, and the payee receives it. In a hypothetical situation, where person 1 is paying person 2, the money passes through an intermediary.

A receipt is sent to both parties by the intermediary who certify that the second person has received the payment. Besides the complete transaction, the receipt also contains a "digital signature" showing who both parties were, as well as the circumstances surrounding the transaction. Moreover, Grigg describes digital signatures as similar to the process of signing a cheque or a document with a personal cryptographic key.

There is one major drawback to Grigg's model in those transactions must be verified by an independent third-party who is neutral, trustworthy, or trusted. In fact, it should be specified that human verification is vulnerable as it is possible that the same third-party verifiers are corrupted, act in their own interest, or are the target of cyberattacks, and this could lead to considerable problems. Nevertheless, technology that can allow a third-party to act as a verifier has progressed considerably since the author wrote his article in 2005. In fact, in 2008, as previously written, a technology called blockchain

[35] *Ian Grigg Systemics, Inc., (2005), "Triple Entry Accounting".*

was introduced, which has drastically changed the now, absent, function of the mediator and the approach in which the subjects communicate with each other[36].

2.2 Triple-entry accounting with Blockchain

Blockchain accounting is mainly based on triple-entry accounting, as argued above. In it we could find three different entries: credit, debit and the receipt. As an alternative to a neutral third party as Grigg suggests, the blockchain is employed. It guarantees that the data are not lost, neutrality, but above all transparency as all the information contained within it can be consulted by all the parties involved in that transaction[37].

In a research study, Deloitte (2016) explained that blockchain accounting may change our perception of accounting. They strongly suggest that instead of having separate registers for each record, everything can be written into a blockchain transaction which would serve as a single ledger and thus constitute "*an interlocking system of enduring accounting records*". Records are then encrypted, which ensures that any changes would be detected and left behind. According to another Big 5 company, Ernst and Young, the adoption of blockchain would offer greater traceability of transactions from start to end point and it represents, by Alex Tapscott, CEO of consultancy Northwest Passage Ventures and co-author of the book Blockchain *Revolution*, the second generation of internet[38].

Both Deloitte and EY argue that blockchain allows all transactions to be recorded in a single ledger, simplifying the process of verifying accuracy. A shared ledger can also benefit departments and subsidiaries with the ability to reconcile between them nearly instantly, transparently, and verifiably. In addition to reducing manual effort requirements, the reduction of manual efforts could significantly enhance efforts to

[36] *Juan Ignacio Ibañez, Chris N. Bayer, Paolo Tasca, Jiahua Xu, Working paper (2021), "Triple-entry accounting, blockchain and next of kin: Towards a standardization of ledger terminology".*
[37] *Piera Centobelli, Roberto Cerchione, Pasquale Del Vecchio, Eugenio Oropallo, Giustina Secundo, (2021), "Blockchain technology for bridging trust, traceability and transparency in circular supply chain".*
[38] *Cynthia Cai, ResearchGate article (2019), "Triple-entry accounting with blockchain, how fare have we came?".*

support strategic planning and wider business decisions by the finance function, particularly during the critical final stages of consolidation[39].

Particularly, blockchain can have a dramatic influence on future outlooks by facilitating new operations and rewriting the whole business models. With this technology, digital, physical and financial assets could be integrated with finance, facilitating real-time transactions. As resources interact and change ownership, information can be automatically recorded, creating a single, digital source of truth shared with all users. In addition, the cost of transferring assets within or across entities and documenting ownership could be significantly reduced.

A firm could gain an immutable view of its assets and transactions in real-time. All data management strategies in businesses are based on enterprise data management, and according to Paul Brody of Global Innovation Leaders, Blockchain, *"Blockchain will be the solution to the multi-enterprise data problem."*

In addition to triple-entry accounting, blockchain technology could also provide insight into the "market" valuation of a firm, as well as its book value. Having independent, unalterable records could enable more frequent and accurate audits, which may be a future stakeholder expectation.

However, it is useful to highlight that this technology is still in the introductory phase of its evolution and it will likely take some time before it is full potential is understood and used. It could disrupt a variety of business fields, such as finance, accounting or insurance, as well as provide them with the ability to report financial information accurately and in timely manner, thus acting as a key business partner.

In addition to triple-entry accounting, smart contracts also contribute to its benefits. In the early 90s, Nick Szabo presented the notion of this particular contract. In his theory, the smart contract is a contract imposed not by law, but by hardware or software that incorporates, into an object, the contractual terms that govern it[40].

Moreover, the development of a code capable of handling both doubtful and self-enforcement contracts has led to greater efficiency and eliminated uncertainty in contractual relationship. Rather than needing to trust each other, the parties would be

[39] *Ernst and Young, article (2016), "Blockchain How this technology could impact the CFO".*
[40] *Kristian Lauslahti, Juri Mattila, Timo Seppälä, (2017), "Smart Contracts – How will Blockchain Technology Affect Contractual Practices?".*

able to trust that the contract would be performed as intend. Szabo to clarify this new sort of contract cited a vending machine. The coins are insert into the machine which dispenses the requested product and its applicable change based on the price shown on the display, through a simple and autonomous mechanism. With the vending machine you can trade with anyone who has coins. In addition, to vending machines, these contracts can be integrated into any valuable property controlled by a digital system.

Later in the early 2000s, Ian Grigg suggested a digital form of this agreement known as the Ricardian contract. In this type of contract, all the essential terms and clauses are included in a digital format that can be view by both humans and computer programs. If necessary, computer programs can proceed to perform this contract on their own. Instead, as described in the original smart contract in Szabo, contracts can only be machine readable, so in practice it is not legally binding. For this reason, in case in which something goes wrong a court may have some difficult in proving malevolent intention[41].

2.3 Smart contract – origins and features

The "inventor father" of the smart contract concept is - as previously mentioned - the Hungarian Nick Szabo who in 1993, driven by his passion for Data Science and statistics in general, elaborates a system through which it is possible to digitize a behaviour depending on certain conditions. However, they were not practical until blockchain[42].

A first telematic approach in the management of commercial relations is represented by e-commerce, where the importance of the trust that is established between the seller and the buyer is of fundamental importance for the simple fact that the seller will only collect the money from his sale. when the buyer has received the goods.

[41] *Ian Grigg, ResearchGate (September 1997), "Digital Training".*
[42] *Annegret Henninger and Atefeh Mashtan, Computers (2021), "Distributed interoperable records: The key to better supply chain management".*

This modus operandi has entailed and still involves some risks for both parties, as the malicious buyer may not pay upon delivery of the goods or the seller may send an asset that differs from the asset being sold.

In e-commerce negotiations there is no platform capable of confirming the authenticity of transactions as it happens through blockchain platforms, in e-commerce the seriousness and reliability of a seller revolve around the reputation that the same has known create around your own name, word of mouth and reviews provide customers with a reliable thermometer that is often valid.

Today many applications used by any category of user such as Tripadvisor, eBay or Facebook work in this way, the terms of appreciation that increase trust between the parties are certainly represented by the quality of the product purchased and by the delivery times of the same, it goes without saying that such a determined contract has less chance of success than a smart contract that uses blockchain technology.

In electronic commerce, the contractors still use the written form and a language that due to its ambiguity is not understandable or rather not processable for the computer, this could give growth to misconceptions that could easily result in legal disputes.

A small evolution in this sense has been known with data-oriented contracts and computable contracts (Harry Surden 2012) able to check whether the terms contemplated in the agreement have been respected, let's see more precisely what it is:

- Data oriented contract

This type of contract is represented by the set of conditions agreed between the parties, subsequently translated into binary language so as to be processable by a computer system, the literary translation of this term represents a data-oriented negotiation, i.e., data records processed by a computer. The “data-oriented contract” mode is widely used in the financial trading and electronic commerce sector - in which the transaction is carried out through electronic interfaces.

- Computable contract

The basis of this type of contract is based on the computability of the data which, passing through a mechanism designed to assess the compliance of the data entered

(prima facie), in essence, an attempt was made to emphasize the result to be obtained, i.e., that the clauses contained in the contract were carried out.

A fundamental implementation step is given by the programmer Ian Grigg who in 1996 develops a solution called Ricardian Contract, which allows to automate the intents of the participants even before the material execution of the contract, cataloguing as precisely as possible all the agents that could affect the terms of the contract itself.

Ricardian Contracts can therefore be defined as the only predecessors of current smart contracts whose literal translation is in fact an "intelligent contract" in this context the human component and with it the interpretative component are replaced by the machine capable of understanding and processing the terms and the conditions of an agreement stipulated between two or more subjects dealing with the management, interpretation and execution of the same.

The Smart Contract basically performs the translation into code of a contract through a computer using a programming language that must be as complex as possible, the computer must be able to translate and interpret punctuation and syntax in such a way as to stem any type of interpretation error.

In particular, the Smart Contract needs legal support for its drafting, but it does not need it for its verification and activation. Precisely because the absence of human intervention also corresponds to the absence of an interpretative contribution, the Smart Contract must be set on extremely accurate information that must summarize all the circumstances, conditions and possible situations. Here the management of data and Big Data in particular becomes an essential critical factor to establish the quality of the Smart Contract. At the same time, it is essential to circumscribe in an extremely precise way the data sources to which the contract is required to comply: the subjects must be determined and protected in the agreement.

2.4 Smart contract applied to Blockchain

Until now it has not been explained whether and why a Smart Contract necessarily needs a blockchain structure to work. In fact, their intrinsic characteristics allow them to simply rely on digital tools, a writing code and a generic platform.

However, a Smart Contract must primarily ensure that the code with which it was written cannot be modified, that the data sources that determine the conditions of application are certified and reliable and that the methods of reading and checking of these sources is in turn certificated. time certified and deterministic. It must therefore be precise both in its drafting and in the management of the rules that determine its application and that govern any anomalies. In traditional contracts, the value of the trust is paid and guaranteed by a third party, typically a lawyer or notary. These are figures who continue to be involved, although in different manners.

However, within clearly defined situations such as production chains made up of different companies, smart contracts have been tested and are now active in which the role of the trustee third party is reinterpreted by the use of the blockchain.

As discussed in the previous chapter it is clear that smart contracts have their own independent use, but if applied to the blockchain they respond to the need to offer greater guarantees of trust, security and reliability that in the past were delegated to a third element identified in the professional figure of the notary. or the lawyer.

The smart contract must mainly ensure that the code with which it was written cannot be modified, that the data sources that determine the conditions of application are certified and reliable, that the methods of reading and checking these sources are in turn certified. The use of the blockchain platform offers greater chances of success for contracts as being an immutable register, the files contained within the blocks of the chain, with the use of public key cryptography, cannot be modified in any way or deleted[43].

Moreover, the smart contract must be composed of three elements, in order to work jointly with the blockchain[44]:

- An account, in which one can enter with private keys of the contractors and a public key owned by the components of the blockchain network;
- The memory quota of the register or the various blocks that will make up the chain;

[43] *Mohanta, B.K.; Panda,S.S; Jena, D.,(July 2018), " An overview of smart contract and use cases in blockchain technology. In proceedings of the 2018 9th International Conference on computing, Communication and networking technologies (ICCCNT).*
[44] *Hien Do Hoag, Duy Phan, Van-Hau Pham, ResearchGate (2019), "A Security-Enhanced Monitoring System for Northbound Interface in SDN using Blockchain".*

- The contract execution code.

These three points contain the explanation of how the smart contract works through the blockchain platform, essentially the two contractors establish the terms and conditions of the contract, which once translated into cryptographic language are introduced into the block, from this moment all the components of the networks (miners) with the public key have the ability to verify the authenticity of the information and approve it, in order to add the approved block to the next block that will be part of the chain.

If the "If / Then" sequence verifies the violation of even one of the clauses that make up the contract, it will block approval and the measures required by law will be activated. The smart contract, on the other hand, will execute its own terms if all the conditions have been met. Payment could be released as a result of a certain event, a software escrow account could be created, an investment could be made much easier and faster, etc.

We see in figure below, how blockchain technology is implemented to smart contracts, but above all how a contract can be translated into a code assuming a technological form that adopts a computer language[45].

[45] *Larry A. Di Matteo, Michel Cannarsa and Cristina Poncibò, Cambridge University (2019), "The Cambridge Handbook of Smart Contracts, Blockchain Technology and Digital Platforms".*

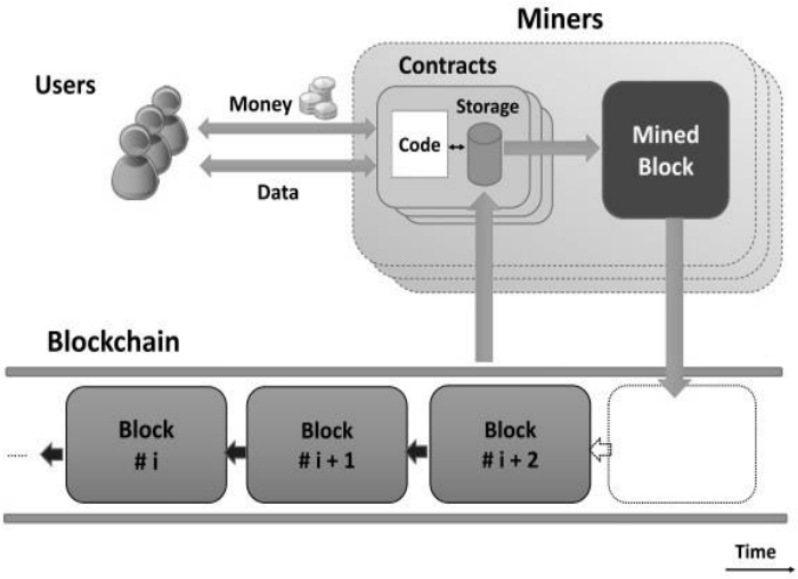

Figure 4: The flow followed by the various clauses of contract to be encoded in machine language and insert into the blockchain (Alby and Van Moorsel, 2017)

Furthermore, smart contracts have the capability to decrease counterparty risk over traditional law. A legal contract acts as a cure to breach - if it is broken, the terms can only be enforced after it has happened. Smart contracts can prevent this, since they operate under the stated terms regardless, bounding the parties without the option to default. Furthermore, in this type of contract the exact object that the code contains is made[46].

Smart Contracts can be developed and implemented through different blockchain platforms, each of which can offer different functions and characteristics and can support more or less complex programming languages.

The Bitcoin blockchain, for instance, offers the possibility of creating smart contracts but has a very limited computational capacity and a restricted language so it is possible to create only a simple logical structure to process single transactions. However, when it comes to writing contracts with complex logic there are many limits, for example the creation of loops is not supported.

[46] *Christopher D. Clark, Vikram A. Bakshi, Lee Braine, (2017), "Smart contract templates: foundations, design landscape and research directions".*

Through Ethereum, instead, the smart contracts can be coded using the solidity language, which allows even complex, branched and looped code instructions. It is therefore possible to create structures of any type and customize them in various ways, including more complex logical ramifications such as loops, revocable limits, etc., which is why many Smart Contracts are implemented thanks to this platform[47].

2.5 Challenge for smart contract

Despite the indubitable advantages briefly mentioned above, the critical issues related to the use of Smart Contracts are also under the magnifying glass. According to some research (Lee, 2018), the average failure rate of a Smart Contract within the Ethereum blockchain is around 3%.

However, if you think of the famous story The DAO (Decentralized Autonomous Organization created by the Ethereum blockchain) of 2016, in which a group of hackers succeeded in stealing a large sum of money belonging to the Ethereum fund by taking advantage of a bug within the Smart Contract, that is by reproducing a condition not foreseen by the structure of the contract, the 'flaw' inside the structure led to an enormous loss amounting to about 3.6 billion Ether[48].

There are many classifications and analyses aimed at clustering their weaknesses in some way, but in this paragraph, we want to highlight the categorization proposed by the research conducted by Maher Alharby and Aad Van Moorsel in October 2017. The four main divisions highlighted by the study are described below:

- Codifying issues: these are the main barriers when developing a contract;
- Security issues: refers to any bugs or vulnerabilities thanks to which malicious entities can launch an attack;
- Privacy issues: refer to the publication of the characteristics of the contract to persons not directly involved;

[47] *Ye-Byoul Son, Jong-Hyuk Im, Hee-Yong Kwon, Seong-Yun Jeon and Mun-Kyu Lee, article (2020), "Privacy-Preserving Peer-to-Peer Energy Trading in Blockchain-Enabled Smart Grids Using Functional Encryption".*
[48] *Nathaniel Popper, The New York Times (2016), "A Hacking of More Than $50 Million Dashes Hopes in the World of Virtual Currency".*

- Performance issues: that is, they can limit the ability of the blockchain structure to become scalable.

Analysing the first field, that is the limits in the coding of the contract, we can identify several challenges that face developers. First of all, the difficulty of developing correct contracts concern the effective functioning in the way established by the two parties, with the risk that part of the value associated with that contract could be lost.

A solution to this problem can be identified in the use of systems for creating semiautomatic contracts, i.e., able to read the contract composed in human language by the two participants and translate it into appropriate rules. In parallel to this, it is also possible to use verification systems that investigate the possible presence of unwanted actions mistakenly included in the contract[49].

Given the invariability of the blockchain, a smart contract cannot be corrected when it is executed, however standards have been identified that allow you to write rules that can be modified or terminated.

In addition, the complexity of programming languages can make drafting a contract even more difficult. Procedural languages, such as Solidity, the code is performed in a series of points where the programmer have to verify what must be done before and what must be done after each step, making the writing of accords error-prone and arduous. Therefore, the use of logic type languages allows both not to specify the sequence of steps to be performed, and to make the algorithms easily codable.

Those who develop contracts via blockchain can be identified as the ultimate authority that decrees their operation and logic and therefore is also responsible for any failure. So, as in the case of the DAO, if a certain condition is not included in the contract by mistake, someone could alter the value of the contract in a way that was not previously foreseen by the creators.

Turning to the security issues, the dependence on the Timestamp, that is the marking of the blocks to start and execute the transactions, may further increase contract

[49] *Folake Alabi, article SSRN (2017), "Taking Contracting Digital: Examination of the Smart Contracts Experiment".*

instability. In fact, generally the Timestamp of a block is based as the local time of the miner who built the block[50].

However, if a dishonest node manages to alter this date up to a maximum of about 15 minutes compared to the correct one, the block is still considered valid, generating an intrinsic weakness in all those contracts that are based on the accuracy of the time stamp. In this regard, a possible solution consists in the use of random numbering as a marking of the blocks, thus making the number fixed.

Furthermore, if two dependent transactions between them that invoke the same contract are contained within the same block, another type of problem may be encountered, known as interdependence between transactions. In fact, a malicious node can alter some contractual conditions, for example reducing the premium for those who solve a question foreseen by a contract and, this transaction can be randomly encompassed in a block that also contains the transaction of another node with the solution proposed to the question. At the same time, therefore, both transactions will be executed and the node that solved the puzzle will receive a lower compensation than the adequate one given the intervention of the opportunist miner.

The suggestion to solve this problem comes from an intrinsic function of the Ethereum structure, namely the SendIfReceived function which authorizes a transaction only when another one referring to the same contract is first accepted by all nodes and executed.

With regard to privacy issues, it can easily be deduced that an encryption using the appropriate language of a contract before sending it via blockchain can make it visible only to those who, such as the parties, possess the decryption keys. Finally, better performance of a Smart Contract can be achieved by replacing the traditional sequential execution of contracts (one contract at a time) with the parallel execution of contracts as long as they are independent from each other.

[50] *Maher Alharby and Aad van Moorsel, International Journal of Computer Science & Information Technology (IJCSIT) (October 2017), "A systematic mapping study on current research topics in smart contracts".*

2.6 Delay in financial statements

Blockchain technology can improve the quality and timeliness of accounting information, making it more beneficial to investors. Accounting-related fraud and manipulation would be significantly reduced if firms kept their financial records on blockchains. Additionally, blockchain-based transactions would improve transparency between firms and allow for real-time reporting since they allow all transactions to be accessible in a company's ledger instantly.

Generally, financial statements provide a summary of what has taken place during a specific period. They are then reviewed by an auditor who issues an opinion on their accuracy. External parties, likes investors and credit risk managers, need to know that the audit is accurate and impartial as well as that the firm has not tempered with the data provided to the auditor. In order to arrange the financial documents and conduct an audit, trust is essential. Here, blockchain technology can be of great assistance[51].

In fact, through its distributed ledger technology, hash chaining, and proof-of-work mechanisms, the blockchain networks record and verify information in a decentralized way without any recourse to authorities, and it makes sure that the data is honest, protected, tamper-proof, and trustworthy. Moreover, blockchain technology can be used to perform financial accounting procedures more transparent, enhancing external reporting quality, and decreasing the information asymmetry between companies and investors[52].

Most of the internal specific data in the enterprise are inaccessible to stakeholders outside it. In light of this, a business and its stakeholders operate in an environment of information asymmetry. The importance of accurate information is still growing, for stakeholders to make the right decisions in choosing to collaborate with, or invest in, specific companies.

For this reason, it is fundamental to offer stakeholders with timely information so that correct conclusions can be reached. In absence of timely financial reporting, enterprises will certainly be exposed to unfavourable results. In particular, a

[51] *Hans Byström, Research article (2019), "Blockchains, Real-time Accounting, and the Future of Credit Risk Modelling".*
[52] *Ting Yu, Zhiwei Lin, Qingliang Tang, (2018), "Blockchain: The Introduction and Its Application in Financial Accounting".*

company's optimal divulgence approach depends on its expenses and revenues. Considering these revenues and expenses, managers make judgments about the composition, elements and timing of accounting relation, etc which will allow you to have a complete plan on the progress of the organization itself[53].

Furthermore, it should be noted that enterprises are not always able to register their financial statements on the same day as the reporting period ends. Especially, organizations may not have direct admission to all of the details to provide in a statement. To collect these data, they must be more or less correct and verified by an auditing firm, which then provides an opinion on the financial statements. Moreover, they must be reviewed and then distributed to designed official institutions[54].

An essential aspect not to be overlooked concerns the relationship between the delay from one quarter to another and the financial statements published by the companies. The time lag between the transaction and its confirmation will be completely eradicated if a corporation embraces a real-time blockchain accounting system where both the general public and key stakeholders can examine the transaction in real-time. Several investigations have analysed the implications of the quarterly lag, but not in relation to blockchain accounting.

It is important to understand how much the non-publication of the financial statements weights on investors as they cannot predict the future performance of the company, much less verify its current stability. In fact, a timely publication of quarterly and annual financial reports is essential for a well-functioning financial market since they provide the most general outlook of a company's financial health and future scenarios. According to several studies, investors react negatively when companies delay reporting, as they interpret it as an indicator of accounting or management difficulties, as well as a method for the entity to alter its own information and data[55].

Especially a study addressed to some French companies found that the delays in reporting, quarterly and/or annually, negatively affect investors who feel discouraged and certainly unwilling to trust these companies, as a delay in this sense, it is perceived

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[53] *Charl De Villiers, The British Accounting Review, (2010)," Shareholders' requirements for corporate environmental disclosures: A cross country comparison"*
[54] *Dhiaa Shamki and Azhar Abdul Rahman, Emerald Insight, (2016), "Does financial disclosure influence the value relevance of accounting information?"*
[55] *Haim Falk and Haim Levy, (December 2021), "Market reaction to quarterly earning's announcements: A stochastic dominance-based test of market efficiency".*

as the reduction of future earnings potential and certainly as a bad transparency on the part of the company[56].

A blockchain accounting data open to stakeholders and/or regulators can become a fundamental requirement for publicly traded companies in the coming years, as it provides the most relevant data, thus raising the effectiveness of financial markets. This requirement, however, is not mandatory, rather recommended, it is safe to assume that companies facing a greater level of pressure from their investors would prefer a higher degree of disclosure. While we support Tapscott's theory which privacy is for individuals, not corporations and even less so for publicly traded companies, we need to consider that greater information transparency between participating entities can only be profitable for the community agency[57].

2.7 Credit risk and credit risk modelling

Credit risk modelling is certainly an area where blockchain accounting system will have a positive influence.

First of all, however, it is necessary to understand what we are going to write about and how the financial models take into account various factors in the evolution of the creditworthiness and the probability of insolvency of a company. All this to understand the implications of a reliable, timely and transparent source of financial information.

Basel argued in 2000 that credit risk is the possibility that counterparty will default on the terms of an agreement. In the same line of thinking Hull John, several years later, defines credit risk as a risk of default on the part of the borrower, the issuer of the bonds and the counterparty in derivative operations. It is natural for financial institutions to manage credit risk for the companies they lend money to, as well as for companies and individuals who purchase debt issued by other corporations. In addition to the direct counterparty risk of borrowing process, a variety of financial

[56] *François Aubert, Université d'Auvergne Clermont, Faculty of Economics and Management - IAE, France, iBEACON Research Group, (2009), "Determinants of corporate financial disclosure timing: the French empirical evidence".*
[57] *Don Tapscott, (2016), "Blockchain revolution, how the technology behind bitcoin is changing money, business, and the world".*

instruments, such as futures, options, bonds and many types of financial derivatives, as well as interbank and intercompany transactions, involve credit risk[58].

In sample term, credit risk refers to the possibility that a contractual party will not fulfil its obligations according to the agreed terms. Essentially it can be defined in three ways:

- Exposure to the risk of default of a party or to the loss of its ability to perform.
- The probability of default;
- When a default takes place, how much of the default can be reclaimed.

We pay attention that the larger the first two points, the larger the vulnerability. Alternatively, the lower the risk, the higher obviously the recoverable amount will be[59].

We can shift in credit risk management if blockchain-based accounting system take off in the near future. In light of what we have covered so far, we can get a better sense of how the blockchain will affect every step in the process by analysing the current risk management process step by step. Furthermore, the likelihood to work with self-executing programs in a decentralised platform is one of the characteristics that could be favourable for more frequent evaluations of the predicted loss, thus potentially decreasing the risk.

2.8 The credit risk management process

Let's start looking more specifically the credit risk management steps[60].

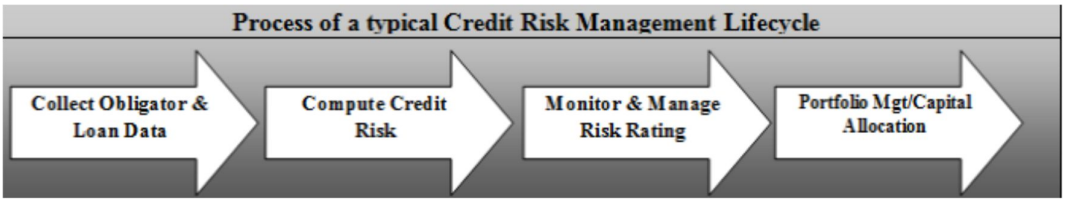

Figure 5: Phase of a Credit Risk Management Lifecycle

[58] *Jon Gregory. (2010), "Counterparty Credit Risk, The new challenge for global financial markets".*
[59] *Ken Brown and Peter Moles, Edinburgh business school, Heriot-Watt University, (2016), "Credit risk management".*
[60] *B. Chitra, U. Vani, International Journal of Science and Research (IJSR), (2014), "Credit Risk Management for Banking".*

The process starts with the identification of risks, which entails assessing the borrower's likelihood of default. A lender, such as a bank, tries to determine the financial standing of the company-borrower and assign it a rating. We have to take into account that the words such as default, insolvency, and bankruptcy can all be defined differently, even though they are often used interchangeably in the literature. Both technical default and insolvency indicate an incapacity of a company to satisfy its current unpaid debts. Additionally, there is a slight difference between default and insolvency in that technical default occurs when the debtor violates terms of the borrowing agreement and can be subject to legal action; however, technical defaults and insolvency do not necessarily lead to liquidation and can last for a limited period of time. It can also be understood that default and insolvency are terms used in the context of bankruptcy, the latter meaning chronic failure to meet the company's obligations and where its total debt exceeds its assets value, or simply, when the company is more valuable dead than alive[61].

The three expressions are used as analogous in this thesis. Various financial and statistical models are used in the identification of risk, including Altman's Z-score and Merton Distance to Default. Real-time blockchain-based accounting systems have a direct influence on risk identification because they make financial information readily available on a daily basis, instead of quarterly, and are also more reliable, as they are only be assured after a rigorous auditing process.

As the second step, the lender outlines the plausibility of the borrower-firm going insolvent and estimates the expected loss as a percentage using the likelihood of default determined in step 1. A lender's loss given default is described as a portion of its exposure in the event of a default by the borrower i.e., it is the total amount to which a lender is exposed[62].

In the Basel model, each of these measurements is used to calculate how much capital financial institutions need to hold. As a result of a blockchain-based accounting system, regulators can almost automatically determine whether a lender satisfies the capital requirements. Additionally, using the blockchain information, an expert

[61] *Edward I. Altaman and Edith Hotchkiss, third edit (2006)" Corporate Financial Distress and Bankruptcy, Predict and Avoid Bankruptcy, Analyse and Invest in Distressed Debt".*
[62] *Maria Misankova, Erika Spuchľakova, Katarina Frajtova – Michalikova, 4th World Conference on Business, Economics and Management, WCBEM (2015), "Determination of Default Probability by Loss Given Default".*

auditor might be needed to compile and assess the lender's position based on the information provided by the blockchain. Nonetheless, as the technology matures, especially in the latter period where the Coronavirus emergency was an accelerator of digitalization for many aspects of our life. It is possible to develop an automated method, such as the "smart contract", to warn or sanction lenders if they fail to meet the required capital[63].

The next step is the pricing step, where the credit condition is revised to incorporate the determined costs. Credit conditions and loan costs are dependent on potential losses, so the borrower is charged an extra fee set on the strength of its capacity to reimburse the loan (Weber et al. 2006). Anybody who has taken a loan from a bank has encountered the system: the deeper your credit rating, the greater the risk premium. This is where the blockchain provides incredible benefits. Through the establishment of a transparent network of transactions, it eliminates much of the counterparty risk. Smart contracts, for example, make it possible to monitor changes in the financial position of borrowers and adjust the loan terms accordingly. The blockchain also helps determine a lender's credit score accurately for more rigorously identifying a premium.

Especially, when used in conjunction with an individual's digital identity profile, the blockchain can account for both sources of information (Tappscott, 2016). Similarly, new types of information can improve corporate credit ratings. Monitoring and implementing the plans are the last steps. Monitoring involves identifying changes that affect the terms of the loan agreement and making any necessary adjustments. Smart contracts can automatically speed up much of this phase, as mentioned above. In the working out stage, the lending institution must intervene if it wants to prevent the loss of the loan and prevent the borrower from going bankrupt. Equally, it is likely to remain in the hands of human accountants and lower-level managers as this is a quite difficult process to automate, but with the help of a transparent system and immutable records should facilitate it.

It is important to note that the first stage of credit risk management is applicable not only to lenders, but also to the company and its stakeholders. By identifying,

[63] *Clifford Chance, Article (2021), "The digital future of syndicated loans: Loans and Tech – now and in the future".*

assessing, and analysing credit risk in a timely manner, management can take right decisions that will improve its financial performance and increase its competitiveness, while for investors they have to assess the company's financial health prior to investment decisions.

2.9 How does blockchain influence the financial accounting profession

The blockchain will undoubtedly change the accounting profession. Accounting will move away from bookkeeping into other value-added activities such as judgment and advice. Being that the rights and obligations arising from transactions may involve the interest of accountants in relation to blockchain technology, the latter may help to enhance the finance profession, by elevating the main focus from basic bookkeeping to more value-added tasks, such as planning and valuation, integrated analysis, and elaboration of different results, and data system assessment. Especially, accountants have to evaluate the true economic value of blockchain records by comparing them with economic reality and estimates.

In addition, accountancy is allowed to play a key role in the expansion and assimilation of blockchain technology. Blockchain models require accountants' expertise in a wide range of areas, including business logic, recordkeeping, and complex rules[64].

Thus, they should participate in the "business" design of different blockchain solutions, along with people who have technical knowledge about how blockchains operate. Accountants can help organizations evaluate blockchain solutions by serving as consultants. The role of the business advisor should be to serve as a bridge between technologists and business stakeholders during the adoption process of blockchain and to provide advice on its impact on their businesses and clients[65].

We can deduce at this point how blockchain technology offers exciting possibilities for financial accounting. It will lead to a reduction in communication and in the management profit, as well as a significant change in identification, performance,

[64] *Sean Stein Smith, Australasian Accounting, Business and Finance Journal (2018), "Implications of Next Step Blockchain Applications for Accounting and Legal Practitioners: A Case Study".*
[65] *Adriana Dutescu and Irina Bogdana Pugna, Proceedings of the 14th International Conference on Business Excellence (2020), "Blockchain – the accounting perspective".*

measurement, and publication of financial accounting, and consequently, to improve the quality of information.

First, accounting ledgers and financial statements will automatically be generated through smart contracts by posting source documents to a public blockchain. This will fundamentally alter how financial statements are measured, presented, and disclosed.

A second benefit of using this technology in financial accounting is that financial statements are automatically created by smart contracts, leading to a reduction in operational risk. As a result, the time lag among the formulation of accounting information and its broadcasting is diminished by the arrangement of accounting information at the right time. In the future, accounting blockchains are expected to increase fraud detection and increase counterfeiting costs largely due to their transparency and traceability.

As a third point, the use of blockchain in financial accounting would result in more speed in the recording of transactions as several operations would be entered at once and the latter would be noticeable to all network participants. This will lead to an increase in the reliability of accounting information since all nodes in the blockchain will verify and supervise the information entered[66].

It is also crucial that we acknowledge that this technology is still in the empirical phase, which is why there are still today several barriers related to data processing capacity, data confidentiality, and regulatory compliance.

The first obstacle we can encounter concern the massive presence of accounting information with which companies' interface, which, given their heavy quantity, could not be managed by current blockchain technologies. Moreover, firms wishing to use this technology will face significant costs since the billing fees will be high.

Another barrier regards the nature of transparency and durability of the data, anyone can view it and download it, in which on the one hand could be certainly advantageous for a firm, but on the other it could lead to an increase in the costs of proprietary information for firms. Indeed, when the company has information that contains

[66] *David Yermack,* Review of Finance*, Volume 21, Issue 1, March 2017, Pages 7–31 (2017), "Corporate governance and Blockchains".*

business secrets, it faces a cost of ownership, which adversely influences the company' business operations. Thus, firms with noticeably high costs of ownership are unlikely to be motivated to use blockchains to release information.

Lastly, another barrier that should not be underestimated is the anonymity of nodes, and the case in which the "51% attacks" can occur, which involves more difficult. Considering how important corporate information disclosures are to stock price, some nodes may try to manipulate the stock price and profit from it by adding false information to the blockchain. In this scenario, nodes can modify the information entered within the blockchain exclusively if they are able to manage more than 50% of the computing power[67].

In addition, in the short term, it is unrealistic to expect all companies to use blockchains as their accounting and broadcasting system. Nonetheless, the first problem can be solved if the technology is developed enough. Companies after verify the benefits and costs, will decide which confidential information will be disclosed on the blockchain. Once these two problems are solved, many companies will see the blockchain as the optimal tool for voluntary disclosure on their data. As such sharing will diminish data asymmetry between the organizations and investors and lower the cost of capital for businesses.

Likewise, there is highly transparent, traceable, and tamper-proof information disclosed by blockchain due to its technical characteristics. For this reason, intentional disclosure across blockchain is an appealing approach for firms looking to reduce information asymmetry. Through the blockchain, entities may be able to share valuable, but non-compulsory, operation in the short term, likes earnings predictions and reports about corporate social accountability.

By self-disclosing, entities can better comprehend investors' needs and ponder better conclusions. Moreover, divulging publicly available information on the blockchain can prove to be a kind of feedback, among other useful things. Investors often focus on past information to verify the firm's current stable image, especially if there are large uncertainties (Drake et al., 2016; Hail et al., 2017). On the other hand, disclosure

[67] *Emon Kalyan Chowdhury, article SSRN (2021), "Financial Accounting in the Era of Blockchain- A Paradigm Shift from Double Entry to Triple Entry System".*

of data through official methods can have a profitable effect on the decision-making process of investors[68].

We can conclude that this technology will be crucial in the future particularly in the financial, insurance, and accounting fields. It will be years, perhaps even decades, before it is fully developed, standardized, and integrated with the Internet and financial architecture. In addition to running faster than before, it will need to be more efficient and run at a lower cost, so that it can also be used by micro and medium-sized businesses. As a result, the benefits will be more accurate records and fewer reconciliations.

So, while blockchain will not be a key business technology, we can still expect a form of distributed ledger technology to emerge. Due to the increased confidence in the accuracy of the information available and the reduction in the time spent disputing documents with others, the accounting will be more efficient. As a result, the basic aims of accounting will be more clearly defined: to interpret the economic significance of transactions and provide information for smarter decisions.

2.10 Environmental impact

This brilliant technology has led to numerous positive changes from both a social and economic point of view, looking at the other side of the coin, however, it emerges the environmental impact that the use of blockchain produces.

If on the one hand, cryptocurrencies are defined as virtual coins and therefore to mint them there is no use of paper, plastic materials or metals, it is equally true that the mining process, or the creation of cryptocurrencies, takes place thanks to the work of numerous computers at high power, which process at high energy intensity, often generated by fossil fuels such as coal, one of the most polluting fuels[69].

The problem, in fact, stems from the way in which operation blocks are aggregated to the blockchain. Proof-of-work is a double-edged sword: if on the one hand it allows

[68] *Tim Loughran, Bill McDonald, article (2014), "Measuring Readability in financial disclosure".*
[69] *Camilo Mora, Randi L. Rollins, Katie Taladay, Michael B. Kantar, Mason K. Chock, Mio Shimada and Erik C. Franklin, Nature Climate Change journal report (2018), "Bitcoin emissions alone could push global warming above 2°C".*

high levels of security for the entire system, on the other it is an incentive to consume as much energy as possible, so as to be more likely to add a block to the chain and win the coins up for grabs.

Basically, every time a node on the blockchain gives the go-ahead to a transaction, it receives a certain number of bitcoins in exchange (currently 6.5, but the number is halved every four years). Not all computers participating in the blockchain materially approve the transaction, but only those who are the first to solve a very complicated algorithmic puzzle. As a consequence, there is a kind of computational race taking place, in which tens of thousands of computers are competing with each other to reach the solution first. In the previous chapter, we discussed how this mechanism encourages participants to increase the power of their computers in order to improve their odds of winning the race and receiving bitcoins in return[70].

Moreover, assuming that anyone can participate in this competition by using an ordinary computer, as was the case at the beginning, is essentially wrong. As the extraction of bitcoins is now carried out by mining pools, which yield hundreds if not thousands of specialized devices associated with each other to maximize the likelihood of winning the computational competition.

China has become unquestionably the dominant mining nation, with the vast majority of professionals engaged in mining cryptocurrencies based there, and 60 percent of the total computing power used for this goal coming from the country[71].

Let's talk more specifically, of the cryptocurrency that marked the birth of the blockchain, as well as the Bitcoin coin in this regard, numerous estimates have been made on the electricity consumption of this cryptocurrency, but among the most interesting is that of Professor Narayanan, in his testimony before the Energy and Natural Resources Commission of the US Senate on 21 August 2018. Taking into consideration that all miners use the most functional technology available on the trade, he estimated that Bitcoin mining consumes an amount of energy «*slightly less than 1% of the world electricity consumption, or slightly higher than the electricity*

[70] *Liana Badea and Mariana Claudia Mungiu-Pupăzan, paper IEEE Access (2019), "The economic and environmental impact of Bitcoin".*
[71] *Andrea Daniele Signorelli, paper (2021), "The (un)sustainable Bitcoin: The significant environmental impact of the cryptocurrency world is causing concern among new generations of investors."*

consumption of the state of Ohio or the state of New York. Other public blockchains also consume a considerable, albeit much lower, amount of energy »[72].

Their energy consumption is impressive: according to the Digiconomist index, which tracks the environmental footprint of bitcoins, every year the transactions of this cryptocurrency require an energy requirement of about 130 terawatt hours, this requirement exceeds for example, the demand of a nation like Argentina and slightly less than that of Sweden.

The latest data on the impact this system has on the environment comes from the University of Cambridge and the International Energy Agency. In 2019 they estimated that mining operations around the world draw on energy sources at a rate of 120 terawatt hours per year, about as much as a medium-sized nation, but according to the US university this could have increase to 147.8. The carbon dioxide spill due to Bitcoin mining varies between 22 and 22.9 tons in a year, levels comparable to those generated by Jordan or Sri Lanka. Numbers that would even risk doubling if, in addition to Bitcoin, all other cryptocurrencies were also taken into consideration[73].

Our explanation of how miner factories consume so much energy leads us to the crux of this problem, which is the computational race between different users. Several ecologists have become interested in finding a less impactful solution to this problem. Thus, with the growing attention to sustainability in the financial sector spilling over to bitcoin and other digital currencies, it is inevitable that the question arises: is cryptocurrency sustainable? It is indeed. As an alternative to bitcoins, many blockchain realities actually use a different system to verify their operations.

The new system, we have already met in the previous chapter, is called proof-of-stake, in which nodes are randomly involved within the blockchain rather than rewarding those who win the computational race. In addition to requiring less energy to run, it admits digital currencies to handle significantly more transactions per second than bitcoins to the tune of several hundreds, going from seven transactions per second to several hundred in a matter of seconds.

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[72] *Arvind Narayanan, (2018), "United States Senate, Committee on Energy and Natural Resources Hearing on Energy Efficiency of Blockchain and Similar Technologies". Available at: https://www.energy.senate.gov/services/files/8A1CECD1-157C-45D4-A1AB-B894E913737D.*
[73] *Ismail, Materwala, paper (2019), "Article A Review of Blockchain Architecture and Consensus Protocols: Use Cases, Challenges, and Solutions".*

This technology is already being used by several of cryptocurrencies, including Cardano, Polygon, Tezos, and other major players in the blockchain world. However, Ethereum's transition to the new system will be where the real breakthrough occurs. The second largest cryptocurrency (with a market capitalization of $ 270 billion) has worked hard to become sustainable[74].

It Unlike bitcoins, all of these realities allow the blockchain to be used for many other purposes, such as tracking student performance, identifying the most promising students and eliminating the country's habit of forging school certificates. For example, Cardano recently signed an accord with the Ethiopian government to apply distributed ledger technology to school management, recognizing the most promising students and reducing tampering with school documents in the country. Unlike Bitcoin, Ethereum is a clear leader in the field of non-fungible tokens, which are cryptographic tokens that allow you to authenticate digital works of art in order to be able to receive economic compensation for that work. Another approach is to exploit the potential of smart contracts, or contracts stored on blockchain that automatically execute once the parties agree on certain terms (for example, payments from a company to a supplier).

[74] *Vitalik Buterin and Virgil Griffith, paper Ethereum foundation (2019), "Casper the Friendly Finality Gadget".*

CHAPTER 3 – Different legislative approaches by states in the blockchain field

3. Introduction of legal issues

The advent of new technologies, with the information revolution and the spread of the global internet in the foreground, has radically changed the way people communicate, interact and relate. Opening up a Pandora's box so full of alternatives, but also full of risks and uncertainties, returning a still fragmented and rapidly evolving picture.

In the opinion of numerous analysts and observers, and in particular from what emerged in the annual meetings of the World Economic Forum, we are at the dawn of the next "big thing" that will distinguish the years to come, a Fourth Industrial Revolution, characterized by an ever-greater huge existence of robotics[75].

Industrial revolution whose protagonist is the blockchain. A technology considered by many to be "disruptive", that is, endowed with an innovative charge so disruptive as to have the characteristics capable of redesigning some of the classical schemes at the foundations of human society.

In light of these facts, legal systems need to address numerous issues in order to create an efficient and comprehensive set of laws. A noteworthy point to note is that there is no single regulatory model that can successfully manage such technology on its own. Nevertheless, the widespread implementation of distributed ledger technology in every sector of the economy has forced central banks and financial regulators to switch their position on distributed ledger technology from an intense initial hostility to a prudence and market-friendly stance[76].

From its introduction, initially as the engine of the Bitcoin payment system to today, this has gone from being a topic for a niche of computer scientists, to an attraction for large world study centres, multinational companies, commercial banks, insurance companies, up to the attention of national governments and international and supranational bodies.

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[75] *Klaus Schwab, World Economic Forum (January 2016), "The fourth industrial revolution: what it means, how to respond".*
[76] *S. Blemus, SSRN (2017), "Law and Blockchain: A legal perspective on current regulatory trend worldwide".*

Among the latter, the European Parliament expressed itself with the resolution of 3 October 2018, showing a clear stance on its usefulness as a tool for protecting personal data and for the autonomy of citizens, but also in terms of maturation for various economic sectors and public services.

Important European countries are embarking on a path aimed at legislating, adopting regulations regarding the blockchain and derivatives. Italy, compared to other European countries, has moved with greater intensity, through the approval of article 8-ter of the "Decreto Semplificazioni" of 2018, subsequently converted by law n. 12/2019, known as the "Normativa italiana DLT", in which the Italian legislator intended to intervene in the field of technologies based on distributed ledgers and smart contracts.

Basically, the blockchain is able to be in line with today's needs for speed, efficiency, simplification, but also for security and transparency typical of the modern information society[77].

This is certainly in line with the history of the evolution of digital media and the internet, highlighting the continuity with the constant predisposition towards a review of all the steps that generate uncertainty.

The rapprochement between the interacting subjects has already seen important developments with the advent of the global network, but it is with the blockchain that a clear change of the traditional paradigm is expected, characterized by the figure of the intermediary, with the function of guarantor and control, to users able to communicate, organize and exchange goods and services on an individual basis, but also in a global and scalable dimension through the consensus mechanism distributed in the network.

In order to be able to set up a theoretical framework about the regulation of the blockchain, it is first of all necessary to understand how it is able to regulate relationships, its ability to create autonomous systems, immutable public registers where the parties are able to meet anonymously in a context without trust (no trust environment) without any form of control by third parties, where trust is settled on the reliability of the underlying algorithm. In particular, through one of its most

[77] *A.M. Gambino, C. Bomprezzi, (2019), "Blockchain e protezione dei dati personali, in Dir. Informazione informatica".*

important applications, smart contracts, which represent the main interaction between blockchain and private law.

It is precisely this mechanism, defined as a thrustless trust, that represents the most revolutionary and dangerous connotation at the same time, capable of raising great legal questions.

In fact, unlike the lex IT, we are faced with an a-juridical phenomenon, involving the possibility of adopting a private and autonomous regulatory framework, imposed solely by the technological architecture with the omission of any central body. For the first time it will also be necessary to deal with a regulation of the phenomenon of interaction not only between human, but also machine to machine, furthermore having the partial claim of constructing almost a parallel reality, in which parties interact in an order not descending from legal norms, but rather by the code[78].

Regulating the blockchain, it will not be a simple task as it will be necessary in addition to the understanding of technical aspects also to the direct implication on the level of law, the only real effective tool to protect legal positions in the face of possible technological misunderstanding.

In this respect, the use of blockchain in order to conclude a transaction between two individuals is a peer-to-peer transaction without the need for any mediator. Despite its decentralized nature, blockchain is a system whose nodes are spread across several jurisdictions, posing a jurisdictional problem. legally, this results in the challenge of determining both the law applicable to a hypothetical lawsuit and the court that would be competent to decide it[79].

Consequently, events taking place on the blockchain are only in part attributed to traditional legal entities[80].
The distributed architecture of the blockchain means that no traditional sovereign powers can manage what happens in this space due to its scattered architecture.

[78] *T. Schrepel, SSRN (2019), "Anarchy, State, and Blockchain Utopia: Rule versus lex cryptographia".*
[79] *K. Wojdyto, Newtech.law (2017), "How may we regulate the blockchain?", available at http:// https://newtech.law/en/how-may-we-regulate-the-blockchain/".*
[80] *S. Asharaf & S.Adarsh, (2017), "Decentralized computing using blockchain technologies and smart contract: Emerging research and opportunities".*

As a general premise we can already understand how the legislative framework is extremely fragmented and, in some ways, unsuitable for regulating a technology of this magnitude. However, some initial attempts at approach, as we mentioned above, are proof that a journey has begun.

3.1 Possible regulatory approaches

Regulators need to keep in mind that applying traditional rules to this technology can lead to inaccurate results and misinterpretation. Being this technology self-governing and autonomous, it cannot be managed through traditional methodologies, as it allows ordinary people to communicate and negotiate with each other in a peer-to-peer fashion without the obligation of an external third party to guarantee the transaction, but at the same time, leaves it open to being exploited for illicit purposes.

State governments attempting to impose their own regulatory frameworks on this technology but it would only be recognized within its territory, and this would lead to enforcing their own laws partially.

Blockchain technologies, as pointed out in the previous paragraph, are still branching out in unpredictable directions and at an unprecedented rate. This has led some countries to adopt a "wait and see" attitude, which consists of waiting for the advancement of technology while still enforcing the existing legal requirements[81].

Currently, this appears to be the most popular approach, as it allows regulators to observe how blockchains develop without having to make explicit statements and take explicit actions. It would be an error, however, to assume this is mainly a passive approach. A wait-and-see approach does not necessarily translate in the enactment of a new regulation; The regulator actively gathers data and acquires experience by consulting stakeholders and specialists, often while also evaluating developments in distinct jurisdictions.

[81] *H. Kartik, Transnational Litigation/Arbitration, Private International Law, & Conflict of Laws eJournal, Vol. 04, No. 11 (2017), "Legal system and blockchain interactions".*

Furthermore, talking about the possible governance of the blockchain, alternative approaches have been identified to guide the hand of parliaments and regulators[82].

Interestingly, these alternative approaches are shown as a boxes or containers, even if their actors, objects, and purposes might differ. Consequently, they should each be treated differently from a legal and policy perspective and are the follow:

- Recycle box;
- Dark box;
- Sand box.

The first method we are going to illustrate is called "recycling box.". In this approach the discovery of new technology here would not affect the existing legal system since the technology would give us a way to resolve all the issues that were previously regulated in other ways.

A prime example of a blockchain-based interbank settlement system is the early Ripple network. Ripple's platform the ability to consolidate global interbank trades in real time on one global ledger, making it one of the most popular platforms for global financial institutions. The institutions, their customers, and hopefully everyone involved will save time and money by comparing this to the multiday batching and settlement processes that occur through global correspondent banking[83].

In blockchain technology has provided banks with a more efficient, faster, and cheaper way to do the things they did in the past. The financial branch is a highly monitored and well-known entity. It is almost assumed that banks still must satisfy all applicable legal requirements despite upgrading to blockchain technology from their legacy settlement systems. In light of these factors, blockchain-based use cases do not pose major regulatory challenges.

Certainly, two fundamental questions must be asked to comprehend if this method can be applied to a specific case: *"Is this blockchain application replacing a back-office function of some sort? Do any regulated actors use blockchain solutions within their traditionally regulated businesses?"*. In the event one of these questions is

[82] *J.A. Maupin, paper (2017), "Mapping the global legal landscape of blockchain and other distributed ledger technologies".*
[83] *Ripple, Ripple promotional paper (February 2016), "The cost-cutting case for banks, the ROI of using and XRP for global interbank settlements".*

answered affirmatively, there is a good chance that governments and regulatory bodies will apply the existing framework to blockchains[84].

This does not imply that no regulatory modifications are required for recycle box use cases. For instance, regulation of Ripple and interbank settlements needs to take into account how banks participating in the shared ledger, which must not, in any way, exercise unlawful actions.

An alternative approach is the one called the "dark box" which draws its name from the darknet[85]. The activities falling in this category require an inevitable close inter-jurisdictional regulatory cooperation among the authority responsible from collecting and analysing the data points use to identify illicit digital activities.

Among the examples of dark box applications, blockchains can be used to enable online drug marketplaces, weapons marketplaces, or other illegal markets for prohibited items, human trafficking networks, terrorist financing and communication networks, tax evasion schemes, etc.

On the dark web, illegal services like these have been available for years, some of which have recently been recreated on blockchains. The Silk Road trial developed by Ross Ulbricht, for example, is infamous for its unregulated online marketplace where everything from drugs to hacking tutorials could be bought and sold. Bitcoin cryptocurrency was used as a form of payments, in the past, one of the most difficult to track, and anonymous navigation software was used on the website[86].

Yet as it turned out with the Ulbricht case, these activities no longer become illegal merely by placing them within a blockchain. However, all in all, it should be emphasized that in this case it is the end pursued through this technology that is illegal and not the latter itself.

Lastly, there is the "sandbox". The third method is probably the most interesting as it is leads to the most disruptive and innovative use of the blockchain and its regulation. In this box, are placed hypotheses in which technology leads to completely novel legal

[84] *Andrea Borroni, (2019), "Legal, perspective on blockchain theory, outcomes, and outlooks".*
[85] *M. Nicotra, Blockchain4Innovation (2017), "Blockchain: governance ed applicazioni".*
[86] *Laurie Segall, article CNN (2015), "Silk Road founder's parents speak out".*

and technological structures and applications. As for these innovations, there is obviously a lot of uncertainty, not only about the benefits but also about the risks.

Instead of setting parameters within the confines of traditional schemes and testing the ability of these use cases to be regulated by alternative standards, some countries have started initiatives where all stakeholders are invited to participate, within a context that is not yet regulated but is being monitored by the authorities to understand how to intervene and regulate any new event.

Specifically, the concept of a sandbox is a result of a recent idea by the Financial Conduct Authority (FCA) to introduce a directive sandbox for UK fintech companies with the aim of taking actions for fair trade within the UK market. Companies, in this situation, can test out new technologies in an environment with light regulatory oversight while closely monitored by the government and for a particular period of time[87].

The third category is based on the reason that certain uses of the blockchain, while legitimate, may have far-reaching implications and consequences that current legislation cannot yet address.

We have identified the following primary characteristics of blockchain use cases for the sandbox division[88]:

- The main focus of the use case: not illegal on its face, but with real risks that governments are unwilling to leave unregulated;
- By employing the blockchain, this objective can be accomplished without relying on traditionally regulated entities;
- It would be harmful to the business case for deploying the blockchain in the first place if the blockchain was forced to conform to the current regulatory scheme;
- It is conceivable that alternate methods could be utilized to address legitimate regulatory concerns.

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[87] *Deloitte, article (2018), "A journey through the FCA regulatory sandbox the benefits, challenges, and next steps Brought to you by the Centre's FinTech Team". Available at: https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/financial-services/deloitte-uk-fca-regulatory-sandbox-project-innovate-finance-journey.pdf.*

[88] *Radostina Parenti, Study Requested by the ECON committee (September 2020), "Regulatory Sandboxes and Innovation Hubs for FinTech: impact on innovation, financial stability and supervisory convergence".*

3.2 Regulatory cases

In light of the aforementioned, regulatory agencies worldwide are still examining the possibilities of regulating blockchain technology. The legal treatment of the blockchain is still a source of much disagreement, considering the current state of development[89].

With the following paragraphs we intend to underline how different states have faced the regulation of this new technology. In fact, it will be seen in the course of reading how some countries such as China initially had a reluctant approach towards it, while others such as the United States, United Arab Emirates immediately tried to regulate and support it.

According to the United States Federal Reserve, cryptocurrency businesses are among the most regulated in the world. Specifically, the two-level governance system embodied in the US system is responsible for effective regulation: that is, at the federal and state levels[90].

At Securities and Exchange Commission (SEC) is among the first at the federal level to comprehend how to implement and exploit blockchain technology to financial services. In November 2015, Commissioner Kara Stein discussed how blockchain technology could be used for tracing securities lending, and margin financing, as well as to supervise the systemic risk.

As this technology is still in its infancy and in an ever-changing state, Commissioner Stein pointed out that «*if the market begins to move toward blockchain technology, regulators need to be in a position to lead, harnessing its benefits and responding quickly to potential weaknesses*»[91].

In addition, the Commodity Futures Trading Commission (CFTC) analysed how blockchains and distributed ledgers might be managed. CFTC Commissioner J. Christopher Giancarlo recently spoke about distributed ledger technology,

[89] *Z. Chen, article Fortune (2018), "How should we regulate Blockchain? It depends on which country you ask".*
[90] *W.A Kaal & Dell'Erba, (2017), "Blockchain innovation in private investment funds- A comparative analysis of the United States and Europe".*
[91] *P. Rizzo, CoinDesk (2015), "SEC Chief Urges Caution but sees blockchain potential.*

particularly affirming the importance of "do not harm regulation" that establishes uniform principles to encourage investment and innovation[92].

Further, another government agency called Financial Crimes Enforcement Network published a ruling where it examines how blockchain technology can be used to facilitate the online exchange of precious metals. According to the regulator in this case, the blockchain should be subject to money transmission regulations[93].

Regarding instead the state level, during the last two years, blockchain regulation has been being pursued with the main goal of researching in which private and/or public sectors the technology could be useful.

Several of these states took a more detached position in some of these cases. The State of Colorado recently introduced a bipartisan bill to encourage government record-keeping with blockchain technology[94].

Other states, instead, immediately tried to embrace this innovation. Like Delaware, which in 2016 proposed the "Delaware Blockchain Initiative", an exhaustive plan created to encourage the adoption and development of blockchain and smart contract technologies in both the private and public sectors[95].

Instead, the 2017 was the year of Illinois and its blockchain development program. The Illinois Blockchain Initiative, with the participation of a number of state and provincial organizations, aims to exploit the novelties created by blockchain. Like Delaware, Illinois also aims to use this disruptive technology to delivery of public services, consolidate the relation between government and citizens in terms of data sharing[96].

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[92] *J. C. Giancarlo, (2018), "Quantitative regulation: effective market regulation in a digital Era".*
[93] *M. Bartlam & M. Radcliffe, (2017), "Blockchain regulation in finance: recent developments and prospects".*
[94] *K. C. Desouza, C. Ye, K. Kabtta Somvanshi, (2018), "Blockchain and U.S. State governments: An initial assessment". Available at http:// https://www.brookings.edu/blog/techtank/2018/04/17/blockchain-and-u-s-state-governments-an-initial-assessment/.*
[95] *G. Thomas Stromberg, Jolene Negre, Mark Reinhardt and Michelle Peleg, Paper Law360 (2018), "Are Headwinds Hampering Delaware's Blockchain Initiative?".*
[96] *Sunil Thomas, Paper NASCIO Award Category Emerging & Innovative Technologies State of Illinois (2017), "Illinois Blockchain Initiative".*

As a whole, the states have adopted very varied positions on this issue, ranging from being unconscious to active participation. It is assumed that over the years, even the most hesitant states due to its fluctuating nature are able to approach.

As for the European Union, initially the approach towards blockchain technology was very slow and cumbersome, causing businesses to stagnate. In addition, it is not always clear if a ruling in one country or region applies to another[97].

As already mentioned in the previous paragraphs, even according to many European institutions, this technology is still in an initial phase and consequently full of uncertainty. Therefore, regulations should wait until technology progresses further. It is believed that early regulation would compromise the technology's future development. The early implementation of blockchain regulations may also fail to regulate relationships properly and reduce the risks associated with their use.

On the European level, the principal blockchain action took place in 2017 when the European Securities and Markets Authority (ESMA), released a statement relating the DLT in use in the securities transactions. Analysing the report, one can verify that this kind of technology offers several benefits, but on the other hand, it is evident that since blockchain applications are still in the early stages, «*it is not yet clear whether existing regulation would need to be adapted for distributed ledgers, or whether new regulation will need to be created*»[98].

Moreover, the Authority has identified several challenges posed by blockchain technology applications, including interoperability and standardization, access to central bank money, governance and privacy concerns, and scalability[99].

In fact, the ESMA has expressed the intention of continuing to monitor developments around the blockchain to determine whether a regulatory response is needed. In response to this, the ESMA stated that «*the majority of respondents highlighted the need for regulators to be involved in the process and the changing business models that result from the adoption of DLT: collaboration between policy makers and those*

[97] *T. Lyons, report the European Union blockchain observatory & forum (2018), "Blockchain innovation in Europe".*
[98] *ESMA, (2016), "The distributed ledger technology applied to security markets".*
[99] *J. Miseviciute, (2018), "Blockchain and virtual currency regulation in the EU".*

involved in the development of the technology itself is of critical importance. It is possible that new regulations will be required for these new roles».

EU officials are carefully studying blockchain technology and its changes day by day. They are notably attentive about transparency and cyber security. Taking a proactive stance towards the blockchain, thus far, has been the approach adopted. Many European countries such as Malta, Switzerland, Germany and, as well as Italy have already begun to regulate this technology and its applications, but it is assumed that in the next few years there will be further developments at the European level.

3.3 Italian regulation

Having analysed the possibilities and problematic ideas that a potential widespread adoption of the blockchain as the basic infrastructure of the Fourth industrial revolution is able to provoke on a legal level, let's now shift the focus on the responses received on the subject of legislative production from some national sates, as well as supranational and international bodies.

Thinking of being able to regulate technological phenomena of this magnitude and with relevant applications in several areas of the economy, if on the one hand it demonstrates the expression of interest in this innovation by national legislators, on the other it often proves to be lacking in real adequacy.

The undoubted originality of the opportunities opened by this technology begins to appear in various private sectors, launching a real challenge to lawmakers and, in general, legal operators from all over the world, who need to make a considerable effort and within a limited time frame. Looking for to answer new and complex questions determined by the novelties of the decentralized structure, for which a radical change is necessary to result in a partial redefinition of the approach, training and *modus operandi* of the contemporary jurist[100].

With the use of the blockchain, the need arises to identify a regulatory framework suitable for regulating disputes that may arise, and in this sense the states attentive to the legislative aspect are moving rapidly, above all because a clear regulation of legal

[100] *I. Walden & T.A. Christou, (2018), "legal and regulatory implications of disruptive technologies in emerging market economies".*

conflicts poses some secure bases for greater use of the blockchain system and at the same time also gives greater confidence for the establishment of new blockchain-based start-ups on their market.

At the same time world and regional powers are moving in this direction, albeit with various declinations of approach, as recorded in the USA, China and the European Union.

Speaking of a situation closer to our world, Italy, as mentioned in the first paragraph, has started for some years to pay particular attention to this sector by intervening with a first ad hoc legislative act, law no. 12/2019, defined as the "Normativa italiana DLT"[101].

Starting the reading of the law n. 12 with regard to simplifications for the support and dissemination of digital administration, it is possible to see the many areas affected by this law. From agriculture, entertainment, schools, infrastructures, tenders and also with regard of commercial negotiations applied to the blockchain where distributed ledgers and smart contracts are defined.

However, the first definition of DLT has already been the subject of criticism, some authors have underlined how this definition contains some gaps and inconsistencies, noting that the standard completely neglects any reference to the economic incentive, the real engine that guarantees safety and functioning thrustless of the register[102].

As regards, instead, the management of technologies based on distributed ledger and smart contract, Italy is considered as a leader, second only to Malta, as well as one of the first important exponents in the world, to recognize the legal status of smart contracts[103].

It is clear from the outset that the Italian legislation intends to follow the correct setting of smart contracts as software operating in conjunction with technologies based on distributed ledgers, in which two or more parties agree in advance on the

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[101] *Legge 11 Febbraio 2019 n.12, Gazzetta Ufficiale, "Conversione in legge, modificazione, del decreto-legge 14 dicembre 2018, n.135, recante disposizioni urgenti in materia di sostegno e semplificazione per le imprese e per la pubblica amministrazione".*
[102] *D. Carboni, M. Simbula, (2019), "Blockchain e smart contract: le debolezze della nuova regolamentazione italiana".*
[103] *Alessandro Billi, (2020), "Blockchain e smart contract: commento all'attuale normativa italiana DLT e rilievi comparati".*

automatic execution of the clauses inserted within. In this way, the inseparable relationship that this maintains with the DLT is underlined and ensured.

Moreover, it is also established that the smart contract must meet the requisite of the written form. This aspect must be considered with the utmost attention, given the particular importance that the Italian legal system attributes to the written form, both ad substantiam and ad probationem, for the purposes of validity or proof of the existence of the fact. Today, in any case, there are still several perplexities and doubts inherent in this step.

Even tough, as pointed out above, the "Normativa italiana DLT" configures the smart contract as software capable of satisfying the requirement of the written form. The case in point designed by the legislator therefore seems to reflect the "hybrid" characteristics of this technology, taking the form of a dualistic phenomenon, halfway between a computer program and a written document.

The rule also presents the obstacle of timestamp, that is the technical procedure that allows the date and time to be compared to data in electronic form by other data in electronic form, in such a way as to give evidence with sufficient certainty and enforceability to third parties of the moment of formation of a document[104].

From this analysis, the intentions that encouraged the Italian legislator to act, among the first at European level, for the legislative regulation of this technology and its applications, in view of a probable diffusion in the short future, showing attention to the impact that these may have in the world of socio-economic relationships.

However, it is at the same time evident that trying to regulate these complex phenomena, in continuous transformation and in a little more than embryonic phase in a single article raises many doubts and perplexities. Even the choice of the regulatory instrument in the context of a non-homogeneous emergency decree such as the "Decreto Semplificazioni", excluding any type of connection with the Civil Code, seems to be dictated more by needs such as speed rather than waiting to provide an organic and harmonious discipline in the comparisons of an articulated and multifaceted phenomenon.

[104] *Laura Cappello, DataGuidance paper (2020), "Italy regulatory approach to blockchain technology".*

Essentially, it can be deduced that the Italian legislation does not provide a detailed discipline but lays the foundations, so that we can begin to experiment by bringing to light the critical issues that the law will have to deal with. It is the proof that something is moving and that a line has been drawn.

To confirm these signals, there is also a recent report produced by the OECD and published on 10 September 2020, which takes stock of the Italian situation with respect to competitiveness in the blockchain market and analyses the recent regulatory framework in the perspective of future public policy.

3.4 China regulation

As in many other countries, China's first approach to the blockchain is related to bitcoin and cryptocurrencies. China was the only country that in the early stages of the spread of bitcoins moved with the explicit aim of inhibiting their use, as according to the leaders of Chinese financial institutions, decentralized management and the lack of certain regulations, they gave cryptocurrency trading great "anarchist potential".[105]

In light of this attitude, in 2013 a communication from the People's Bank of China (BPC), issued jointly with five other institutions, including the Ministry of Industry and Information Technology (MIIT), places a veto that establishes the prevention of risks of bitcoins.

The notice aims to defend property rights, the renminbi's official currency status, preclude money laundering and guard financial stability. Furthermore, bitcoins are defined as a virtual asset and it is expressly emphasized that they cannot have any monetary property, essentially prohibiting any type of economic transaction that exploits the cryptocurrency. Despite these limitations imposed on bitcoins, cryptocurrencies have found considerable response in China since 2013.

In fact, small investors and developers have started to create alternative cryptocurrencies to bitcoins such as VeChain and Neo. In addition, many Chinese start-ups, founded in this period, have invested heavily in developing blockchain technology applications. Equally, starting from 2017, the government has begun to

[105] *Alice Ekman, Paper (2021), "China's blockchain and cryptocurrency ambitions".*

ban the use of all cryptocurrencies and to prevent the so-called Initial Coin Offerings (ICOs), a crowdfunding mechanism typical of digital currencies[106].

This "war" by China on cryptocurrencies has often obscured the attention that the country has instead dedicated and is dedicating to the development of blockchain technology. Furthermore, the very idea that China is against cryptocurrencies is itself misleading. In fact, in June 2020, the BPC began circulating information and details on the imminent birth of the national digital currency, known as shùzì rénmínbì (数字 人民币, "digital renminbi"). The official document in which the objectives, functioning and distinctive features of the currency are explained was issued in July 2021[107].

Concerning the Blockchain, China's path begins to take better shape starting from 2016. In that year, the same MIIT that had drafted the warnings on the risks of bitcoin together with the People's Bank of China published the "White Paper on the development of blockchain applications and technologies in China ". The document analyses the state of evolution of the blockchain and proposes guidelines for the development of this technology in China. There are six new generation technologies that the document identifies as important sources of application and therefore of investment of the blockchain, namely cloud computing, big data, the IoT, telecommunications, cryptography and knowledge engineers[108].

Furthermore, the document also focuses on the need to standardize this technology, not only at the national level, but also at the international level. It is precisely in these years that Chinese scientific research on managerial applications of blockchain technology begins to develop. To this day, China ranks third in terms of the number of scientific articles on the subject and is in the top 10 of the countries with the largest number of studies cited[109]

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[106] *Von Carnap, Kai, paper Merics (2021), "China Sets Hopes on Blockchain to Close Cyber Security Gaps", Available at: https://merics.org/en/short-analysis/china-sets-hopes-blockchain-close-cyber-security-gaps.*

[107] *Phyllis Papadavid, Paper Asia House research (2021) "The digital renminbi and its economic pathways".*

[108] *Marcelo Corrales, Mark Fenwick, Nikolaus Forgó, (2020), "Disruptive Technologies Shaping the Law of the Future".*

[109] *Liang Cai, Yi Sun, Zibin Zheng, Jiang Xiao, Weiwei Qiu, Paper (2021)," China region special section Big trend: Blockchain in China".*

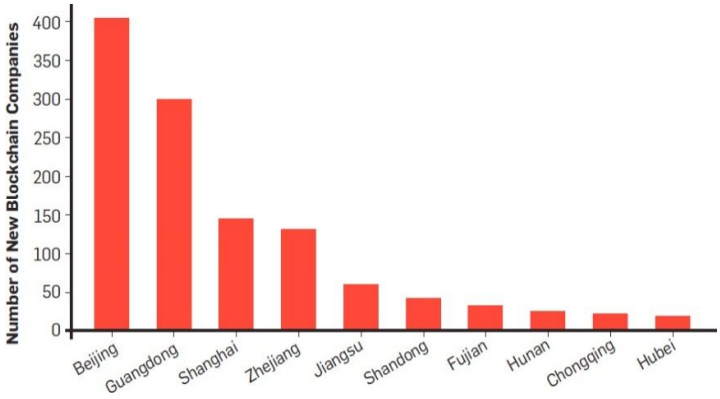

Figure 6: Top 10 Chinese cities with the number of blockchain companies

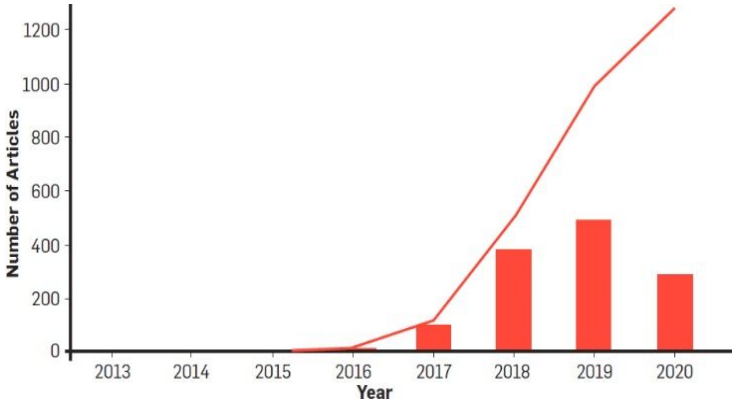

Figure 7: Total amount of China's Blockchain articles 2013 to 2020. It can be seen that over the years, China has been more exposed to this technology.

There are many sectors in which new blockchain applications are starting to be proposed. In general, we think of the banking sector, the agri-food sector, the efficient use of energy resources and the value chain. Also interesting is the case of the application of the blockchain in the so-called "e-government", an approach initiated in Foshan in the Guangdong province. It is the pioneer example in which the blockchain is used at the government level, with the aim of improving public services such as digital identity and food safety and quality, where the blockchain allows rapid and certain checks[110].

Over the years, the blockchain has become an element of primary interest for the Chinese Communist Party. In 2018, for example, the publishing house of the People's

[110] *Alexander N. Chen, Yumei Chen, Paper (2009), Macau University of Science and Technology, "Critical success factors on e-government application-from the view of government workers in Guandong".*

Daily, the party's official newspaper, publishes the book "Blockchain - A Guide for Party Leaders". From the same year, however, the note from the National Cyber Security Agency resumed work on the standards of the aforementioned 2016 White Paper.

The note underlines the need to deepen the knowledge of blockchain technology, clearly identifying its potential and risks, before proceeding with the development of new technological standards. This principle develops on two parallel tracks. On the one hand, priority must be given to the development of “urgent” standards, i.e., those with already consolidated technologies at the base. On the other hand, certain sectors, such as IT security, need to reach a technological maturity that still today do not have the ability to think about their standardization.

Furthermore, in January 2019, the Agency released the "Regulations on the management of blockchain information services" which establish what content can be offered by service companies that use blockchain technology, forcing them to register with the Agency.

The goal is to guide the "safe development" of the blockchain in order to achieve the consolidation, as already repeated several times, of a national technological standard. The 2019 is also the year of the official crowning of the blockchain by President Xi Jinping. In his speech during the 18th Politburo, the president stressed that blockchain is a key element in developing "independent innovation of key technologies".

Furthermore, the fact that blockchain has also become part of this group of technologies considered fundamental by the Chinese Communist Party underlines, once again, the importance that it plays within Chinese development strategies. The last two years have marked a further acceleration of the PRC's projects on the use of the blockchain.

Of particular importance in 2020 is the launch of the Blockchain-based service network (BSN), which defines itself as a "common infrastructure for the implementation and operation of blockchain applications globally". The BSN Development Association brings together various public and private entities led by the State Information Centre

(SIC), a group of experts engaged in the analysis and resolutions of disputes under the leadership of the National Development and Reform Commission (NDRC)[111].

The platform is divided into two realities. The first internal, where among others it has partnered with China Mobile, China Telecom and Baidu AI Cloud, and the second international, where it also collaborates with Google Cloud and Amazon Web Services[112]. Moreover, the BSN website lists more than 100 nodes in China and 7 in international cities, including Paris, Sydney and Tokyo. By exploiting the notion of open innovation and thus introducing simultaneously enterprises and industry experts, the fundamental goal that the BSN sets itself is to diminish the costs of developing new blockchain applications.

Basically, anyone who wants to use the blockchain as the backbone of their service can rely on the basic infrastructure made available by the BSN. By being part of this network, it is also possible to improve the infrastructure itself. While, on the one hand, it is offered the possibility of making blockchain systems more standardized and interoperable, on the other, this platform has centralized supervision, a feature not inherent with the nature of blockchain[113].

Despite the perplexities that the Chinese government has always shown towards the blockchain in general and the virtual currency in particular, it is crucial to remember the evolution that has taken place in Chinese policies. China sets itself clear goals regarding the use of blockchain, committing itself to implement the platforms and in the first phase of this transition which will end at the end of 2025, China has the idea of achieving an "advanced level" of world development[114].

In the second phase of development which will end by 2030, the Republic of China will adopt blockchain technology as a platform for development for all economic sectors, from

[111] *Jesper Schlæger, Policy & Internet article (2010), "Digital Governance and Institutional Change: Examining the Role of E-Government in China's Coal Sector."*
[112] *Dwayne Winseck, Journal of Information Policy (2017), "The Geopolitical Economy of the Global Internet Infrastructure".*
[113] *Joseph Holbrook, (2020), "Architecting enterprise Blockchain solutions".*
[114] *Iris Hong, article Asia Financial (2021), " China sets goal to be blockchain world leader by 2025".*

manufacturing to the digital economy and substantially the entire governance system of the country.

3.5 United Arab Emirates regulation

The United Arab Emirates (UAE) has chosen different approaches to manage blockchain technology. Instead of banning it like China or South Korea, the country's leaders have decided to embrace this new technology. The philosophy of government authorities regarding blockchain is moderately positive. They think that technology can improve the quality of life of all people living in the UAE[115].

Since the launch of Blockchain technology in 2016, the UAE government has maximized its use as a platform to improve payment productivity and efficiency. We learned that Blockchain is enforcing a shared ledger database that records and shares transactions as it occurs across its network of users.

The use of Blockchain has created, as already pointed out above, to digital money known today as cryptocurrency. These typologies of digital money entered in the market and created a considerable impact on the UAE government, several blockchain policies and regulations on cryptocurrencies were used to safeguard the people of the application[116].

Among the regulatory bodies, Abu Dhabi Global Market (ADGM) is the most active, with extensive regulations already in place in 2018. To keep up with global developments in blockchain regulation, the ADGM's laws, regulations and guidance notes are regularly updated. Consequently, ADGM has garnered considerable interest from international industry participants, particularly from operators of central virtual currency exchanges. In November 2020, after several years of delay and conflicting statements, the Securities and Commodities Authority (SCA) issued a regulation on crypto assets after implementing a wait-and-see route over several years. With Decision No. 23 of 2020, in

[115] *National program for artificial intelligence, article, "Blockchain guide". Available at: https://ai.gov.ae/wp-content/uploads/2020/01/Blockchain_EN_v1-online.pdf.*
[116] *Mohamed Noureldin Sayed and Nesrin Ahmed Abbas, ResearchGate (2018), "Impact of Crypto-currency on Emerging Market Focus on Gulf countries".*

fact, cryptocurrency activities are regulated including the offer, issue, listing and trade of the latter within its territory[117].

In addition, Dubai, at the end of September 2017, introduced a cryptocurrency called "EmCash". The latter, developed by the State Economic Department in partnership with the companies Emcredit and ObjectTech, is characterized by the fact that it is not issued in a predetermined quantity, but will be created, based on the request and joint decisions of the State Economic Department and Emcredit. At the moment however, the UAE government has not enacted specific legislation to address blockchain technology. However, there is an inherent obligation to integrate Blockchain across various sectors and industries in the UAE[118].

Specifically in 2020, the UAE government committed to using Blockchain in normal life, thus establishing the Global Blockchain Council and the Dubai Blockchain Strategy 2020. The Global Blockchain Council is responsible for evaluating and analysing blockchain transactions. As a result, the government has been able to assist in operations involving the financial and non-financial sectors.

Unlike the first mentioned above, the Dubai strategy is geared toward three major themes, that are[119]:

- Government efficiency: By implementing blockchain and enabling a paperless digital layer for all government services, the strategy will contribute to increased government efficiency.
- Industry creation: By providing an enabling environment for start-ups and businesses, will contribute to the creation of the blockchain industry.
- Leadership: Dubai aspires to influence global innovation in blockchain technology and turn into the hub for blockchain education.

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[117] *Mohammed El Hadi El Maknouzi & Hicham Sadok, article ISSN (2021), "Regulation of virtual currencies in the United Arab Emirates: accounting for the emerging public/ private distinction".*
[118] *Ed Clowes, Staff Reporter (August 2017), "New cryptocurrency launches in Dubai, backed by real economic activity", Available at: http://gulfnews.com/business/economy/newcryptocurrency-launches-in-dubai-backed-byreal-economic-activity-1.2070453.*
[119] *World economic Forum, White paper (2020), "Inclusive Deployment of Blockchain: Case Studies and Learnings from the United Arab Emirates". Available at https://www3.weforum.org/docs/WEF_Inclusive_Deployment_of_Blockchain_Case_Studies_and_Learnings_from_the_United_Emirates.pdf.*

To reduce operational and systemic risks in the virtual currency industry, the government has established benchmarks on its regulatory framework. In addition, consumers are protected from financial harm, such as fraud and cybercrime, by the regulations.
Dubai has recently announced its intention to develop a cryptocurrency regulatory framework that will take effect this year. In this regard, the UAE government has also developed the UAE Blockchain Strategy 2021, which aimed to convert 50% of government transactions to a blockchain platform by last year.

3.6 Data privacy and blockchain

Although there are many positive aspects of blockchain technology, it should be noted that it operates, at least to date, in the absence of a complete legal discipline both within the Italian and European territory. For this reason, the implementation of the blockchain platform requires the resolution of some important legal issues, the first of all is certainly the protection of user's privacy rights within a transaction[120].

In this regard, it is particularly difficult to believe that the blockchain can operate in compliance with the new rules of the General European Data Protection Regulation no. 2016/679 and better known with the acronym "GDPR", which came into force in 2018.

The twofold objective that the GDPR sets itself to protect the sensitive data of the subjects involved is to establish a general framework aimed at the protection of the rights for the defence of personal information and at the same time facilitate the free circulation of the information among several members of the EU[121].

Despite this, there have been several aspects of tension within these technologies and the GDPR in recent years. Broadly speaking, two main obstacles can be highlighted which mainly concern the structure and organization of the blockchain.

[120] *Pritesh Shah and Daniel Forester, Davis Polk & Wardwell, and Matthias Berberich and Carolin Rspè, Hengeler Mueller, Paper Practical law (2019), "Blockchain Technology: Data Privacy Issues and Potential Mitigation Strategies".*
[121] *Céline C., New Journal of European Criminal Law (2016), "EU Data Protection Rules Applying to Law Enforcement Activities: Towards a Harmonised Legal Framework?".*

As a starting point, the GDPR is focused on relationship between a natural or at least a legal person with their personal data, i.e., the data controller, to whom data subjects can contact to have their rights respected under EU legislation. on data protection. The solution of this problem is essential to establish against which subject to make any claims in the event of unlawful data processing. In the case of centralized registers, it is possible to impute responsibility or co-responsibility for the processing of personal data directly to the central authorities that manage and validate the information entered in the registers, while in the case of distributed registers on which the blockchain operates, due to pulverization and delocalization of the nodes, it is still not possible to identify certain criteria for the identification of data processors.

Secondly, the GDPR is based on the assumption that data can be modified or deleted, where necessary, to meet the legal terms of Articles 16 and 17 of the GDPR. Blockchain, however, makes such data changes deliberately burdensome, if not impossible precisely in such a way to guarantee data integrity and the growth of trust in the system. In this situation, the two attitudes are opposed, creating perplexity in the operators[122].

In such a framework, it is necessary to proceed with an extensive interpretation of the main provisions of the GDPR, namely those that establish the rights of the parties to the procedure of personal data such as:

- the right of rectification;
- the right to be cancelled;
- the right to limit the processing;
- the right to data portability.

This interpretative effort is, in fact, necessary to ensure a minimum coordination between the provisions of the GDPR and the blockchain while waiting for the adoption of a complete legislation that fills the gap on the subject, in order to avoid those operators in the blockchain market having to be forced to equip themselves with systems capable of ensuring the maximum level of guarantees provided for in the GDPR, supporting the related high costs.

[122] *European Parliamentary Research Service, (July 2019), "Blockchain and the General Data Protection Regulation: Can distributed ledgers be squared with European data protection law?".*

We will now consider two of the main rights to which the GDPR places fundamental importance, namely the right to be cancelled and the right of rectification, which go slightly in contrast with the immutable and anonymous of the blockchain. One of the main innovations introduced in art. 17 of the GDPR, is the right of the interested party to obtain the correction of incorrect data regarding him, as well as the addition of incomplete personal data[123].

Although in the application experience, including in Italy, there were greater requests for the elimination of personal data compared to those for rectification, the blockchain, as it is based on the substantial immutability of the transmitted data, cannot but clash with the recognition of this right provided for by the GDPR. The blockchain is in fact like a rigid chain and this is its peculiarity, once a node is composed it remains unchanged and unalterable, which is why, it must be used with knowledge and great awareness.

However, the regulation in question provides that "taking into account the purposes of the data processing" the interested party may request the rectification also through a supplementary declaration. Given the last-mentioned provision, it would be possible to believe that, if the blockchain allowed the addition to the chain of an additional block of data aimed at rectifying what was previously stored, it could be argued in accordance with the right of rectification. The blockchain itself should therefore be restructured in order to allow the modifiability of the data in this sense.

Furthermore, based on the content of art. 17 GDPR, under certain circumstances described below, the subject has the right to request that the controller deletes their personal data, including:

- the interested parties oppose the processing and there are no legitimate reasons for its continuation;
- the personal data have been unlawfully processed;
- The deletion of personal information is required by the European Union or the Member State in which the process is conducted;
- Data about a minor under 16 years of age has been collected in connection with the provision of information society services.

[123] *Eduard Fosch Villaronga, Peter Kieseberg, Tiffany Li, Article SSRN (2017), "Humans forget, machine remember: Artificial intelligence and the right to be forgotten".*

To verify whether or not the functioning of the blockchain can violate such a right, it is once again necessary to start from the consideration of its effectiveness characteristic, but at the same time of problematic nature, that is the substantial immutability of the data inserted in the block chain. Moreover, it is necessary to keep in mind that the second paragraph of art. 17 GDPR submits the obligation to delete data to the consideration of the available technology.

This provision can represent a point of legitimation of the blockchain, a technology that by its nature does not allow the elimination of personal data. Some authors then suggested implementing formal procedures on the blockchain platform for the cancellation of the access keys to the chain data. Once the access key has been eliminated, the data would in fact continue to exist on the blockchain chain without, however, granting the possibility of accessing it, substantially resulting in a sort of oblivion[124].

In the discipline of the right to be cancelled regulated for by the national laws of some countries of the Union, however, it was possible to observe a definable "soft" application regarding the obligation to delete data, given that the GDPR itself, by not defining the concept of cancellation, in this sense allows margins of discretion.

For example, in Germany, as established by art. 35 of the relevant Data Protection Law, it is accepted that the data cannot be destroyed if specific storage means make it impossible, accepting the alternative solution of limiting the processing. Even considering the European case law on the cancellation of data from the internet, an approach can be noted that tends to consider cancellation also the adoption of suitable mechanisms to avoid the subsequent distribution and dissemination of personal data for which oblivion is required.

In the Google-Spain case, faced with the request of a Spanish citizen to prevent their personal data from appearing in the search results, the Court of Justice of the European Union has identified a limit to the claim of the right to be cancelled: it is not It is possible to request from the search engine the cancellation of personal data that are held by the data controller who published the information, but only the disconnection from this data, so that the cancellation only concerns the contents of the online search and not also the

[124] *Cravath, Swaine & Moore LLP, the centre of global enterprise paper (2020), "The Right to be Forgotten Meets the Immutable: A Practical Guide to GDPR-Compliant Blockchain Solutions".*

data confer on the site of the original source. The case in question therefore represents a jurisprudential precedent in which the right to be forgotten has therefore been declined as the right to de-index[125].

Another feature of the GDPR concerns the territorial scope of application, which is difficult to connect with blockchains that operate at an extra-territorial level, since they make use of a series of nodes located in different points of the planet without referring to specific jurisdictions. Surely the new regulation of the GDPR has extra-territorial content, to the point that it must also be considered applicable to those blockchains that even have only an indirect connection with the European Union[126].

In this sense, art. 44 of the GDPR stipulates that any transfer of personal data to a third country or international organization after it has been transferred there, can only take place if the controller and the data processor meet a series of conditions.

As part of the conditions for the transfer of personal data, article 45 of the GDPR gives the European Commission the right to declare that a third nation, or the international body in question guarantees a reasonable degree of data protection, with Member State competent authorities to adopt binding national data protection regulations[127].

It could thus make it necessary to modify the blockchain mechanism to take into account any prohibitions and binding regulations both at European and national level, with the consequence that market operators would have to bear significant compliance costs.

In essence, the GDPR and the blockchain share the goal of empowering people and reducing assimilation between them and the organizations that process their data. However, the decentralization provided by the blockchain requires that the data processed and stored on it be distributed among community members. And this can end up generating tension.

Regardless of the above, several studies are still needed if a real solution is to be obtained. It is fair to argue that, considering the current stage of development, many, if not most,

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[125] *Tika Lubis, Paper SSRN (2016), "The ruling of google Spain case: The right to be forgotten or the right to censorship?".*
[126] *Jana Moser, R3 Reports, "The Application & Impact of the European General Data Protection Regulation on Blockchains".*
[127] *Cedric Ryngaert and Mistale Taylor, article Cambridge University Press (2020), "The GDPR as Global Data Protection Regulation?".*

of the blockchain technologies are not in line with the GDPR. It is certainly possible to find ways to mitigate the impact of the GDPR on the blockchain and to allow blockchain companies to comply for future coexistence with the regulation, but to complete this step, there is still a lot to do.

CHAPTER 4 – Application fields: beyond accounting and finance

4 Blockchain: global trend

In the previous chapters we have dealt with the meaning and role that blockchain technology assumes within the economic market at a theoretical and conceptual level, now we will face a review of the application of the blockchain, to underline in a practical way how this emerging technology is becoming the protagonist by conquering segments of increasingly significant activity in future years.

The blockchain has carved out a significant space for itself in the economic and social debate of recent years. Between 2016 and 2018, nearly 500,000 articles and publications interested in the subject were published and about 4 million search results were recorded on Google. If in 2018 the global market value was around $ 1.2 billion, it is estimated that in 2025 this value could reach 39.0 billion, with an average annual growth rate of 64.4%[128].

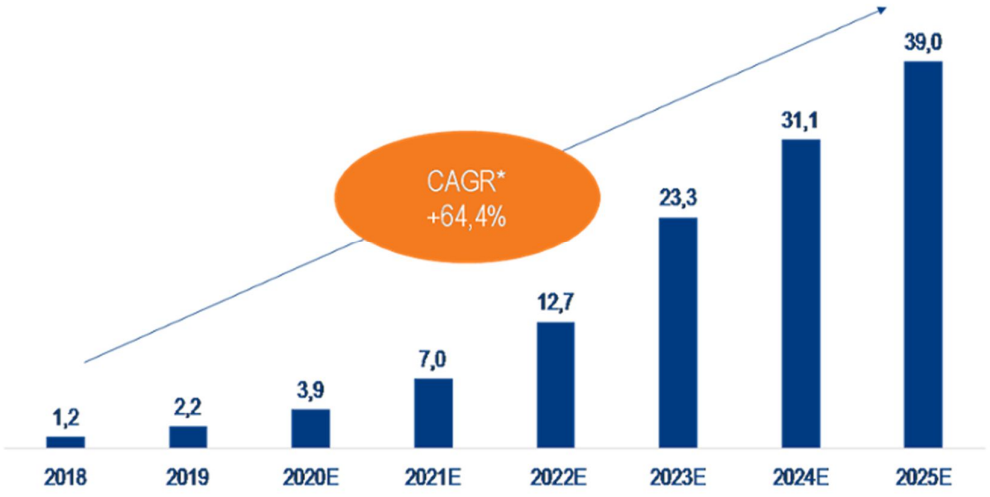

Figure 8: Estimate of annual growth in the use of blockchain technology from 2018 to 2025.

The attention of investors proves to how its multiple applications make the blockchain one of the technologies that could have a substantial influence on the financial and

[128] *Shanhong Liu, report Statista (2020), "Size of the blockchain technology market worldwide from 2018 to 2025"*

society in the next 10-15 years. Global investments in start-ups related to the blockchain world went from 450 million euros in 2014 to 7.9 billion euros in 2018.

For two years, the entire planet has been facing a pandemic that has led to a radical change in the rules of life and consequently the way of studying, working and economically has changed, all countries have had to adapt to new ways operational, and it is precisely in the last two years that a massive recourse to the use of this technology has been observed. According to some authors, this technology is among the 10 most important for managing the amount of work resulting from the Covid-19 pandemic, facilitating and guaranteeing the authenticity of some fundamental operations, first of all the tracing and distribution of drugs[129].

Several studies concerning Public Health and Health suggest using the blockchain, for example, to ensure the authorities in the correct disposal of potentially infected waste and waste deriving from the use of surgical masks, syringes adopted for the large vaccination campaign still underway, to be sure that the devices used to test patients in a testing centre are certified and of quality, to manage the vaccine distribution and delivery and to develop a tracking system capable of ensuring privacy and at the same time being efficient[130].

What was written previously underlines that the Covid19 emergency has not stopped the development of Blockchain technologies which, on the contrary, in 2020 entered a phase of greater maturity.

Out of 1,242 initiatives surveyed from 2016 to 2020, 267 have been launched in the last twelve months at an international level by companies and public administrations, which include 70 announcements and 197 concrete projects. Compared to 2019, concrete projects have grown by 59%, a sign of a market that is emerging from the media hype to focus on more operational initiatives and the creation of ecosystems. Moreover, 47% of the cases mapped in 2020 use existing platforms, a sign that the

[129] *Amirul Azima, Muhammad Nazrul Islamb, Paul E. Spranger, Iberoamerican Journal of medicine (2020), "Blockchain and novel coronavirus: Towards preventing COVID-19 and future pandemics".*
[130] *Vinay Chamola, Vikas Hassija, Vatsal Gupta and Mohsen Guizani, paper (2020), "A Comprehensive Review of the COVID-19 Pandemic and the Role of IoT, Drones, AI, Blockchain, and 5G in Managing Its Impact".*

attention of operators is increasingly shifting towards the development of applications and less towards the creation of new platforms[131].

Furthermore, in 2020 decentralized finance has seen applications, users and invested capital multiply, until the announcement of the development of Diem (formerly Libra, the digital currency sponsored by Facebook), while the use of cryptocurrencies and Stablecoins has grown.

It was the pivotal year of the entry of Central Banks digital money: first of all, the Chinese DCEP, in the experimentation phase, which was followed by explorations, analyses, prototypes of other institutions and the promise by the European Central Bank to give life to the Digital Euro[132].

As regards, the most active countries in the Blockchain, we find the United States in the first place, with 72 projects started in the last five years, and China, with 35 cases, followed by Japan (28), Australia (23) and South Korea (19). With 18 cases, Italy remains in the top ten of the countries with the most initiatives, despite the slowdown in investments by companies, which in 2020 are worth 23 million euros, 23% less than in 2021.

A declining market, due to the health emergency that has limited the launch of new initiatives and has prompted companies to focus on projects that are already active, but more mature: 60% of the expenditure concerns operational projects, 28% pilot projects, only 11% proof of concept and just 1% training. Finance is the most represented sector, with 58% of spending, and the only one to have increased investments (+ 6%), followed by agri-food (11%), utilities (7%) and PA (6%).

These are the effects of the survey carried on by the Blockchain & Distributed Ledger Observatory of the School of Management of the Politecnico di Milano, presented on January 22, 2022 during the online meeting "*Blockchain: the hype is over, get ready for ecosystems*".

To date, therefore, we can deduce how blockchain technology is still strongly associated with cryptocurrencies, such as Bitcoin. However, in addition to

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[131] *Onat Kibaroğlu, Financial Markets, Institutions and Risks, Volume 4 (2020), "Self-Sovereign Digital Identity on the Blockchain: A Discourse Analysis".*

[132] *Takuma Yatsui, Mitsui & Co. Global Strategic Studies Institute Monthly Report (November 2020), "Implications of China's digital yuan initiative- potential impact and future focal points".*

applications in the financial sector, its potential extends to many other sectors, such as commerce, supply chain management, manufacturing, energy, creative industries, healthcare and public administration.

4.1 Application of Blockchain

From what we have mentioned above, the success that the blockchain is enjoying at a global level certainly derives from the high degree of versatility of use that this technology allows in a wide range of sectors, even substantially very different from each other. This aspect leads us to consider that the blockchain, unlike cryptocurrencies, can last over time and is indeed destined to be the reference technological solution.

In this paragraph we will therefore focus on the main sectors, subsequently bringing to light tangible and real examples in which this technology has found space and brought about a great revolution.

Finance and economy are actually the most advanced branches. The financial sector appears to be the leader of the blockchain for many years to come. Other sectors including energy, industrial products, healthcare, and utilities are expected to follow[133].

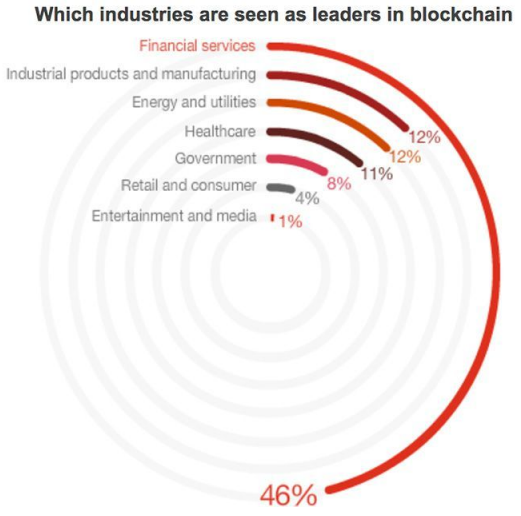

Figure 9: World Economic Report experts shows proportions of sectors effected by DLT in 2018.

[133] *Dr. Burcu Sakız and Prof. Dr. Ayşen Hiç Gencer, report of international conference on Eurasian economies (2019), "Blockchain Technology and its Impact on the Global Economy".*

As can be deducted from the graph, the massive use of the blockchain is certainly in financial sector. In fact, since there are no intermediaries to manage the transactions, the blockchain would reduce the costs of banks' commissions, allowing savings, speed and reliability of transactions.

It therefore becomes essential to invest in this new technology for banks and financial institutions, which seek to grab a fairly large slice of this new market, which immediately reveals countless possibilities and opportunities. Furthermore, the use of the blockchain would accelerate the back office and management functions, resulting in huge savings spread across the entire system[134].

Another field that has certainly found advantages with the encounter with the blockchain is the insurance sector. It has the ability to access secure and decentralized transactions, forming a solid foundation to prevent fraud, to ensure greater governance, to have better data and reporting. Insurance notifications can be updated with greater care as changes occur, thus improving risk management and maximizing capital and fund opportunities.

For insurance institutions, the use of the blockchain opens up opportunities both at technical and market level. Under the first profile, there is the convenience to interact with a third-party ecosystem in order to reduce the costs of management platforms as well as improve and increase the customer experience and market share. Regarding the second aspect, insurance institutions can have a new and advantageous corporate governance model through improved access to data, more refined risk management systems, adhering with their products and services[135].

Also, the agrifood sector, and more generally the supply chain, seems to be one of the sectors in which blockchain can express itself at its best since greater transparency and traceability of the entire production chain and supply chain is increasingly required.

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[134] *Michael Casey, Jonah Crane, Gary Gensler, Simon Johnson and Neha Narula, Geneva Reports on the World Economy (2021), "The Impact of Blockchain Technology on Finance: A Catalyst for Change".*
[135] *Aniket Mahanti, Janet Light and Wajde Baiod, Journal of international technology and information management (2021), "Blockchain Technology and its Applications Across Multiple Domains: A Survey".*

In this sense, can be provided an infrastructure that registers, certifies and tracks both goods and products as well as containers and transport. The advantages that blockchain can bring to agrifood are numerous if we think of decentralization, shared control, immutability and preservation of information, quality, originality and origin of products; and this is even more true for the processing industry and for activities and developments related to food certification[136].

Moreover, with the use of this technology it is possible to structure supply chains with a greater degree of openness, effectiveness and safety. In this way, each actor, ranging from the producer of raw materials to companies that work on packaging and retail, can give their data to the system and control those coming from others, with maximum transparency.

As regards, instead, the Internet of Things (IoT) industry sector can find interesting solutions by virtue of the fact that this technology makes data exchange easier, safer and faster and for this reason can make interaction between connected IoT devices more feasible.

In addition, the blockchain offers a management platform for the correct identity of things, thanks to which it is possible to achieve supply chain certification solutions based also on data from the IoT, as well as working on supply chain documentation.

Finally, as we may have noted earlier, another sector that has found an advantage is that of healthcare. In fact, medical-health institutions, thanks to a data management system based on blockchain technology, can know in advance the patient's medical record, having certain and certified information on their past available, and monitor developments. The use of blockchain also allows hospitals, taxpayers and other healthcare facilities to share data and access to their networks in a secure and fast way, thus breaking down a typical challenge of this field[137].

A system structured according to these terms benefits both the individual patient who sees better, more suitable and relatively faster care administered, and the sector as a whole which is in an optimal condition to provide more quality services.

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[136] *Giorgio Alessandro Motta, Bedir Tekinerdogan and Ioannis N. Athanasiadis, paper (2020), "Blockchain applications in the Agri-food domain: the five waves".*

[137] *Alexandre Pòlvora, Publications Office of the European Union (2019), "Blockchain now and tomorrow assessing multidimensional impacts of distributed ledger technologies".*

We also find the Public Administration since as a whole it could benefit from this technology as regards the governance of internal processes and administrative procedures, the reduction of transaction costs, the increase in trust in transactions, interoperability between the various public entities. On the basis of the blockchain, for example, land and property registers can be conceived, so that subjects such as notaries and public officials are placed in a position to make registrations in an immediate, faster and safer way. The same goes for business registers[138].

Furthermore, the blockchain can be used for personal data structures and digital identity documents, shared and implemented in this system, obtaining a series of advantages in terms of fighting tax evasion and crime.

Finally, a large sector that has benefited is certainly that of electricity, and the most interesting and disruptive contributions concern the concepts of smart grid and prosumer.

- Smart grid applied in the area indicates the intelligent and rationalized management of energy production and consumption, through dedicated analytics and exchange platforms. The main purpose is the maximum reduction of costs and waste in terms of energy, time and money.
- Prosumer, indicates the dual function of the electricity user as both the final consumer and the producer. The prospects opened in this area, thanks to the use of the blockchain, are inherent in the possibility of exchange between peers in the energy market. Participants are, in fact, given the opportunity to exchange electricity from certified and guaranteed renewable sources with each other at a price lower than that of fossil sources, since each transaction takes place in the absence of the utilities that manage the service.

It is precisely these two revolutionary concepts that have led to the birth of real smart cities based on blockchain able to connect, modify the way of transmission and notification between people and private and collective entities[139].

[138] *Aleksandra Igorevna Makarova, Igor Borisovich Khmelev, Anatoly Dmitrievich Ten, Svetlana Pivneva, Nataliaya Vitkovskaya, Article (2021), "Blockchain Impact on Public Administration Processes in the Digital Economy".*
[139] *Gheorghe-Alexandru STATIVĂ, Irina Gorelova, Marta-Christina Suciu and Marco Savastano, report (2020), "Smart grids, prosumers and energy management within a smart city integrated system".*

4.2 Smart City

In the last few years, we may have heard repeatedly the term "smart city". A concept that was born with the aim of optimizing and innovating public services, offering the citizens who live there a higher quality of life.

Smart cities therefore aim to offer advanced services in the fields of health, transport, waste management, urban safety, maintenance of structures that house schools, hospitals, nursing homes, museums and are aimed at evaluating and using systems for the reduction, monitoring and management of energy consumption.

However, the concept of smart city is still in an embryonic state, as in order to be defined as a "smart city" it is first necessary that it be efficient, innovative, sustainable and therefore able to guarantee its citizens a high quality of life, and to do this it must be able, in essence, to use these new integrated technological systems, that is, through the use of IoT technology.

They are designed to foster efficient operations and enhanced citizen participation through the use of new-age urban development. In response to the challenges posed by rapidly growing populations, smart cities have become a necessity. There is growing evidence that urban development is growing rapidly within cities, and it is expected that only 42% of the world's population will not live in urban regions by 2050[140].

Since cities continue to expand, successful management of urban growth is crucial for sustainable development, especially in low- and middle-income countries, where urbanization is expected to be most rapid. Most countries will face challenges in providing services to the population, including housing, transportation, energy systems, infrastructure, employment, as well as basic services, such as healthcare and education[141].

Smart cities based on IoT technologies can contribute to improving the quality of life, but this "smart" urban landscape, with numerous connected devices and a large

[140] *United nations Organization (ONU), Revision of world urbanization prospects, 2019. Available at: https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf.*
[141] *Bharat Bhushan, Aditya Khamparia, K. Martin Sagayam, Sudhir Kumar Sharma, Mohd Abdul Ahad, Narayan C. Debnath,(2020), "Blockchain for smart cities: A review of architecture, integration trends and future research directions".*

communications network, undoubtedly creates new security challenges - challenges that cannot be easily addressed by conventional cyber security solutions.

It is vital to point out at the outset that the notion of a smart city is defined differently in literature.

Some authors argue that smart cities are environments with a high capacity for innovation and learning, utilizing digital infrastructures to operate in the physical, institutional, and digital spaces of cities as well as incorporating the creativity of the population and institutions. This concept is ambiguous, making it difficult to determine how the adoption of information technology impacts the development of smart cities[142].

As described by others, smart cities encompass multiple paradigms across different domains, such as economy, people, government, mobility, environment, and life, and encompass a variety of use cases such as environmental monitoring, traffic analysis, utility monitoring, smart public transportation, electronic voting, e-commerce, jobs, local events, real-time incident reporting, and health care. In this case, the administration collects the data of the aforementioned domains and processes reports in order to improve and make the most of the services of this city[143].

Others, on the other hand, define it as an environment that has integrated IT and communication technology, creating interactive spaces that extend the capabilities of computation into the real world[144].

In general, smart cities integrate sophisticated information technology with recent innovations to enhance a wide range of urban infrastructure prospects. At the infrastructure level, smart cities basically encompass four key points[145]:

- Social Infrastructure;
- Physical Infrastructure;

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[142] *Nasulea, Christian & Mic, Stelian-Mihai, ResearchGate article (2018), "Using Blockchain as a Platform for Smart Cities".*
[143] *Paola Gori, Maria Luisa Stasi and Pier Luigi Parcu, article in SSRN Electronic Journal (2015), "Smart city and sharing economy".*
[144] *Alan Steventon and Steve Wright, Springer, London (2006), "Intelligent spaces: The application of pervasive ICT".*
[145] *Haque, A.K.M.B.; Bhushan, B.; Dhiman, G., (2021), "Conceptualizing smart city applications: Requirements, architecture, security issues, and emerging trends".*

- Institutional Infrastructure;
- Economic Infrastructure.

Moreover, the success of a smart city relies on the relationship between the public and private sectors as a considerable effort create and support a data-driven environment is not attributed to the local government, but to the people who operate there. In addition, we can deduce that the main objective of a smart city is essentially to make the exchange and integration of data within the system easily accessible to citizens, allowing them to propose change and corrections interactively.

Blockchain, which offers peculiarities such as decentralization, security, suitability, etc., is well suited to develop and help the birth of the so-called smart cities. To realize them, a point not to be underestimated is the spreading of infrastructure. The substantial part of the installations in smart cities is made up of smart homes and buildings which, with IoT technologies and networked sensors give life to the latter[146].

In order to facilitate the creation of smart cities, researchers around the world have been focusing on IoT, WSNs, and cloud integration. It is worth noting that blockchain is the newest technology that can be used to facilitate of smart and sustainable cities.

Moreover, one of the hottest topic todays is the fusion of Blockchain and IoT (BIoT) which find application in everything, from creating smart hospitals to the programming of intelligent transporting arrangements, as well as improving infrastructure communication and efficiency of operations in a smart city[147].

Using blockchain, cities will gradually begin to be completely digitalized, in which each plant will be controlled remotely via the connection networks, limiting human effort and moderating huge sums of money and time.

After understanding these concepts, we can get to the crux of out topic: how such disruptive innovation can lead to cities becoming smarter and smarter.

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[146] *Bhushan, B., Khamparia, A., Sagayam, K.M., Sharma, S.K. Ahad, M.A, Debnath, N.C., article (2020), "Blockchain for smart cities: A review of architectures, integration trends and future research directions".*

[147] *Bhushan, B., Sahoo, C., Sinha, P., Khamparia, A. (2021), "Unification of Blockchain and Internet of Things (BIoT): Requirements, working model, challenges and future directions".*

4.3 Blockchain within Smart cities

Smart cities require highly compatible and appropriate technological ecosystems to function and flourish. A lack of communication will result in slow systems, unable to communicate with each other as they speak different languages. It is precisely in this condition that our blockchain enters the scene.

This is particularly effective for cities. By imagining a city as an intelligent network of connected urban objects (street lamps, meters, parking lots, waste bins, Wi-Fi hotspots, video surveillance cameras, etc.), the blockchain allows all components and devices to be linked together by same cryptographic chain of trust, and to manage exchanges of accurate, safe, and invariable data between them. The first reason for approving blockchain is therefore cybersecurity.

Using Blockchain technology, in fact, local and regional institutions can become more transparent, while the most sensitive data can be communicated without security and confidentiality being compromised. As a result, blockchain is used as a kind of interoperable platform that enables citizens to actively participate in the decision-making processes affecting their communities[148].

In order to guarantee interoperability and organization across smart cities, coordination is key. This topic has gained traction in several states. For example, according to a white paper released by Japan's cabinet office in March 2020 on how smart cities should be structured, interoperability is recognized as crucial element to the advancement of smart cities.

In addition, G20 Smart Cities Alliance brings together municipal, regional and national governments, private-sector partners, and residents around the world, in a single purpose - to foster flexibility and interoperability for the implementation of smart city technologies[149].

A recently published interoperability framework proposes a three-layered scheme for how blockchain can be implemented in smart cities:

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[148] *Carmen Rotuna, Alexandru Gheorhita, Alin Zamfiroiu, Dragoș Smada Anagrama, article (2019), "Smart City Ecosystem Using Blockchain Technology".*

[149] *World Economic Forum in collaboration with Deloitte, Report preview (2021), "Governing smart cities".*

- **Business models layer** cover parts of governance, data standards, legal frameworks, and commercial models. They, therefore, provide insight into the various business entities, processes, components, and standards in blockchain business networks, and also disclose their relationships;
- **A platform layer** consists of mechanisms for consensus, smart contracts, validation, and authorization;
- **The infrastructure layer** contains hybrid clouds, managed blockchains, and proprietary elements**.** Moreover, it is not just about solving a technical obstacle to achieving interoperability. In fact, it is also requires solving a governance issue, data ownership issue, as well as the preparation of business models that incentivize ecosystem stakeholders to cooperate.

Besides, we could consider mobility as a service (MaaS), one of the expected smart city services. The continuous connection of multiple transport systems seamlessly provides extremely profitable mobility services. In order to realize MaaS, blockchain can be used to exchange data and share revenue among multiple transport workers, and the latter may take place across cities. At the business model layer, we should address the issues of data standardization - such as people movement and IoT data - as well as those of commercial models, like revenue distribution among transportation entities[150].

At the platform level, smart contracts, which are computer protocols that allow self-executing, credible, and transparent transactions, may be used to enable transport ticketing. It is important to note that blockchain platforms sometimes use different coding languages for smart contracts, which could cause interoperability problems for ticketing. At the infrastructure layer, instead, the existence of proprietary components may pose a challenge in achieving interoperability at the infrastructure layer, since permissioned blockchains (those with an access control layer in place to ensure that certain actions can only be executed by a select group of participants) are usually used for data exchange across multiple transportation systems.

[150] *Lidia Signor and Piia Karjalainen (ERTICO – ITS Europe), Maria Kamargianni and Melinda Matyas (UCL – MaaSLab), Ioanna Pagoni (University of Aegean), Tito Stefanelli, Giuseppe Galli and Patrizia Malgieri (TRT), Yannick Bousse (UITP), Vasilis Mizaras and Georgia Aifadopoulou (CERTH), Suzanne Hoadley (Polis Network), Marijke De Roeck and Katia Kishchenko (City of Antwerp), Thomas Geier (EMTA), article (2019), "Mobility as a service (Maas) and sustainable urban mobility planning".*

The same model could be used in other fields, such as real estate and energy. One of the main objectives of the real estate sector is to substantially reduce the rental procedures of properties via blockchain, but for example to streamline the moving process it is necessary to harmonize and develop systems concerning the original residence and the new one. In some cases, through the use of different blockchain platforms it could create various obstacles for this reason they should be coordinated with each other in the first place. In the energy sector, however, efforts are underway to use blockchain to conduct energy transactions within a region.

Furthermore, as pointed out above, different entities could use different blockchain platforms, so in this situation, it is possible to utilize the three-layer model of interoperability described above. Smart cities have the potential to solve a variety of societal issues and improve the quality of life – but it will be essential for smart cities to ensure interoperability and be able to collaborate with each other.

Other important aspect to take into account is that the blockchain can be used to improve the reputation of companies related to their environmental activities. Through its system a smart city generates a significant amount of sensitive information, requiring an oversized storage field to intervene securely and according to predetermined access policies[151].

Cyber-attacks remain a significant threat to the security of online transactions, as evidenced by recent data. By utilizing a distributed model, blockchain technology uses entropy to reduce the effects of these phenomena, indirectly decreasing the fragility of the systems it supports.

According to what has been written, it may appear that the implementation of this technology is simple or can only give advantages, however, that is not entirely true, since it is constantly evolving, but it certainly brings great innovations to those who use it.

The Blockchain has also been criticized for its scalability. Energy usage and transaction processing can sometimes be inefficient with Blockchain solutions. Furthermore, security is not entirely assured. While Blockchain-based smart cities offer high integrity, their

[151] *Shubhani Aggarwal, Rajat Chaudhary, Gagangeet Singh Aujla, Neeraj Kumar, Kim-Kwang Raymond Choo, Albert Y. Zomaya, Journal of network and computer applications (2019), " Blockchain for smart communities: applications, challenges and opportunities".*

information reliability is unstable without any kind of independent or impartial system to manage or check the integrity of data coming into contact with the Blockchain[152].

Citizens, equally, can reserve a high degree of trust within a blockchain-based smart city. In that they can trust and feel secure in the raw data feeding into it, as well as in the way they are processed, although in some cases they have imperfections due to the still embryonic stage of this technology[153].

Further, exist several benefits of the implementation of IoT and Blockchain together. We all know how important IoT is nowadays, however, IoT has some problems related to privacy and security which can be overcome by integrating Blockchain technology. This results in improved efficiency in smart cities networks, and thus gives us a transparent view of a system[154].

It should also be noted that many people are not aware of the great opportunities that the use of the blockchain can bring, especially in large cities. Blockchain, *in primis*, can connect technologies that can be helpful for people in many ways.

The more we use this technology the more benefit we can derive from it. Blockchain has the ability and potential to make things easier to use and access. This is has led to creating many small and big networks as well. Therefore, there are many such applications of Blockchain that can be implemented in cities[155]:

- Easy and smart payments: Blockchain provides security when performing payments and requests are sent to the respective virtual machines while performing the payments. In addition, it continually updates the information regarding the payments and maintains a proper history;

[152] *Higinio Mora, Julio C. Mendoza-Tello, Erick G. Varela-Guzmán, Julian Szymanski, article (September 2021), "Blockchain technologies to address smart city and society challenges".*
[153] *Rourab Paul, Nimisha Ghosh, Suman Sau, Amlan Chakrabarti, Prasant Mohapatra, article (2021), "Blockchain based secure smart city architecture using low resources IoT".*
[154] *Nguyen, D.C.; Pathirana, P.N.; Ding, M.; Seneviratne A., article (2020), "Blockchain for 5G and beyond networks: A state of the art survey".*
[155] *Abhirup Khanna, Anushree Sah, Vadim Bolshev, Michal Jasinski, Alexander Vinogradov, Zbigniew Leonowicz and Marek Jasi ´nski, Sustainability (2021), "Blockchain: Future of e-governance in smart cities".*

- Identity Services: nowadays, many organizations use this technology for identification purposes. They use unique login services and authenticate personal identity using the same, which helps prevent identity theft and fraud;
- Transportation Management: provides a single link of payment for various forms of public transport, which includes ridesharing services. A person using a taxi and bus can pay through a single-mode using Blockchain technology;
- Government Services: it helps in maintaining a proper record of documents and identity information of the citizens. This technology will enable the delivery of focused and personalized government services.

4.4 Benefits and challenges of smart cities

In the classical sense, the infrastructure of a city is identified in the complex of capital goods that are not used in the production process, but give rise to fundamental services for the functioning of the economic system, we include in this category bridges, roads, ports , the buildings that give life to the city and the services to its inhabitants, in summary, in the context of smart cities, any physical, electrical and digital element represents the backbone of the smart city itself, and is therefore considered as its infrastructure[156].

The infrastructures of a city must be included in two categories, hard infrastructure and soft infrastructure.

In the macro category of hard infrastructure buildings relate to institutions, this means that the physical location of a building in a specific place gives rise to the need to build roads, lighting systems, parking lots, homes, thus creating a network of poles that intersect, interconnecting the entire city[157].

The other macro category is represented by soft infrastructures that involve the human capital of a city, as the relationship of dialogue between citizens and institutions is encouraged through the use of networks for the development of goods and services by expanding administrative boundaries because it is it is precisely through these

[156] *Saraju P. Mohanty, Article in IEEE Consumer Electronics Magazine (July 2016), "Everything you wanted to know about Smart Cities".*
[157] *Colin McFarlane and Ola Söderström, article (2017), "On alternative smart cities: From a technology-intensive to a knowledge-intensive smart urbanism".*

exchanges that one can arrive at the authentic concept of an organic metropolitan city, where substantial changes can be brought about for the improvement of the living conditions of each individual. This exchange of information and ideas takes place through ICT (Information and Communication Technologies) or wireless communication systems such as personal computers and audio-video technologies that allow users to exchange and archive information.

In the following paragraph we will see some examples of soft infrastructure where the combination of automation, machine learning, blockchain and IoT is allowing the adoption of technologies for multiple applications, such as intelligent parking that allows drivers to find free parking nearby. of one's position, avoiding traffic congestion and the consequent increase in CO2 emissions, allowing the digital payment of any user / subscription / penalty, simply through the use of an application or the intelligent management of traffic to monitor the flows of traffic and optimize the synchronization of traffic lights, again to reduce traffic congestion and pollution.

The characteristics of the smart city must include, the management of energy saving and environmental efficiency with the construction of buildings with low energy dispersion and high seismic isolation, especially if built in areas affected by earthquakes. Smart buildings can offer or better guarantee structural health monitoring and feedback to determine when maintenance is needed, whether ordinary or extraordinary[158].

Many cities have taken steps to install street lighting systems with the use of street lamps that attenuate the intensity of the light in the hours when the streets are less busy, or by installing photovoltaic panels for the production of electricity to be used for the lighting of schools, hospitals therefore trying to have energy autonomy by optimizing the exploitation of their resources, thus planning energy supplies, proving to be self-sufficient.

An ecosystem conceived in a smart way and replicated on a large scale would certainly lead to less waste of energy and a tangible improvement of human and environmental conditions of life and this is precisely the direction that is sought to be followed also at a European level by starting multiple activities at long term aimed at

[158] *Simon Joss, ResearchGate article (2019), "Smart city: from concept to practice".*

energy sustainability, and urging individuals to use renewable energy given the dramatic situation of global warming that the entire planet is undergoing.

In Italy, although there has been a slower approach to the smart city concept than in other countries, there are examples of cities that have developed new organizational systems and structured some activities with the aim of achieving the objectives proposed by the European Union.

We can recall here the experience of Genoa which has shown that it cares about the environment. The Ligurian capital has historically based its economy on heavy industry and port activity. Today it focuses on the High-tech industry, creating business and work.

The goals that the city achieves are considerable[159]:

- With the TRANSFORM call, using renewable energies it supplied energy to public and private buildings with sustainable heating and air conditioning in the pilot district called Mela Verde;
- With the Celsius call, Genoa has experimented with the reuse of energy that would have been dispersed through a turbo expander that recovers energy by exploiting the pressure jump in the gas distribution pipes of the city network, thus reducing the emission of co2 in the air and creating sustainable energy.

The advantages that we find in the previous paragraphs in relation to the preparation of a smart city are important for the reduction of pollution, for the improvement of living conditions, for the preservation of the environment, but also the aspects that perhaps are still little today must be considered. accepted and act as a brake on the development of the smart city project on a global level

One of all is certainly the decrease in the privacy of each individual since he feels constantly monitored, everything gravitates around the network, everything is connected and unfortunately cybernetic scams are on the agenda, a solid and secure system of collection and storage is required. data, to prevent hacking or misuse of stored data.

[159] *Flavio Fabbri, Key4Biz article (2015), "Smart urban labs, progetto 'Trasform' per l'Agenda Europea delle Smart Cities".*

On the other hand, one of the most demanding challenges is represented by the power supply of connectivity in fact with thousands or even millions of IoT devices that must connect and work in unison, it is necessary to rationalize energy supplies and implement technological platforms[160].

In some circumstances, it is citizens or institutions who are reluctant to meet and use these technological innovations. In addition to the need for the public and private sectors to align with the needs of citizens so that everyone can contribute positively to the community. In fact, a solid system is needed that can give security to its users.

4.5 The case of United Arab Emirates: Smart Dubai City

In this paragraph we will consider a State which has made innovation a lifestyle. We are talking about the United Arab Emirates.

It is a contemporary, advanced and dynamic reality. A relatively "young" State that, in just under 50 years, has been able to transform itself into one of the most developed economies in the Middle East, relying on large stocks of oil and natural gas, but also knowing how to exploit in an optimal way - for commercial and tourist purposes - the particularly favourable geographical position located between Asia, Europe and Africa.

In recent years this region has made an extraordinary leap in its process of economic transformation and aiming in particular to ensure sustainable development by taking care of the environment to achieve the ideal balance between economic and social progress[161].

At the basis of this dynamic is the need to free the country's development from traditional oil dependence, inaugurating a strategy of economic diversification and building a development model based on innovation, technology and creativity. This process, in fact, has allowed the United Arab Emirates to constantly raise the quality

[160] *Chiehyeon Lim, Kwang-Jae Kim, Paul P. Maglio, Cities (2018), "Smart cities with big data: Reference models, challenges, and considerations.*
[161] *Karam Shahrour, article (2020), "The evolution of Emirati foreign policy (1971-2020): The unexpected rise of a small state with boundless ambitions".*

of life of its population, to climb the international rankings of competitiveness and productivity and to attract talents and economic activities from all over the world[162].

Both at the federal level and individual emirate levels, are multiplying their efforts aimed at experimenting with the use of new technologies as necessary units for the diversification course. The government has set itself the goal of developing smart cities, using blockchain technology for its transactions, experimenting with ambitious financial technology projects (fintech) and launching a centre for the fourth industrial revolution. Most of these developments are concentrated in Dubai which is establishing itself as the technological hub of the whole region.

In this regard, the priorities for the Emirate of Dubai include an increasingly active involvement of the private sector in the economy. Economic policies are focusing on environmental improvement for business management and providing incentives for the growth of small and medium-sized ventures, in order to stimulate entrepreneurship and employment growth.

The strategy, in fact, aims to promote technological innovation through the development of smart cities, software and applications as well as the strengthening of the IT and telecommunications industry to enhance the quality of services provided to the population[163].

Technological innovation will also be achieved through the production of advanced technology systems in areas of global interest in the field of semiconductors, nano-technologies and three-dimensional printers, together with the adoption of technologies of the future in a wide spectrum of sectors, such for instance blockchains and financial innovation (fintech).

As a result, the emirates have launched a series of advanced technology initiatives, such as the Smart Government or Smart Cities program. It can therefore be deduced that unlike other Governments, which move cautiously and suspiciously, the United Arab Emirates and in particular the Government of Dubai is introducing the Blockchain in the country with great courage and audacity, even carrying out pilot

[162] *Elias Aad, Gulf Business article (2021), "Why smart cities are important to the UAE". Available at: https://gulfbusiness.com/why-smart-cities-are-important-to-the-uae/.*
[163] *Immanuel Azaad Moonesar Ph D.R.D, Mark Batey, Melodena Stephens Balakrishnan, David J. Hughes, ResearchGate article (February 2019), "Government innovation and creativity: A case of Dubai".*

projects concerning the road transport, energy, health and other very important sectors[164].

Among the most recent developments are the creation of EmCash, already mentioned above, its own cryptocurrency for the payment of government and non-government services, the archiving of government documents and transactions and the launch of a system to make transactions safer, be able to register real estate contracts and connect the homeowner with companies that provide electricity, water, and telecommunications services.

In doing so, Dubai is attracting the attention of international companies, such as Oracle, Microsoft, Cisco, SAP and many others, eager to approach the world of Blockchain. Furthermore, Dubai's ambitious development plan aims to make it the most sustainable and technological city in the world by 2030. Indeed, it is very likely that it could become a global hub for the advancement of Blockchain, thus attracting more and more people, up to double its inhabitants in just under ten years[165].

Moreover, highlighting the profile of the appearance of smart cities, with Silicon Park, UAE demonstrates its commitment to providing intelligent technological spaces that improve commerce, tourism, and people's well-being. In its role as a technology hub for the region, Dubai is expected to take the lead in leveraging technology to reduce operational costs, grow revenue, and satisfy all stakeholder expectations, including residents' and visitors' demands for comfort and convenience[166].

Recently, the Crown Prince of Dubai, Shaikh Hamdan Bin Rashid Mohammad Al Maktoum, expressed his idea of how smart cities will have to alleviate future obstacles such as increasing population leading to a lack of space in cities, food shortages, and also the problem of climate change. To overcome these impending difficulties the emirate of Dubai will create cities of the future that will utilize artificial intelligence to diminish crime and improve traffic or provide horizontal agriculture to solve the problems of the food crisis and create sustainability.

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[164] *Loredana Manushaqa, Jawad Amellal, Tudor Holotescu, ResearchGate article (2019), "Blockchain implementation in smart cities".*
[165] *Government of Dubai, The executive council, "The Dubai plan 2021", available at: https://tec.gov.ae/en/web/tec/dubai-plan-2021.*
[166] *Mark Sutton, Construction week middle east (2019), "Inside the smart city plans of Dubai's under-construction Silicon Park". Available at: https://www.constructionweekonline.com/projects-tenders/180689-dubai-silicon-oasis-authority-reveals-silicon-park-design-construction-progress-in-2019.*

The UAE will not only use technology to boost its economy and businesses, but it will also improve the lives and livelihood of those who live and work there. The UAE appears to be on its way to becoming a major player in the tech world.

To reinforce what emerges from this first introduction, it will now be explained how Dubai intends to develop the entire city with the application of the blockchain. It will be the first city to be fully operated using this technology[167].

When we speak about Dubai, we must immediately think of one of the most technologically advanced cities in the world. It is one of the seven emirates that compose the United Arab Emirates. With an economy worth $ 83 billion, it is the richest and most populous city in the country.

Since its inception in the 1970s, Dubai has developed into a regional commercial and tourist hub. From a global perspective, it is an economic, financial and investment centre that attracts numerous international companies which decide to establish their headquarters in the free zones of the Emirate. This fame is also due to the country's expansion into areas including tourism, real estate, retail, travel and logistics[168].

At the base of this economic growth there has been a strong and productive contribution from the government which has involved technology within the country and performed to accelerating this digital conversion of the city, taking advantage of every opportunity, and also assuming the risks that could derive from the transformation itself.

The technological path of the city began in 1999 with the birth of its first ICT strategy which was followed by several projects such as Dubai Internet City, Dubai e government, Dubai Smart Government, the Dubai Smart Office with the launch of the Dubai Blockchain Strategy in 2016. Since that year, a series of choices have led to the definition of various projects and updates in the industrial field, bringing Dubai ever closer to set its goal.

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[167] *Ashwani Kumar, Khaleej Times article (October 2021), "Abu Dhabi, Dubai top smart city Index 2021 in the Middle East". Available at: https://www.khaleejtimes.com/uae/abu-dhabi-dubai-top-smart-city-index-2021-in-middle-east.*

[168] *Aisha Bin Bishir, report (2022), "Dubai: A city powered by blockchain / Blockchain for Global Development II.*

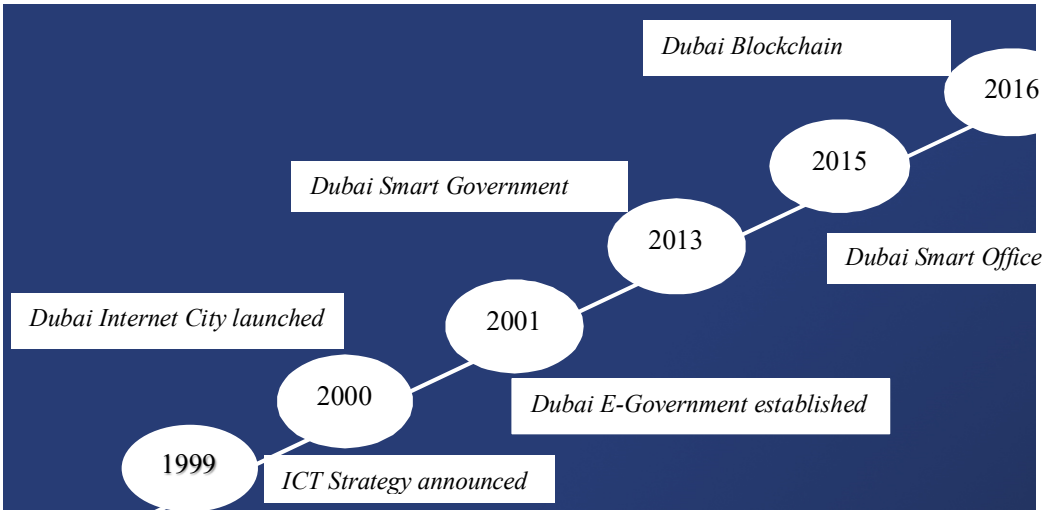

Figure 10: Technological projects evolution of Dubai

Furthermore, the city of Dubai is today one of the main centres of world economic power which for some time has also decided to invest in renewable energy, first of all exploiting the free potential offered by the sun, a decidedly favourable source in a desert area such as that of the United Arab Emirates[169].

Let's go more into to detail. Dubai has long been considered the "city of the future" due to its innovative technological advances. An example of this is the Dubai Blockchain Strategy, first launched in October 2016 and born from a collaboration between the Smart Dubai Office and Dubai Future Foundation to observe and test ongoing technological developments. Basically, it is a program that aims to make Dubai the first city in the world with a government based exclusively on the Blockchain.

Moreover, having approved the Dubai Blockchain Strategy, the city will explore and exploit the newest developments in DLT technology every year to realize the purpose of the strategy and improve an individual's experience in Smart City.

However, it is correct to point out that the attempts made by the emirates began two years before the launch of Dubai Blockchain Strategy. Indeed, a citywide implementation effort, led by Smart Dubai began in March 2014. The office will educate both the private and public sectors on the potential of the blocks and will hold

[169] *Steve Harris, article (2018), "Technology in Dubai – Birth of technology hub", Orange Business services.*

workshops with key stakeholders, public and private, to identify which services can be optimally improved thanks to blockchain and priorities for implementation[170].

Dr. Aisha Bint Butti Bin Bishr, CEO of Smart Dubai, believes that the city is well-positioned to establish itself as a global centre for blockchain and cryptocurrencies, potentially becoming a blockchain city in the near future. In fact, she released in an interview with the Wall Street Journal declaring: «*We want to make Dubai the first city in the world able to fully exploit this technological opportunity, following our smart city plan which at this point is ready to integrate new shared blockchain-as-a-service solutions*». She later replies «*It is destructive to existing systems, but it will help us prepare for the future*».

Thanks to the establishment of the Smart Dubai Office (SDO), whose primary objective is to make Dubai a fully-fledged "smart" city, the first results were not too late: in 2017 Dubai was nominated Smart City by the jury of the seventh edition of the Global Smart City Awards, announced at the Smart City Expo World Congress, not only for his projects concerning the adoption of the Blockchain at the city level, but also for the implementation of the same in government services in support of the creation of an industry that supports start-ups and businesses in general[171].

To understand how the concept of smart city in Dubai is interpreted, it is sufficient to go to one of the three police stations that today operate without human presence. Basically, within these stations it is possible to pay fines, report accidents or other without having to speak to an agent. In addition to the three "commissariats" already actives, the government recently announced the opening of a fourth within the World Islands, the archipelago of islands designed to resemble the earth's surface from above.

One step at a time, artificial intelligence is becoming a daily tool to move the city and its offices. In the plans envisaged by Smart Dubai 2021, artificial intelligence will also be used to constantly monitor the level of exhaustion and stress of bus drivers traveling around the city, thus significantly reducing - according to the calculations of the Road Transit Authority - the number of accidents.

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[170] *M. Sajid Khan, Mina Woo, Kichan Nam and Prakash K. Chathoth, Sustainability, article (2017), "Smart City and Smart Tourism: A Case of Dubai".*
[171] *Nick Michell, article (2017), "Dubai named smart city 2017", CitiesToday.*

Finally, another objective not to be underestimated of the Smart Dubai plan is to make the city, as well as the most innovative from a technological point of view, the happiest in the world. For this reason, people's happiness continues to be used as an indicator of ultimate success, and this is an important note: it highlights how the technologies in question can help us make daily activities easier, reduce crime and make a more secure city[172].

[172] *Sam Williams, Report (2019), "Building happiness in Dubai", Brunswick Review The integrity issue.*

Conclusion

This thesis was drawn up with the intention of exposing the functioning of blockchain technology from its conception to its spread in the various economic fields (pharmaceuticals, agro-food, banking, etc.) both nationally and internationally, focusing my attention first on the enthusiasm created towards this new technology and subsequently on the perplexities and mistrust of the users who used it.

A quiet normal reaction, from the moment in which one takes on a topic that has recently developed and has a high innovative impact.

To date, the theme is not yet fully explored in all its facets, and it would be hasty to give clear-cut judgments or reach certain conclusions, in any case, however, following the analysis carried out, some interesting reflections can certainly be made.

On one hand it is undeniable that the blockchain is one of the most important innovations of the twenty-first century, probably the most important in the financial field, this technology, which allows you to provide a unique and unmodifiable "cryptographic certificate" to guarantee the execution of a transaction, without the need to have a third party or an intermediary acting as a "validator", it is certainly a revolutionary element that could bring benefits in the future, both in terms of costs and speed of processes.

On the other hand, the environmental impact caused by mining in order to maintain the integrity of the system is not negligible. In a historical moment in which the main sectors of the economy are committed to reducing their environmental impact, and investors are acquiring ever greater sensitivity and awareness in terms of ethics and sustainability regarding the activities in which they bring their capital, it is therefore unthinkable that an innovation that is a candidate to change the way in which financial transactions are carried out and the related data are recorded, has such high environmental costs.

There is nothing to take away from the fact that this technological innovation is still in an embryonic phase, and with the appropriate modifications and regulations, it could become one of the technologies capable of making that leap in quality in terms of safety, transparency, and speed, elements that today are of fundamental importance.

Also in the accounting field, it is a revolutionary technology. The accounting department can optimize many current processes via blockchains, such as data analysis and machine learning, and this will significantly increase its efficiency and value.

Consequently, the accounting profession will require new skills. Some professional figures will lose their role, aimed above all at the areas of reconciliation and intermediation, in fact, the figure of the mediator, identified mainly by banks or the public administration will substantially change their way of operating, while other areas like technology, consulting and other value-added activities will flourish.

Therefore, we can conclude that with the use of blockchain systems, the accounting will be more active and dynamic by enabling greater confidence in information and reducing time spent arguing over documents with other parties. By focusing on the ultimate goals of accounting, namely interpreting the economic significance of operations, providing better information to support business decisions, and the effectiveness of financial reporting will be enhanced.

As we have seen, in the continuation of this thesis, there are many applications in which the blockchain finds space for implementation, we focused in particular on the functioning of smart cities in which artificial intelligence is a fundamental element.

The concept of smart city completely revolutionizes the way of city's life in a perspective of sustainability able to make the most of its economic and human resources, to implement its technologies in order to review and plan its operation based mainly on energy saving and trying to offer a better quality of life to its inhabitants.
On the basis of the path followed, we were able to find that both public and private contributions are necessary to create a smart city. The European Union has made important funding available to encourage the development of this concept, especially to encourage research into technologies for the reduction of CO2 emissions, announces for tenders were launched to access the funds and the results were then found in reality, as in the case of Genoa which participated and won some proposed announces.

However, it should be emphasized that becoming a smart city is currently not allowed for small towns as the costs to be faced would be too high, it is necessary to collect a lot of data, process them, but above all it must be highlighted that one does not become a smart city for having participated and won a ban, it is necessary to continue and persevere by putting into practice real strategies to rethink and reorganize the economic context of a city.

The example that we have explored in this thesis is that of Dubai. The UAE have shown, perhaps more than others, that they are able to develop strategies and actions that are truly targeted in terms of eco-sustainability and for the near future it would be important for this project to be replicated on a larger scale, always remaining be vigilant in the conscious and responsible use of these technologies.

Finally, in the period of gathering information on the topic, we were able to assess that this technology cannot find a concrete application on a large scale, also highlighting the aspects that do not allow this technology to take off.

In my opinion, in order for this to happen, there is a lack of global regulation that guarantees both users and investors to use this technology, thus removing this shadow of braking insecurity. Another aspect, obviously not to be overlooked, is represented by the high energy costs and on this I was able to verify that many efforts are aimed at the study of eco-sustainable solutions.

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