



T.C.

ANKARA YILDIRIM BEYAZIT UNIVERSITY
INSTITUTE OF SOCIAL SCIENCE

**BLOCKCHAIN IN DIGITAL MARKETING TECHNOLOGY AND THE
ROLE ON TRUST CASE STUDY IN TÜRKİYE**

Master of Science in Business

Annamyrat ARTYKOV

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ANKARA, 2024

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Thesis Supervisor

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APPROVAL PAGE

The thesis titled “BLOCKCHAIN IN DIGITAL MARKETING TECHNOLOGY AND THE ROLE ON TRUST CASE STUDY IN TÜRKİYE” prepared by Annamyrat ARTYKOV was accepted unanimously by the following jury as a master thesis in the Department of Business, Institute of Social Sciences, Ankara Yıldırım Beyazıt University.

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DECLARATION

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Annamyrat ARTYKOV

XXXXXXXXXX

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To my father and my mother, who endured years of hardship and toil for the sake of my bright future.



ABSTRACT

BLOCKCHAIN IN DIGITAL MARKETING TECHNOLOGY AND THE ROLE ON TRUST CASE STUDY IN TÜRKİYE

One crucial aspect of Industry 4.0 involves the utilization of Blockchain, a technological protocol that digitally records and authenticates every contract, transaction, or payment for purposes such as identification, verification, storage, and sharing. By enabling decentralized communication among participants, Blockchain eliminates the need for centralized servers and facilitates the secure flow of information. As a distributed ledger system, Blockchain technology is both secure and immutable, making it ideal for applications requiring high levels of trust, such as supply chain transactions and government services. This study examines the role of blockchain technology in building trust across various sectors, with a particular focus on Türkiye, from a marketing perspective. Within the scope of marketing studies indexed in the Web of Science database, 55 articles containing the terms "Blockchain" and "Trust" in their titles were analyzed. The findings reveal that blockchain's decentralized structure, data integrity, and transparency are pivotal in fostering trust, particularly in digital marketing. By securely processing user data, ensuring immutable records, and facilitating transparent transactions, blockchain positively impacts consumer perceptions, enhances brand trust, reduces the need for intermediaries, and fosters trust-based relationships with customers. In marketing fields such as digital advertising, customer relationship management, and supply chain management, blockchain strengthens trust and enables long-term relationships between brands and consumers. However, academic research remains limited in sectors such as agriculture and food, and sports and entertainment, indicating that blockchain's potential in these areas is still underexplored. In the context of Türkiye, the impact of blockchain on trust-building emerges as a significant research area, highlighting the need to address this gap in the academic literature.

Key Words: Blockchain Technology, Trust, Digital Marketing, Marketing Integration

ÖZET

DİJİTAL PAZARLAMA TEKNOLOJİSİNDE BLOK ZİNCİRİ VE TÜRKİYE'DE GÜVEN ÜZERİNE ROLÜ VAKA ÇALIŞMASI

Endüstri 4.0'ın en önemli unsurlarından biri, her bir sözleşme, işlem veya ödemenin dijital olarak kaydedilip doğrulandığı bir teknoloji protokolü olan Blockchain'in kullanımıdır. Bu teknoloji, katılımcılar arasında merkezi sunuculara ihtiyaç duymadan bilgi akışını kolaylaştırarak merkezi olmayan bir iletişim sağlar. Dağıtık bir defter sistemi olan Blockchain, güvenli ve değiştirilemez bir yapıya sahiptir. Bu özellikleri sayesinde tedarik zinciri işlemleri ve kamu hizmetleri gibi yüksek düzeyde güven gerektiren uygulamalar için idealdir. Bu çalışma, Pazarlama perspektifinden Blockchain teknolojisinin farklı sektörlerde ve özellikle Türkiye'de güven inşa etme konusundaki rolünü incelemektedir. Web of Science veri tabanında pazarlama alanındaki çalışmalar kapsamında, başlıklarında "Blockchain" ve "Trust" terimlerini içeren 55 makale analiz edilmiştir. Analiz sonuçları, Blockchain'in merkeziyetsiz yapısı, veri bütünlüğü ve şeffaflık gibi özellikleriyle dijital pazarlamada güven oluşturunca bir unsur olduğunu göstermektedir. Blockchain, kullanıcı verilerini güvenli bir şekilde işleyerek, değiştirilemez kayıtlar ve şeffaf işlemler sunmakta, bu da tüketici algısını olumlu etkileyerek marka güvenini artırmakta ve aracılara duyulan ihtiyacı azaltmaktadır. Dijital reklamcılık, müşteri ilişkileri yönetimi ve tedarik zinciri gibi pazarlama alanlarında güveni artıran Blockchain, markalar ile müşteriler arasında uzun vadeli ilişkiler kurulmasını sağlamaktadır. Ancak, tarım ve gıda ile spor ve eğlence gibi sektörlerde akademik çalışmalar sınırlıdır ve Blockchain'in bu alanlardaki potansiyel uygulamaları hâlâ keşfedilmeyi beklemektedir. Türkiye bağlamında, Blockchain'in güven oluşturmadaki etkisi önemli bir araştırma alanı olarak öne çıkmakta ve bu alandaki akademik boşluğun doldurulması gerektiği vurgulanmaktadır.

Anahtar Kelimeler: Blockchain Teknolojisi, Güven, Dijital Pazarlama, Pazarlama Entegrasyonu

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ABBREVIATIONS

E-cash	Electronic cash
dApps	Decentralized Applications
NFT	Non- Fungible Token
PoW	Proof of Work
PoS	Proof of Stake
PBFT	Practical Byzantine Fault Tolerance
DPoS	Delegated Proof of Stake
FBA	Federated Byzantine Agreement
PoA	Proof of Authority
P2P	Peer-to-Peer
SPV	Simplified Payment Verification
DLT	Distributed Ledger Technology
SCM	Supply Chain Management
GDPR	General Data Protection Regulation
PPC	Pay-Per-Click
PDPL	Personal Data Protection Law
ICO	Initial Coin Offering
BCTR	Blockchain Türkiye Platform
BIST	Borsa İstanbul
B2B	Business to Business
DeFi	Decentralized Finance
CSCMP	Council of Supply Chain Management Professionals
BCLabs	Blockchain Research Laboratory
ITCA	Information Technologies and Communication Authority
CBRT	The Central Bank of the Republic of Türkiye

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INTRODUCTION

Blockchain technology emerges as a quite necessary aspect in this era of industrial 4.0 current industry. A revolutionary protocol for recording and preserving contracts, transactions, and payments in a completely digital format was introduced by blockchain. Initially described in the context of virtual currency, blockchain has now grown to be used as a general application platform supporting maximum-capacity, zero-latency value transfer and solving all challenges around peer-to-peer transactions (Rajasekaran et al., 2022). It is seen across various industries such as banking systems: payments; remittance; e-notary service chains, E-commerce, and retail stock markets, supply chain networks private and public, person-to-person direct borrowing programs, bill analysis, the cloud data infrastructure, payroll systems, data privacy features etc. This adaptable technology is now finding applications in many areas beyond its original purpose. This innovative technology, which combines cryptography with the principles of computer science, database management as well as economics and monetary systems ensures that every participant - or node in the network can have a copy of this ledger. As a result, we have created an independent database system where all transactions will be verified by its participants without intermediaries (Michael et al., 2018).

At their core, Blockchains decentralize some types of security and approval that are generally controlled by only one entity; they do this under the guise of executing these functions as a network. The story began when in 2008 one single person (or group of people) named Satoshi Nakamoto released the now-popular virtual currency "Bitcoin" which created an opportunity for a very interesting technology called Blockchain. Blockchain Technology can securely transfer an unlimited variety of data types, and it does much more than that as well - serving as the underlying framework for Bitcoin or multimedia and communication (Vujičić et al., 2018). Specifically, the blockchain acts as a way to validate transactions between users in the network. It is, well, mostly a base of blocks and operations that form these said blocks but also possess uncertain validity (Böhme et al., 2015). Although there are great benefits that blockchain can provide, users need to focus on safeguarding their private encryptions. This is obviously one of the best applications in cryptology online. And that is exactly where we get to see Blockchain as a defining technology, if people become victims of password theft, they can lose their valuable data and bear financial losses but with other examples, the data stays encrypted, rendering users unable to access some key datasets without their passwords. Therefore, people have to be careful and protect their personal keys actively if they want the benefits of blockchain technology (Rajasekaran et al 2022). As per the Global Blockchain

Survey of Deloitte, companies are focusing on using blockchain in supply chain management. While farming out work to these new suppliers, renewal cost and quality of raw materials are not the sole determinants-there are several others- logic or even enterprise-level logistics must be considered. Remaining up to date with new technology not only helps better meet the needs of customers but also aids in continual improvements. Issues like trust deficit among parties in the chain communication gaps, standardizing data, and finally transparency indicates how blockchain-based technologies can be perfectly suited for addressing supply chain related issues (Deloitte, 2019).

Blockchain is fundamentally changing the way that traditional information-sharing systems work and offers functions for authenticating people, identifying them, keeping their data safe and transferring it. As there is a web of computers and not centrally located servers data can flow from one party to another, which is established by the blockchain. Blockchain was birthed to enable values such as security, transparency, and most importantly immutability inherent in its decentralized ledger community. These traits make blockchain an attractive option, especially for trust-required applications such as supply chain and public sectors (Rejeb et al., 2020). Many countries, including Türkiye, are looking at how blockchain technology can deliver trust and a bevy of strategically important use cases to different verticals. Then again, theirs is not an unopposed blockchain integration. In this study, it is aimed to examine the participation of Türkiye in this area and above all; Building a Blockchain-based Technology action that can be implemented will analyze bureaucratic obstacles and opportunities (Aktaş, 2018).

The potential offered in employing blockchain technology on a vast scale across Türkiye has the power to modernize supply chain operations and public services. However, there are a few obstacles to the implementation of this technology. These challenges include regulatory uncertainties, technology integration complexities, and legacy infrastructure deficiencies. Effective collaboration and concerted actions within the Turkish community of stakeholders are vital to overcome these challenges and orient themselves towards the maximization of benefits from blockchain initiatives. It is also way important for the local policies and regulations, which evidently results in a successful blockchain technology implementation within Türkiye. This paper aims to evaluate how Türkiye has used practices on using blockchain technology, current status, and future forecasts (Soran & Kılıç, 2018). In addition, to strengthen the Türkiye's approach for blockchain technology some education and publicity activities should be initiated. If businesses and Government entities comprehending these capabilities of blockchain

technology identify its benefits, it should encourage both sides to seek higher investments in Blockchain-based solutions. Thus, it is important to encourage public-private partnerships and create blockchain technology-centric training programs (blokzincir.bilgem.tubitak.gov.tr, 2024).

The purpose of this thesis is to conduct a comprehensive analysis review of the use of Blockchain technology in Türkiye, with a particular emphasis on evaluating its strengths and weaknesses. The study aims to determine the extent to which Blockchain technology is implemented both in Türkiye and globally. A comparative analysis will be conducted to explore the application methods and usage approaches of Blockchain technology in specific sectors within Türkiye and around the world. This examination will integrate theoretical concepts with practical applications, offering insights into what has been achieved and what still needs to be accomplished. By adjusting theory with practice, the thesis seeks to ensure that the adoption of Blockchain technology in institutions and companies conforms with current practices and that the recommended actions are effectively implemented. A comprehensive analysis review will be conducted by compiling high-quality articles and theses published in Türkiye and around the world to investigate Blockchain Technology in Digital Marketing and its impact on trust.

CHAPTER I: Blockchain in Literature

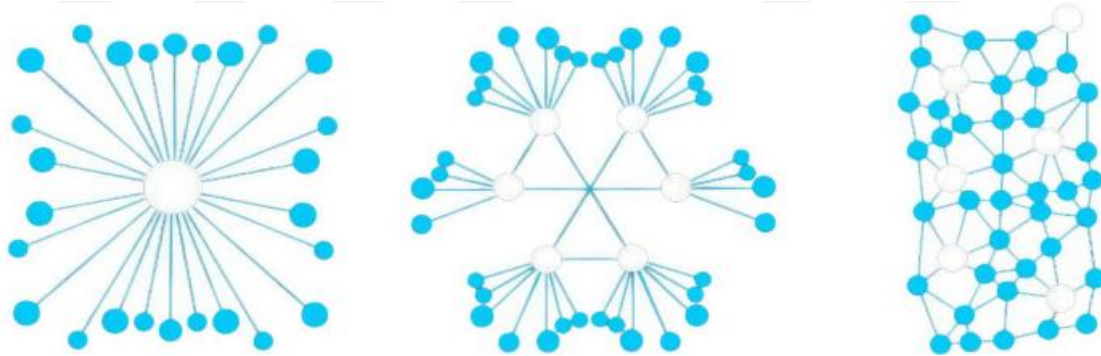
What's Blockchain?

This chapter explores the foundational structure and conceptual framework of blockchain technology. It delves into the various types of blockchain, its advantages and disadvantages, key features, and fundamental components. Additionally, the applications of blockchain in supply chains, as well as the risks and challenges associated with the technology, are analyzed in detail. The chapter aims to provide a solid foundation for understanding the core dynamics of blockchain technology.

There is no single standardized definition of Blockchain Technology in the literature. A definition for the technological aspect of Blockchain Technology is a computer science-based design type that allows transaction records to be stored on networks of interconnected blocks with so their historical data can also be timestamped. This data structure is unequivocal such that it simply does not allow information, once entered into the database cannot be retroactively even altered or removed and thereby auditing of stored transactions becomes super easy as every transaction can view in traced steps back to source block plus executed contract. Blockchain: a system, as for corporations or social institutions that are concerned about fraud (Agarwal et al., 2017). A blockchain is a data structure that makes it possible to create an immutable and independent ledger of digital transactions. Blockchain is a decentralized technology and disrupts traditional banking systems. Databases can be categorized into three fundamental classifications based on the storage location of the data they contain (Celep, 2018).

- Centralized Database
- Decentralized Database
- Distributed Database

The network structure of Blockchain Technology is shown in Figure 1. Blockchain is characterized by its adaptable technology, which functions within a distributed framework on the internet. It is known for its exceptional speed, reliability, and convenience.



Central Database Structure Decentralized Database Structure Distributed Database Structure

Figure 1: Structure of Blockchain (Celep, 2018).

A blockchain is created by grouping transactions into blocks, each of which has a reference to the block before it. The integrity of the complete transaction history is guaranteed by this chain structure. Depending on how the blockchain is constructed, consensus techniques like proof of work or proof of stake are used by network users to validate transactions (Nakamoto, 2008). In the blockchain, each block includes the data from previous blocks before them after it is processed through a hash algorithm. A new block, when added to the blockchain requires including the hash value of its previous. In other words, every information stored inside the blockchain is cryptographically hashed much like being password protected. Hence, anyone trying to change a transaction in the system would have calculated the hash value of all previous transactions starting from last. This, however, is in practical terms not feasible as the computed results should be the same across all miners (Taş & Kiani, 2018). According to another definition, Blockchain Technology refers to a data structure that is duplicated, distributed, and synchronized across multiple sites, countries, and/or institutions through the utilization of consensus algorithms. Every event that transpires within the network is meticulously verified and meticulously recorded at the respective nodes. The very first block in the blockchain, known as the "genesis block", serves as the initial building block of the entire chain (Usta & Doğantekin, 2017).

In addition to cryptocurrencies, blockchain technology is being researched for a plethora of use cases such as voting systems, supply chain management, and in industries like healthcare or banking. Its decentralized and distributed architecture makes it attractive for boosting confidence in a range of digital interactions. In this context, the strengths and weaknesses of blockchain technology are summarized in Table 1.

Table 1: Strengths and weaknesses of Blockchain Technology.

Strengths	Weaknesses
Unquestionable acceptance of truth	New technology acceptance challenges
Open-source code	High skill requirement
distributed architecture	Distance to end user
High security through cryptography	Immature
Fast transaction opportunity	Complex architecture, low testability
Transparency and resistance to retroactive change	Synchronous operation of different protocols

1.1. Structure of Blockchain

From the standpoint of its creation, Blockchain is a new type of decentralized system that records and manages transactions and other forms of data. A survey of the current research reflects upon hurdles and potential progress in blockchain technology. The public key infrastructure method, used by Bitcoin actually allows you to encrypt data with one key and decrypt it only with another. This method ensures protection and obstructs any effort to modify the Blockchain (Wang et al.,2019). The technology that has made it possible is blockchain, which operates on a decentralized network where everyone maintains an identical ledger of transactions. Transactions are stored in blocks that are linked to each other using cryptographic hashing. These secure node agreements and validate transactions through consensus techniques like proof-of-work, and proof of stake respectively. Whenever that happens, the chain adds a block of immutable records to create an agreement. Just like the Bitcoin script system, each transaction output is associated with a unique locking-script coin-minting condition, which can only be resolved by providing a corresponding unlocking script to satisfy all required conditions (Wang et al.,2019). It secures mining (in proof-of-work systems) Its essential characteristics include decentralized, encrypted safety and records distributed in a clear manner (honesty), secure agreement mechanisms for concessions to all partners involved as well as the immutability of these business procedures (Lei et al., 2017).

Blockchain 1.0 refers directly to the first emphasis of blockchain technology, which emerged alongside Bitcoin development. One of the most important things in this is their usage of proof-of-work mechanism to allow peer-to-peer transactions which are safe, decentralized and doesn't need a third party. The Bitcoin blockchain is an open, permanent public log of cryptocurrency transactions. While this is by far the most basic generation of blockchain technology (compared to 2.0 or even more so, maybe now with the advent of Cosmos and

Polkadot as potential generations-in-waiting), Blockchain 1. One of the first blockchains, the Bitcoin blockchain is built on top of advanced design principles for E-Cash (electronic cash) systems from as early in history as the 1980s - a decade which saw the enactment by Satoshi Nakamoto (Choi & Siqin, 2022). A Blockchain Core: Status Quo For Every Cryptocurrency A cryptocurrency needs a blockchain core, to active nodes from any computer. Furthermore, wallet software, mining equipment, and the actual operation of physical collection are recognized as basic to Blockchain 1.0's technical aspects. This stage is evolving, and early forms of Blockchain 2.0 are emerging as well (Swan, 2015).

Blockchain 1st generation, capable of exchanging digital currency only with other features of smart contracts Blockchain 1.0 was Bitcoin. This generation is characterized by the introduction of programmable smart contracts, that enable abstract ledgers like Ethereum. An example of **Blockchain 2.0** is Ethereum which allows DApps to be hosted on it. Its functionality intends to be much broader than simple financial transactions, including other automated and decentralized capabilities. The introduction of smart contracts encourages the innovation of various industries, from supply chain applications to management and finance, as it allows for more sophisticated and flexible interactions (Mohammed et al., 2021).

Blockchain 3.0 is the third generation of blockchain technology. But this evolutionary path has been done for a purpose: to address the issues that held back previous generations. Finally, those working on Blockchain 3.0 solutions aim to deliver faster transaction times, a lower energy footprint (especially in proof-of-work systems), and interchain compatibility. It aims to drive widespread adoption by streamlining the blockchain ecosystem. It promises some massive advantages in speed, safety, and flexibility for enterprises as this technology matures. Rather than a single blockchain reigning supreme, the future may hold several independent blockchains or distributed ledgers that focus on specialized industries - which in turn will lead to overall higher levels of success (Mendoza, 2020). Projects like Polkadot, Cosmos, and Cardano are generally described as falling within the terrestrial space of blockchain 3.0 as features around improved consensus mechanisms, comprehensive smart contracts capabilities, and cross-blockchain communication start to come into focus. Ledgers are not one-size-fits-all For example, the performance and capacity requirements of a ledger that is used in IoT would be quite different from a ledger used within financial services (which traditional Blockchain was never designed to do) Blockchain 3.0 use case examples include Healthcare, Cybersecurity, IOT (Internet of Thing), Web Services as well as Voting and Supply Chains (Choi & Siqin, 2022). Though the industry has come far in just over a decade since an anonymous author

published his/her mysterious whitepaper with strong acknowledgment of under-utilized potential for this technology (Mendoza, 2020).

1.1.1. Types of Blockchain

Public blockchains are open-source, which means anyone can become a node and partake in the decision process. That said, users themselves may or may not benefit from their process. The ledgers are public and no one party has control over these records. Users on the blockchain retain a copy of the ledger locally and use distributed consensus to make decisions. Public blockchains are characterized by decentralization and immutability. That means when a transaction or record hits the blockchain ledger, it is there in time for good; once verified by the network you can never write off transactions. Some benefits of public blockchains are: (Joshi, 2020)

- **Distributed Ledger:** Every node within the blockchain network participates in verifying transactions.
- **Open data access:** Everyone in the team are empowered to get, change and represent data (open concept of Data Privacy).
- **Property of immutability (or irreversibility):** The minute an entry comes into the ledger and gets verified, they can never again be eradicated or changed.

This transparency and decentralization of the public blockchain structure enhances security, trust in an online world. This system opens up participation to everyone for proofing data and authorizing moves. A public blockchain, on the other hand, is problematic in terms of scalability and energy efficiency. However, it is likely to remain an important role in the digital economy and data governance going forward (Yang et al., 2020).

A private Blockchain is a limited and permissioned blockchain network that is run by one or multiple known organizations. Access is permissioned, with required credentials for participation and a consensus process that tends to be more efficient than public blockchains. Private blockchains are commonly used for internal applications in enterprise settings and control the privacy of information and scale at rates beyond public chains. In a private blockchain, transactions and data are not open to the public; only the parties involved can access them. Advantages of Private Blockchain (Joshi, 2020)

- **Permissioned blockchain:** The consortium controls what information is recorded on the blockchain.
- **Greater privacy:** Only approved parties can view transactions on the blockchain.
- **Greater scalability:** Organizations can decide to add or remove the instance in their network.

The private blockchains are accustomed to the implementation in enterprise, this will find its narrow priority since it helps to interchange just between the selected nodes. For example, a consortium of financial services firms might choose to deploy a private blockchain that enables them to share transaction data with only the relevant parties (Yang et al., 2020).

1.1.2. The differences between public and private blockchain

The main difference between public and private blockchains is in network accessibility and authorization: public blockchains allow any participant to join, while private blockchains restrict access to certain entities. Besides, there is a third-party issuance in public filing, which is not there in predetermined participants only in the private filing (Jayachandran, 2017).

There are two main types of public and private blockchains with different types of filing added to them. There are:

Table 2: Types of blockchain configurations.

Public Blockchain	Private Blockchain
• Supply Chain • Finance • Data Traceability • Metaverse (Virtual Universe) • NFT (Non-Fungible Token) • Voting	• Cyber Security • Law Enforcement • National Defence • Private Communication • Military

1.1.3. Consortium Blockchain

It is a public blockchain type where a certain set of institutions of an organization shares the blockchain network. In a consortium blockchain, stakeholders form a cooperative to underwrite within a jurisdiction with known members contrary to the public blockchain which is accessible to all and the private which is controlled by an individual. In this category, the blockchain framework utilizes permissioned access where users come together to overwrite and

validate the blockchain simultaneously. The process of validating and generating new blockchains in this particular technology is a collective process that pools the active participants from various centers. It eliminates centralizing authority. The consortium blockchain has been utilized in enhancing cooperation and data sharing in different industries such as finance, energy, and supply chains. The blockchain brings on board singularity in the control and management of private blockchain and security features. It provides sufficient capacity for multiple stakeholders, thus promoting a model of cooperation that is safe and effective in different industries. (Diri, 2022).

1.1.4. Hybrid Blockchain

It features both public and private technology. Initially, it has a certain degree of open networks and allows people to partake in the system. The usage of hybrid systems is limited to some data or transactions that one cannot have access to despite the purview of decentralization and openness. The framework adapts to a variety of fintech cases due to the need to compromise on matters of privacy and openness (Geroni, 2021). A key advantage of hybrid blockchains is their wide-ranging applicability across different industries. For example, in supply chain management, companies can share certain data with their partners while keeping other confidential information secure. This technology offers businesses greater control and the flexibility to customize their operations, promoting collaboration while ensuring data protection. Hybrid blockchains are expected to become a significant solution that will likely see growing adoption in the future (Alkhateeb et al., 2022).

1.1.5. Enterprise Blockchain

Business use of the blockchain primarily refers to enterprise level which also means as a business blockchain. It exists as a tool to create bespoke blockchain solutions for any individual or business, in order to provide transparency, improve security and streamline processes. Enterprise blockchains, however, are usually private or consortium and not open to everyone. Blockchains can be specifically designed according to the business, and corporations obtain opportunities to focus on their supply chains that are invigorated by secure transaction capabilities which in turn would make a huge contribution towards improving operations as well. Enterprise blockchain platforms such as Hyperledger Fabric and Quorum are some of the more common examples (Nanayakkara et al., 2021).

1.2. Blockchain Technology & Fundamentals

Blockchain is revolutionary in that you can record transactions securely and it does not rely on trust. By basic definition, it is decentralized meaning no one central authority oversees the system; all nodes must agree to confirm transactions known as a consensus model, which includes cryptographic hashing which ensures data or information integrity (existence on the blockchain), leads to immutability where the alteration of digitally recorded and agreed upon by many parties data very hard without disrupting everyone else's digital lives otherwise causing more damage than good; its use case allows smart contracts (space where something sensible enters) known in its early days were "optional" digitized automatons responsible for managing labeled instructions now be simple switches turning off/on with error-proof scripts (Tasdelen, 2024). Its fundamental component consists of data components which are built for storage and sharing between users Data is defined as a large amount of information that inherently means nothing and becomes useful only when it changes, classification, interpretation, or analysis intended to form the basis for decision-making. These can be both numbers and textual descriptions extracted out of observations or measurements that act as a signal to describe an event. Data classification can also be done in terms of whether data is unstructured or structured and other than this, the measures which any organization employs to secure its data. Moreover, all data sets are available to be used efficiently by various models, and storage formats can also have the data stored for reuse later times (Celep, 2018).

Within a database, there are configurations that represent how data is stored and connected. Data has no meaning if one does not know the functions that bind it together so any database must contain a copy of every function on top of macOS and other applications. We are living in a world of technology where all companies, enterprises using Databases to store the information [This also applies for even common individuals]. Whether it is an online query, or a search done on mobiles and tablets, they help in delivering the desired information for users as quickly as possible (Gupta et al., 2020). Those able to participate in the system use cryptographic keys, and transactions occur over a peer-to-peer network. Other than those features making blockchain technology well associated with cryptocurrencies, it has much potential to be used across various industries such as supply chain management and finance (Dong et al., 2023).

1.3. Advantages and Disadvantages of the Blockchain Technology

Blockchain technology keeps track of each and every action, thus the data can be checked by all parties involved. These records are immutable and cannot be altered or deleted. The results of these records, ensure the integrity, permanence, and reliability between all participants in the chain of Blockchain (Bahga et al., 2016). Built on the idea that blockchain is trusted, this concept involves many unknown participants. The ultimate aim is to help these faceless individuals find and make real purchases. Moreover, trust can be increased by creating stronger cooperation and keeping updated records (Songara et al, 2017).

The mechanism of replicating transactions ensures that the output is transparent on the Blockchain. The idea is that each transaction on the blockchain network has been replicated on one of the computers (wordpress.com, 2016). This allows every transaction to be disclosed at all points, meaning the actions are transparent to everyone on the blockchain. Nobody can act behind the curtains so nobody is capable of making any transaction in an under-observed manner inside all blockchain systems (Songara, 2017). Thus, blockchain users have the power to control data and transactions. In the Blockchain if the offender is capable of enough computational power to overwrite or delete the information across all computers involved in the blockchain before the next block is added, changes or deletions of information is conceivable. When there is only a small number of computers in the network, the technology is more likely to be fragile to remove the network. However, the more number of computers in the network, the more durable and unbreakable the network is (Golosova & Romanovs, 2018). The blockchains achieve the state of immutability through the acceptance and dissemination of transactions across the blockchain. After a transaction is connected to the blockchain, it is impracticable to change or delete it. However, whether or not those changes are possible are completely reliant on the nature of the system. In a centralized structure, modifications may be made due to changes to the system being determined by one person. In a decentralized system such as the blockchain where all the transactions involve in the network have been copied on all the computers across all the blockchain networks, this point becomes insurmountable (Fauvel, 2017).

Blockchain technology simplifies complex ecosystems by consolidating numerous ledgers into a single public ledger, streamlining transactions among participants. To enhance security within the Blockchain, individual user IDs are implemented for network management. Each interaction is uniquely identified by an assigned ID linked to a specific account within the

Blockchain. Security is further bolstered through an automated chain of hash functions, ensuring data encryption across the network. Notably, every block within the Blockchain generates a hash value, with each new hash incorporating the previous block's hash value. This hash typically encompasses block type, ID number, previous hash value, creation time, user ID, miner level, Merkleroor, and information on previous transactions and associated hashes. The inherent design of Blockchain automates hash generation, safeguarding data integrity by preventing tampering with hash values (Wenhua et al., 2023). The blockchain technology will be designed in a manner to find-out & fix the issues, so as not left any space for trace-back of error blocks. This capacity of Blockchain is the very characteristic that allows it to solve problems, and in fact, be a solution (Golosova & Romanovs, 2018). After all, the real advantage comes with faster approximate solutions. Such a process could take more time in the conventional approach, such as processing and transaction initiation with banking institutions. Yet, with blockchain technology integrated it massively decreases the processing and opening time to a few minutes or even seconds from what previously used to take around three days (Blockchaintechnology.com, 2016).

On the other hand, the biggest weakness of blockchain technology is its immense energy consumption. Without frequent facility access, and heavily updated reads along with them, therefore right away correct balances on a continuous ledger. When you create a new node, it will communicate with the other nodes at once. This way, it allows transparency in the network. Potential miners compete to solve many difficult questions per second on the network in order to verify transactions. This Deep Step tracker takes a lot of computational power and effort. While the above steps require extreme fault tolerance in each node, which guarantees continuous operation and ensures that data stored on the blockchain is accessible only by very strict conditions, these actions take time as well as power. In consequence, each node replicates all of the work to achieve consensus on their end separately which is wasted (Fauvel, 2017). The large energy consumption of Blockchain is mainly caused by the high request for signature verification. Validation of any transaction onto the Blockchain requires a cryptographic signature, which can be computationally intensive. This reliance on computation resources will add to the overall energy consumption of the system (Golosova & Romanovs, 2018).

Blockchain suffers from serious cons of its own, and one major con is cost. The process itself costs on average \$75 to \$160 per test due largely in part of the significant energy usage required. This is one of the reasons as already mentioned for this situation The other factor that

is contributing to creating this chicken and egg problem is the exponentially high initial capital investment for the implementation of Blockchain (Wenhua et al., 2023).

The first point of concern is the balance between the number of nodes and reasonable expenses for the users. The problem is that there are not enough nodes, which are essential for the normal and efficient functioning of the blockchain. Therefore, the expenses are quite high and keep growing due to large rewards for the nodes. However, as the nodes are not ‘working hard’, the speed of the completed transactions is slow. In reference to the expansion of Blockchain and the need for more computation, the system has been growing. The problem is that not all the existing nodes are capable of performing the actions required. The situation has two options. First, the sides of the ledger are being reduced, as existing nodes cannot store a full copy of the Blockchain, which discards its immutability and transparency. Second, the chain is becoming more centralized (Fauvel, 2017). As a technology capable of being an underlying and supporting mechanism for multiple protocols at once, blockchain has to satisfy the demands from projects developed on it-alas with all integration challenges between these very same protocols. Of course, the dispersed characteristics associated with blockchain demand dynamic storage space. Security measures introduce a complex architecture that, depending on the consensus mechanism used, can result in disadvantages such as high energy consumption or a limitation of testability and process with end users (Golosova & Romanovs, 2018).

The advantages and disadvantages of blockchain technology are summarized in table 3 below, based on the details explained above. Table 3 provides a comprehensive overview by evaluating the strengths of the technology alongside the challenges it presents.

Table 3: The Advantages and Disadvantages of Blockchain Technology

Advantages	Disadvantages
Immutable and unalterable data ensure reliability and integrity.	High energy consumption: Significant computational resources required for transaction verification.
Transparency through replication of each transaction across all computers in the network.	High transaction costs: Average test costs range from \$75 to \$160. (Wenhua et al., 2023)

Decentralized structure gives users control over data.	Decentralization leads to slow transaction speeds and insufficient node numbers.
Enhanced security through a chain of hash functions: Each block is linked to the previous one.	Storage challenges: As blockchain grows, it becomes harder for nodes to store the entire chain, leading to centralization.
Faster transaction processing: Reduces the time from days to seconds compared to traditional systems.	Integration challenges: Supporting multiple protocols simultaneously requires a complex structure.
Secure data encryption: Unique user IDs protect identities.	Consensus mechanisms result in high energy usage and complexity for end users.
Simplifies complex ecosystems by consolidating ledgers into a single public ledger.	High initial setup costs: Significant capital required for blockchain implementation.

1.4. Key Features of Blockchain Technology

One of the features that makes Blockchain technology unique and powerful is its distinct set of characteristics. Unlike centralized management systems, Blockchain operates in a decentralized manner, addressing the challenge of malicious control. To date, no centralized code has successfully controlled all devices or bypassed security protocols implemented through Blockchain's immutable and tamper-proof structure (Pilkington, 2016). One of the foundational strengths of Blockchain lies in its cryptographic methods, which ensure the security and confidentiality of transactions. These cryptographic techniques safeguard sensitive data, making it nearly impossible for unauthorized parties to access or alter transaction records. For instance, each block in the Blockchain is linked through a cryptographic hash, creating a secure chain of records that cannot be manipulated. Furthermore, immutability is a cornerstone feature of Blockchain. Once data is recorded, it becomes virtually irreversible, establishing a tamper-proof environment. This feature is particularly significant in industries requiring high levels of trust, such as financial services, supply chain management, and healthcare. By

ensuring that transaction data remains unaltered, Blockchain fosters a trustworthy system where participants can rely on the authenticity of information (Rajasekaran et al., 2022).

Transparency is another vital component of Blockchain, enhancing the confidence of all participants in the network. It allows every party involved to access and verify the entire transaction history, ensuring accountability. For example, in supply chain operations, Blockchain enables stakeholders to trace products from origin to destination, eliminating fraud and increasing trust. Moreover, Blockchain technology streamlines processes by reducing intermediaries, which not only cuts costs but also significantly reduces transaction times. Traditional systems often require multiple parties to validate a single transaction, leading to delays and inefficiencies. Blockchain, on the other hand, facilitates near-instantaneous transactions, saving time and resources (Aoun et al., 2021). Smart contracts further elevate Blockchain's capabilities by introducing automation. These self-executing contracts operate based on predefined rules, removing the need for third-party intervention. For instance, in real estate transactions, smart contracts can automate payment releases once conditions, such as property transfer, are met, expediting the entire process. Cost savings are another compelling aspect of Blockchain technology. By minimizing reliance on service operators and reducing paperwork, organizations can allocate resources more efficiently. This cost-effectiveness is particularly valuable in sectors like banking, where Blockchain replaces traditional methods of reconciliation and record-keeping (Efanov & Roschin, 2018).

Lastly, Blockchain's traceability feature ensures accountability by recording every transaction in the system. This characteristic is especially crucial for auditing and compliance purposes, as it provides a complete history of actions taken within the network. For example, in the food industry, Blockchain can track the journey of goods, ensuring quality and safety standards are met (Rajasekaran et al., 2022). Together, these characteristics of security, transparency, automation, efficiency, and traceability form the pillars of Blockchain technology. They empower organizations to address critical challenges, optimize operations, and build trust across a wide range of applications, from digital marketing to supply chain management (Zhang et al., 2019).

1.5. Basic Components and Types of Blockchain

According to the way trust is established in different scenarios, Blockchain can be divided into two types: Permissionless Blockchain and Permissioned chain. A **permissionless blockchain** (also called a public blockchain) is an open network where anyone can participate and update the consensus-based ledger. This trust among network nodes is forged with the reverberations of computing power in a decentralized system. Yet, this creative approach also poses its own difficulties such as wasted resources and inefficiency. Key Takeaways: In a public blockchain, such as Bitcoin, the most common usage is in unregulated; anonymous environments where developers are free to experiment and prototype (Golosova & Romanovs, 2018). It is the basic type of blockchain that functions in a partially closed or private process and allows only restricted people to be involved with it. All members are given different rights to participate on a blockchain. This blockchain works by establishing a trust relationship in advance, often via identity certificates. **Permissioned blockchain** benefits over permissionless, such as greater efficiency. It can also be divided into permissioned blockchains, consortiums, and fully private. A consortium is a blockchain between many institutions, the provider creates reconciles, and maintains ledgers of consortium members. In some cases, the full openness and decentralization of a public blockchain are not necessary, as this inefficiency once again may prevent meeting needed demands when combining with other technologies for progressive improvements. Therefore, the ideal blockchain model for some specific scenarios is consortium blockchain. A fully private blockchain is more centralized than consortium blockchains. One single organization holds total control of data creation, reconciliation, and maintenance activity - no one outside can infer with or access the ledgers (Zeng et al., 2020).

1.5.1. Consensus Protocol

The consensus protocol in a blockchain is the foundational mechanism that enables all nodes within the network to agree on which transactions should be added to the ledger. This process is essential in maintaining the integrity, consistency, and security of the distributed ledger. By validating transactions before appending them to the blockchain, consensus ensures that all participants share a unified version of the truth, a critical requirement in decentralized systems where no central authority exists (Ai, & Cui, 2021). The consensus protocol eliminates the need for trust between parties by providing a transparent and tamper-proof mechanism for transaction validation. It ensures that all nodes agree on the validity of a block before it is permanently added to the chain, thereby preserving the reliability of the ledger. Furthermore,

the protocol is designed to address challenges such as data transmission interruptions, data loss, or delays caused by issues like disabled nodes. In such cases, the consensus mechanism works to prevent discrepancies and maintain the seamless operation of the blockchain (Milutinovic et al., 2016).

For a consensus protocol to function effectively, it must meet three critical criteria: security, liveness, and fault tolerance. Security involves protecting the blockchain from malicious actors who may attempt to alter data or compromise the network. Liveness ensures that all active and functional nodes contribute to the consensus process, guaranteeing the network's continuous operation (Filatovas et al., 2022). Fault tolerance means the system can withstand and adapt to unpredictable behaviors or failures by some nodes without disrupting its overall functionality. These features collectively make consensus protocols the backbone of blockchain technology, enabling the validation and verification of transactions in a trustless environment (Wang et al., 2020).

Despite their importance, consensus protocols are not without challenges. One significant issue is scalability, as the increasing size of blockchain networks can lead to delays and higher computational requirements. Another challenge is energy efficiency, particularly in mechanisms like Proof of Work, which demand significant computational power and have been criticized for their environmental impact (Erdamar, 2018). Additionally, ensuring decentralization while maintaining efficiency remains a complex task, as some protocols may inadvertently favor centralization. To address these challenges, researchers are exploring innovative solutions and hybrid models that combine the strengths of existing protocols while mitigating their weaknesses. As blockchain technology continues to evolve, consensus protocols will remain at the core of its development, driving advancements in security, scalability, and efficiency across various applications (Filatovas et al., 2022).

Within an authorized consensus protocol for Bitcoin transfers;

- New transactions are disseminated to nodes,
- Every node gathers recent transactions and organizes them into blocks,
- In each cycle, a randomly selected node transmits its block,
- Assuming all transactions are legitimate, the block is approved by other users,

- Nodes confirm their acceptance of the block by incorporating the transaction digest into the subsequent block (Narayan et al., 2016).

Consensus plays a pivotal role in upholding the integrity and security of the decentralized system. While numerous consensus protocols exist, two of the most renowned ones are: POW and POS.

1.5.2. Proof of Work (PoW)

The Proof of Work consensus protocol is an algorithm used to discover a new hash value for the block created. Generating this hash value is a computationally expensive task that requires power and energy, but verifying the data it represents can be done at very low cost. The existence of certain rules, as described above in the mechanism for creation blocks motivates network nodes to make use of a brute force algorithm and create hash values with a predefined structure it indeed is an added requirement (Basegio et al., 2018). It is a consensus algorithm that have two types of nodes: Prover and Validator Nodes. The computational heavy lifting of generating blocks according to the protocol falls on prover nodes, whereas validator nodes process proofs with much fewer resources. The claim that the proof process is expensive (in terms of resource demand), as well as what often results to different resource allocation for prover and verifier nodes, are part by design meant to simultaneously attain two very important goals. Its main purpose is to avoid Sybil attacks where malicious nodes or stakeholders try to get into the network by creating a large number of fake identities. Though the number of fake identities generated by malicious nodes could be in large numbers, the resulting impact on the network is small owing to their insufficient computational power. Furthermore, this consensus algorithm protects the network from both forking and double-spending attacks. This blockchain is then the chain that spends almost as much processing power on creating blocks to have been created; (Tran et al., 2022).

1.5.3. Proof of Stake (PoS)

In the PoS consensus mechanism, validators are selected to create new blocks depending on the amount of cryptocurrency they hold and willing to "stake" as a form of security deposit. This new system is designed to reduce overall energy consumption compared with PoW (proof-of-work) and relies on economic incentives that reward participants who maintain the security of a network. Proof of stake, on the other hand, is a proposal from some Bitcoin community

that aims at reducing the transaction-laden manner and high energy consumption related to Proof of Work consensus protocol making it far more user-friendly. Rather than a mining system, the Proof of Stake protocol proposes an intermediate solution through ownership as to its cryptographic value. This trade-off can mean you either have to lock up an amount of crypto for a period of time or stake some as collateral. By doing this, the Proof of Stake protocol uses ownership or reserves tied to cryptographic values as a Sybil attack protection measure. Compared with the Proof of Work protocol, which separates miners' opportunity cost from its on-chain occurrence in off-chain investment profits and capital losses; such arrangement requires large amounts of computation power outside systems as well as consumes an enormous amount of electricity (Xiao et al., 2020). Since the Proof of Stake-based consensus process doesn't actually involve any mining, a Proof of Stake miner is also sometimes called an investor. So, immediate reconciliation with the least expenses is possible as a result of using virtual resources. Even though the aforementioned trade-off presents better environmental sustainability, faster transactions, and cost savings; however, its acceptance on current networks has been slow due to security concerns (Garcia-Alfaro et al., 2017). In addition to PBFT (Practical Byzantine Fault Tolerance), DPoS (Delegated Proof of Stake) is another consensus mechanism as well as many others. However, just about every other consensus protocol comes with its own benefits and trade-offs in terms of security, and scalability adoption incentives from a decentralization perspective. The choice of consensus algorithm usually depends on the specific goals and characteristics of a blockchain network. The consensus protocol is paramount in ensuring that all nodes on the network agree about the legitimacy and order of transactions. It is used to alleviate the worries of Double spending and keep up the general integrity of the blockchain (Aggarwal & Kumar, 2021).

1.5.4. Practical Byzantine Fault Tolerance (PBFT)

Practical Byzantine Fault Tolerance (PBFT) - This algorithm is used as a consensus mechanism to provide fault tolerance in distributed systems. Byzantine Fault Tolerance (BFT) is a fundamental concept that determines the degree to which we trust it works correctly even if there are some malicious/faulty components. This is a significant problem that PBFT overcomes by offering an algorithmic solution and thereby effectively blends the state of this borderline (Hao et al., 2018). The process involves designating nodes on the network into either leader or backup node roles, in which a backup will take its place if the lead were to fail and

honestly distributed amongst all of the ones once they reached consensus through the majority. More nodes indicate more security for the system. Execution speed: PBFT can deal with transactions once the amount of malignant or faulty nodes in the network does not surpass one-third of all its node (Eroğlu, 2022).

1.5.5. Delegated Proof of Stake (DPoS)

The next step from PoS is the DPoS consensus protocol, which works by letting each node in a network vote for other nodes to represent them and process transactions on their behalf. This single voice of the electing nodes takes on transaction validation responsibilities and is paid to create blocks. Therefore, it is apt to describe the DPoS consensus protocol as a kind of "board vote," not unlike deliberative decision-making (Qiu, 2018). A deposit equal to 100 times the total revenue in a block must be made by an umpire for it to register its nodes. Once the registration is done successfully, he makes sure the online presence on most of the time with expected profitable targets. If the obligations to other stakeholder node's agreed-upon targets are not met, this may result in the votes that branched from and supported all of those single outcome states being revoked which will demote that representative's node. The proposed consensus protocol aims to preserve energy consumption and leverage verification acceleration by cutting the number of nodes related to these processes into as few as possible (Qiu, 2018; Xiao et al., 2020). To break down the process exactly: each node in blockchain networks has a vote that depends on how much cryptographic power is owned. These nodes then choose some number of random representatives across the network to do the voting and block append work. Hence, these elected officials carry out their duties in a set period of time and earn income through several means like fees on transactions or block rewards. This income can either be distributed among the nodes, from which representatives were acquired (whether shared or entirely by the representative), depending on how network is structured (Özdamar, 2022).

1.5.6. The Federated Byzantine Agreement (FBA)

Federated Byzantine Agreement (FBA): The algorithm protocol ensures a guaranteed and cost-effective consensus in the decentralized environment, which confirms secure transactions between nodes. FBA enables this by allowing each member to maintain local security with the other supported members, ensuring trust relationships. This mechanism creates a safe and efficient consensus method in the distributed system, removing centralized

administrators. Unlike the traditional PBDF consensus, which demands all nodes in a network to communicate with every node through any type of implementation process on those routers or firewalls; this built-in FBA mechanism requires just a few communications between each and every single pair within that replicated system. A subset of the configuration used is a quorum slice that belongs to this particular node, hence establishing trust with the node. This means that a node in the network depends on this subset of nodes to confirm any transaction (Yoo et al., 2019). Once the majority of these nodes approve the transaction, it is carried out. Since consensus is developed by bringing feedback with each of the fewer nodes, the FBA consensus mechanism shows a superior performance when compared to the broad networks (Such as random-site networks) Introduced in the Stellar network in 2014, the consensual mechanism would become popular over time offering a scalable framework that can help speed up decision making. The most ubiquitous use of FBA is in the Stellar protocol (Sayın, 2022).

1.5.7. Proof of Authority (PoA)

A consensus mechanism in the world of cryptocurrencies and blockchain is Proof of Authority (PoA). This technique is by creating and checking blocks made from those entities of the system that have permission to do so. As PoA is well publicised for its efficiency and security advantages, it is often used in private or permissioned blockchain networks. In 2017, Gavin Wood (co-founder of Ethereum) proposed PoA in place as a potential alternative to resource-depleting methods that existing mechanisms took. This model of consensus is based on the simple presumption that a predetermined set of trusted and authorized nodes, referred to as authorities, process transactions in permissioned networks because all involved parties are known identity-wise with a certain degree of trustfulness. These are different entities with a very important task when it comes to the correct functioning of the network services (A. Singh et al., 2022).

1.5.8. P2P (Peer-to-Peer) Protocol

P2P (Peer-to-Peer): A network architecture that enables data to be shared directly between computers. Every single participant in the network talks to each other and uploads their data directly, no intermediary is required. P2P protocols create a decentralized network that increases reliability, scalability, and longevity. Via a peer-to-peer (P2P) system, communication can be done directly between the sides. P2P services are frequently used by buyers and sellers

for commerce. A search, browse, and rate feature, payment gateway systems with escrow services, etc are the characteristics provided by such platforms (Hayes, 2017). This sector has already seen the use of blockchain technology for some time now, 73 implementing a cheap and P2P structure used in most sharing applications. This innovation enables individuals and institutions to make transfers without the use of a third-party intermediary such as a bank or credit card company. Instead, they can exchange digital wallets directly with other parties for goods or services. This causes the commission fees to be eliminated as well as dissolve the boundaries between countries (Aktaş, 2018).

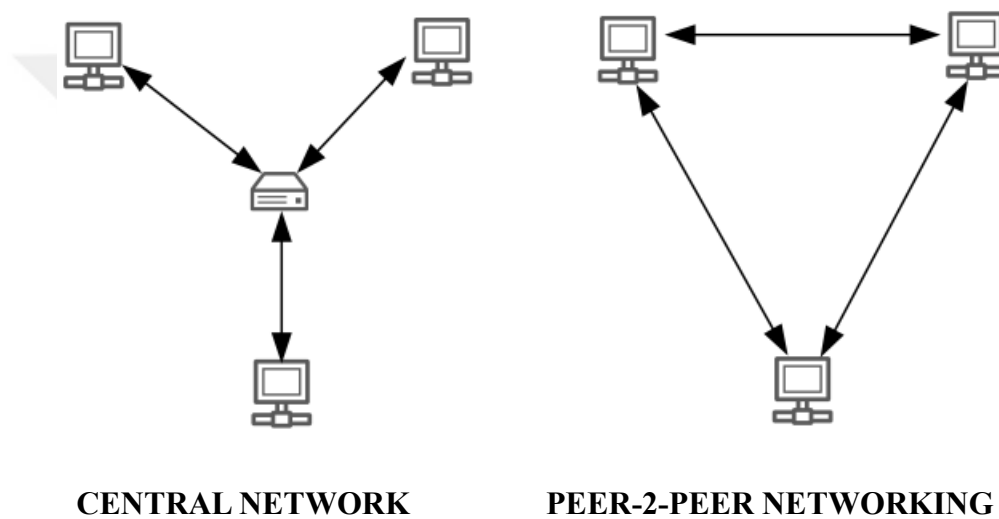


Figure 2: Peer-to-peer network. (Tran et al., 2020).

At a high level of blockchain applications each peer in the network among peers, all are equal they are called nodes. They are also the only set of miners who have full node capabilities that allow them to independently validate and filter transactions on each block, from genesis up until now all transaction data records will be stored in your personal database without enforceable restrictions. More light node users, however, are missing from knowledge of blockchain structure except certain blocks and using only Simplified Payment Verification (SPV) service in contrast to this ability that had all a full-node user who has downloaded the complete more than 200 GB Blockchain schema on their computer (Durbilmez, 2018). P2P simply stands for Peer-to-peer which is a network framework that is decentralized, scalable, and reliable in nature hence it can be used efficiently everywhere from file sharing to cryptos like bitcoin exchanges and distributed computing. The decentralized nature of it substantiates the strength and reliability of its system, endowing features like data redundancy as well as

scalability capabilities. But one needs to always weigh Security and Privacy related disadvantages carefully as well (Cao et al., 2020).

1.5.9. DLT – Distributed Ledger Technology

Distributed Ledger Technology (DLT) is a digital database technology that spreads across multiple sites and is updated at the same time on an interconnected network. The main goal of DLT is to secure and make data sharing more transparent, where no central power should exist. While blockchain is probably the most popular user of DLT, it has to be realized that different organizations define and divide into several structures which may include other than blockchain (Barolli et al., 2018). Distributed Ledger Technology allows data storage on a network of decentralized nodes. The distributed ledger or the record structure is connected to databases that every user on the network keeps up and updates all alone without needing other nodes. Similar to regular systems, in which the central server tracks all records and transmits them to users as needed, every node has its own state of a ledger, and arrives at independent decisions. In that case, the result will be validated by reaching conclusions. This provides a great ensemble of flexibility in the collection, storage, verification, and transmission for both fixed fields (e.g., chaincode) as well as dynamic ones within a network. (Soran & Kılıç, 2018).

1.6. Blockchain and Supply Chains

Applying blockchain technology to Supply Chain Management has the power to be a game changer for many industries. Thus far, the waiving of intermediaries in transactions has triggered a restructuring process among traditional relationship models. After the negotiation's conditions happen, the contract is triggered, and money and goods are sent to terms which were stored by this smart contract. This entire process does not involve any intermediaries anywhere, which results in much faster transactions as well as a lower transaction fee and more trust. Since every single node, or player in the network has a copy of the ledger which means that entity-owned ledgers are transparent and accountable (Al-Saqaf & Seidler, 2017). Smart contracts play a pivotal role in this transformation. Once the conditions of a negotiation are agreed upon and stored in the blockchain, the contract is automatically triggered upon fulfillment of those conditions. This process initiates the seamless transfer of goods and funds between parties without requiring third-party involvement. This automation not only accelerates the transaction timeline but also reduces operational costs, as intermediary fees are entirely eliminated (Chang, & Chen, (2020).

In addition to transparency and efficiency, blockchain enhances security within supply chain networks. The decentralized and cryptographic architecture significantly reduces the risk of fraud or data breaches, as altering a single transaction would require simultaneous manipulation of all copies of the ledger across the network—a virtually impossible task. This robust security framework provides businesses with confidence in the integrity of their operations, while also reassuring consumers about the authenticity and quality of the goods they receive (Azzi et al., 2019). By integrating blockchain technology, supply chains can achieve unprecedented levels of efficiency, accountability, and trust. As industries continue to embrace this innovation, the ripple effects will likely extend beyond operational improvements, influencing how companies collaborate, compete, and deliver value in a rapidly evolving global marketplace. This transformative potential underscores blockchain's critical role in shaping the future of supply chain management (Oriekhoe et al., 2024).

According to the CSCMP, Supply Chain Management is an integrated planning and controlling of all functions in a Company or Firm that performs tasks such as sourcing/procurement (more commonly purchasing), conversion, and logistics management... It also highlights a vital need for coordination & collaboration with channel partners such as suppliers, intermediaries, third-party service providers, and customers. In other words, supply chain management oversees the systematic movement of materials and products going both into a company (from suppliers) and also coming out both within individual companies themselves as well as several organizations together. (Council of Supply Chain Management Professionals (CSCMP), 2018)

Stock and Boyer (2009), performed an exhaustive search of the literature to ascertain 173 definitions used in supply chain management among other meanings. These authors presented a comprehensive definition that includes relationship management between the family and business units within one firm or among interdependent organizations. These components include material suppliers, buying, production facilities, and logistics on one hand; the last two being non-existent without sales & marketing or vice versa. SCM (Supply Chain Management) serves as an intermediary between the output of suppliers and the input to consumers by passing materials, services, finance, etc., from their original source to their end use simultaneously. In this manner, SCM allows the value in screening the profitability of an operation to be added and custom satisfaction guaranteed (Stock & Boyer, 2009).

1.7. Risks of Blockchain Technology and Challenges

One of the biggest hindrances to blockchain technology advancement is the lack of defined regulations. The lack of a single concerted framework across the globe will hamper blockchain technology from becoming a global standard due to varying laws between countries. This uncertainty could inhibit innovativeness and increase the potential for resistance. Additionally, transaction validation and recording are often time-consuming and resource intensive on most existing blockchains which leads to issues around scalability. With many blockchain networks facing scalability hurdles, they are struggling to support a large volume of transactions that might be required in order for them to gain widespread acceptance (Gervais et al., 2016).

Though blockchain technology is well known for its high security level, no system could be totally safe from hacking efforts. Smart contracts and decentralized applications are also self-executing pieces of code that would be written in the blockchain, some parts can have vulnerabilities as it is prone to bugs or any other adversarial conditions that hackers could take advantage of (Chang et al., 2020). Since mining is an important process to execute blockchains, especially those that work with proof-of-work (PoW) consensus mechanisms have high energy consumption. So all that energy consumption has caused some worry about the impact of this technology on external, environmental resources. Criticism has thus far ensued, with increasing calls for environmentally sustainable methods to reduce potential negative consequences of blockchain energy usage (Gervais et al., 2016).

Blockchain operates with its unique protocols and standards, so there are different blockchain platforms that are designed especially to clarify the business opportunities. This incompatibility amongst the platforms makes them less effective and cumbersome for end users to use if working across several such environments. Blockchain technology is known for transparency, but with this great functionality comes the question of privacy. These blockchains are often public in that anyone can see the transactions, which is no good if you want to keep your transaction private. Balancing transparency and privacy will be one of the primary obstacles for blockchain technology to overcome (Carter, & Jeng, 2021). Whether this vision can eventually be realized or not, one thing is clear - transparent, secure, and trustless are characteristics which have the power to revolutionize many industries using blockchain technology. But there are substantial hurdles before this technology can become as common, due to many regulatory issues, scalability problems, and security holes. With such inherent risks

in blockchain, addressing them in ways that mitigate these issues is crucial as this technology continues to evolve and its capability grows (Zamani et al., 2020). Although blockchain technology provides a lot of advantages, it is also accompanied with some risks and challenges when used. In order to be able to successfully run programs that use blockchain technology, a deep understanding is required of these risks and how to handle them. Given the below, the potential risks of blockchain-based programs are discussed in detail (Lindman et al., 2017).

1.7.1. Technological Risks

The development of blockchain technology is at an early stage, and the scope for risk through novel technological infrastructure exists. A myriad of technical challenges can detrimentally impact the performance of blockchain applications, from scalability issues to transaction speed limits or data storage capacity constraints. This factor is an additional technological risk, given the unsuitable and non-uniform standardisation in different blockchain platforms (Malhotra et al., 2022).

1.7.2. Security Risks

The security of these blockchain systems relies on cryptographic techniques to provide a solid foundation. Yet blockchain networks naturally are not impervious to hacks. If the software is flawed in a way that takes place on the blockchain (as with smart spaces), it provides an area for malicious attacks. Additionally, the future risk of quantum computing's ability to undermine cryptographic algorithms may weaken blockchain security in ways that are still largely unknown. All types of user data and financial assets can be put at risk due to security violations (Zamani et al., 2020).

1.7.3. Legal and Regulatory Risks

The rapid evolution of the blockchain may surpass legal and regulatory frameworks. Varying blockchain technology laws and policies between countries could create ambiguities for projects using tokens on a chain-based compliant protocol. Companies can incur operational inefficiency and costs due to legal and regulatory risks (Yeoh, 2017).

1.7.4. Financial Risks

Projects leverage blockchain technology are usually accompanied by substantial costs of development and implementation. Large corporates are able to implement these services with a cut and paste because they have the resources, but for small/medium enterprises it involves

high up-front costs in implementation, training cost, integration, etc which puts them at financial risk when deploying. Finally, uncertainty surrounding the longer-term sustainability of blockchain projects adds financial risk. This could also raise questions about the sustainability or probabilistic failures of blockchain projects in general, negatively affecting investor sentiment (Lazarenko & Avdoshin, 2019).

1.7.5. Operational Risks

Using blockchain technology to enable trust among financial entities could spell a world of change to current business processes. However, these changes could meet resistance from within the organization, and result in employees struggling to keep up. Also, the implementation of blockchain-based systems might lead to technical and operational complexities as well. The successful completion of blockchain projects hinges on their disguise as being competitive, just as it does for any other serious business (Walch, 2015).

1.7.6. Social and Ethical Risks

Anonymity, and data transparency, are the exact features of blockchain technology that present serious social risks. In particular, anonymity makes it impossible to monitor illegal activities and identify criminal transactions in an effective way. In addition, releasing data transparently may be a breach of the privacy rights of individuals in these datasets. These social and ethical concerns may influence the adoption of blockchain projects within communities (Tang et al., 2020). In conclusion, blockchain-based programs may face several risks and challenges in implementing/integrating them. Successfully mitigating these risks is crucial to the future of blockchain technologies. They should include these risks in their considerations and account for them when they plan to operate blockchain projects. The success of blockchain-based programs can be improved by identifying potential risks and developing a risk management strategy proactively to exploit opportunities presented by this technology (Tang et al., 2020).

CHAPTER II: Trust, Marketing and Blockchain Technology

Following the foundational discussion in the first chapter, this chapter focuses on the relationship between trust and blockchain technology. It examines the impact of blockchain on transparency and trust in digital marketing. The adaptation of blockchain-based programs into digital marketing strategies, their main areas of application, and their sectoral distribution are discussed extensively. This chapter seeks to highlight the implications of blockchain technology within the marketing domain.

Marketing and blockchain are interconnected as the technology may secure the operations, and underpin transparency and trust during transactions, providing security and privacy at the same time. For instance, blockchain creates several decentralized ledgers that help marketers check and verify all available data and monitor and process various operations. Blockchain also permits secure management of customer interaction, established by technologies 65% is made possible by blockchain. Smart contracts are at the core of blockchain as these automatic programs process all transactions and allow marketers to use this technology automatically. Blockchain's decentralized ad networks provide a swifter process of delivering and paying for digital ads, increasing the effectiveness of campaigns due to less fraudulent traffic. Tokenized systems like loyalty programs are also created by blockchain (Tan et al., 2023). The best example is frequent flyer miles or game purchases; customers are rewarded with tokens that can be spent later. Finally, supply chain transparency and payments made with cryptocurrencies provide an opportunity to do many other technological processes without financial agents which can grant a competitive advantage to stakeholder servicing marketers (Rejeb et al., 2020).

2.1. The Relationship Between Trust and Blockchain

One of the most profound and wide-reaching effects of blockchain technology, particularly in marketing, is on trust. Blockchain technology serves as a decentralized and immutable ledger that can try its best to facilitate marketing activities or collaborations fostering trust in it (Ebrahim, 2020). Blockchain technology primarily helps maintain transparency and accountability for any marketing initiatives. They allow marketers to create a transparent transactional record on the blockchain and hence they provide secure storage of ad spendings, campaign performance data, and customer interaction, which is easy against any compliance audit. This increased transparency builds more trust for consumers, advertisers, and

governmental units due to decrease concerns about fraud, manipulation, or unethical behavior (Hawlitschek et al., 2020).

Moreover, the validation and authorization of any manner of digital assets can be perfectly assured with the support of Blockchain Technology. With the help of blockchain-enabled solutions, marketers will be able to prove both the reliability and authenticity of digital content which may lead to new horizons in preventing counterfeit products damaging consumer goods, misleading advertising claims, or intellectual property rights infringements. Therefore, the process of meticulous verification feeds confidence among consumers as they have no doubts when interacting with verified or painstakingly validated marketing materials (Becker & Bodó, 2021). In addition, blockchain technology allows for decentralized and peer-to-peer transactions further reducing reliance on intermediaries or even intermediary platforms during marketing trades. The decentralized nature of a blockchain allows the individual to have more control over their data and digital identity which breeds trust, and organic connection in marketing. In addition, blockchain technology and smart contracts in play makes agreements easier to understand for all parties involved which can lead to a faster execution of contracts, namely the meaning of this part especially related with trustworthiness transactions on marketing (Shin, 2019). The net effect of blockchains on trust within marketing derives from their ability to create transparent, secure and decentralised systems infrastructure which allows stakeholders to more easily engage in building or enhancing that vital foundational layer. Using distributed ledger technologies, marketers are building trust in this foundational layer of their strategies consumers and advertisers alike (Shin, 2019).

Trust is a fundamental element in digital technologies and directly affects users' perception of systems. In traditional systems, trust is usually based on a central authority or intermediary institutions. However, blockchain technology has changed this understanding and moved trust to a decentralized structure. Blockchain's basic features such as transparency, immutability and decentralization redefine trust between individuals and institutions. For example, the fact that a transaction can be seen by all participants reduces the risk of any manipulation and creates a reliable environment among users. Therefore, blockchain is not only a technology, but also a paradigm shift that integrates trust into technology (Ali et al., 2023). The features offered by Blockchain allow trust to be redefined in the digital world. First of all, thanks to its transparency feature, all transactions can be seen and verified by all participants in the network. This minimizes the risks of fraud and manipulation (Ali et al., 2023). In addition, the immutability feature of Blockchain means that transactions cannot be deleted or changed

retroactively, which increases the sense of trust by preserving data integrity. Decentralization, on the other hand, allows users to interact directly without the need for an intermediary to carry out transactions. This feature ensures the creation of a reliable infrastructure, especially in areas such as finance, supply chain and marketing. Blockchain positions trust not only as a tool, but as the basic building block of the system (Shin & Bianco, 2020).

Trust is a critical factor in marketing because it greatly affects image, loyalty and overall brand perception for consumers. It is the trust and confidence consumers have in a brand, product or service. The basis of this trust is that the brand stands for a set of attributes dependability, integrity, consistency and openness (Popova et al., 2019). Building trust in marketing initiatives is indispensable for paving the way to a long-lasting relationship between brands and customers. If they trust a brand, consumers will interact with the brand more often, buy from them, and recommend it to their peers. As a result, trust is such an important part that it allows organizations to grow their audience and consequently provides them with a competitive advantage by increasing customer loyalty (Popova et al., 2019).

Trust affects consumer decision-making because it reduces confidence in the brand and lowers the perceived risk. If consumers trust the label of a specific brand, then it leads to less anxiety while purchasing or availing themselves of its products or services. As a result, it facilitates the building of trust amongst consumers in which brands can build their reliability and assurance that they will properly meet the needs and expectations of customers without any chances of disappointment (Ebrahim, 2020). Given the importance of trust in marketing today, brands are cranking out new ways to influence consumers and brand communication tactics left and right as they seek better customer retention rates. Through transparent communication, ethical marketing practices, quality customer relations, and reliable information sources cleaner signals from the brand can penetrate consumer clutter to create credibility with consumers (Fletcher & Peters, 1997). The bottom line is that trust in marketing, as we know it today, lies at the foundation of brand-consumer relationships. Brands that build and maintain trust will expand their customer base, be competitive, and thrive for a long time (Manzoor et al., 2020).

2.1.1. Cryptocurrency Trends and Trust (2013–2024)

The most well-known currency in cryptocurrencies is Bitcoin. When we analyze the ups and downs of Bitcoin between 2013 and 2024, it is possible to define the trust in cryptocurrencies.

The years 2013–2015 were the early bubble period of bitcoin, following which it stood at a peak price of around \$1200 once again. It saw a major uptick in mainstream media coverage and people were interested, not just as something to use but for the technology itself. However, this was not sustainable and when the Mt Gox exchange collapsed in 2014 it spread fear throughout bitcoin traders leading to a large sell-off (bankrate.com). This period highlights the immaturity of a young market to security issues and the rich nature of early-stage cryptocurrencies (investopedia.com).

Throughout 2017, the price of Bitcoin reached new record highs that only tightened further up to almost \$20k by year-end. The Initial Coin Offering (ICO) craze and the public's broader embrace of cryptocurrency in turn fed into massive speculative investments, driving this dramatic increase. Meanwhile, the launch of Bitcoin futures by the Chicago Mercantile Exchange and growing talk hereabout about regulating embraced to push them up even higher. This is the kind of spike you see in a bubble when (fear of missing out) FOMO and hype blind people to value, causing prices to exceed sustainable levels (coindesk.com).

In 2018, the next year saw a huge pullback as the price of Bitcoins fell. The bursting bubble of speculation mechanisms, more rigorous regulatory review, and crash by a lot of ICO (Initial Coin Offering) projects dealt the coin with devastating price hits. This time brings to the fore precisely these outcomes we saw coming given an overheated speculation phase and serves as a timely reminder of how imperative well-adapted regulation for crypto is needed (diplomacy.edu, Kamberi 2019).

Growing stagnation experienced the price of the Bitcoin market from 2019–2020. Factors such as the 2019 halving event, more institutional involvement, and overall changes within cryptocurrencies all had a hand in this stabilization. The maturing market of this era, featuring refined investors and more institutional involvement changed the trajectory from that explosive growth path to one that is more tempered and sustainable.

Bitcoin saw an even faster adoption in 2020 and entering the new year of 2021 it went parabolic reaching over \$60,000 for the first time ever (bitcoinmagazine.com). The economic havoc wrought by COVID-19 has driven people to look at Bitcoin as a safe haven investment alongside renowned institutions like Tesla and PayPal who started taking bitcoin payments increasing its digital asset allure. That it was the next digital Gold, and similar things were echoed by institutional investors, too.



Figure 3: Bitcoin Price 2021 (Bitcoin price graph, Investing.com).

In the years from 2022 to 2024 onwards, markets are still finding price discovery and bitcoin continues its historic volatility. Indeed, the price swings since then have been closely intertwined with broader macroeconomic forces such as inflation fears and central bank actions in addition to regulatory updates. The recent trends show that although the market is not yet mature, Bitcoin's price has become more influenced by general economic conditions and its gradual positioning within a global financial system.



Figure 4: The price of Bitcoin from 2013 to 2024 (Investing.com).

The relationship between Bitcoin and influential figures or organizations has been a recurring theme in the cryptocurrency market. Under Elon Musk's leadership, Tesla has played a significant role in shaping Bitcoin's market perception and value. Tesla's announcement in 2021 of its investment in Bitcoin and its subsequent decision to accept Bitcoin as a payment method marked a pivotal moment, boosting investor confidence and driving significant price surges. Although Tesla later paused Bitcoin payments citing environmental concerns, its initial actions underscored the impact a single corporation could have on the cryptocurrency's valuation.

Elon Musk, beyond his role at Tesla, remains a central figure influencing the cryptocurrency landscape. His social media statements, often cryptic or satirical, have been known to cause dramatic price fluctuations in Bitcoin and other cryptocurrencies. This influence demonstrates the sensitivity of decentralized markets to centralized figures, raising questions about market stability and the potential for manipulation.

The influence of figures like Elon Musk and Donald Trump on Bitcoin is evident in the significant price fluctuations observed. Particularly, the period from December 2023 to December 2024 highlights the impact of these dynamics on Bitcoin's value. **Figure 5** provides a detailed visualization of Bitcoin's price movements during this time. The graph clearly illustrates the sharp price surge following Trump's election victory, marking a historic milestone as Bitcoin reached \$100,000 for the first time. This underscores the profound influence of political events and prominent individuals on the cryptocurrency market.

The graph not only elucidates market behaviors but also highlights how Bitcoin diverges from traditional market dynamics. It emphasizes the pivotal role that influential figures play in shaping the cryptocurrency landscape. This data contributes to a broader understanding of Bitcoin's volatility and the factors driving its market movements.

Bitcoin (BTC) Price Chart

→ Dec 2023 — Dec 2024



Figure 5: The Price of Bitcoin (1-year price chart Dec 2023 – Dec 2024) (investing.com)

Such events emphasize the broader implications of cryptocurrency as a global financial asset influenced not only by market fundamentals but also by corporate strategies, individual actions, and political developments. This dynamic interplay underscores the need for robust regulatory frameworks and strategic foresight to ensure the stability and sustainable growth of digital assets in an increasingly interconnected world.

2.1.1.1. Bitcoin Price Volatility and Blockchain Adoption

Price volatility in Bitcoin, a leading cryptocurrency, significantly impacts the perceived trustworthiness and adoption of blockchain technology. These price fluctuations can also influence investor and user perceptions of blockchain's stability, strength, and long-term viability (Zournatzidou et al., 2024). Given the extreme volatility of Bitcoin prices, there are often questions about whether blockchain technology is rock solid. The dramatic fluctuations when Bitcoin surges or plunges can shake the confidence in blockchain as a financial back end.

Such fluctuations could make potential consumers and investors view blockchain as an unstable innovation. Yet, for anyone who appreciates the decentralized and nascent technology blockchains are volatile nature might not only be expected but welcomed as a sign of progress (Al Guindy, 2021).

Times such as the 2017 bubble and the resulting crash in 2018 can also be detrimental to confidence in blockchains. More often than not, these phases are perceived as hype-driven more than technological advancements which can harm trust. Again, security is very important and even helps build up trust in blockchain. High-profile disasters such as the Mt. Gox exchange collapse or any of the many security breaches in cryptocurrency need just one news cycle to completely shatter trust that blockchain is inherently secure and reliable by design. On the other hand, incidents like this often expedite enhancements to blockchain security protocols that can eventually restore and even heighten trust (Köse et al., 2024). Institutional adoption helps build a lot of trust in blockchain technology; the only thing it does not help with is making your product bulletproof as decentralized networks can. The trust in the blockchain was significantly increased by companies that accepted Bitcoin, including Tesla and PayPal (especially during a time when everything goes on lockdown and the pandemic strikes). The fact that increasingly more institutions are engaging with blockchain shows us it is in essence not only a speculative instrument but behind the bang as well an extremely solid technology. The potential deployment of investment-grade money and clients further boosts the full degree between individual users as well as corporate players, cementing blockchain into its financial ecosystem (Al Guindy, 2021).

Two Aspects of Trust Regulatory developments both enhance and undermine trust. Increased regulatory scrutiny after large price fluctuations does not necessarily have to diminish trust in blockchain. Crucially, clear regulation can instill trust with a permanent legal structure under which the ecosystem of blockchain is supposed to be functioning. Restrictions, on the other hand, can mean uncertainty and lack of trust to potential users who might not want to experience challenges or risks in using a sector that is already heavily controlled (Zournatzidou et al., 2024). The relationship between Bitcoin's price fluctuations and trust in blockchain technology is multifaceted and nuanced. While volatility and speculative bubbles can erode trust, periods of growth fueled by institutional adoption and regulatory clarity can significantly enhance it. Understanding these dynamics is crucial for anyone considering investing in or developing blockchain solutions (Köse et al., 2024).

2.2. Transparency and Trust in Digital Marketing

In the world of digital marketing, transparency, and trustworthiness are two pillars that consumer-business relationships rely on. Transparency is the observable demonstration of marketing campaigns, and business activities in a language that communicates easily with individuals; across further embed, there remains trust where consumers have confidence within an assumption to experience real dependability when obtaining commodities from businesses. This is where transparency becomes the bedrock of consumer choice by offering authentic, reliable information about products and services in digital marketing (Cambier & Poncin, 2020). Just remember that brands, being honest in their advertising and showing something exactly how so open to the literal naked eye of a consumer provides that unfiltered high-level confidence brand experience. Trust enables consumers to deal with companies safely without the risk of being exploited. However, a business must act on grounds of transparency and to reduce the trust issue in digital marketing because even if they are not always sales-ready techniques or measurement tactics... It has to do genuine communication, correct information ethical practices. This, in turn, will help you enhance your brand image and customer satisfaction while also helping you establish a long-term relationship with your customers (Veltri et al., 2023).

2.3. Blockchain Technology Application in Digital Marketing

Today, much of our daily activities have been perfected through digital advancement, making it nearly impossible to progress without utilizing internet marketing. In recent years, blockchain technology has made revolutionary changes in marketing strategies. Operating outside a single point of failure has written blockchain into numerous pages of digital marketing, presenting it in an infrastructure that securely enables transactions with full transparency (Rejeb et al., 2020). Blockchain technology provides a number of key benefits that are invaluable when it comes to data performance and transparency in the online ad business. By using blockchain technology, it can make the data absolutely solid and safe for use in digital marketing strategies. Blockchain technology Verification systems, if implemented in the industry can scale down some common problems such as Ad fraud and click fraud. This guarantees advertisers and marketers that their campaigns are reaching a human audience (Rabby, et al, 2022). Moreover, the consumer data being stored in the blockchain secures

personal information from theft and gives companies a leg up on regulations like General Data Protection Regulation (GDPR).

When it comes to digital advertising, blockchain has a profound impact on the way trust is built within this industry. When people started realizing the value of data privacy and security, Blockchain technology was seen as a means to increase consumer confidence in keeping transparent records that can be traced back. One of the stand-out use cases in terms of blockchain solutions is when managing loyalty programs as consumers need to know that their points and rewards are managed from a fair place using secure ways. Aside from protecting brand reputations, blockchain can be used to detect fake goods and help meet the needs of product traceability along with the supply chain. As a result, consumers can buy with confidence and in the knowledge that they are buying genuine products (Jain et al., 2021). A seamless, end-to-end solution to better control and visibility of ad spend is provided by blockchain technology in the digital marketing landscape. In contrast to conventional advertising models that generally have poor visibility about fund distribution, with blockchain technology advertisers can get real-time access to their spending and know every single allocation they made. This heightened awareness results in more targeted and rational spending of advertising dollars (Liu Y., 2022). Additionally, the use of smart contracts makes automated and trustless payments between advertising publishers and content producers possible which leads to a fairer ecosystem in digital marketing (Rejeb et al., 2020).

2.4. Adaptation of Blockchain-Based Programs to Digital Marketing Strategies

Implementing blockchain-based technologies alongside a direct digital marketing strategy can lead to a significant transformation in your entire digital advertising operations. This change will have substantial implications for transparency, security, and efficiency, including trust in areas such as buying, selling, and data exchange within the online marketplace. In the system sector, this transformation is sustained with scholarly initiatives that scrutinize and define information on how blockchain technologies could be integrated with commerce as a significant portion of marketing practice. Deep dive into the basics of blockchain to research how this distributed and immutable ledger technology records, verifies data accuracy & is integrated with smart contracts for transaction automation (Rabby, et al, 2022). Researchers investigate how using a blockchain-based system would affect essential marketing performance measures, i.e., advertising effectiveness as well as customer engagement by

conducting empirical studies in terms of case studies, experimental simulations, or real-world decisions. Scholarly research also elaborates on the intricate aspects that come with incorporating blockchain technology into digital marketing strategies. Realizing such has implications with regard to organizational readiness, regulations, and technology barriers that impact adoption (Wang et al., 2022).

Academic research can help inform business professionals and policymakers in understanding the benefits, challenges & opportunities associated with the marketing-oriented adoption of blockchain. Thus, this has led to emergent marketing strategies in the digital era. Therefore, by turning theoretical understanding into practical strategies, academic work regarding the implementation of blockchain in marketing will not only improve our scholarly comprehension towards this topic but also promotes innovation and transformation to modern-day digital landscape (Rejeb et al., 2020). Smart contracts that can be taught using blockchain technology and automatically executed. Save Time Companies and Do Fast Work Delivery Process in ads Campaign also on-time payment. Loyalty and reward systems can be tokenized, as well - something that is rather important to maintain customer engagement in the long run. They increase customer engagement by giving it back to a digital token or cryptocurrency which makes the client loyal (Handayani et al., 2023).

However, there are several impediments to fit together Blockchain technology with your marketing strategy. A Digital Transformation can include the digitalization of the physical artifacts and processes of a company or an organization -as part of their broader & complex agent devices also goals, but it too has legal constraints (e.g., security measures) that must be legally regulated up with related questions tiers at governance there -the Digital Highway. Therefore, it is necessary to reconsider these barriers in the business models implementing blockchain marketing solutions and launch plans ahead (Nalbant & Aydın, 2023). Blockchain Technology is making a huge revolution in Digital Marketing Strategies. Businesses that harness and manage this technology effectively are now gaining a competitive edge in the market by fully customizing their customer experience.

2.5. Main Usage Areas of Blockchain Systematics of Digital Marketing

Transparency, security, and data integrity are all areas where blockchain technology can revolutionize digital marketing. It refuses to have any borders and can be found among many dimensions fighting ad fraud, moving towards user identity decentralization, or enabling secure data-sharing between businesses (like in this case study) as well as automating advertising

campaigns with the use of smart contracts. Blockchain also makes it easy for the brand to receive user reviews, which is one of the biggest challenges in current digital marketing and a win-win, since brands can treat these as an asset - even tokens that gather value as more people review them. Enterprises that are building these applications underscore blockchain's ability to help drive more transparency, trust, and data control in the digital marketing ad-tech space (Rejeb et al., 2020).

2.5.1. Defi Usage Areas

The DeFi (Decentralized Finance) ecosystem is a dynamic and transformative domain that comprises eight interconnected components: Compliance and Identity, Marketplaces and Liquidity, Asset Tokenization, Wallet and Asset Management, Payments, Lending, Prediction Markets, and Stablecoins. Each of these elements plays a pivotal role in reshaping the traditional financial landscape, offering decentralized, transparent, and innovative alternatives to conventional systems (Werner et al., 2022). Compliance and Identity ensure regulatory adherence and verification of user identities within the decentralized framework, balancing security and privacy. Marketplaces and Liquidity facilitate seamless trading and asset exchanges, fostering accessibility and efficiency. Asset Tokenization converts tangible assets into digital tokens, enabling fractional ownership and broader market participation (Jensen et al., 2021). Meanwhile, Wallet and Asset Management tools empower users with secure, user-friendly solutions to store and manage their digital assets. Payments simplify cross-border transactions, offering speed and cost-effectiveness, while Lending platforms disrupt traditional credit systems by enabling peer-to-peer loans without intermediaries. Prediction Markets leverage crowd wisdom to forecast outcomes in various sectors, and Stablecoins provide stability in an otherwise volatile cryptocurrency environment, ensuring reliable transactions (Zhou et al., 2021).

Beyond DeFi, blockchain technology is revolutionizing supply chain management. It introduces unparalleled end-to-end visibility and traceability, allowing businesses to monitor goods from their origin to the final consumer. This innovation ensures product authenticity, minimizes fraudulent activities, and builds consumer trust. Furthermore, blockchain enhances logistics and inventory management, offering businesses higher efficiency and greater transparency across operations (Makarov & Schoar, 2022). A cornerstone of this transformation lies in smart contracts—self-executing contracts with terms directly embedded in code. Smart contracts automate business processes, reducing reliance on intermediaries and significantly

cutting transaction costs. These contracts streamline contractual agreements, ensuring rapid, accurate execution without manual intervention, thereby increasing operational efficiency (Werner et al., 2022). In essence, blockchain technology and the DeFi ecosystem collectively represent a paradigm shift, driving efficiency, transparency, and innovation across financial services and supply chain management. As these technologies evolve, they promise to unlock new opportunities for businesses and individuals alike, reshaping traditional structures to better align with the demands of the digital age (Schueffel, 2021).

2.5.2. Transparent Ad Campaigns

Transparent advertising campaigns are those in which ad deals are conducted openly and executed with transparency at every step throughout the supply chain, from media purchases to placement and delivery. These campaigns address long-standing challenges in the digital advertising ecosystem, such as ad fraud, unreliable reporting, and a lack of visibility regarding ad placement. Blockchain technology offers a transformative solution by introducing transparency into every transaction within advertising. Each action is permanently recorded on a decentralized ledger, ensuring that all metrics ad impressions, clicks, and other engagements are verifiable and free from manipulation. This functionality significantly reduces the risk of fraudulent activities, which have historically undermined advertisers' confidence and budgets (Agrawal et al., 2023). By integrating blockchain into advertising campaigns, trust is established among advertisers, publishers, and other stakeholders. This trust stems from the assurance that all parties involved are engaging with a fair and reliable system. Blockchain provides a level of visibility that allows advertisers to track every dollar spent, ensuring that their investments are yielding legitimate results. Additionally, blockchain-based systems simplify the auditing process by offering an immutable record of transactions, enabling advertisers to verify payments, ad placements, and performance metrics in real-time. This transparency not only enhances accountability but also empowers advertisers to optimize their strategies based on reliable data. Furthermore, blockchain's decentralized nature eliminates the reliance on intermediaries, reducing costs and ensuring that more resources are directed toward effective campaign execution rather than being absorbed by middlemen. By fostering openness and fairness, blockchain technology revolutionizes the advertising landscape, creating a new standard for ethical and transparent campaigns. This evolution benefits not only advertisers but also publishers and end-users, who can engage with a more trustworthy and efficient digital advertising ecosystem (Aliahmadi et al., 2022). As a result, the integration of blockchain into

transparent ad campaigns paves the way for a future where trust and efficiency drive advertising success, reinforcing the credibility of the entire industry.

2.5.3. Decentralized Identity Verification

Decentralized identity verification is a transformative approach to authentication and digital identity management, utilizing blockchain technology to eliminate reliance on central nodes or intermediaries. Unlike traditional centralized systems, which require individuals to share sensitive personal information with third-party organizations, decentralized authentication allows users to retain full control over their identity (Tangade et al., 2018). In these systems, users secure their identity on a blockchain and selectively share specific aspects of it with service providers or platforms based on their needs. This ensures that personal information is not overexposed or misused, significantly reducing the risk of identity theft and unauthorized access to sensitive data. The immutability of blockchain further enhances the security of decentralized identity verification by ensuring that credentials are tamper-proof and originate from trusted sources. This feature makes the system inherently more secure and user-centric compared to conventional authentication mechanisms (Liu et al., 2024).

Decentralized identity verification offers numerous advantages over traditional systems. First, it provides individuals with greater autonomy and privacy, as they are no longer required to entrust their data to centralized entities that may be vulnerable to breaches or misuse. By giving users the power to control their identity, blockchain-based systems foster a sense of security and confidence. Additionally, these systems are highly resistant to fraud due to their decentralized nature, which prevents any single point of failure (Sedlmeir et al., 2021). Blockchain ensures that all data is encrypted and stored across a distributed network, making unauthorized alterations virtually impossible. Furthermore, decentralized authentication eliminates the need for intermediaries in identity verification processes, streamlining operations and reducing costs for both users and service providers. For example, a user can authenticate themselves to access online services without the involvement of a third party, enabling faster and more efficient transactions. This also reduces the complexity of compliance with data protection regulations, as sensitive information is stored securely on the blockchain rather than being held by multiple organizations (Avellaneda et al., 2019).

Another critical benefit of decentralized identity verification is its potential to empower underserved populations who lack access to traditional identity verification methods. By leveraging blockchain, individuals can establish and verify their identity using minimal resources, making this technology particularly valuable in regions with limited infrastructure. The flexibility of decentralized systems also supports interoperability, allowing users to access a wide range of services across different platforms without repeatedly verifying their identity (Alsayed et al., 2019). This not only improves user experience but also enhances trust between stakeholders by ensuring that all parties operate within a secure and transparent ecosystem. As blockchain technology continues to evolve, decentralized identity verification is expected to play a pivotal role in shaping the future of digital interactions, offering a robust, efficient, and privacy-focused alternative to traditional authentication methods (Stockburger et al., 2021).

2.5.4. Eliminating Ad Fraud

To focus on eliminating ad fraud, we need to start small and aim to detect deceptive behaviors in the digital advertising space. Minded to boost greater transparency and integrity in the advertising ecosystem using disruptive technologies like blockchain. Ad fraud affects advertisers paying for non-human interactions or invalid activity bot traffic and click intern and impression (Alzghoul et al., 2024). Blockchain technology is a must-utilize weapon in curbing fake ad with its decentralized and immutable ledger capturing every single transaction happening across the advertising supply chain. This makes it incredibly hard for bad actors to manipulate data or commit fraud by recording each ad impression, click or interaction on the blockchain in a secure way. This transparency lets advertisers know the source of their traffic, so they can be sure it is what should have been sent (Kim et al., 2023). Additionally, the use of blockchain technology makes ad inventory transparent and enables advertisers to track where their ads are being placed so that they align with brand values. This increased transparency with enforced accountability and accurate data solution results in a more trustworthy advertising environment that is less subject to fraudulent activities. In the end, both advertisers and publishers decide all this is done for them or hence making it a win-win situation (Kim et al., 2023).

2.5.5. Token-based Incentive Programs

Token incentivization models use tokens to motivate, reward, and represent specific activities or behaviors within a given platform application ecosystem. These are digital assets created on a blockchain and that have various monetary values, such as loyalty points, rewards,

or used within an ecosystem (Cong et al., 2020). One of such applications is the use of token-based incentive schemes in digital marketing and online communities, to encourage users' participation for content creation or targeted interaction. Allowing users to earn tokens with actions they want to be taken (in-app sharing, survey completion, or referrals within the platform). These points can then be exchanged for a variety of benefits like members-only rewards, special discounts, greater premium-level access, or resellable tokens which may serve as other forms of digital or physical assets (Chen et al., 2023). The primary function of blockchain technology is bolstering an unalterable system to ensure transparency, security, and memory for each token transaction. With the aid of smart contracts-self-executing agreements with predefined rules, a certain quantity of tokens based on specified criteria gets automatically dispensed. It makes the reward system much more efficient and reliable by doing this process automatically. Generally speaking, token-based incentive schemes use blockchain technology to reward users for their participation and interaction within digital platforms (Cong et al., 2020).

2.5.6. Verified User Reviews

The verified users include feedback or opinions submitted online by consumers who have had their reviews and/or experiences authenticated using a third-party verification system. In the digital platform, e-commerce and service-oriented websites domain exploiting genuine users' reviews means that we should adopt measures to ensure a certain trust in the reviewer (Li et al., 2017). By using blockchain technology, it is possible to create a decentralized and tamper-proof system that can significantly improve the reliability of user reviews. Peer Review on the Blockchain/blockchains can store user reviews in a secure fashion so as to prevent anyone from changing or re-writing their review. The fact that a review cannot be changed or deleted afterwards is ensured by the decentralized structure of this blockchain. This feature is successful in reducing the danger of fictitious or misleading content consumer feedback, thus improving user review reliability (Ghuli et al., 2017). In building trust with possible consumers, one of the more principal outcomes of verified user reviews is for what they are able. Such transparency provides users the tools to make more educated decisions in their responses around purchasing products or services, as they know that all reviews are being provided by actual customers who have interacted with the product (Christidis & Devetsikiotis, 2016). In essence, verified user reviews harness the potential of blockchain technology to establish a feedback system that is not only more dependable but also transparent, thereby enhancing authenticity and trustworthiness within the area of online reviews (Ghuli et al., 2017).

2.5.7. Applications of Distributed Ledger Technology (DLT)

Distributed Ledger Technology (DLT) has transformed the **financial sector**, particularly through the rise of cryptocurrencies like Bitcoin and Ethereum. It has also revolutionized payments and money transfers by reducing costs and increasing the speed of international transactions (Soltani et al., 2022). In **supply chain management**, DLT enhances traceability, allowing for the comprehensive tracking of products from their point of origin to the final recipient. Additionally, it provides robust anti-fraud measures by verifying the authenticity of goods throughout the supply chain (Soltani et al., 2022). In the **healthcare sector**, DLT ensures the secure and immutable storage and sharing of patient records. It also facilitates the detailed tracking of drug production and distribution, improving transparency and safety within the pharmaceutical supply chain (Soltani et al., 2022). In the field of **law and contracts**, DLT enables the use of smart contracts, which are digital agreements that are automatically executed and enforced without requiring human intervention. These innovations streamline legal and contractual processes, ensuring efficiency and reducing the risk of disputes (Soltani et al., 2022). Overall, DLT offers secure, transparent, and decentralized data management solutions across various industries, despite challenges like scalability and energy consumption. Its ability to surpass traditional systems makes it a pivotal tool for modern applications (Soltani et al., 2022).

2.5.8. Applications of (FBA)

The Federated Byzantine Agreement (FBA) protocol has found significant applications, with Stellar being its leading implementation. Stellar is primarily used for cross-border payments and asset transfers, leveraging the FBA protocol to enable quick transaction settlements at very low costs while ensuring high security (Yoo et al., 2019). Additionally, the FBA protocol plays a critical role in distributed systems, where establishing trust is essential before further operations. Its versatility allows it to support various applications, including financial services, supply chain management, and digital identity verification (Bashir, 2017).

2.5.9. Applications of (PAO)

Proof of Authority (PoA) consensus algorithm is a widely used mechanism in private, permissioned blockchain networks, particularly for enterprise applications, supply chain management, and government-oriented solutions. It is also instrumental in fostering secure and efficient interinstitutional collaborations, enabling organizations to work together with greater

confidence and reliability (De Angelis et al., 2018). PoA operates within a centralized framework where only a select few nodes hold the authority to validate transactions, ensuring streamlined governance and oversight. This structure significantly reduces energy consumption and computational demands compared to other consensus mechanisms. Moreover, PoA delivers faster transaction confirmations and higher throughput, making it an efficient solution for private blockchains and enterprise-specific use cases. Its practical benefits are evident in scenarios where reliability, scalability, and cost-effectiveness are prioritized, showcasing its value in diverse industry applications (Xiao et al., 2020).

2.5.10. Applications of P2P (Peer to Peer)

Peer-to-peer (P2P) network structures play a crucial role in various applications, offering decentralized and efficient solutions across different domains. In the area of cryptocurrencies, P2P networks facilitate the verification and recording of transactions, as seen in Bitcoin and similar digital currencies. These networks enable secure and transparent exchanges without the need for intermediaries. Beyond cryptocurrencies, P2P protocols are widely utilized in distributed computing projects, such as SETI@home, where computational power from multiple participants is aggregated to achieve large-scale data processing tasks. Additionally, P2P protocols like BitTorrent are integral to file-sharing systems, enabling the efficient distribution of large file collections by leveraging the collective resources of users within the network (Tran et al., 2020).

2.6. Systematic Literature Review

Out of the publications in the field of marketing indexed in Web of Science, 55 contain the terms "blockchain" and "trust" in their titles, and these articles were analyzed. A analysis review of 55 articles on Blockchain and Trust in marketing shows how this technology impacts customer trust. Research shows that features like blockchain's decentralised structure, data integrity and transparency are trust builders especially in the digital marketing space. With Blockchain user data is processed securely, records are immutable and transactions are more transparent. This has a positive impact on consumer perception, builds brand trust and reduces the need for intermediaries, reduces transaction costs and builds trust based relationships with customers.

The articles also show that blockchain is directly involved in the processes of building and managing trust in different areas of marketing such as digital advertising, customer relationship management and supply chain. The transparency and security of blockchain

enables long term trust relationships between brands and customers by putting customer interactions on a firmer foundation. In this sense blockchain is not just a technological innovation but a powerful tool to amplify marketing strategies. Table is below:

Table 4: Analysis of articles on blockchain and trust in Web of Sciences. / Finance And Economy Sector

Article Title	Topic	Method	Sector	Results
Circle Of Trust: a high volume, energy efficient, stake blind and high attack tolerant Blockchain Consensus Protocol (Ravindral Rahul, 2019)	Blockchain & Consensus Protocols	Trust score system, Hierarchical network, Transaction tunneling	Cryptocurrency and Finance	The proposed "Circle of Trust" consensus protocol addresses high transaction volumes, energy efficiency, and attack tolerance without favoring wealthy miners. Using a trust score system to reward reliable miners, it scales with transaction volume and aims to resolve issues common in popular cryptocurrencies.
Trust, reputation and ambiguous freedoms: financial institutions and subversive libertarians navigating blockchain, markets, and regulation (Faria Ines, 2019)	Blockchain & Finance	Socio-technical analysis, Interviews, Observations	Finance and Cryptocurrency	Blockchain technology impacts trust and reputation-building processes between financial institutions and alternative communities. This technology offers new ways of creating value by balancing decentralized governance and market regulations.
Trust in Blockchain Cryptocurrency Ecosystem. (Ur Rehman, M. H., Salah, K., Damiani, E., & Svetinovic, D., 2020)	Blockchain & Cryptocurrency	Risk analysis and comparative analysis of cryptocurrencies	Cryptocurrency sector	Key trust issues include security, transparency, governance, and economic risks in cryptocurrencies. Recommendations for mitigating these issues through regulatory and security enhancements.
Blockchain Architecture for Auditing	Blockchain & Auditing	Blockchain-Based Auditing	Finance and Accounting	Examined the potential of FutureAB, a blockchain-based

Automation and Trust Building in Public Markets (Cao, S., Cong, L. W., Han, M., Hou, Q., & Yang, B., 2020)		Automation and Trust Building		platform, to automate auditing processes and build trust in public markets.
Can Bitcoin be Trusted? Quantifying the Economic Value of Blockchain Transactions (Cole, B. M., Dyhrberg, A. H., Foley, S., & Svec, J., 2022)	Blockchain & Cryptocurrency	Transaction Identification Methodology (TIM), Algorithms	Cryptocurrency Markets	Bitcoin's transaction volume is inflated 8 times, real transaction costs are 3-7 times higher, and wallet numbers are exaggerated. TIM provides a more accurate representation by separating economic value from security value.
Assessing citizens' behavior towards blockchain cryptocurrency adoption in the Mano River Union States: Mediation, moderation role of trust and ethical issues (Koroma, Jonathan, et al., 2022)	Blockchain & Cryptocurrency	Mediation, Moderation Role of Trust and Ethical Issues	Cryptocurrency and Digital Finance	The study evaluated citizens' behavior in adopting blockchain cryptocurrency, focusing on trust as a mediator and ethical issues as a moderator. Findings indicate that technology commitment and blockchain transparency positively influence adoption behavior.
Designing for Trust in Blockchain Platforms (Zavolokina, Liudmila, Noah Zani, and Gerhard Schwabe., 2023)	Blockchain & Trust	Design Science Research	Blockchain Platforms	Proposed design elements to enhance user trust in blockchain platforms.
Facilitating interorganizational trust in strategic alliances by leveraging blockchain-based systems: Case studies of two	Blockchain & Banking	Case Studies, Affordance theory	Banking & Finance	Investigated how blockchain technology's technical features facilitate collaboration and build trust at data and process levels. Case studies of two eastern banks

eastern banks (Chen, Renee Rui, Kun Chen, and Carol XJ Ou., 2023)				showed that blockchain enhances reliability and facilitates collaboration.
Building Trust Takes Time: Limits to Arbitrage for Blockchain-Based Assets (Hautsch, N., Scheuch, C., & Voigt, S., 2024)	Blockchain & Finance	Blockchain-based algorithm (PDBFT), Bitcoin network and order book data	Financial Markets (Cryptocurrencies)	Demonstrated the need for reliable consensus protocols in blockchain-based trading, but these protocols increase arbitrage costs due to their time-consuming nature.
The role of fintech startups and big banks in shaping trust expectations from blockchain use in mainstream financial markets (Kaniadakis, Antonios, and Paige Foster. 2024)	Blockchain & Financial Trust	Qualitative case studies, Ethnographic methods, Semi-structured interviews	Finance and Banking	The study explored how fintech startups and large banks influence trust in blockchain use, showing that blockchain's transparency and immutability must adapt to big banks' requirements. Fintechs drive blockchain adoption by introducing innovations and leveraging big banks' resources.
Blockchain-enabled auction for cloud resource provisioning: a survey on trust and economy (Singhal, R., Sharma, V., Singhal, I., & Bansal, V., 2024)	Blockchain & Cloud Resource Provisioning	Literature review, Comparative analysis	Cloud Computing and Economy	The study explored blockchain's role in auction models for cloud resource provisioning, highlighting its ability to enhance transparency, trust, and economic efficiency. It also examined how blockchain can improve security and trust in centralized auction systems.

Table 5: Data Security and Network Technologies Sector

Article Title	Topic	Method	Sector	Results
The Issue of User Trust in	Blockchain & Trust	Qualitative analysis,	Decentralized systems	Examined trust factors in decentralized

Decentralized Applications Running on Blockchain Platforms (Bracamonte, V., & Okada, H., 2017)		Website content analysis		applications on blockchain platforms. Found inconsistencies in definitions of decentralization, trustlessness, and autonomy. Proposed future research directions to clarify these concepts.
Trusted Registration, Negotiation, and Service Evaluation in Multi-Agent Systems throughout the Blockchain Technology (Calvaresi, D., Dubovitskaya, A., Retaggi, D., Dragoni, A. F., & Schumacher, M., 2018)	Blockchain & Multi-Agent Systems (MAS)	System design, Implementation, Smart contracts	Distributed Systems and Data Security	The proposed system integrates multi-agent systems (MAS) with blockchain technology to ensure reliable and transparent processes in agent identity management, service registration, negotiation, and evaluation. Tested across various scenarios, it offers a robust foundation for secure interactions and agent reputation assessment.
BDTF: A Blockchain-Based Data Trading Framework with Trusted Execution Environment (Su, Guoxiong, et al., 2020)	Blockchain & Data Trading	Blockchain, Trusted Execution Environment (TEE), Intel SGX, Ethereum	Data Trading	Proposed a decentralized, trusted data trading platform using blockchain and TEE. This platform ensures fair data exchange between buyers and sellers, eliminating risks caused by centralized platforms.
PoolCoin: Toward a distributed trust model for miners' reputation management in blockchain (Kaci, A., & Rachedi, A., 2020)	Blockchain & Miner Trust	Distributed trust model, Job market signaling model	Blockchain and Mining	The proposed PoolCoin blockchain system introduces a trust model to manage miner reputation, ensuring that only reliable miners participate by excluding malicious ones and optimizing performance for honesty within mining pools.

Achieving Intelligent Trust-Layer for Internet-of-Things via Self-Redactable Blockchain (Huang, Ke, et al., 2020)	Blockchain & IoT Security	Revocable chameleon hash (RCH), Self-redactable blockchain (SRB)	IoT and Big Data	An intelligent trust layer for IoT using self-redactable blockchain (SRB) was proposed, allowing automatic error correction with temporary trapdoors. Experiments demonstrated that this system is secure and efficient for IoT applications.
Tunneling Trust Into the Blockchain: A Merkle Based Proof System for Structured Documents (Bruschi, F., Rana, V., Pagani, A., & Sciuto, D., 2021)	Blockchain & Smart Contracts	Merkle tree-based proof system, XML-Merkle tree	Blockchain and Smart Contracts	Proposed a proof system for structured documents using Merkle trees. This system creates compact proofs about the content of web documents and allows these proofs to be efficiently verified on-chain by smart contracts.
Blockchain-Based Trust Auction for Dynamic Virtual Machine Provisioning and Allocation in Clouds (Xu, H., Liu, W., & Liu, X., 2021)	Blockchain & Cloud Computing	Smart contracts, Data encryption, Auction mechanism	Wireless Communications & Mobile Computing	The effects of a Blockchain-based system on establishing trust in dynamic virtual machine provisioning and allocation in cloud computing are studied. The feasibility of the Hyperledger Fabric-based prototype system is proven with experimental results.
Design, Implementation, and Evaluation of Blockchain-Based Trusted Achievement Record System for Students in Higher Education (Awaji, B., & Solaiman, E., 2022)	Blockchain & Education	System design, Smart contracts, Usability testing	Higher Education and Academic Records	A blockchain-based achievement record system was proposed to reliably verify students' academic achievements and certificates. The system is user-friendly and efficient, showing notable improvements in usability, performance, and cost compared to existing methods.
Testing and Substantiation of	Blockchain & Data Security	Zero Trust Model,	Information Security	The proposed approach uses blockchain to

Zero Trust Devices with Blockchain Procedures for Secured Data Transfer Approach (Selvarajan, Shitharth, et al., 2024)		Blockchain, Mathematical modeling	and Networks	verify zero trust devices, blocking unauthorized users and ensuring data integrity during transfer. Tested across five scenarios, it demonstrated 78% greater effectiveness than existing methods.
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Table 6: E-Commerce and Retail Sector

Article Title	Topic	Method	Sector	Results
Trading Real-World Assets on Blockchain: An Application of Trust-Free Transaction Systems in the Market for Lemons (Notheisen, B., Cholewa, J. B., & Shanmugam, A. P., 2017)	Blockchain & Trade	Design Science Research and Applied Study	Second-Hand Car Market	Blockchain ensures secure and transparent trading of vehicles. It reduces information asymmetry and lowers transaction risk.
Document Verification using Blockchain for Trusted CV Information (Marella, V., & Vijayan, A., 2020)	Blockchain & Document Verification	Design Science Research Methodology	Human Resources and Recruitment	Using blockchain for CV information verification reduces costs, saves time, and makes the recruitment process more efficient.
Trusted Systems of Records Based on Blockchain Technology: A Prototype for Mileage Storing in the Automotive Industry (Preikschat, Katarina, et al., 2021)	Blockchain & Automotive	Prototype Development , Smart Contracts, IoT	Automotive (Second-Hand Car Market)	Blockchain reduces mileage fraud. It provides a reliable, transparent, and decentralized record system. However, there are limitations such as scalability and transaction costs.

A Novel Auction Blockchain System with Price Recommendation and Trusted Execution Environment (Shih, Dong-Her, et al., 2021)	Blockchain & Online Auction	Smart contracts, \u000B-Sutte Indicator, Intel SGX technology	E-Commerce and Auction	The proposed system uses Intel SGX (Software Guard Extensions) and blockchain to offer price recommendations and secure transactions in online auctions, reducing information uncertainty and mitigating the winner's curse via smart contracts. Tests revealed that the recommended pricing significantly influenced top bids.
Blockchain as a resource for building trust in pre-owned goods' marketing: a case of automobile industry in an emerging economy (Nigam, Achint, et al., 2022)	Blockchain & Automotive	Qualitative Analysis (Focus Group Discussions and Personal Interviews)	Second-Hand Car Market	Blockchain can increase customer trust and improve marketing performance by reducing information asymmetry. However, adoption may involve technical challenges and costs.
Increasing Trust and Value of Mobile Advertising in Retailing: A Survey Design, Machine Learning Approach, and Blockchain in the Trust Path (Hajian, Ava, et al., 2024)	Blockchain & Mobile Advertising	Survey Design, Machine Learning, Text Analysis	Retail (Mobile Advertising)	Blockchain and cybersecurity enhance trust in mobile advertising. Mobile learning increases the value of ads, strengthening purchase intent.
Enhancing enterprises trust mechanism through integrating blockchain technology into e-commerce platform for	Blockchain & E-Commerce	Proof-of-Authority (PoA) consensus mechanism, Pseudorandom number generator (PRNG),	Small and Medium-Sized Enterprises (SMEs) and E-Commerce	The proposed model integrates blockchain into e-commerce platforms for SMEs, enhancing security with an energy-efficient Proof-of-Authority (PoA) consensus mechanism. Using a

SMEs (Asaithambi, Sasikumar, et al., 2024)		Accumulated validators number (AVN)		pseudorandom number generator and accumulated validator count, the system saves energy and improves transaction security.
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Table 7: Energy and Environment Sector

Article Title	Topic	Method	Sector	Results
A Secured and Trusted Demand Response System Based on Blockchain Technologies (Tsolakis, Apostolos C., et al., 2018)	Blockchain & Energy	Theoretical Review and Applied Study	Energy Management (Demand Response)	Blockchain enhances security and reliability in demand response systems. It monitors energy data and ensures secure and transparent transactions.
Trusted Transactions in Micro-Grid Based on Blockchain (Yu, Yunjun, et al., 2019)	Blockchain & Microgrid	Hierarchical Bidding and Transaction Structure (HBTS)	Energy sector, particularly renewable energy and local electricity markets	The proposed HBTS model improves the transaction security and efficiency in micro-grid P2P trading by using a bidding strategy based on Bayesian probability and Hyperledger Fabric's blockchain security mechanisms.
A trusted energy trading framework by marrying blockchain and optimization (Chen, Sijie, et al., 2021)	Blockchain & Energy Trading	Distributed Optimization and Blockchain	Energy	Proposed a framework for secure energy trading by combining blockchain and distributed optimization.
A trusted peer-to-peer market of joint energy and reserve based on blockchain (Ping, Jian, et al., 2023)	Blockchain & Energy Trading	Blockchain-based algorithm (PDBFT), Numerical Simulation	Energy Sector (Electricity Markets)	Proposed a blockchain-based trading mechanism for energy and reserve, improving efficiency and trust in the peer-to-peer market. Reduced market costs by 16.03%.
Towards efficient privacy and trust in decentralized	Blockchain & Renewable Energy	Qualitative Analysis and	Renewable Energy and P2P Trading	A decentralized P2P energy trading marketplace was

blockchain-based peer-to-peer renewable energy Marketplace (Tkachuk, R. V., et al., 2023)		Performance Evaluation		developed using Hyperledger Fabric, providing secure, transparent transactions and protecting user privacy. Performance tests indicated high transaction capacity with low latency.
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Table 8: Unmanned Vehicles and Internet of Things (IoT) Sector

Article Title	Topic	Method	Sector	Results
Using Blockchain Technology to Build Trust in Sharing LoRaWAN IoT (Lin, J., Shen, Z., & Miao, C., 2017)	Blockchain & IoT	Blockchain integration, Architecture design	IoT and Network Technologies	Ensured reliable and decentralized structure of LoRaWAN networks using blockchain technology. This method enhances security and integrity in data transmission while reinforcing trust in network operators.
Pinocchio: A Blockchain-Based Algorithm for Sensor Fault Tolerance in Low Trust Environment (Zeng, Chen, et al., 2020)	Blockchain & Sensor Networks	Blockchain algorithm, Fault tolerance, Experimental validation	IoT and Sensor Networks	The blockchain-based Pinocchio algorithm enhances fault tolerance in sensor networks and protects against data manipulation in low-trust environments. The Geppetto algorithm optimizes resource consumption through hash power control.
Trust-based Gateway Selection in a Multi-Tiers Blockchain Architecture (Bachi, Y., Rachedi, A., & Menacer, D. E., 2021)	Blockchain & Security	Distributed Trust Model and 2-Stage Selection Algorithm	Blockchain Architecture and IoT	The trust model evaluates node behaviors and performances to select the gateway node. This model encourages node cooperation and penalizes malicious behaviors.
Blockchain-Empowered Trusted Networking for	Blockchain & UAV Networks	Max-min routing algorithm, DBFT	Unmanned Aerial Vehicles (UAV)	Examined the impact of a blockchain-based system on secure and reliable networking in

Unmanned Aerial Vehicles in the B5G Era (Jian, Xin, et al., 2021)		consensus mechanism		UAV networks. Proposed a three-dimensional connection time and multi-point relay-based DBFT consensus mechanism.
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Table 9: Real Estate and Construction Sector

Article Title	Topic	Method		Sector	Results
Trust in a viable real estate economy with disruption and blockchain (Veuger, J. 2018)	Blockchain & Real Estate	Interviews, Exploratory Conversations, Peer Review		Real Estate	Examined the potential of blockchain technology to enhance trust, transparency, and efficiency in the real estate sector.
Reducing Information Asymmetry and Building Trust in Projects Using Blockchain Technology (Cerić, A. 2021)	Blockchain & Construction	Theoretical Review and Applied Study		Construction Projects	Blockchain technology reduces information asymmetry and builds trust in construction projects. It ensures all project participants have access to information, thus establishing more reliable relationships.
Blockchain-based digitization of land record through trust value-based consensus algorithm (Yadav, A. S., & Kushwaha, D. S. 2021)	Blockchain & Land Records	Trust value-based consensus algorithm, IPFS		Real Estate and Land Management	Examined the impact of a blockchain-based system on the digitization of land records and prevention of fraudulent activities using a trust value-based consensus algorithm. The proposed consensus algorithm reduces message exchange load by 50%, resulting in faster and more efficient transaction processing.
Rebuilding Trust in the Construction Industry: A Blockchain-Based	Blockchain & Construction	Design Science Research and Applied Study		Construction Management	Blockchain rebuilds trust in the construction sector. It enhances trust through distributed ledgers, smart contracts, and transparency.

Deployment Framework (Lu, W., Wu, L., & Zhao, R. 2023)					
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Table 10: Digital Marketing and Advertising Sector

Article Title	Topic	Method	Sector	Results
Enhancing the Retailer Gift Card via Blockchain: Trusted Resale and More (Lu, Y., Tang, Q., & Wang, G. 2021)	Blockchain & Retail	Theoretical Review and Applied Study	Marketing and Retail (Gift Cards)	Blockchain technology enhances the reliability and functionality of gift cards. It ensures trusted resale of unwanted cards, keeps card balances confidential, and increases retailer transparency through external audits. This system requires minimal changes to the existing gift card infrastructure and allows users to use their cards securely.
Marketing without trust? – Blockchain technologies in the sharing economy as assemblage and pharmakon (Haynes, P., & Hietanen, J. 2023)	Blockchain & Sharing Economy	Philosophical Analysis and Critical Perspective	Marketing and Sharing Economy	Blockchain technologies have the potential to revolutionize the sharing economy by eliminating hierarchical structures in marketing. However, they transform trust from a social element to a technological protocol.
Trust in blockchain-enabled exchanges: Future directions in blockchain marketing. (Tan, T. M., & Saraniemi, S. 2023)	Blockchain & Trust	Semi-structured interviews with blockchain experts	Marketing, NFTs, Digital Advertising	Blockchain offers three unique features that increase trust compared to traditional exchanges: trust with mathematics and cryptography, transparency of information, and verification of digital assets.

Table 11: Health and Data Sharing Sector

Article Title	Topic	Method	Sector	Results
Trust Modeling for Blockchain-based Wearable Data Market (Chowdhury, Mohammad Javed Morshed, et al., 2019)	Blockchain & Wearable Data	Trust Modeling and DREAD (Damage, Reproducibility, Exploitability, Affected-users, Discoverability) Model	Health and Data Sharing	Proposed a trust model and system architecture to enhance trust in a blockchain-based data market.
Trusted and Secure Blockchain-Based Architecture for Internet-of-Medical-Things (Bhattacharjya, Aniruddha, et al., 2022)	Blockchain & IoMT	Blockchain-based architecture, ECDSA, PoW consensus	Health and IoMT	Examined the impact of a blockchain-based system on secure and reliable data communication in IoMT. The feasibility of the proposed architecture was experimentally validated using the MultiChain platform.
Blockchain governance and trust: A multi-sector thematic systematic review and exploration of future research directions (Polcumpally, Arun Teja, et al., 2024)	Blockchain Governance and Trust	Thematic Systematic Review, SALSA technique	Multi-sector (Finance, Health, Academia, Natural Resources)	Blockchain technology enhances transparency and systemic trust, applicable across sectors; advocates for a trust-based governance model; highlights future research gaps.

Table 12: Supply Chain and Logistics Sector

Article Title	Topic	Method	Method	Results
Blockchain technology as an enabler of consumer trust: A text mining literature analysis (da Silva, C. F., & Moro, S., 2021)	Blockchain & Consumer Trust	Text mining, Topic modelling latent Dirichlet allocation (LDA) algorithm	Telematics and Informatics (Various Sectors)	Examined the role of blockchain technology in enhancing consumer trust. Analysis using text mining and topic modeling revealed that important aspects of consumer trust, such as traceability and privacy,

				have not been sufficiently explored.
Designing trust-enabling blockchain systems for the inter-organizational exchange of capacity (Große, Nick, et al., 2024)	Blockchain & Capacity Exchange	Design principles, Experimental evaluation, Design Science Research	Supply Chain and Logistics	Examined the impact of a blockchain-based system on trust-building in inter-organizational capacity exchange. Identified six design principles and tested their impact on trust perception through experiments.
Enhancing trusted synchronization in open production logistics: A platform framework integrating blockchain and digital twin under social manufacturing (Zhang, Zhongfei, et al., 2024)	Blockchain & Production Logistics	Blockchain and Digital Twin-Based Framework	Open Production Logistics	The proposed framework integrates blockchain with digital twin technology to improve trusted synchronization in production logistics. A case study demonstrated enhanced system reliability and reduced operational costs.

Table 13: Smart Manufacturing and Production Sector

Article Title	Topic	Method	Sector	Results
A trust transitivity model of small and medium-sized manufacturing enterprises under blockchain-based supply chain finance (Jiang, Rong, et al., 2022)	Blockchain & Supply Chain Finance	Trust Transitivity Model, Intuitive Fuzzy Set Theory	Small and Medium-Sized Manufacturing Enterprises	A blockchain-based trust transitivity model using electronic payment receipts was proposed to ease financing issues for SMEs by incorporating both direct and indirect trust. The model's validity was confirmed with numerical examples.
Securing Big Data Integrity for Industrial IoT in Smart Manufacturing Based on the Trusted	Blockchain & Smart Manufacturing	Trusted Consortium Blockchain (TCB) Framework	Smart Manufacturing	The proposed TCB framework ensures big data integrity in heterogeneous IIoT networks, offering high transaction efficiency and low latency.

Consortium Blockchain (TCB) (Juma, M., Alattar, F., & Touqan, B., 2023)				Experimental results show TCB outperforms other consortium blockchain frameworks in reliability.
“In the Metaverse We (Mis)trust” Third-Level Digital (In)equality, Social Phobia, Neo-Luddism, and Blockchain/Cryptocurrency Transparency in the Artificial Intelligence-Powered Metaverse (Jin, S. V. 2024)	Blockchain & Metaverse	Third-Level Digital (In)equality, Social Phobia, Neo-Luddism, and Blockchain/Cryptocurrency Transparency	Metaverse and Digital Technologies	Found that digital equality, trust, and blockchain transparency positively impact Metaverse adoption intentions. Identified social phobia and neo-Luddism as significant factors affecting this relationship.

Table 14: Agriculture and Food Sector

Article Title	Topic	Method	Sector	Results
Blockchain-based Farming Activities Tracker for Enhancing Trust in the Community Supported Agriculture Model (Nguyen, D. H., Tuong, N. H., & Pham, H. A., 2020)	Blockchain & Agriculture	System architecture design, Smart contracts	Agriculture and Food Security	A blockchain-based tracking system was proposed to boost consumer trust in community-supported agriculture (CSA). By recording farming logs, this system allows consumers to track product origins, ensuring data integrity and reliable production transparency.
Smart Agricultural Futures Market: Blockchain Technology as a Trust Enabler between Smallholder Farmers and Buyers	Blockchain & Agriculture	Social Capital, Design Science Research (DSR)	Agriculture and Food	Blockchain technology enhances trust between smallholder farmers and buyers, improving the efficiency and reliability of agricultural trade. This approach has the potential to reduce market and financial

(Kumarathunga, M., Calheiros, R. N., & Ginige, A., 2022)				risks while mitigating production risks.
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Table 15: Sports and Entertainment Sector

Article Title	Topic	Method	Sector	Results
Trusted Player Transfer Evaluation for Sport Markets Based on Blockchain and Locality-Sensitive Hashing (Liu, Chao, et al., 2021)	Blockchain & Sports	Blockchain algorithm, Locality-Sensitive Hashing, Experimental validation	Sports and Transfer Market	Ensured reliable and transparent evaluation of player transfers using blockchain and LSH (Locality-Sensitive Hashing). This method protects the confidentiality of transfer fees while guaranteeing fair and legal transfer processes.

2.7. Sectoral Distribution of Blockchain

The analysis indicates that the "Finance and Economy" sector leads in the volume of research publications when compared to other sectors. This predominance can be linked to the early integration of blockchain technology within financial contexts and the area of cryptocurrencies. The substantial focus on finance is further bolstered by continuous innovations, the proliferation of cryptocurrencies, and the expansion of decentralized finance (DeFi) platforms. The inherent benefits of blockchain, including transparency, security, and operational efficiency, have been widely applied in various domains such as financial transactions, accounting frameworks, and digital payment systems. This context elucidates the pronounced academic interest in this particular sector.

In contrast, sectors like "Agriculture and Food" and "Sports and Entertainment" exhibit a lower volume of research activity. This disparity suggests that the application of blockchain technology in these fields is still emerging, with numerous potential uses yet to be thoroughly investigated. For example, in the agriculture and food sector, blockchain could enhance value through improved traceability and transparency in production methods; however, the existing academic discourse in this area is relatively sparse. This scenario underscores the necessity for increased research and empirical studies within these sectors. Exploring the possibilities of blockchain technology in less-studied domains could play a crucial role in facilitating its wider

acceptance and implementation. The table below illustrates various sectors and their subheadings, highlighting the potential applications of blockchain technology.

Table 16: Sectors Classifications of Blockchain

Sector	Subheadings
Finance and Economy	Finance and Cryptocurrency, Financial Markets (Cryptocurrencies), Finance and Accounting, Cryptocurrency and Digital Finance, Banking/Finance, Finance and Banking
Digital Marketing and Advertising	Marketing, Digital Advertising, Marketing and Sharing Economy, Marketing and NFTs, Telematics and Informatics (Various Sectors)
Energy and Environment	Energy Sector (Electricity Markets), Renewable Energy and P2P Trading, Energy Management (Demand Response), Energy
E-Commerce and Retail	Marketing and Retail (Gift Cards), Retail (Mobile Advertising), E-Commerce and Auction, Small and Medium-Sized Enterprises (SMEs) and E-Commerce
Unmanned Vehicles and IoT	IoT and Network Technologies, IoT and Sensor Networks, Unmanned Aerial Vehicles (UAV), IoT and Big Data
Supply Chain and Logistics	Supply Chain and Logistics, Blockchain Platforms, Open Production Logistics
Real Estate and Construction	Real Estate, Real Estate and Land Management, Construction Projects, Construction Management
Data Security and Network Technologies	Distributed Systems and Data Security, Information Security and Networks, Blockchain Architecture and IoT
Health and Data Sharing	Health and Data Sharing, Health and IoMT (Internet of Medical Things), Higher Education and Academic Records

Agriculture and Food	Agriculture and Food, Agriculture and Food Security
Sports and Entertainment	Sports and Transfer Market, Metaverse and Digital Technologies
Smart Manufacturing and Production	Smart Manufacturing, Small and Medium-Sized Manufacturing Enterprises



CHAPTER III: Blockchain Technology in Türkiye

Building on the global applications and trust dynamics of blockchain discussed in the second chapter, this chapter shifts the focus to an examination specific to Türkiye. It begins with an overview of global insights into blockchain in the digital world, followed by an exploration of the historical development and applications of blockchain in Türkiye. Key areas such as government policies, supply chains, and digital marketing are analyzed. Finally, cryptocurrency trends and Türkiye's position in this domain are evaluated. This chapter aims to contextualize blockchain applications in Türkiye within a global framework.

Blockchain technology is gaining increasing attention in Türkiye, aligning with the country's digital transformation strategies. Türkiye has taken significant steps toward exploring the applicability of blockchain in public policies, the financial sector, and various industries. Notable initiatives include blockchain-based digital currency projects and the adoption of this technology by institutions such as the Central Securities Depository (MKK). The government views blockchain as a tool to foster trust, transparency, and accountability and has been working to shape regulations in this field (Usta & Doğantekin, 2024). In Türkiye, blockchain applications are primarily concentrated in financial services, supply chain management, and digital marketing. Additionally, efforts by local governments to test blockchain for applications such as land registry and public services are noteworthy. Similar to global trends, the adoption of blockchain technology in Türkiye aims to enhance trust, improve operational efficiency, and prevent fraud. However, realizing its full potential will require clearer regulatory frameworks and further research into sector-specific applications (Aydoğdu & Meder 2024).

3.1. Blockchain in Digital World: Global Insights

In the digital world, blockchain technology has emerged as a trustworthy platform for facilitating transparent transactions between parties. Originally developed for Bitcoin, blockchain has become a cornerstone of trust in the digital landscape by eliminating the need for intermediaries (Hawlitschek et al., 2020). Blockchain revolutionized the concept of trust in finance with its emergence. With blockchain delivering a permanent record of transactions, fraud is practically removed providing transparency. However, the use of blockchain has not stopped with financial. It can be applied to many industries where trust and transparency are needed, such as supply chain management, healthcare systems, voting systems, etc (Werbach, 2018).

Blockchain technology as a mechanism lets organizations create trust by offering transactions and data that are unalterable to all stakeholders. This can also help strengthen overall operational efficiency, reduce costs, and improve accountability. However, it is important to also view blockchain technology in its implementation as something that comes with a few obstacles itself such as regulatory compliance requirements or the potential issue of standards and frameworks between different public blockchains (Truong et al., 2021). Blockchain technology has lots of potential and that is to change the way we build trust/confirm in this digital economy by providing a decentralized, transparent & un-hackable platform where you can transact data. Technology is likely to take on an even larger role in improving trust within different industries and broader applications globally as it further develops over time (Tan & Saraniemi, 2023).

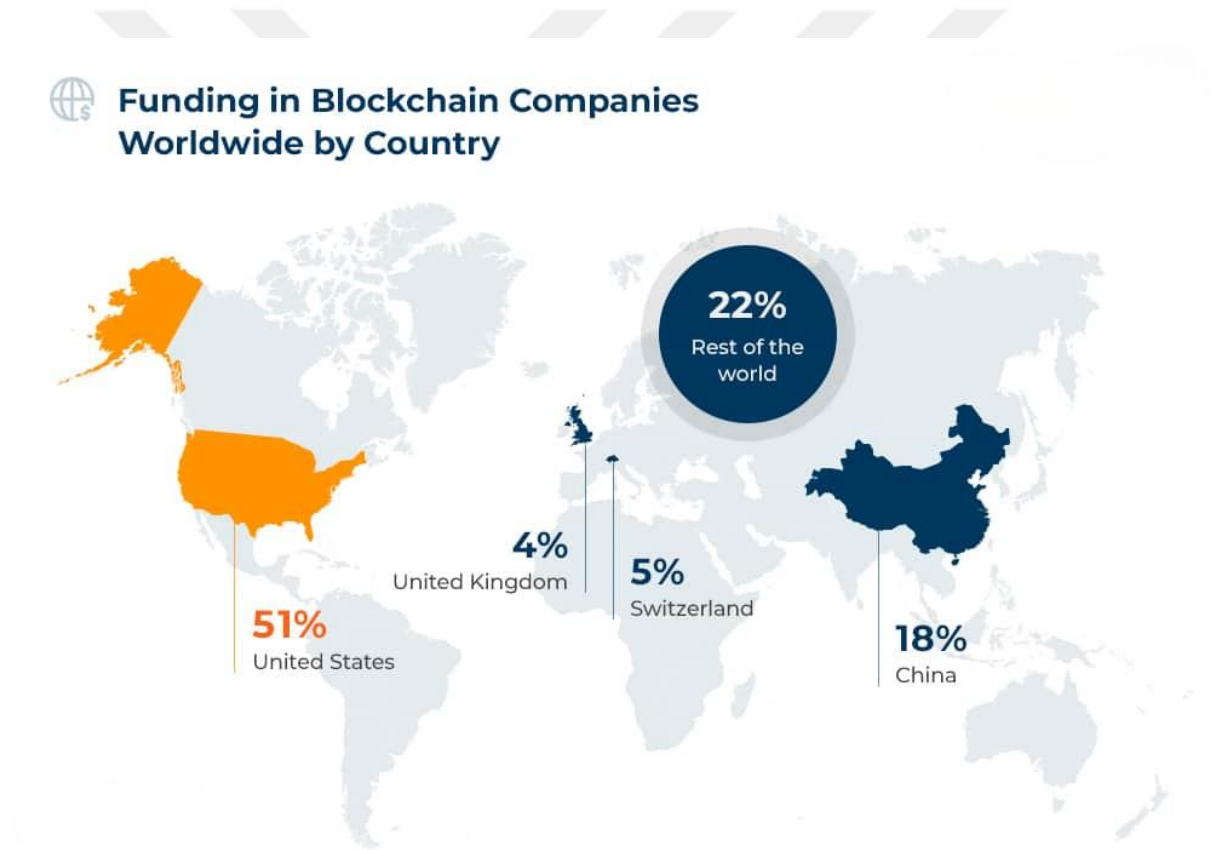


Figure 6: Funding in Blockchain Companies Worldwide by Country (Statista.com)

The **Figure 6** highlights the global distribution of funding in blockchain companies, as per data from Statista. The United States dominates the landscape, accounting for **51%** of total funding, showcasing its leading role in fostering blockchain innovation and adoption. This reflects the country's advanced financial systems, favorable regulatory frameworks, and strong venture capital ecosystem. Following the U.S., **China** captures **18%**, emphasizing its growing

influence in blockchain technology, driven by government-backed initiatives and significant investments in research and development.

Europe's contributions are evident, with **Switzerland** (5%) and the **United Kingdom** (4%) playing notable roles. Switzerland, with its "Crypto Valley," has established itself as a hub for blockchain startups, benefiting from clear regulatory guidelines and supportive policies. Meanwhile, the U.K.'s position underscores its efforts to remain competitive in the digital economy amidst global advancements. The **22%** share labeled as "Rest of the World" signifies the increasing decentralization of blockchain investments, with regions like Southeast Asia, the Middle East, and Africa gradually gaining traction. These regions are leveraging blockchain to address local challenges, particularly in financial inclusion, supply chain transparency, and e-governance. This global funding distribution not only showcases the varied adoption of blockchain technology but also underscores the potential for further geographical diversification as emerging markets continue to integrate blockchain solutions into their economies.

3.2. Blockchain's History and Development in Türkiye

Türkiye's blockchain journey began with Bitcoin and the rise of individual interest in this digital asset. The early 2010s saw individual investment in digital currencies like Bitcoin go wild. The 2017 crypto market boom brought attention to blockchain and crypto assets. In November 2017, the Blockchain Research Laboratory (BCLabs) was founded within the BİLGEM UEKAE Mathematical and Computational Sciences Unit. Its primary objective is to conduct research and development activities focused on the infrastructure, implementation, security and privacy assessments, business models, crowdfunding strategies, and various technical aspects of blockchain technologies, tailored to the requirements of both public and private entities (blokzincir.bilgem.tubitak.gov.tr, 2024). The Interbank Card Center is one of the most important institutions conducting testing studies in the field of blockchain technology in Türkiye. Interbank Card Center is closely interested in blockchain technology and is testing the system in their own center with a blockchain application called "Partridge" under the motto "Bye Bye Cash", abbreviated as BBN. However, this swift growth underscores the necessity for regulatory frameworks (Karahan & Tüfekci., 2019).

Akbank became the first bank in Türkiye to agree with Ripple to use blockchain technology in international money transfers. Akbank launched a pilot study on corporate

payments through its subsidiary Akbank AG operating in Germany in order to speed up international money transfers and reduce costs (Akbank, 2017).

In 2021 Türkiye introduced strict regulations against the dangers of cryptocurrency and blockchain. The Central Bank of the Republic of Türkiye (CBRT) issued the “regulation on prohibition of use of crypto assets in payments” and thus banned the use of cryptocurrency for payment of goods and services (www.tcmb.gov.tr, 2021). This was seen as a way to mitigate the risks of blockchain based monetary assets to the financial system especially on market risk and money laundering concerns (www.bddk.org.tr, 11,2013).

Two notable institutions of such nature are the Presidency Digital Transformation Office and the Information Technologies and Communication Authority (ITCA), both of which realized the potential blockchain technology holds for Türkiye, especially in terms of its potentials to be implemented in non-financial use cases. The strategic note published by the Presidency Digital Transformation Office in 2020 revealing how blockchain can be used in public services and digital governance marked a significant step in this regard and also shared Türkiye's vision on blockchain within the frameworks of public services (T.R. Presidency Strategy and Budget Presidency, Eleventh Development Plan 2019-2023). Likewise, ITCA emphasized how blockchain contributes by increased security and transparency as well as efficiency in both the public and private sectors. In 2021, the authority created a number of research and regulatory proposals regarding blockchain technology and made them available for public review (Can & Akman., 2024).

Digital Turkish Lira Project is one of these infamous projects in which the Central Bank of the Republic of Türkiye (CBRT) illustrates use cases of blockchain technology as a public good with its public initiatives in Türkiye since 2021. Through a pilot study that tests the Digital Turkish Lira based on blockchain infrastructure, the Central Bank of Türkiye (CBRT) is investigating how applicable digital currencies can be used. This initiative is a major step towards facilitating the presence of blockchain technology in finance as a decentralized infrastructure. Testing phases have begun in 2021, and the earliest stage of the Digital Turkish Lira Project with an ending date projected by 2023 (www.tcmb.gov.tr. 2022).

Today, Türkiye is working to improve blockchain and digital financial instruments regulation. To promote the use of blockchain technology in private sector implementation, ranging from banking, supply chain management and digital identities to smart contracts, a number of strategies and incentives are being developed. According to reports, the government

has started working on a legislation and regulatory framework for blockchain technology. Significantly, the Blockchain and Digital Technologies Commission is initiating its operations to establish standards of blockchain suitable for the digital economy (Usta & Doğantekin, 2024). The advancements in blockchain technology indicate its potential for diverse applications across both public and private sectors in Türkiye, contributing to the establishment of a trust-oriented digital infrastructure. Türkiye is focused on incorporating this technology into its financial system and digital transformation initiatives through the formulation of relevant regulations pertaining to blockchain (Usta & Doğantekin, 2024).

3.3. Blockchain Technology Applications in Türkiye

Türkiye has embraced the transformative potential of blockchain technology, aligning itself with a growing global trend. As blockchain gains prominence worldwide, Türkiye is taking significant steps to explore its applications across various sectors. At the core of this adoption lies the concept of trust, which is both a primary driver and one of the most prominent advantages of blockchain technology. By leveraging its decentralized and immutable nature, Türkiye is striving to integrate blockchain into multiple areas to enhance transparency, security, and efficiency.

In the **finance sector**, blockchain is being utilized to foster trust in transactions and improve the efficiency of financial operations. With the adoption of cryptocurrency services and blockchain-based platforms by leading financial institutions such as Garanti BBVA, Türkiye is witnessing a shift toward decentralized financial solutions. These platforms not only reduce reliance on traditional intermediaries but also offer faster, more secure, and cost-effective financial services. Trust plays a pivotal role here, as blockchain ensures that all transactions are verifiable and tamper-proof, significantly reducing the risk of fraud and errors (Usta & Doğantekin, 2024). The **defense industry** is another area where blockchain is making strides. The secure and transparent features of blockchain technology are particularly valuable in defense applications, where the integrity and confidentiality of data are of paramount importance. Blockchain can be utilized to track and manage supply chains, ensuring that critical components and materials are sourced ethically and securely. Furthermore, blockchain's ability to prevent unauthorized access to sensitive information enhances trust within this highly sensitive sector. In the **public and private sectors**, Türkiye is exploring blockchain to improve administrative efficiency and build trust between citizens and institutions. The government is researching blockchain's potential in areas such as customs transactions, land registry

management, and public service delivery. By recording transactions on an immutable ledger, blockchain provides a reliable and transparent framework for public administration, reducing the risks of corruption and inefficiencies. In the private sector, businesses are increasingly recognizing blockchain as a tool to enhance operational efficiency and gain a competitive edge, particularly in supply chain management, logistics, and digital identity verification (Delice et al., 2024). Blockchain technology is also finding applications in **education and healthcare**. In education, Türkiye is exploring blockchain-based systems for open and distance learning, creating secure platforms to store and verify academic credentials. This eliminates the risk of fraudulent certifications and ensures that student records are accessible yet tamper-proof. In healthcare, blockchain is being utilized to securely manage patient data, track pharmaceuticals, and streamline processes such as insurance claims. By establishing a transparent and secure system for data management, blockchain is fostering trust among patients, healthcare providers, and regulatory authorities (Akdağ & Akan, (2017).

As research on blockchain continues to expand in Türkiye, its integration into various sectors demonstrates the country's commitment to innovation and digital transformation. However, it is notable that much of this progress is still in its early stages, and there is significant potential for further development (Gulen & Karaagac, 2024). Notably, the integration of blockchain could address many trust-related challenges in Türkiye, from enhancing financial inclusion to improving transparency in governance. Türkiye's proactive approach to exploring blockchain technology highlights its potential to become a leader in the field. By focusing on trust as a fundamental element, blockchain applications in Türkiye are poised to create a more transparent, efficient, and secure future across industries. As research and implementation progress, Türkiye can further establish itself as a hub for blockchain innovation, contributing to the global advancement of this transformative technology (Erol et al., 2021).

3.3.1. Government Policy

In Türkiye, the use of blockchain technology in public services is oriented towards increasing transparency and improving access to government solutions. Most notably, blockchain is used for digital identity verification and data management which increases the trust of citizens in government services saving time by eliminating bureaucratic procedures (Topcu & Sarıgül., 2020).

The realization of the Blockchain Research Laboratory (BCLabs) to be associated with TÜBİTAK Informatics and Information Security Advanced Technologies Research Center (BİLGEM) in the National Electronics Cryptology Institute, will create an impulse both at public institutions as well as other institution sectors in Türkiye. The laboratory has been set up to work on research and development in different aspects of blockchain technologies such as infrastructure, implementation & installation security analysis; privacy issues, business model evaluation; crowdfunding mechanisms, technical details, etc. The lab collaborates with leading industry experts, to deeper understand the technology landscape and help build tangible skills for developers while looking into technical solutions such as security. In line with these efforts, BİLGEM has hosted two workshops on blockchain technology in 2018 and 2019 respectively (TUBİTAK-BİLGEM.com 2023).

The 11th Development Plan for the period 2019-2023 in Türkiye encompasses additional progress in blockchain applications within the public sector. The plan details investments in necessary hardware and software to establish the blockchain technology infrastructure. Furthermore, infrastructure projects will be completed to incorporate blockchain technology into transportation and customs services. Additionally, there is an emphasis on the implementation of a blockchain-based digital Central Bank currency (T.R. Presidency Strategy and Budget Presidency, Eleventh Development Plan 2019-2023).

In 2019, the Ministry of Commerce established the first official blockchain institution in Türkiye, marking a significant step in integrating blockchain technology into government operations. This initiative underscores the Ministry's intent to stay aligned with technological advancements, especially as the private sector rapidly develops and implements innovative solutions. The primary focus of this agency lies in enhancing export and import practices, reflecting blockchain's potential to revolutionize international trade processes. Furthermore, the Ministry's collaboration with ATEZ, a prominent software technology company, to monitor global blockchain activities and its membership in the Blockchain Türkiye Platform highlight its commitment to leveraging blockchain's advantages (ATEZ Software Technologies, 2020).

The adoption of blockchain technology in government policy presents notable benefits and challenges, as summarized in **Table 17**. On the one hand, blockchain ensures and protects data integrity, provides verification for transparent data generation, reduces costs, and enhances reliability and immutability. These attributes align with the Ministry's objectives to streamline operations and build trust in public services. On the other hand, the implementation faces

restrictions, such as data quality issues due to uncertainties in data origin, challenges related to the lack of a mature technological infrastructure, potential storage limitations over time, and difficulties in updating immutable records. This dual perspective highlights both the transformative potential of blockchain and the need for careful planning and infrastructure development to address its challenges effectively.

Table 17: Advantages and Restrictions of Blockchain Technology Adoption in the Government Policy.

Advantages	Restrictions
Ensuring and protecting data integrity	Data quality issues related to uncertainty of data origin that arises due to data entry
The verification of data generated by each block ensures the desired level of transparency	Implementation challenges arising from the lack of a mature technological infrastructure
Cost reduction	The potential emergence of storage challenges over time
Ensuring Reliability and Immutability	The immutability challenge arising from the difficulty of updating information

The legal infrastructure with regard to blockchain technology in Türkiye is a bit limited. In Türkiye, conversations around blockchain are mostly centered on its use within the financial industry. This focus can be attributed to the fact that blockchain technology is born out of finance, and India has one of the highest numbers in global cryptocurrency adoption. Türkiye is the fourth highest in terms of its population participating with cryptocurrency according to the World Bank (2020), equaled only by Nigeria at 32%, Vietnam and the Philippines are both huge fans as well reaching 20% using cryptocurrencies (Buchholz, 2021). Blockchain technology is economically employed by banks and financial institutions, particularly in the payment system sector and the digital identification confirmation process. Many large banks in Türkiye, such as Garanti BBVA, İş Bankası, and Akbank, employ this technology in their operations for international remittance and trade financing. These institutions are able to perform their financial transactions rapidly, safely, and cost-effectively thanks to blockchain technology (Usta & Doğantekin, 2024).

Blockchain technology has a significant implicit on revising Türkiye's fiscal sector. Since its preface in 2009, it has attracted growing interest from the fiscal community, especially from 2014 onward. This technology enables fiscal deals that are more transparent, secure, and effective, while also reducing costs by dwindling the reliance on interposers (Çaşkurulu &

Arslan, 2021). Türkiye is proactively espousing blockchain operations and is involved in colorful enterprises in this area. For illustration, Turkish banks are exploring innovative results that use blockchain for foreign trade backing deals. also, decentralized finance (DeFi) operations are gaining fashionability in Türkiye, perfecting the effectiveness of services similar to lending, insurance, and payment systems, there are still several specialized and nonsupervisory challenges that need to be overcome for wider relinquishment of this technology (Türkmen & Durbilmez, 2019).

The emergence of cryptocurrencies and global stablecoins used in commercial transactions, which accompany the rapid rise of digital payment mechanisms, central banks have started to work on issuing their own alternative digital currencies by getting involved in this process. In this context, the issuance of Central Bank Digital Currencies (CBDCs), which represent the digital version of fiat money (fiat money), as legal tender has become an important agenda item worldwide. While some central banks are investigating the benefits and costs of CBDC issuance and its design, some have started to develop prototypes within the framework of pilot applications; and some countries have directly implemented it. In parallel with global developments, the Central Bank of the Republic of Türkiye (CBRT) is also working on issuing Digital TL. Digital TL, the electronic form of TL issued by the CBRT, is a currency that will enable payments without using cash and will have a different structure than crypto assets. An important step has been taken in the process that started in 2021; Although there is no clear timetable for its issuance yet, studies continue within the framework of the technological, economic, financial and legal dimensions of the subject (Delice et al., 2024). In conclusion, while blockchain technology offers significant openings for Türkiye's fiscal sector, it requires a careful and strategic approach. As the use of this technology grows, it's anticipated that fiscal services will continue to evolve and enhance (Bozdoğanoglu, 2023).

3.3.2. Supply Chain

The use of blockchain technology in the agricultural and food supply chain in Türkiye is seen as a significant step towards enhancing traceability and transparency of products. The IBM Food Trust blockchain application has been adopted to ensure traceability in the supply chain of agricultural products in Türkiye. This application enables tracking the origin and movements of products throughout the entire supply chain, from producers to consumers, thereby improving food safety and quality control. For instance, in a project conducted in Türkiye, the traceability of agricultural products produced by farmers was ensured through blockchain technology. This project transparently shows the farm of origin, production

conditions, and the processes the products have undergone. Consequently, consumers can verify the source and quality of the products they purchase, while producers can document the reliability and quality of their products (Gulen & Karaagac, 2024). More and more global scale companies such as Koç Holding have started to use blockchain for their supply chains because of the traceability. Also, with the help of blockchain monitoring documents can be made to determine the origins of products reduce counterfeit goods, and increases consumer confidence (Koçdigital. com). The blockchain platform developed using national resources, will be based on the logistics and customs regulations existing within the borders of Türkiye. The consortium will seamlessly connect to the global supply chain after a successful completion of phase one. In addition, this project is a vital step for Türkiye which struggling to the digitalization process and increase its competitiveness in international trade field (Külahlı & Çağlıyan, 2022).

3.3.3. Digital Marketing and Advertising

Digital Marketing and Advertising is one of the essential, fastest-growing industry in Türkiye that holds a great deal at Business. After the boom in digital technologies and the establishment of the internet, business in Türkiye had gain a lot changes on its way with this new era habits of consumption making them to adapt even more market wise using their marketing strategies via online. This includes SEO, Social Media Marketing, Content Marketing, Email Marketing, and Pay-Per-click advertising. SEO is the optimisation of content as well technical elements for enhancing website visibility on search engines, while Social Media Marketing which works towards creating brand recognition and participating with your target markets in networks including Facebook, Instagram, Twitter & LinkedIn (Bala & Verma, 2018). Türkiye has high rates of social media usage, which means your campaigns will be highly effective in terms of promoting products. Content marketing is all about creating and distributing valuable, compelling content to the right audience. Email marketing features tactics for building lasting relationships and driving sales Leads anyone to a method of exchanging direct email messages with leads from prospective or current consumers. Pay-per-click (PPC) advertising uses a fee model in which advertisers pay for individual clicks on their ads, and it is conducted through platforms such as Google Ads or paid social media campaigns (Usta & Doğantekin, 2024).

Digital Marketing & Advertisement Success in Türkiye with Big Data Analytics and Performance Measurements Variety of Analytics: These Analytical tools and software measure the effectiveness that exists with digital campaigns, then develop more (or less) for improving

those areas. Equipped with tools for conversion rates, customer interactions, and sales to keep track of the performance while offering an environment for remodeling sections that could be done better. Big data analytics and Artificial Intelligence applications, Business intelligence Frameworks used in production In Türkiye, it is moving towards enormous steps with customer segmentation and personalized marketing strategies. The priorities for all businesses must be ad fraud, data security, and privacy concerns (Topcu & Sarıgül, 2020). In particular, domestic legislation and the legal context of digital marketing activities defined in standards such as the Personal Data Protection Law (PDPL) govern it. Furthermore, this causes marketers to continuously readjust their strategies on account of the trends in digital platforms and algorithms change almost every month. Focusing on Türkiye, the digital marketing and advertising market is recognized for its rapid growth opportunity thanks to highly modernized approaches (Medeni et al., 2023).

The young and tech-clever population, consequently is aiding in making digital marketing strategies more efficient as well as embracing new technology advancements like no other. Today, as the wave of digital transformation continues to roll through Türkiye and Turkish firms have more creative ways to keeping their competitive edge in Digital Marketing & Advertising thanks to data-driven practices. Therefore, the digital marketing ecosystem in Türkiye is growing and transforming with parallel steps to global trends (Akdağ & Akan, (2017).

3.4. Cryptocurrency Adoption: Türkiye vs. the Global

Indeed, around the world blockchain technology has a significant role in relieving trust problems and enhancing transparency and efficiency in many sectors. The paper also presents a comparative analysis of Türkiye and other regions, in which commonalities as well as differences are identified. Also, that technology the commercial quickly diffusion in Türkiye and worldwide. However, the trust and acceptance of this technology are varied in different countries (Ante et al., 2023). This analysis explores the approaches of selected countries, including Türkiye, towards cryptocurrencies and blockchain, categorizing their attitudes as either "positive," "negative," or "neutral." Illustrated in table 18.

Table 18: Approaches of Selected Countries and International Institutions Towards cryptocurrencies and Blockchain (Akgiray, 2019).

Countries	Blockchain	Cryptocurrency	Their Approach
France	Positive	Neutral	Reports have been prepared for cryptocurrencies and Blockchain applications are supported.
Canada	Positive	Neutral	Reports have been prepared for cryptocurrencies, a special task committee has been established for blockchain, and a site screening system has been established for the security of data.
United Kingdom	Positive	Neutral	Reports have been prepared for cryptocurrencies, a special task committee has been established for blockchain, and a site screening system has been established for the security of data.
Australia	Positive	Neutral	Reports have been prepared for cryptocurrencies, a special task committee has been established for blockchain, and a site screening system has been established for the security of data.
Singapore	Positive	Neutral	Regulations regarding cryptocurrencies have been made. A special task committee for Blockchain has been established.
Japan	Positive	Positive	Reports were prepared for cryptocurrencies, statements were made, and a blockchain special task committee was established.
China	Positive	Negative	Cryptocurrencies are banned. Blockchain special task committee has been established.
India	Positive	Positive	Reports have been prepared for cryptocurrencies. Statements of intent regarding the use of blockchain have been announced.
Russia	Neutral	Negative	Cryptocurrencies are banned. A special task committee for Blockchain has been established.
Middle East and North Africa (MENA)	Positive	Positive	Reports have been prepared for cryptocurrencies. Statements of intent regarding the use of blockchain have been announced.
Türkiye	Positive	Neutral	A special task committee for Blockchain has been established.

Source: (Akgiray, 2019).

As you can see from the above, it is China and Russia that hold a negative attitude about using cryptocurrencies. India, Japan, and Middle East, and North Africa region also key for a favorable sentiment towards cryptocurrency access. This table 18 shows the absence of regulatory action and/or reporting on this matter by countries in this region, denoted as 'neutrality'. By and large, countries/organizations that are ambivalent or against the usage of cryptocurrencies tend to be supportive of blockchain technology. Russia is fallible to this rule due to its own native projects (Akgiray, 2019).

The global adoption of blockchain technology is driven by a variety of applications in industries including supply chain management, financial services and the public sector. Global recognition has been accomplished by platforms and applications such as IBM Food Trust, Ripple, R3 Corda, and Provenance amongst others in regard to the use of blockchain technology as blockchains gain global attention. Blockchain technology has been used for the e-government services of Estonia and Dubai (Auer et al., 2023).

In Türkiye, blockchain technology is still in its infancy but is steadily evolving with applications across various sectors such as financial services, supply chain management, and the public sector. Leading initiatives include Garanti BBVA's launch of a cryptocurrency service and digital assets investment fund, as well as the Istanbul Chamber of Commerce's plans to develop a blockchain-enabled trading platform. Additionally, the Turkish government is actively exploring the use of blockchain technology in areas like customs transactions and land records, demonstrating a growing interest in its adoption (Kocabas et al., 2024).

As detailed in Table 19, the usage and adoption of blockchain technology in Türkiye differ significantly compared to global trends. While blockchain usage worldwide is more common and spans diverse areas such as supply chain, finance, public sector, and other industries, Türkiye's focus is currently limited to finance, supply chain, and public sectors. Notable platforms and applications in Türkiye include Garanti BBVA Crypto and the Istanbul Chamber of Commerce's blockchain platform, while globally recognized platforms like IBM Food Trust, Ripple, R3 Corda, Provenance, and VeChain dominate the landscape. Furthermore, government participation in Türkiye remains in the research phase, whereas many governments worldwide have moved toward active implementation. This comparative analysis underscores

the potential for Türkiye to expand its blockchain initiatives and align more closely with global developments.

Table 19: Comparisons usage area of blockchain technology.

Feature	Türkiye	World
Blockchain Usage	Developing	Common
Usage areas	Finance, Supply Chain, Public	Supply Chain, Finance, Public, Others
Important Platforms and Apps	Garanti BBVA Crypto, Istanbul Chamber of Commerce Platform	IBM Food Trust, Ripple, R3 Corda, Provenance, VeChain
Government Participation	In the Research Phase	Active Use

3.6. Blockchain Applications: Türkiye and the Global

Blockchain technology emerges as an innovative tool that accelerates economic and social transformation among countries; each nation adopts this technology according to its specific needs and objectives, making significant strides toward enhancing transparency, security, and efficiency. This situation highlights how different countries are developing their blockchain applications and the global impact they are creating (Aydoğdu & Meder 2024). The United States, China, Singapore, and Switzerland stand out among the leading countries in blockchain technology applications. The United States has a large blockchain ecosystem and attracts many startups and investors. In contrast, China is advancing rapidly through state-backed initiatives, while Singapore is heavily investing in blockchain research, facilitated by its progressive regulatory framework. Switzerland, often referred to as "Crypto Valley," hosts over 450 blockchain enterprises, benefiting from its permissive policies. Collectively, these nations significantly influence the global adoption and advancement of blockchain technology (Hakkarainen et al., 2024).

Blockchain technology has seen widespread adoption in public services globally, with countries like Estonia and India leading the way. In contrast, Türkiye's applications in this sector are still in the early stages of development. However, Türkiye is actively working to enhance its use of blockchain in various areas, including digital identity verification and health record management, where Estonia and the United States have set benchmarks (Ante et al., 2023). Regarding digital currency, China and India are both making great progress with innovative projects, whereas Türkiye is just in the early stages of investigating similar initiatives. There is a growing global trend toward the use of blockchain technology in supply chain management,

and Türkiye is embracing this innovation to improve operational efficiency and transparency. This pattern represents a growing recognition of blockchain's potential to transform traditional methods (Aydoğdu & Meder 2024). Moreover, blockchain has revolutionized data security and transparency on an international scale. Türkiye is leveraging this innovative technology not only in financial transactions but also in supply chain management. Additionally, the fight against financial crimes has benefited from blockchain advancements, particularly in countries like China. Türkiye is making strides in this area as well, developing projects aimed at combating financial crimes through blockchain solutions (Kocabas et al., 2024).



CHAPTER IV: Future Impacts of Blockchain-Based Programs

4.1. Future Application of Blockchain

Building upon the exploration of blockchain applications in Türkiye presented in Chapter 3, this chapter shifts the focus to the technology's future potential on a broader scale. While Chapter 3 analyzed blockchain's role in sectors such as government policy, supply chain, and digital marketing within Türkiye, Chapter 4 extends this discussion to examine the global and sectoral future of blockchain-based programs. This chapter also investigates the strategic transition processes businesses undergo to adopt blockchain systems and highlights emerging trends and opportunities. By doing so, it provides a comprehensive outlook on how blockchain is expected to shape the dynamics of industries and society in the years to come.

The potential impacts of blockchain technology will not only expand its current application areas but also transform various sectors ranging from business to public services. Existing domains such as finance, healthcare, supply chain management, and identity verification are set to benefit from blockchain's security, transparency, and efficiency. However, the future implications of blockchain technology will extend far beyond these boundaries (Rani et al., 2024).

The same tech can mean an altogether more transparent world across multiple sectors. In a word, that answer is blockchain the uneditable and very much seeable nature of its distributed ledger ensures steep transaction correctness. This is especially useful in areas such as finance, B2B (business-to-business) automation, and health care where cross-company trust matters the most. This is a security advantage of using blockchain since it has decentralized characteristics that allow hackers to have difficulty in their cyber-attacks on this network. Each transaction corresponds to the previous one, and all of these transactions are encrypted in complexity which makes it very difficult for hackers who want to tamper with this chain. This extra layer of security would keep your money from operating the grid, prevent fraud, and verify everything you put in (Lindman et al., 2017). Traditional finance is a dying breed, replaced by the DeFi (Decentralized Finance) platform which has been enhanced exponentially with blockchain technology. Both the assets and investments are owned by an owner (campaigner) In simpler words, DeFi is just a way of performing normal finance-related tasks through decentralized devices and digital currencies. DeFi are platform providing inclusive and efficient financial services to everyone globally. Deeper blockchain-based digital identity solutions can return even more autonomy to individual data sovereignty. These are the systems that ensure

that your Digital Identity is supported and hence security system of this digital environment, through which all other transactions are done digitally too (Alamsyah et al., 2024).

4.2. The Sectoral Future of Blockchain

Blockchain technology is emerging as a transformative force across various sectors, revolutionizing traditional systems by introducing unprecedented levels of transparency, security, and efficiency. Its applications are already reshaping industries such as finance, healthcare, and supply chain management, with future advancements expected to deepen and diversify its impact.

In the financial sector, decentralized finance (DeFi) platforms are leading a paradigm shift by eliminating the need for traditional financial intermediaries. These platforms offer faster transaction processing times and significantly lower costs, democratizing access to financial services. For instance, individuals in underserved regions can now participate in global financial systems without requiring access to conventional banking institutions. Moreover, the integration of blockchain in financial services enhances security through encryption and immutability, reducing the risk of fraud and cyberattacks. Another promising application is digital identity verification, which empowers individuals with control over their personal data. Blockchain-based digital identities ensure that sensitive information is securely stored and accessed only with the user's consent, fostering greater autonomy and privacy in financial transactions (Shoetan & Familoni, (2024).

The healthcare sector is also benefiting from blockchain's potential to address critical challenges such as data security and interoperability. By creating a secure and transparent system for managing patient records, blockchain ensures that medical data remains confidential while allowing authorized parties to access it when necessary. This is particularly valuable in emergency situations where quick access to accurate patient information can save lives (Shinde et al., 2024). Furthermore, blockchain can be utilized to combat counterfeit drugs by enabling end-to-end tracking of pharmaceuticals throughout the supply chain. Each step, from manufacturing to delivery, is recorded on the blockchain, ensuring authenticity and reducing the risks associated with fake medications. Blockchain also opens doors for innovative applications such as smart contracts, which can automate insurance claim processes, making them faster and more efficient for both patients and providers (Al-Nbhany et al., 2024).

In supply chain management, blockchain provides unparalleled traceability and transparency, addressing long-standing issues like counterfeiting, fraud, and inefficiencies. By

recording every transaction and movement of goods on a decentralized ledger, blockchain enables stakeholders to track products from their origin to the final consumer. This capability is particularly valuable in industries like food and pharmaceuticals, where ensuring the authenticity and safety of products is crucial. For example, a consumer could verify the journey of a product, ensuring it adheres to ethical sourcing or quality standards (Oriekhoe et al., 2024). Additionally, blockchain facilitates logistics and inventory management by automating processes through smart contracts. These self-executing contracts can trigger payments, restock orders, or delivery confirmations without the need for manual intervention, thereby reducing operational costs and human error (Duan et al., 2024).

The cross-sectoral integration of blockchain is further bolstered by its ability to foster trust and collaboration among stakeholders. By providing a tamper-proof record of transactions, blockchain eliminates the need for intermediaries, streamlining processes and enabling direct peer-to-peer interactions. This not only increases efficiency but also builds confidence among parties, as all participants can independently verify the data on the blockchain. As blockchain technology continues to mature, its potential applications are expected to expand into new areas such as energy, education, and public administration (Oriekhoe et al., 2024). In the energy sector, for instance, blockchain could facilitate peer-to-peer energy trading, where individuals can directly buy and sell surplus energy. In education, blockchain could revolutionize credential verification, allowing institutions to issue tamper-proof certificates that can be easily validated by employers. Governments could also leverage blockchain to enhance transparency and accountability in public administration, reducing corruption and improving service delivery (Rani et al., 2024).

The blockchain technology is poised to become a cornerstone of digital transformation across industries. Its ability to provide secure, transparent, and efficient solutions addresses long-standing challenges and opens new opportunities for innovation. However, to fully realize its potential, ongoing investment in research, development, and collaboration will be essential. By embracing blockchain, industries can not only optimize their operations but also build a more trustworthy and interconnected global economy.

4.3. Transition Processes of Companies to Blockchain-Based Programs

Typically, the implementation of blockchain-based programs by companies requires a careful and strategic approach (Alam et al., 2021). This complex procedure involves a number of crucial steps, which are generally as follows:

The adoption of blockchain technology begins with spreading awareness about its potential benefits and risks. Managers and employees need to understand how blockchain operates, the challenges it addresses, and the opportunities it presents for their organization's operations. Structured programs or detailed workshops can help provide the necessary education on blockchain. Successful adoption relies heavily on these awareness and education efforts, as they lay the foundation for informed decision-making and strategic integration (Raimundo & Rosário, 2021). Once the awareness phase is complete, it is crucial to conduct a thorough needs assessment to identify business processes and operations that can benefit from blockchain integration. This step involves defining clear objectives, timelines, and success indicators to guide the organization's blockchain strategy. Strategic planning ensures that the adoption process aligns with the organization's goals, creating a well-structured roadmap for implementation (Kaplan et al., 2008).

Choosing the right blockchain technology and platform is another critical step in the adoption process. Organizations must evaluate available platforms and select one that best suits their needs. Collaborating with technology providers and blockchain experts can streamline this process, ensuring a seamless transition and a robust technical foundation for blockchain applications (Seno et al., 2018). Pilot projects play a pivotal role in testing the feasibility and effectiveness of blockchain within an organization. These small-scale initiatives allow businesses to evaluate the benefits, limitations, and relevance of blockchain technology in real-world scenarios. By analyzing the outcomes of pilot projects, organizations can gain valuable insights into how blockchain can enhance their operational processes and address specific challenges (El Khatib et al., 2022).

The successful scaling and integration of blockchain solutions into existing systems require careful planning and resource allocation. Beyond technical challenges, organizations must also focus on change management to ensure a smooth transition. By incorporating blockchain solutions effectively, companies can significantly improve operational efficiency and gain a competitive edge (Dang et al., 2019). Ongoing monitoring and continuous improvement are essential to sustain the effectiveness of blockchain solutions. Regular assessments can help identify performance issues or errors, enabling organizations to refine their approach. Staying updated on the latest advancements in blockchain technology and exploring new opportunities ensures that companies remain competitive and innovative in their

adoption journey. Continuous improvement fosters the long-term sustainability of blockchain systems (Hammoudeh et al., 2019).

The transition from traditional systems to blockchain-structured frameworks is not just a technological shift but a strategic process that requires meticulous planning and execution. By embracing blockchain technology, companies can enhance security, transparency, and operational efficiency, ultimately achieving a significant competitive advantage. However, success in this endeavor demands a strategic approach, supported by education, robust planning, and a commitment to continuous improvement. The successful adoption of blockchain technology requires a holistic approach, beginning with building awareness and education, followed by strategic needs assessment, careful technology selection, and collaborative efforts. Pilot projects serve as a testing ground to evaluate the practicality of blockchain in real-world scenarios, while integration and scaling ensure the seamless incorporation of blockchain solutions into existing systems. Continuous monitoring and improvement further enhance the effectiveness and sustainability of blockchain applications. By addressing each of these phases strategically, organizations can unlock the transformative potential of blockchain technology, achieving greater transparency, efficiency, and competitiveness in a rapidly evolving digital landscape.

CHAPTER V: Discussion and Conclusion

This chapter synthesizes the findings from previous chapters, drawing connections between the theoretical and practical applications of blockchain technology. While Chapter IV explored the potential future impacts of blockchain, this final chapter reflects on these insights, critically analyzing their implications for trust-building, digital marketing strategies, and sectoral advancements. The discussion focuses on the broader implications of blockchain adoption, addressing both its challenges and transformative potential. Finally, this chapter presents key conclusions, offering recommendations for researchers, policymakers, and industry stakeholders, and outlining avenues for future research to further explore the untapped potential of blockchain technology.

The application of blockchain technology, which has been successful in many areas around the world and Türkiye draws great attention. This technology has been implemented by both domestic and international companies with success. A combination of security, transparency, and efficiency offered by blockchain has made it one of the fastest-growing technologies. New use cases in different industries have unfolded which suggests its transformative capacity. Blockchain technology changed the transactional and record-keeping protocols of many sectors. Due to the technology implemented in blockchain, banking has seen a quicker method of handling money transfers with fewer intermediaries while reducing overall transaction costs. Banks in Türkiye like Garanti BBVA and Akbank have moved to blockchain solutions for international money transfer which has increased their transaction speed while making it more secure. The use of blockchain technology in this process is leading toward more transparent and tamper-proof validation methods, allowing for a safer transition to digitized document management amongst numerous other developments.

Blockchain also helps in the monitoring of products throughout their entire life cycle, creating a significant advantage for Supply Chain Management. Retail companies are using blockchain to track where the product originated and how it is transferred between places so that their customers have trust in the products that they claim. Tracking products all the way back to where they are sourced is not only vital for quality control but also a requirement due to regulatory compliance. The use of blockchain technology has shown a lot that it is more possible and beneficial to many industries than just virtual currency. Secure, Transparent & Efficient Transactions: This trait has provided a lot of businesses who are looking to streamline their operations and earn customer trust. It is thus slated to not only expand further but enforce

betterment across all types of industries around the globe including those within Türkiye where more businesses want in on what can be done with this technology. More instances of blockchain technology being built into existing platforms, alongside new applications allow for this to be seen as a race in how quick individual organizations can adopt them over rivals/competitors to set his or her own standard leading the rapidly evolving economy.

The use of blockchain technology in the public sector makes it easier to make some services faster and safer. In public administration, the application of this technology can make it possible to attain goals such as improving the quality of public services, lowering transaction costs and speeding citizens' access to them; softening inter-institutional conflicts and bureaucratic obstacles; and increasing automation via smart contracts. The government needs to serve more of the population digitally for digital public services to get bigger. However, even as development in infrastructure progresses, efforts to increase digital literacy need equal emphasis. The analysis of the benefits and drawbacks at all stages is invaluable to make a wise decision when implementing blockchain technology, by anchoring it against key criteria such as accountability, transparency efficiency effectiveness, and reliability, particularly in service delivery for the public sector. The more examples of the use of blockchain technology in both public and private services that we have, the stronger will be any predictions concerning its future development. The only concrete advice which one can offer is that governments are actually investing to improve their understanding about this technology, exploring new use cases and running pilots at some of the institutions. In doing so, institutions should utilize the knowledge of internal and external stakeholders to guide them through this process; design a required technical structure in collaboration with these partners; complete their staff training service user-orientated strategies as well, also ensure necessary security precautions are taken against potential risks.

Blockchain technology is a key tool in creating trust and productivity across a host of sectors in Türkiye. Institutions like banks, healthcare companies, large enterprises, and the public sector are setting up processes to drive efficiency while appealing to consumers through blockchain. However, for technology to live up to its promise and potential, there are still areas where developments have yet to be made: regulation; trust in technology; knowledge. In 2018, the creation of the Blockchain Türkiye Platform (BCTP) was another cornerstone development for the wider application of blockchain in the public sector. The most important goal of this platform is to position, in terms of blockchain technology, Türkiye as a leading country. The BCTP is pivotal in gathering blockchain knowledge, and coordinating multiple events and

training sessions while also generating valuable reports. As BCTP works with private non-profit organizations in cooperation with universities and non-governmental public institutions, it is expected to play a much more influential role in the adoption of blockchain technology throughout Türkiye. Developing a sound regulatory framework will be instrumental in ensuring blockchain technology is employed in the safest and most effective manner. Further steps in building the necessary trust in blockchain as a technology include education efforts aimed at both companies and customers, teaching them how it can benefit them while explaining how exactly this elusive beast works. In the face of such challenges, public-private partnerships among others and further growing expertise in blockchain are a must.

Türkiye has shared the mission to find a balance between innovation, regulation, and security when it comes to blockchain technologies. As the blockchain ecosystem evolves, trust-building initiatives and informed decision-making processes are critical to success. For instance, the Istanbul Chamber of Commerce is pushing to create a blockchain trading platform that shows just how quickly different industries are getting to plot out ways for implementing this tech. The International Conference on Applied Cryptography and Network Security as well as the International Conference Trust (Trustworthy Computing) is highly essential executing more development and research in blockchain technology. Such events provide to identify solutions for academic work, observation of results, and technological progress respectively. For different industries, partnerships are important in the formation of blockchain solutions to become better and more widely adopted. In addition, government backing for blockchain ventures and interest in the advancement of new education programs on it will also bolster Türkiye 's place as a hub for blockchain innovation.

Blockchain technology is on the verge of changing digital marketing as we know it by offering innovative solutions to problems that have long plagued this industry. Blockchain solves this problem as it provides marketers with an easier way to communicate and do deals directly, without hundreds of middlemen. Since the ledger is immutable, blockchain provides a guarantee that data and transactions are legitimate, so marketers can use blockchains to verify that their campaigns/reports are right. Decentralized advertising networks on the blockchain remove intermediaries that stand between advertisers and publishers, lowering costs for advertisements and ensuring fairness in payment to each party. It also helps make data more secure and privacy, by encrypting the information of any given customer in order to spread it out greatly lowering breach risk as well as enhancing compliance with new privacy regulations thanks to this technology. Marketers are able to improve customer engagement and strengthen

brand loyalty by introducing tokenized rewards/loyalty programs. The utilization of smart contracts also helps to automate many campaign management details, providing transparency and accountability for both advertisers when it comes to ad placement, payments and performance tracking. It helps in building trust among consumers who care about where and how their food or product is sourced, as it captures the origin of a supply chain product and its journey details using blockchain-enabled technology. Blockchain technology is yet to reach full potential within the marketing industry but as its adoption grows amongst marketers it will transform digital marketing, bringing benefits such transparency; security and efficiency into both Marketing operations and client/customer interactions.

In all, this is how Blockchain technology has revolutionized the Digital Marketing Industry for better security and transparency. These benefits of protecting data, improving consumer confidence, and reducing advertising costs have led to its continued incorporation into digital marketing strategies. Going forward, the potential of blockchain technology to change digital marketing applications is anticipated but this space will develop even more creative solutions thanks in part to an ever-growing number of users. As a result, an in-depth analysis of the possibilities that blockchain technology holds for digital marketing is poised to give brands and marketers an edge when it comes to staying ahead. As we will see, this means a more secure and transparent marketing ecosystem for businesses as well as their customers - creating an entirely new level of trust in the advertising industry. The improvements to and the utilization of blockchain technology growth in Türkiye, as well as globally means a substantial period for digital marketing is on its approach: advanced strategies that guarantee consumer trust and engagement.

In this study, This section presents a analysis of blockchain's application and its role in fostering trust within various sectors. The research included 61 articles sourced from the Web of Science database, filtered using the keywords "*Blockchain*" and "*Trust*" with a specific focus on the field of *Marketing*. After a thorough review, 55 relevant articles published between 2017 and 2024 were analyzed and categorized systematically. The findings were tabulated and subsequently classified into distinct sectors to provide a comprehensive overview of blockchain's integration into industry-specific applications.

It is noteworthy that sectors like *Finance and Economy* and *Supply Chain and Logistics* dominate the literature, reflecting the significant interest and advancements in these areas. Conversely, sectors such as *Agriculture and Food* and *Sports and Entertainment* have received

comparatively less attention, indicating potential opportunities for future research. Despite blockchain's broad applicability, no studies were identified from a Turkish context within the analyzed articles. This gap highlights the need for further research into blockchain applications in Türkiye, particularly in underrepresented sectors like agriculture, sports, and manufacturing. Such efforts can provide valuable insights into the regional adoption and integration of blockchain technology.

The literature review highlights that while the global application of blockchain technology in marketing has been extensively explored, there is a lack of studies specific to Türkiye. Researchers in Türkiye can contribute significantly to the literature by examining blockchain's impact across various sectors such as marketing, finance, healthcare, and supply chain management. Notably, Türkiye's regulatory policies and local dynamics provide a unique opportunity to advance blockchain applications. Conducting more application-focused research within Türkiye would not only enhance the global literature but also foster innovation in local industries.

Blockchain technology holds the potential to revolutionize not just specific sectors but entire business models. However, this transformation requires meticulous strategic planning, education, and continuous improvement. For countries like Türkiye, adopting blockchain technology in alignment with local needs and global trends offers a promising pathway. Increasing academic and industry-driven studies in Türkiye could be pivotal in expanding the blockchain ecosystem and aligning it with international standards.

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