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BLOCKCHAIN AND THE RISE OF THE KNOWLEDGE ECONOMY

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Abstract

Blockchain is viewed by many as a potentially transformative technology for the economic world. Using blockchain can facilitate the transition towards a knowledge-based economy, which involves creating value using the infinite resources of knowledge and expertise, in other words, developing wealth from an intangible capital or inheritance. Thanks to its properties of immutability, traceability, and timestamping, blockchain technology holds great promise for a better economic future. It offers the potential for a more transparent, smooth, and democratic economic system for all stakeholders involved. This document explores the potential applications of the latest blockchain technology and presents its projected implementation in fields such as commerce, agriculture, and more. It highlights the crucial contributions of blockchain in advancing knowledge economy.

Index Terms: Blockchain, Cryptocurrencies, Digital currencies, Digital identity, Distributed ledger, Knowledge-economy, Payment, Retail, Smart contract, Supply chain.

1. INTRODUCTION

The world is undergoing constant technological evolution, impacting daily lives and business operations. The internet's proliferation has enabled remote coordination of numerous economic activities, including production, export, and agriculture.

Blockchain has the potential to greatly transform the economy, according to numerous experts. It was initially developed in 2008 by an individual or group using the pseudonym Satoshi Nakamoto within the cryptography field.

This technology promises disintermediation, transparency, and reliability, especially during a period of mistrust and dissatisfaction with traditional intermediaries, such as banks. Additionally, this technology has the potential to revolutionize economic systems and the way value is exchanged, significantly transforming various application areas.

Using blockchain technology can facilitate the shift towards a knowledge-based economy, creating value from the limitless resources of knowledge and expertise available wealth generation from intangible heritage or capital. What is the potential impact of this application on the growth of the knowledge economy?

2. BLOCKCHAIN OR DISTRIBUTED LEDGER TECHNOLOGY

Blockchain is a chain of blocks that store information of all types. It is commonly defined as a technology that is transparent, secure, and devoid of a central controlling body used for information storage and transmission.

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Blockchain functions as a kind of distributed ledger, bundling together digital systems that document asset transactions and their details simultaneously in various locations. It represents the most recognized DLT technology today.

A blockchain is a shared, immutable database that facilitates the process of keeping records and tracking these records in a shared environment. Blockchain, thus, is simply a technology that builds a trust worthy service in a not necessarily trustworthy environment. Blockchain is a form of distributed ledger technology (DLT) that allows for secure, transparent and immutable storage of information on a network of interconnected computers called nodes. It is a technology that enables the creation of a digital record of transactions or other types of data, which are recorded in blocks that are chained together in chronological order, hence the name “blockchain” [1].

In a blockchain, each block contains a set of data, such as transactions, records or other types of information. These blocks are linked to each other using cryptography, where the information in one block is referenced by the subsequent block and so on, forming a continuous and sequential chain of blocks [1].

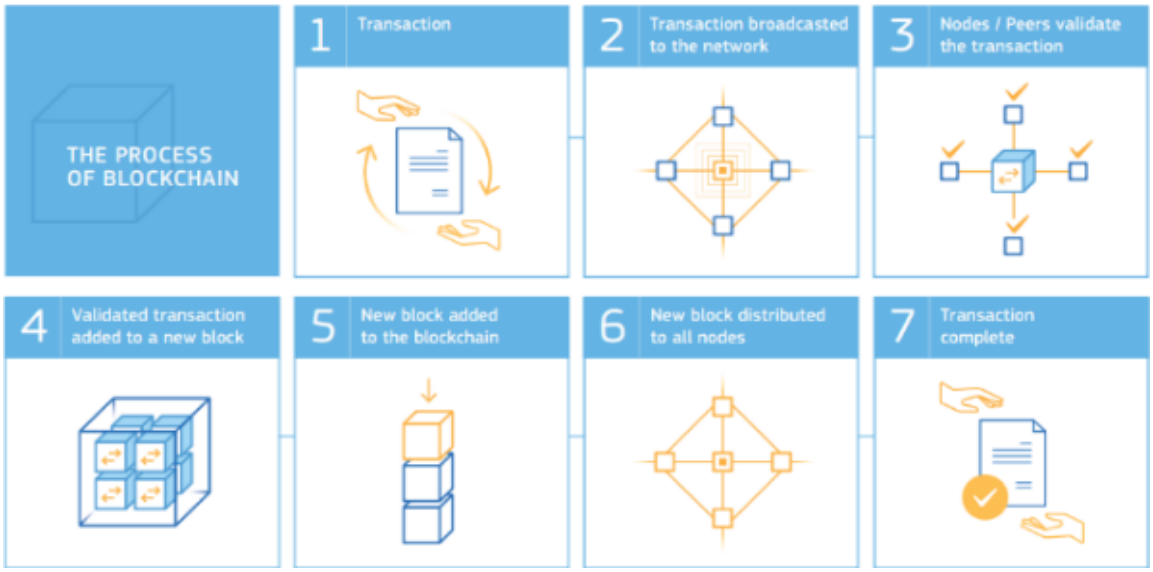

Fig 1: How blockchain works [2]

A blockchain is a digital record of transactions – or ledger – that is decentralized (no single entity controls the distributed (records are shared with all participants) and secured using a blend of proven cryptographic technologies.

A blockchain is managed by computers or servers – called “nodes” – on a peer-to-peer basis without the need for the intermediaries who traditionally authenticate transactions (such as banks in the case of financial transactions). Data added to the blockchain are shared with all participants in the network and are verified and validated by anyone with the appropriate permissions on the basis of the consensus protocol of the blockchain [3].

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The diagram below illustrates the contrast between a traditional centralized ledger and a distributed ledger:

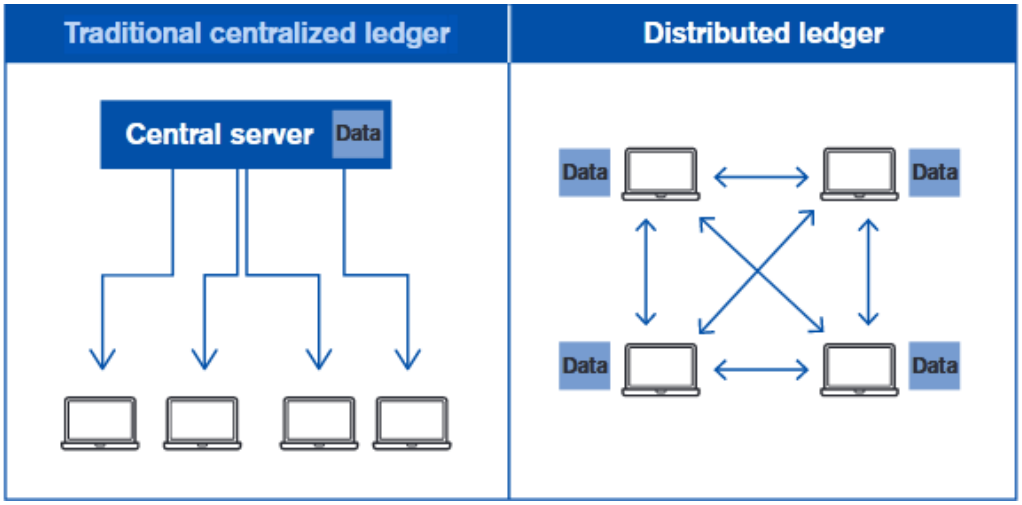

Fig 2: Centralized versus distributed ledger [3]

3. THE SPECIAL FEATURES OF BLOCKCHAIN TECHNOLOGY

By analyzing how blockchain operates, we can identify its key features that distinguish it from other technologies, especially current systems used in economic activities such as payment systems [3]:

3.1. A decentralized, distributed and transparent architecture of trust:

Information added to the blockchain is immediately visible to all participants in the network and distributed – i.e. each peer keeps a complete copy of the data (or as close to it as possible), and updates, if any, are shared with the whole network without anyone having to trust a single central third party.

Blockchain ensures immediate, across the board transparency permissioned blockchains, trust and the readability of some information can be restricted to participants with permission to better suit the objectives of the blockchain.

3.2. High security, immutability and traceability:

The concomitant use of various cryptographic techniques and the decentralized and distributed nature of blockchain platforms make such platforms highly resistant to attacks compared to traditional databases.

However, although the technology itself provides for a high level of security, weaknesses remain in relation to smart contracts, user interfaces and private keys used for encryption, which can be stolen via conventional attacks if they are saved on an individual user's computer or a centralized server.

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Information, when added to the blockchain, is time-stamped and cannot be easily modified. This has several implications:

- First, it makes it easy to track attempted changes. This is particularly important in a world where digital objects can be copied, modified and shared around at virtually no cost. Blockchain's immutability makes it possible to easily authenticate products and documents – however, it is important to note that, while Blockchain can help prevent fraud on the ledger, the tamper-resistance of the technology cannot prevent false information from being fed into the ledger**.**
- Second, the immutable and distributed nature of the technology negates the need for database backups, thereby fundamentally changing disaster recovery. Once information is added to the blockchain, it is shared with the whole network and saved on all nodes, and it is near impossible to modify. If one node is affected by a disaster, information can easily be recovered.

3.3. Automation

The use of smart contracts, i.e. self-executing computer programmes, makes it possible to automatize processes, payments, etc., thereby enhancing efficiency.

Smart contracts: in the context of DLT, are programs that are written on the underlying distributed ledger and are executed automatically by nodes on the network. Any instruction that could be executed by a computer could theoretically be run by a smart contract. Transactions or data recorded on the distributed ledger trigger the smart contract and the actions taken are in turn recorded in the ledger. Another way of putting this is that smart contracts "allow for logic to be programmed on top of the blockchain transaction" [4].

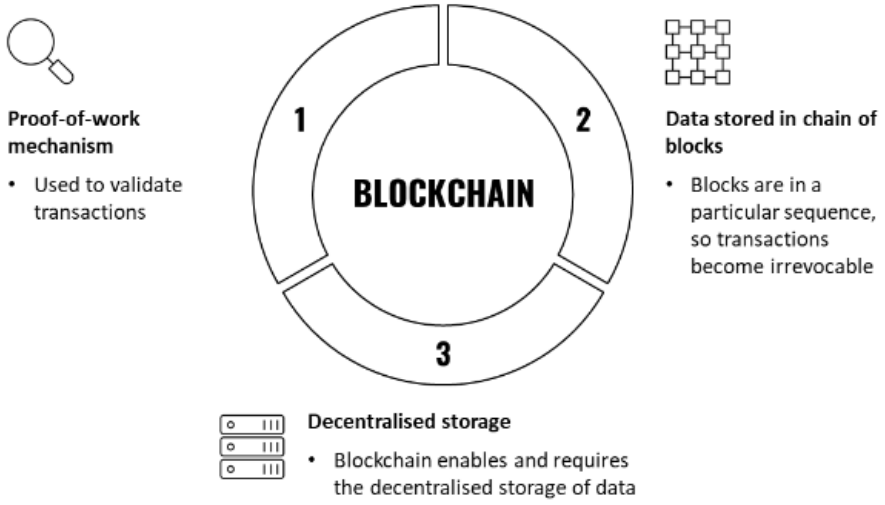

Fig 3: Key features of blockchain [5]

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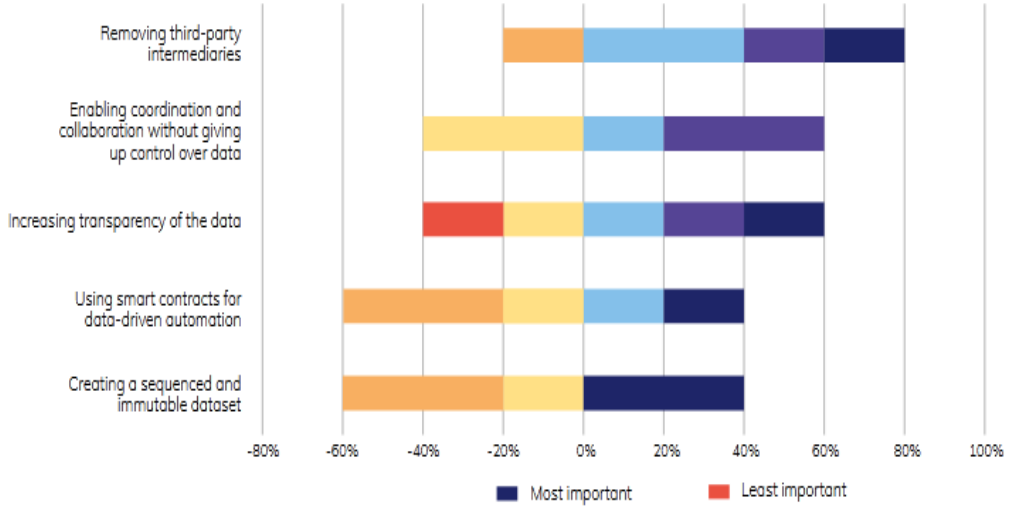

Fig 4: Motives for adopting blockchain [6]

The term "blockchain" is commonly linked to crypto-currencies, yet it pertains to a category of distributed ledger technology that displays widespread use beyond crypto-currencies. It holds the capacity to transform the economic realm and incite the rise of a knowledge-based economy. By offering technologically advanced, cost-effective, and secure services, blockchain has the potential to enhance transparency and efficiency across various economic sectors. As depicted in the figure above, blockchain technology can yield significant economic benefits.

4. POTENTIAL APPLICATIONS OF BLOCKCHAIN

Blockchain has the potential to increase efficiency in various economic sectors such as trade finance, governance, customs clearance, insurance, and logistics. Its implementation could lead to innovative opportunities and advancements.

Several blockchain initiatives and projects are being established in various sectors and countries, such as in the USA, Switzerland, etc.

The subsequent points will clarify how blockchain technology can enhance the value of any activity, regardless of its nature.

4.1. Towards the digital identity paradigm and the dematerialization of property

4.1.1. The digital identity

This topic spans all other areas of economic activity. In the blockchain space, digital identity offers unique representation to any subject in any transaction. It is therefore a pivotal component of blockchain applications, with the potential to bring about change in many different sectors that rely on identity, but provide other services [7].

Out of the 7.9 billion people worldwide, one billion is unable to provide proof of their identity. Without an identity, individuals cannot own land, houses, or property. They also

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cannot open a bank account, which leads to no access to trade, credit, or development aid without an intermediary. Additionally, without an identity, individuals have limited access to healthcare, except for emergency care provided during disasters. Children without an identity cannot attend school, and adults without an identity have no right to vote or access to justice.

Digital identity is the secure use of one's identity attributes to access resources. Blockchains are changing the field of digital identity by moving away from organization-managed authentication and access control, towards a model based on the individual's ability to verify attestations. This involves transitioning from a centralized model, in which users create login credentials and disclose personal information to individual services, to a decentralized model that empowers users to retain control of their personal data. This approach also resolves the significant security issues linked to data centralization, which is vulnerable to repeated hacking attempts. A decentralized approach allows individuals to verify their identity or a particular aspect of it, such as age, to access the desired service [8].

The following diagram summarizes the principle of digital identity:

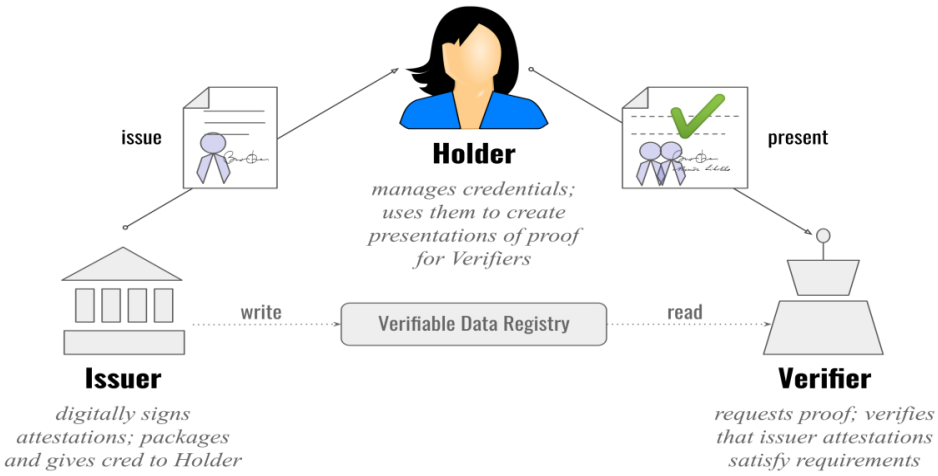

Fig 5: The principle of digital identity [8]

A decentralized identity system has three entities: (1) an issuer (such as a company or university) provides a decentralized identifier (DID) to a holder (such as an employee or student), (2) the holder presents attestations or supporting documents to a verifier (such as an administrative service) based on this identifier, for example, to access a service, and (3) the verifier or service verifies these credentials.

In practice, a DID serves as a hyperlink to a document that contains the DID's cryptographically protected fields in their entirety. The document is stored in a Verifiable Data Registry, which can vary in its degree of centralization based on whether it's placed in a blockchain or other types of databases. This verifiable data registry serves as an indirect intermediary between the issuer of a verifiable certificate and the verifier. The

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holder has control over the information they choose to share by providing verifiable attestations. They can attest to all or some of their attributes without the issuer's knowledge, once informed [8].

4.1.2. Land and title deeds

Access to land, proof of identity, and enforceable title deeds are fundamental to inclusion in society. For the most disadvantaged, these not only provide access to financial services but also guarantee their identities. In countries where there is no land ownership registry, implementing a blockchain offers advantages such as an immutable register and easy querying. Geolocation tools also aid in identifying and marking unregistered land.

By digitizing the cadaster, land titles can be dematerialized, which solves the problem of potentially losing paper documents during natural disasters or conflicts. Finally, the lack of a centralized organization accountable for registering and maintaining a registry can address corruption concerns in specific areas of the government, especially those involving arbitrary seizures or confiscations [8]

4.1.3. Certification and notarization

In addition to digital identity and land registry, it is important to be able to verify the authenticity and existence of various documents, such as contracts, diplomas, leases, photos, and legal deeds, at a specific point in time. Previously, this process necessitated the involvement of a third-party public official to certify a document's existence and ensure its integrity. Using a trusted third party comes with a price, as does being one. For instance, a university or school that confers degrees must maintain a record of alumni and be available for inquiries from corporations and other entities seeking to substantiate an individual's graduation from that institution. Registering the diploma's fingerprint on a public blockchain significantly simplifies the process of verifying its authenticity [8].

4.2. A new array of financial services

Blockchain technology has a range of potential applications that could benefit the financial industry, specifically banking and insurance. Its versatility makes it useful for various fields and purposes.

4.2.1. Expansion of banking activities

4.2.1.1. Cryptocurrencies or digital currencies: DLT has been closely linked to digital currencies since its inception because it was invented as the underlying technology of the cryptocurrency Bitcoin. The inventor of Bitcoin, writing under the pseudonym Satoshi Nakamoto, described the technology in a 2008 white paper as an “electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party.” Nakamoto has not been identified until this day, having erased his entire online presence in 2011 [4].

The traditional payment system depends on several players and a set of instruments and procedures to process transactions. Conversely, the cryptocurrency payment system operates in a decentralized, "pair-by-pair" system that eliminates intermediaries.

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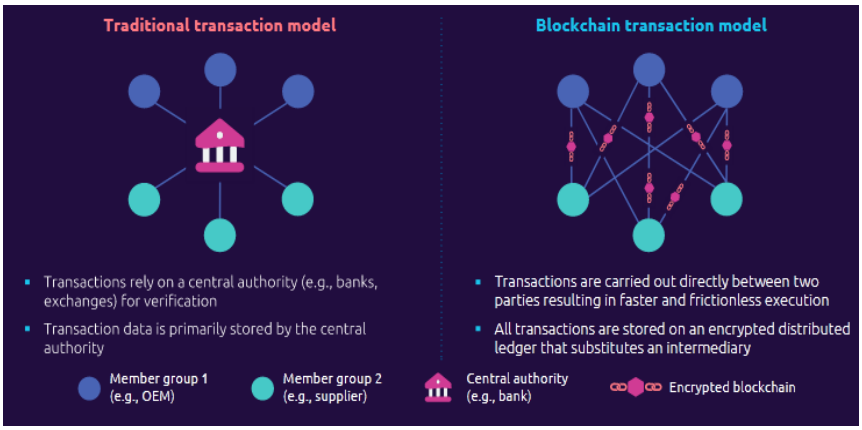

Fig 6: A simplified blockchain transaction model [9]

In recent years, much has been discussed about central bank cryptocurrencies. Several governments are planning to incorporate blockchain technology into their payment systems and establish a national cryptocurrencies known as central bank digital currencies (CBDCs). CBDCs are a digital form of fiat money issued by a central bank [10].

4.2.1.2. Financial inclusion and cross-border payments

Digitalization has the potential to disrupt existing equilibria of cross-border use of currencies. Some of the attributes of these new forms of digital money could drive adoption in ways that are distinct from existing dynamics. They lower transaction costs by reducing reliance on banks, widen access to services and promote financial inclusion through mobile devices, and open the possibility of complementary services offered on social networking and e-commerce platforms of global scale. It is thus possible to envisage a variety of plausible adoption and use outcomes [10].

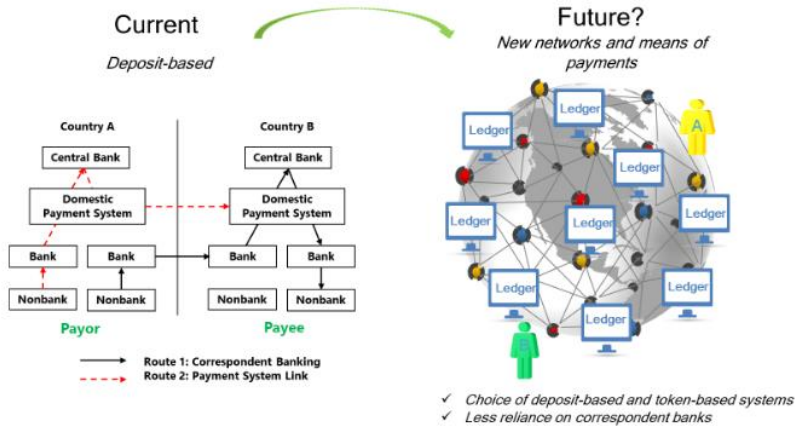

Fig 7: Evolving Landscape for Cross-border Payments [10]

Disintermediation leads to faster, more efficient, and less costly transactions due to the reduction of players involved.

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4.2.2. Improving the Insurance Industry

Financial institutions could use smart devices and the IoT to tag their claims on physical assets, making them trackable and traceable. Because digital currencies enable the storage and transfer of value rapidly and securely for all users large and small, they also enable risk assessment and management [11].

Internet of Things (IoT): IoT is the global network of “smart” versions of regular physical objects. What makes an object smart? Its ability to do its tasks automatically and more efficiently through the help of embedded computing hardware, sensors, actuators, and software. But the defining feature that makes an object smart is its ability to connect to the Internet, which opens a bunch of possibilities [12].

Decentralised finance (DeFi) blockchain technology can address traditional pain points in insurance, such as lack of trust, high transaction costs and the tension between confidentiality and transparency. Ultimately, DeFi and blockchain could potentially transform the insurance industry by reducing operational costs, facilitating the development of new business models and opening up new insurance opportunities, for example in inclusive insurance.

DeFi describes the infrastructure, processes and technologies developed to disintermediate financial services. It is a set of alternative financial markets, products and systems that operate using crypto assets and smart contracts based on blockchain or similar technology. DeFi deploys smart contracts to execute a variety of financial services activities on a blockchain without financial intermediaries, with payments often made through crypto assets in digital wallets [13]. We will study the case of smart contracts in the next few points. In the insurance industry, there is potential for discussion surrounding the implementation of DeFi/Blockchain insurance.

DeFi insurance refers to a blockchain-enabled, mutual risk-sharing arrangement without a centralised financial intermediary. Blockchain insurance refers to smart-contract based re/insurance and new insurance opportunities or efficiency gains derived from blockchain technology [13].

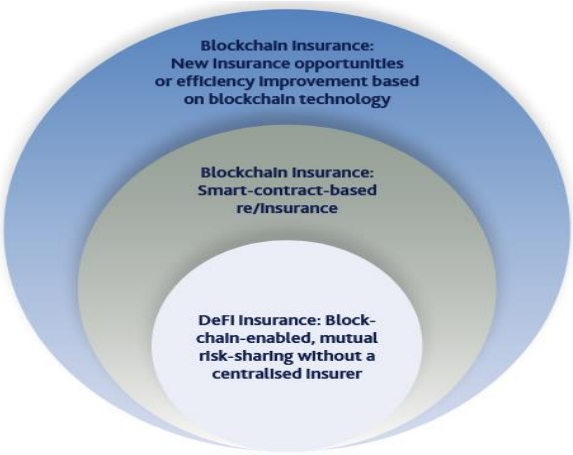

Fig 8: DeFi/Blockchain insurance [13]

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DeFi insurance can be described by the following eight features:

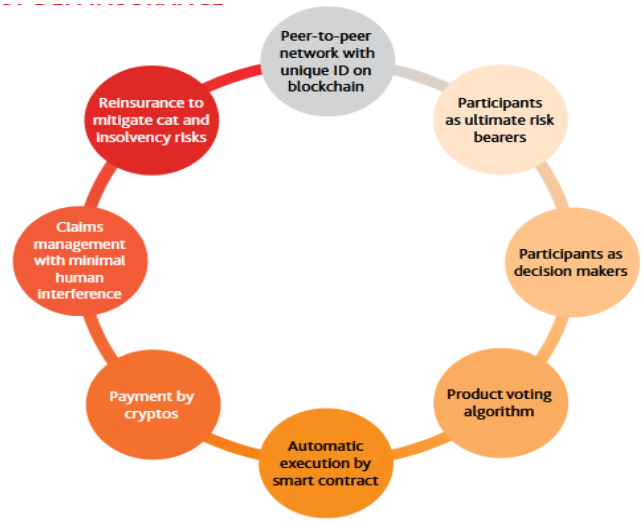

Fig 9: Features of DeFi insurance [13]

4.2.2.1. DeFi/blockchain insurance vs. conventional insurance [13]

Three pain points affect the centralised insurance model:

- **Trust:** On the one hand, the information advantage of policyholders can lead to dverse selection and moral hazard. On the other hand, individuals may be concerned about insurers' ability and/or willingness to pay claims.
- **High transaction costs:** The expense ratio reflects the transaction cost of a centralised insurance model. Sales, underwriting and claims management are labour intensive and thus costly.
- **Transparency:** The operations of insurance companies, including claims and capital management decisions, can be a black box for policyholders.

DeFi and blockchain technology could potentially revive mutual risk-sharing by addressing and easing some of the pain points mentioned above. For example, blockchain based identity and evidence systems improve the efficiency and effectiveness of verifying underwriting information and claims, making exchange of information between parties easier. This offers a way to reduce information asymmetry, improve trust and transparency between policyholders and insurers, and ultimately reduce the transaction costs of insurance. DeFi/blockchain insurance may also improve the accessibility and customisation of insurance products.

4.2.2.2. DeFi/blockchain for moren inclusive insurance

DeFi/blockchain insurance could narrow protection gaps and promote financial inclusion by expanding insurance services to the un (der) served. DeFi/blockchain enables peer-to-peer insurance solutions that meet the demands of un (der) served socio-economic groups.

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Such groups in the context of insurance usually include those that are geographically remote, or have low incomes or poor financial literacy. Their protection gaps include agricultural risk, health/maternal risk and longevity risk. DeFi insurance enables such individuals to form a risk pool without the approval or interference of insurance intermediaries. Insurance services can be provided completely online, from underwriting to claims, greatly improving the accessibility of insurance to individuals living in remote areas. A DeFi/blockchain system may also reduce the operational costs associated with insurance, thus improving the affordability of inclusive insurance for low-income populations. Finally, purchasing a DeFi/ blockchain insurance product via smartphone applications or mobile phone networks can be as simple as buying other goods online, which improves the customer experience and attractiveness of insurance coverage for individuals with poor financial literacy [13].

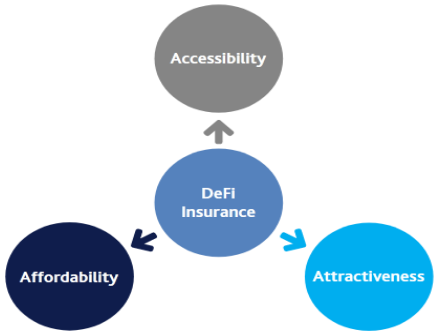

Fig 10: The "Triple-A Impact": How DeFi/Blockchain improves financial inclusion in insurance [13]

DeFi/blockchain insurance remains a niche that has not yet driven major growth of the insurance market nor significantly improved financial inclusion in insurance.

4.2.3. Encouraging Investment

Accessing financing or financial markets in the current system can be a challenge due to the various requirements that must be met, such as having a specific fund and experience, which can be particularly onerous for micro, small, and medium-sized businesses. However, blockchain technology presents a solution by enabling direct interaction with investors through its "peer-to-peer" system, circumventing the need for intermediaries and their associated requirements.

4.3. Towards a revolutionary and more responsible trading

Commercial operations are marked by the complexities of their processes, notably in cross-border trade, which necessitates specific administrative procedures, unique players, and accompanying costs. Trade is funded by traditional payment methods, including cash and checks, which involve multiple parties and heavy use of paper. However, these methods have drawbacks, such as payment delays due to validation time and susceptibility to fraud. The transparency and security provided by blockchain technology is driving contemplation on its potential to automate processes, boost transaction efficiency, and fortify trade security. Blockchain could simplify and accelerate

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trade transactions and lower costs, providing opportunities for micro, small, and medium-sized enterprises that struggle to obtain trade financing due to high costs. Automating the process with Smart Contracts could further reduce the cost of verifying transaction attributes.

A computer scientist, legal scholar, and cryptography expert named Nick Szabo is credited for developing the concept of a smart contract. He defined a smart contract as "a set of promises, specified in digital form, including protocols within which the parties perform on these promises. So, a smart contract is a computerized algorithm (yet another way of describing it), which performs the terms of the contract. However, this definition does not differentiate smart contracts from some already well-known contractual constructs implementing automated performance, such as vending machines [14].

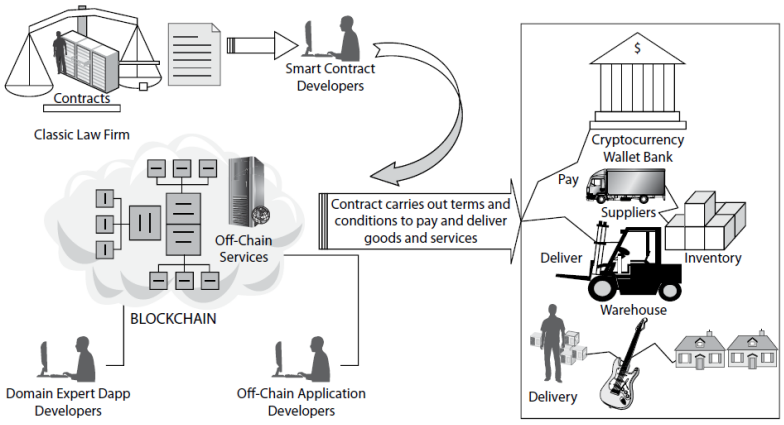

Fig 11: Smart contract flow [14]

4.3.1. Retail and Supply Chain

Managing product supply chains is complex and demanding. The need for transparency has led to growing interest in applying blockchain technology. This approach offers an opportunity to address recurring issues that breach both supplier and consumer rights, including traceability.

4.3.1.1. The five primary benefits that blockchain can provide for manufacturers

The top five blockchain opportunities that manufacturers are pursuing are [15]:

- **Supplier contract management:** Smart contracts can be used to transform transaction efficiency, improving speed of execution and supporting faster dispute resolution. Responsive contracts eliminate inefficiencies associated with regular contracts.
- **Digital thread:** Digital thread is a communication framework that connects traditionally siloed elements in manufacturing processes and provides an integrated asset view. Blockchain adds trust to this ecosystem when multiple partners are involved.

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- **Production tracking:** Manufacturers need instant information on the products completed by their EMS (electronic manufacturing services) providers. A blockchain helps track and authenticate in real time.
- **Tracking asset maintenance:** Blockchain, along with technologies such as IoT, helps in determining whether an asset has been maintained according to schedule, especially when multiple parties are involved.
- **Tracking recalled products:** Blockchain enables product or component tracking by recording a product's entire manufacturing journey, from the origin of its components until the product reaches the consumer.

4.3.1.2. Tracking provenance is turning out to be a major use case for blockchain in the consumer goods industry

The top five blockchain opportunities consumer product organizations are pursuing are [15]:

- **Tracking provenance:** Blockchain allows businesses and consumers to trace a product's origin, attributes, and any change of ownership.
- **Tracking critical parameters:** For products that are sensitive to storage conditions, blockchain, coupled with IoT, can help companies track conditions, such as temperature during transit.
- **Monitoring asset conditions:** Blockchain, coupled with technologies such as IoT, helps in monitoring the condition of assets in remote locations.
- **Regulatory compliance:** A blockchain can maintain a product's entire history and allows regulators to determine whether that product has been manufactured and handled in a compliant manner.
- **Providing warranties:** Blockchain helps to establish the proof of ownership of a product. This allows organizations to extend warranties to customers with genuine products and avoid losses in warranty frauds.

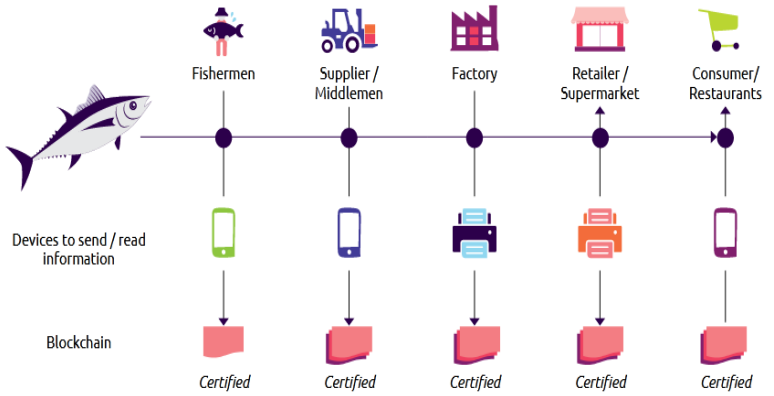

Fig 12: Simplified process for ensuring the provenance of a tuna fish [15]

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4.3.1.3. Retailers are focused on digital marketplaces and preventing counterfeits

The top five blockchain opportunities that retail organizations are pursuing are [15]:

- **Blockchain-enabled market place:** Trust in the intermediary (marketplace) is replaced with trust in the underlying code and consensus rules. Blockchain technology allows this verification to be undertaken at minimal cost, even at scale.
- **Preventing counterfeit products:** With the ability of blockchain to track the origin of each part of a final product, it is possible to have an audit trail that is visible to all relevant parties. This ensures the authenticity of goods and reduces counterfeiting.
- **Inventory and pilferage tracking:** End-to-end visibility from suppliers to retailers ensures transparency and authenticity where multiple suppliers are involved.
- **Tracking return goods:** Blockchain systems help retailers ensure returned goods are tracked back to their suppliers, along with contracts to better manage returns.
- **Loyalty program management:** A blockchain-enabled loyalty program can be used to create a single wallet for loyalty rewards, providing convenience to customers and improving trust when multiple businesses are involved in the same program.

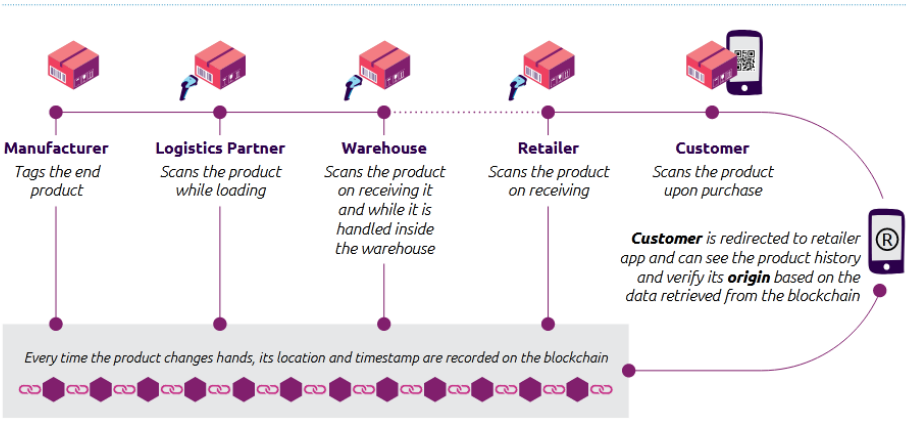

Fig 13: Simplified process for tracking products using blockchain [15]

Supply chains have become increasingly complex over the years. Traceability, responsiveness, and trust issues remain barriers to more efficient supply chain networks. Blockchain's ability to remove these constraints can unlock value both by reducing inefficiencies and creating new opportunities [15].

4.3.2. International trade

The number of headlines claiming that Blockchain can revolutionize various areas of international trade, from trade finance to customs procedures and intellectual property, are legion. The transparent, decentralized and immutable nature of Blockchain has sparked the interest of private actors – and governments – to explore the potential of this technology to enhance the efficiency of trade processes [3].

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International trade transactions involve a multitude of actors and continue to rely extensively on paper, A multitude of documents have to be submitted in the context of international trade transactions [3].

The figure below illustrates the complexity of the processes involved in international transactions.

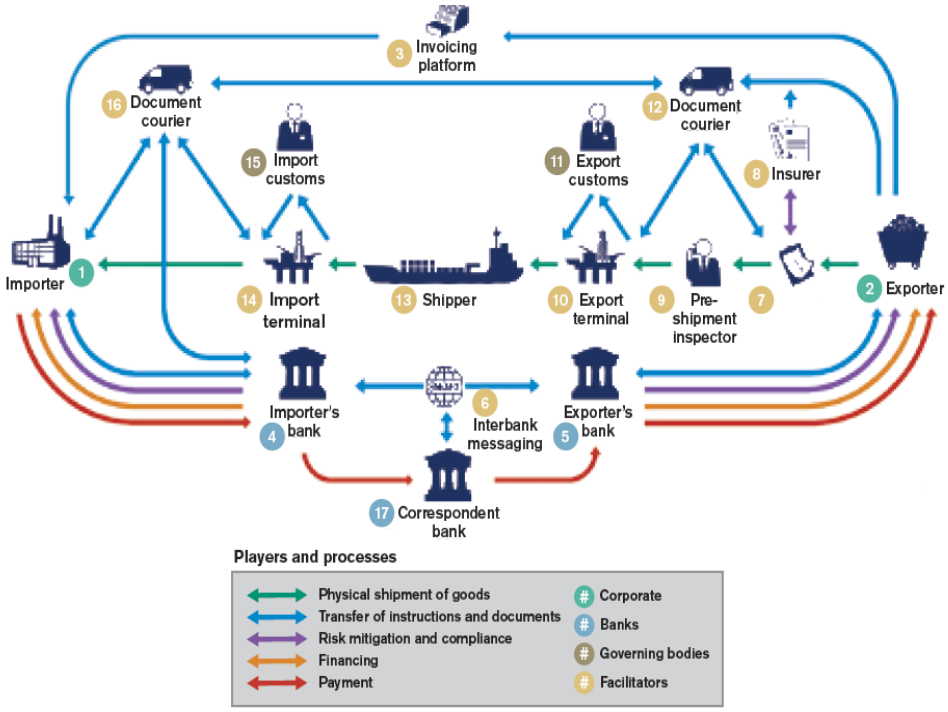

Fig 14: The traditional trade finance process is highly fragmented across multiple entities and processes [3]

Not only do these various paper intensive processes increase coordination and administrative costs, they are also prone to errors, losses and fraud. Although notable progress has already been achieved, full digitalization of cross-border trade transactions of goods is not yet in sight.

The complexity and costs associated with international trade in goods has led an increasing number of companies and governments to investigate how Blockchain could be used to cut paperwork and enhance processes involved in the export of goods, from trade finance to border procedures and transportation, with the hope of moving closer to truly paperless trade [3].

4.3.2.1. More secure, transparent, and faster payments

The transparent and secure nature of Blockchain has raised hopes and led an increasing number of banks to explore how Blockchain could help automate the process, improve efficiency of transactions and enhance security.

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An illustration of a letter-of-credit transaction in both centralized and decentralized systems is displayed in the next figure**:**

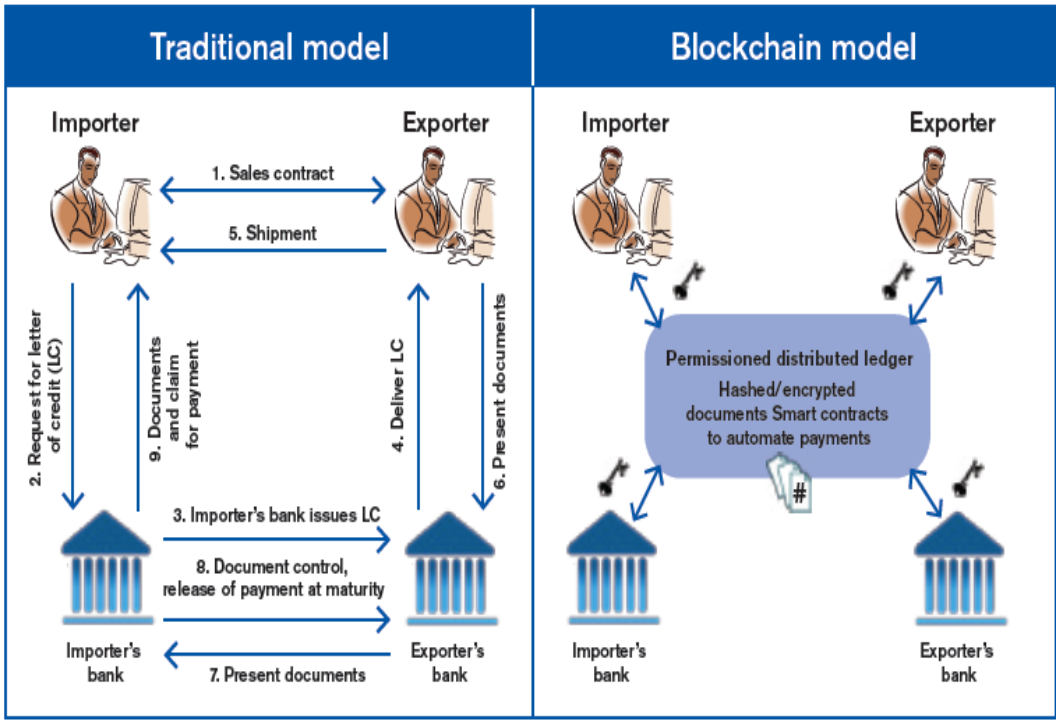

Fig 15: Example of letter of credit process [3]

4.3.2.2. Optimized Transportation and Logistics

Potential benefits of this technology for the transportation and logistics sector are arguably wide-ranging and include helping to track ships and trucks, optimizing loading capacity, reducing administrative and coordination costs, increasing transparency in prices, ownership and in the entire transportation chain, accelerating payments through the use of smart contracts, enhancing security and reducing fraud, and simplifying claim settlement by creating an immutable record of freight history.

International shipments are usually handled by various companies along the way. Having all relevant shipping information shared with authorized partners in real time on a secure blockchain that guarantees that any data added has not been tampered with, can significantly improve coordination, accelerate processes and cut costs.

One of the key benefits that Blockchain offers when it comes to transportation and logistics is the possibility of enhancing collaboration between the various companies involved, while at the same time allowing them to retain control of sensitive information and of who knows what and when [3].

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The figure below presents a Global Trading Platform that utilizes blockchain technology:

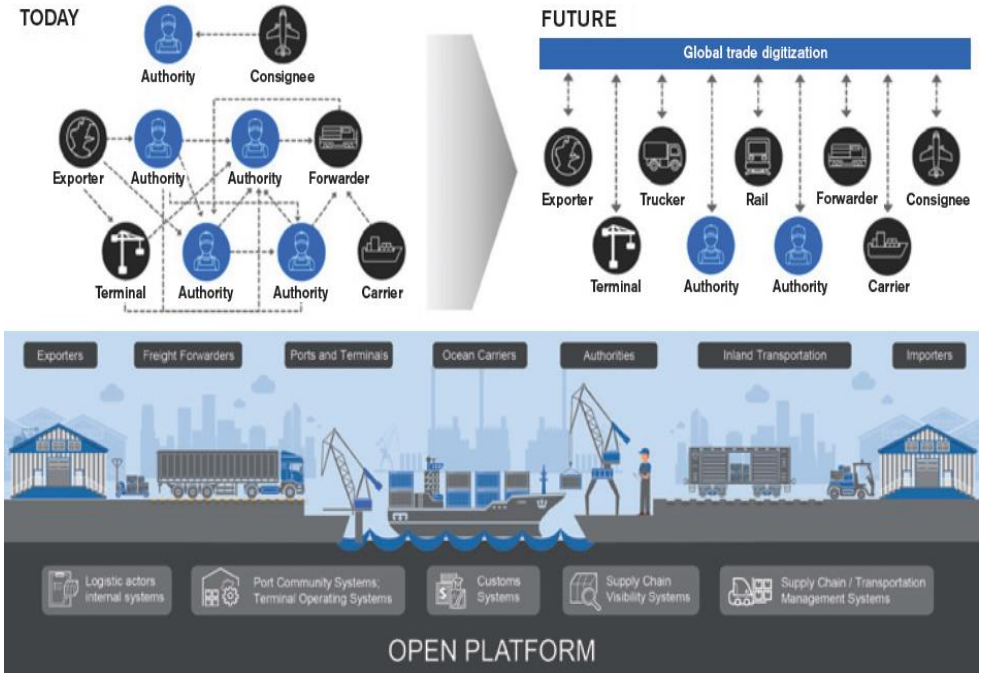

Fig 16: Blockchain-based global trade platform [3]

This section assesses how blockchain benefits the different stakeholders in the retail industry, both locally and internationally. It explores the potential opportunities that blockchain presents in this sector [16]:

- Blockchain technology presents several potential opportunities to transform international trade to become more efficient and transparent. These include border procedures, transportation and logistics, and the tracking of goods.
- Blockchain has the potential to create a global asset web by facilitating transactions and the movement of assets. However, this requires the development of a conducive regulatory framework.
- Blockchain is playing an increasingly important role in trade finance by making the process more efficient, less expensive, and creating a more reliable and accessible record of trade. The technology could have a truly transformative impact on border procedures by assisting with interagency coordination, certification and licensing, document and cargo integrity, and customs procedures.

4.4. Agriculture and food

The use of the blockchain technology in the agro-food value chain holds the promises of both increasing efficiency of supply chain management, and providing farmers, food industry businesses, government and consumers with greater assurance about the safety, quality and authenticity of the inputs they use for their agriculture and food

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production (seeds, agrochemicals, primary product), the agriculture and food products they import, and the food they consume [16].

4.4.1. Blockchain and traceability in the food system

The goal of incorporating blockchain technology is to regulate food safety.

Food safety issues drive the innovations behind **IBM Food Trust**. **IBM Food Trust** is a mature solution presented to address such concerns. Tailored to different types and sizes of players within the food system, the solution features multiple traceability modules [8]. **IBM Food Trust** is a modular solution built on blockchain, benefiting all network participants with a safer, smarter and more sustainable food ecosystem [17].

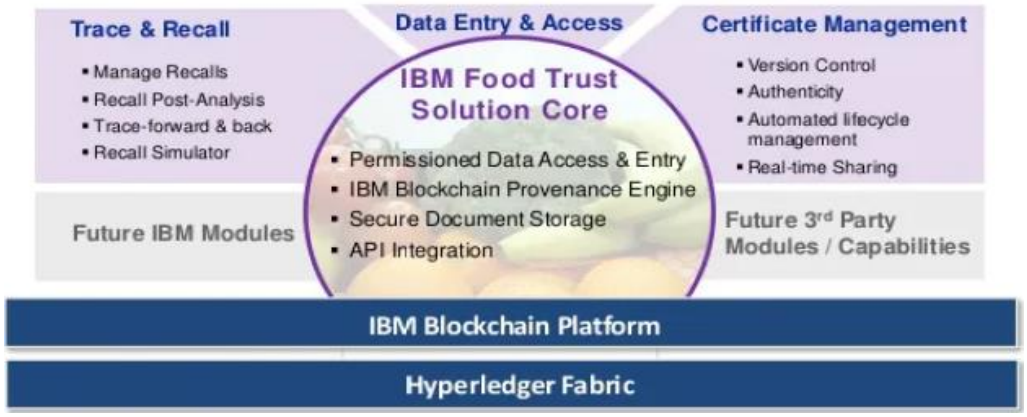

Fig 17: IBM Blockchain [8]

Blockchain traceability projects enhance monitoring and responsiveness to food safety concerns, resulting in significant benefits for stakeholders in the supply chain. Upstream of the food system, brands, distributors, and consumers must be placed at the center of the debate.

4.4.2. Blockchains and Agriculture Markets

Another area of application for blockchain technologies in the agricultural is the creation of exchange platforms and markets, the use of blockchain in such platforms can increase transparency and reduce transaction costs, benefiting both producers and consumers like **Gavea** platform.

Gavea is a secure blockchain-based trading platform, designed to cultivate customer loyalty with targeted marketing, push notifications, and an uninterrupted chat service [18].

The platform promotes social responsibility among its participants through multi-level verification of environmental, social, and governance criteria, as well as full traceability of counterparty trading positions. The use of blockchain eliminates intermediaries between buyers and sellers, resulting in reduced costs and faster exchanges [8].

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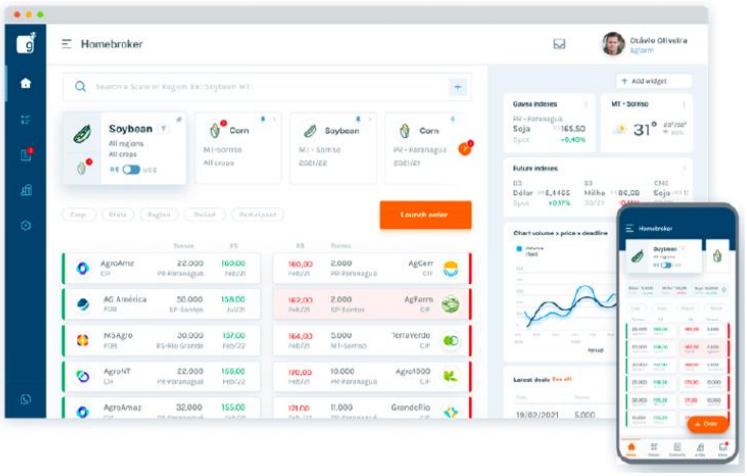

Fig 18: Gaeva private trading platform [8]

The food system is increasingly global, complex, and time sensitive. It is important to focus on the international dimension of the food system, and the role of governments in providing efficient and safe trade in agriculture and food supply chains. One of the most important aspects of legitimising the use of blockchain in agricultural supply chains is the digitalisation of information in a way that is verifiable, accessible by all stakeholders, and ideally builds upon established and trusted systems [16].

4.5. Health Care

In the health care sector, professionals use digitization to manage assets and medical records, keep inventory, and handle ordering and payments for all equipment and pharmaceuticals. Today, hospitals are full of smart devices that oversee these services, but few communicate with one another or take into account the importance of privacy protection and security in direct patient care.

Blockchain-enabled IoT can use emerging applications to link these services. Applications in development include monitoring and disease management (e.g., smart pills, wearable devices to track vital signs and provide feedback) and improved quality control. Imagine an artificial hip or knee that monitors itself, sends anonymized performance data to the manufacturer for design improvements, and communicates with a patient's physician, "Time to replace me."

Technicians will be unable to use specialized equipment if they haven't taken prerequisite steps to ensure their reliability and accuracy. New smart drugs could track themselves in clinical trials and present evidence of their effectiveness and side effects without risk of modified results [11]**.**

4.5.1. A new model for Health Information Exchanges

A blockchain powered health information exchange could unlock the true value of interoperability. Blockchain-based systems have the potential to reduce or eliminate the friction and costs of current intermediaries.

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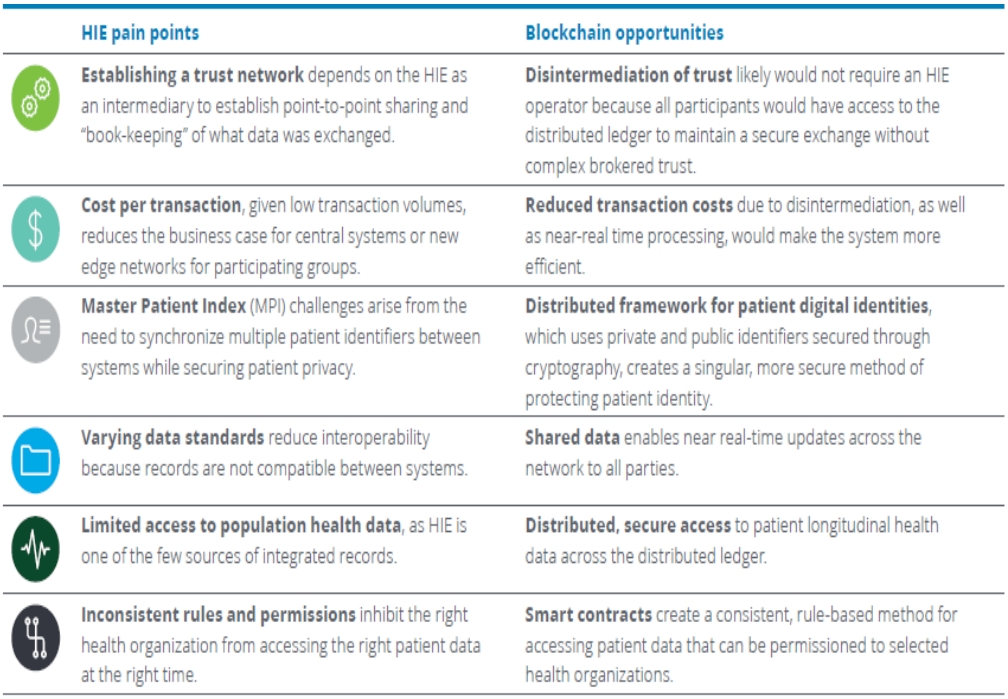
The exchange of Personal Health Records and Health Information Exchange (HIE) data via the Integrating the Health care Enterprise (IHE) protocol is an important part of addressing the challenges of system interoperability and accessibility of medical records. The strategy outlined to date provides the technical requirements and specific incentives for health systems to meet the Meaningful Use interoperability standards necessary to support the envisioned National Health Information Network, buttressed by a network of HIEs operating on a broad scale. That unrealized scale, driven in large part by insufficient incentives outside of compliance, threatens the viability of HIEs and merits exploration of new models [19].



	HIE pain points	Blockchain opportunities
	Establishing a trust network depends on the HIE as an intermediary to establish point-to-point sharing and "book-keeping" of what data was exchanged.	**Disintermediation of trust** likely would not require an HIE operator because all participants would have access to the distributed ledger to maintain a secure exchange without complex brokered trust.
	Cost per transaction, given low transaction volumes, reduces the business case for central systems or new edge networks for participating groups.	**Reduced transaction costs** due to disintermediation, as well as near-real time processing, would make the system more efficient.
	Master Patient Index (MPI) challenges arise from the need to synchronize multiple patient identifiers between systems while securing patient privacy.	**Distributed framework for patient digital identities**, which uses private and public identifiers secured through cryptography, creates a singular, more secure method of protecting patient identity.
	Varying data standards reduce interoperability because records are not compatible between systems.	**Shared data** enables near real-time updates across the network to all parties.
	Limited access to population health data, as HIE is one of the few sources of integrated records.	**Distributed, secure access** to patient longitudinal health data across the distributed ledger.
	Inconsistent rules and permissions inhibit the right health organization from accessing the right patient data at the right time.	**Smart contracts** create a consistent, rule-based method for accessing patient data that can be permissioned to selected health organizations.

Fig 19: Health Information exchange and Blockchain [19]

4.5.2. Drug traceability

According to the World Health Organization (WHO), one out of ten medications circulating globally is of "inferior quality and falsified," while one out of four medications in developing countries falls under this category. The manufacture and distribution of fake medicines today pose a threat to all significant therapeutic categories, including drugs, vaccines, and in vitro diagnostic products. According to WHO, low and middle-income countries, areas of conflict and civil unrest, and weak or non-existent health systems suffer the most from the issue of substandard or falsified medical products.

The scientific community is exploring blockchain models and solutions to combat drug counterfeiting. A distributed registry is considered the most appropriate response to the problems of counterfeit drugs and their traceability, from the production site to the patient [8].

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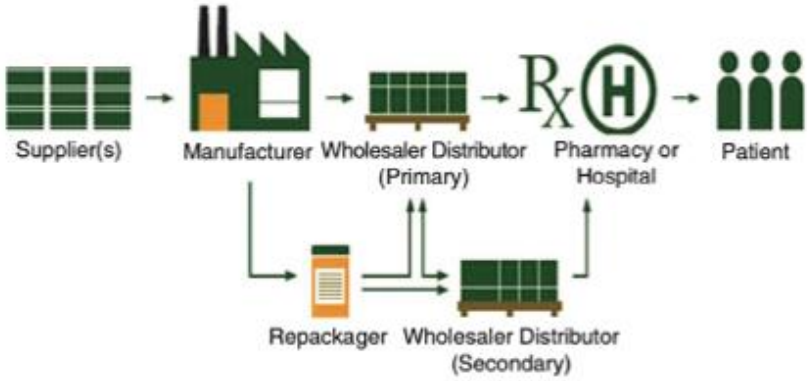

Fig 20: The pharmaceutical supply chain [8]

While blockchain technology is not a panacea for data standardization or system integration challenges, it does offer a promising new distributed framework to amplify and support integration of health care information across a range of uses and stakeholders. It addresses several existing pain points and enables a system that is more efficient, disintermediated, and secure.

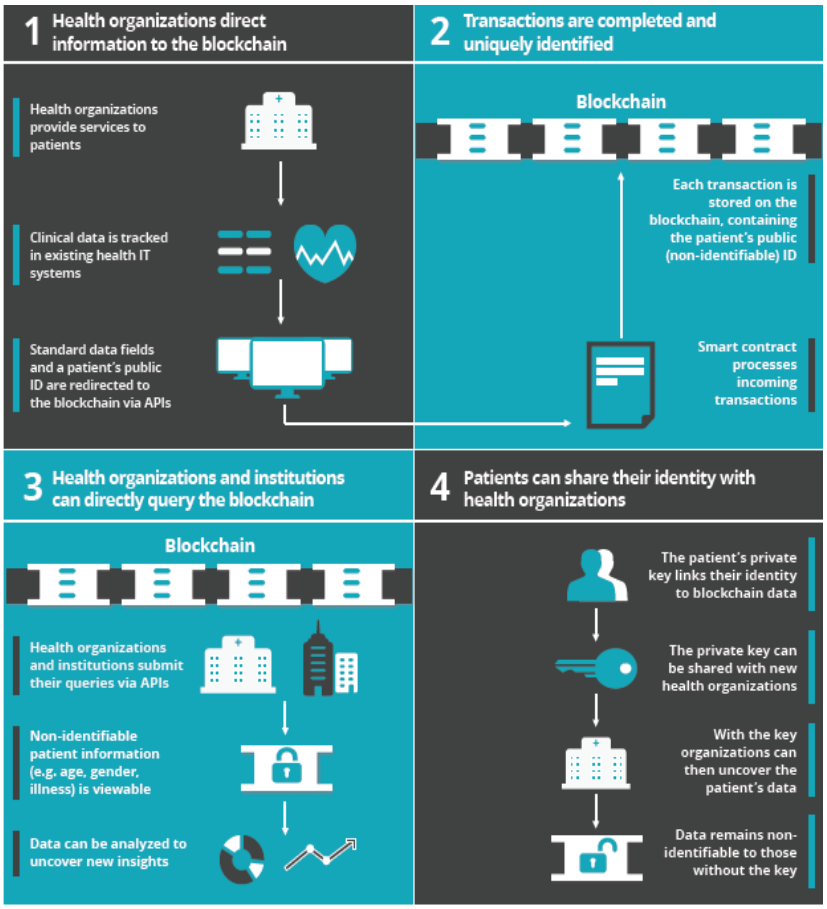

Fig 21: Illustrative Healthcare Blockchain Ecosystem [19]

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4.6. Certificates and accreditation

4.6.1. Education

Whether certifying a diploma, training, experience, or employment contract, blockchain relies on the identity of the person and utilizes decentralized identity and verifiable attestations. The contribution of blockchain in the digital identity field inverts the current model based on authentication and access control, managed by an organization, to a model based on attestations verifiable by the same person.

Looking at blockchain applications for certification in education, this technology could help higher education institutions to notarise digital certificates. This could be done with more scale and speed, transparency and visibility and, above all, with immediate trust in the credentials that attest the capabilities of the graduate or jobseeker applying for a job. Ultimately, it could have an impact on the employment prospects and professional careers of students and graduates.

Fig 22: Diplomas management [20]

4.6.2. Job Market

It is possible to certify professional experience through a company-issued verifiable certificate, indicating that a person has worked within the company.

The integration of blockchain platforms in the workplace will allow companies to streamline their hiring process and enable workers to safeguard their rights. We take the example of Talent Cloud, a Canadian platform that aims to create a talent engine that can move as swiftly as needed to ensure that the Government of Canada has access to all the digital talent it needs for project-based work. Talent hired will have access to union representation, pension, rights, and benefits. The talent engine will be designed in such a way that it illuminates the skills and stories of those who are underrepresented and unseen, and will encourage hiring authorities to place value on these experiences, leading to greater diversity in hiring outcomes and a hiring experience for all that is validating. Driven by portable digital credentials, the talent engine will bring a rich set of data on the skills ecosystem available to the Government of Canada, allowing for more optimized recruitment and mobility targeting existing gaps and emerging priorities [21].

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4.7. Renewable energy

Blockchains and distributed ledger technologies enable the operation of decentralized energy systems and microgrids, facilitating peer-to-peer interactions between producers and consumers on energy markets. Collective self-consumption refers to the local production, consumption, sale, or purchase of clean electricity with the assurance that all transactions will be recorded in a distributed system. Surplus electricity can be sold, and in case of a shortage, electricity can be bought locally [8].

Founded in 2014 in Dhaka, Bangladesh, SOLshare is a subsidiary of consulting firm MicroEnergy International GmbH (MEI). Its main activity is designing, manufacturing, managing, and selling an innovative charge controller for Solar Home Systems (SHS). The charge controller manages the interconnection between multiple users on a decentralized, low-voltage DC microgrid and facilitates electricity trading for households and small businesses in densely populated off-grid villages.

SOLshare enables the establishment of distributed and dynamic microgrids, which can provide solar energy to remote populations without any access to the power grid [8].

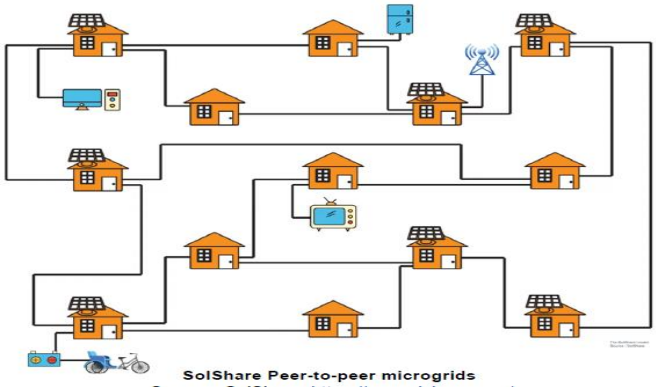

Fig 23: SolShare Peer-to-peer microgrids [8]

Photovoltaic panels on residential homes generate electricity for personal use and enable the sale of surplus energy within a network built between neighbors.

5. CONCLUSION

Blockchain may be the crucial missing component that enables us to move beyond good intentions and implement an efficient traceability solution. This gradual process will eliminate the ethical and commercial deviations of this industry, ultimately benefiting the sustainable development of producing countries.

Blockchain technology can offer economic players new solutions and methods for collaboration and governance. Thanks to its disintermediation feature, it enables collaboration between users without recourse to an intermediary (open, decentralized collaboration) and facilitates the coordination process, resulting in perfect traceability, visibility and trust between stakeholders. Additionally, this platform offers a less complex and lower-cost alternative to traditional systems.

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Small businesses face significant obstacles in the traditional financial system when looking to launch, as they lack the same opportunities as larger companies. These hurdles include high start-up costs and difficulty accessing financial services due to complex requirements set by intermediaries such as banks and states. Blockchain enables access to a vast pool of internet users from diverse geographical locations, without having to comply with the current system's prerequisites.

Blockchain is expected to play a crucial role in the knowledge economy by enabling the measurement, control, and traceability of production processes. This will result in a streamlined transaction process, reducing the risks involved for the parties. Additionally, the technology will enable the more efficient use of resources, resulting in faster and more cost-effective operations. Additionally, storing files digitally minimizes the need for printing documents and saves space, ensuring the accuracy and trustworthiness of information. This leads to simpler commerce, a more efficient and transparent administrative relationship with the public, and increased financial inclusion.

Blockchain is a highly promising technology that supports multiple use cases by providing transparency, speed, and reliability. It has the potential to democratize the economic sector.

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