LUISS

Department of

Business and Management

Course of **International Operations and Supply Chain**

Blockchain technology and Last Mile delivery

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Abstract

Purpose - This thesis explore how Blockchain can be used to improve Last Mile delivery logistics and more generally its use throughout the Supply Chain. The use of new technologies, such as drones and route optimization systems, and their impact on sustainability is also explored.

Methodology - Starting with a literature review, nine hypotheses were developed. The hypotheses were tested through the analysis of a dataset derived from the responses given by 156 companies to a survey regarding the topics of Blockchain and the Last Mile.

Findings - Adoption of blockchain technology has a positive effect on product traceability and transparency, quality control and origin of raw materials. The use of route optimization systems and drones for Last Mile delivery has a positive impact on sustainability, but there are also limitations to consider.

Value - This research analyzes Blockchain, a technology that is attracting increasing attention in several industries and whose benefits have not yet been fully explored.

Keywords - Blockchain, Last Mile, Drones, Sustainability

Paper type - Research paper

1. Introduction

Blockchain is a technology that is attracting increasing attention in several industries, including logistics and delivery. Its ability to create a shared, immutable digital ledger between multiple parties enables transparency, security, and immutability of data (IBM, 2023).

This thesis will explore whether and how Blockchain can be used to improve last-mile delivery logistics and more generally its use throughout the supply chain and how companies are responding to this transformation.

The last mile is the final stage of a product delivery process, from supplier to end customer (Lim et al, 2018). It is a crucial stage of the logistics process, as it represents direct contact with the customer and can significantly affect customer satisfaction (Brown et al, 2021). However, the last mile also presents a number of challenges, including delivery management, traceability, security, and punctuality (Zang et al, 2019).

Blockchain can offer solutions to these challenges, enabling greater transparency, security and immutability of data on the location and status of delivery, as well as the ability to automate some logistics processes. In addition, Blockchain can enable greater collaboration and cooperation among the different parties involved in 'last-mile delivery, such as suppliers, carriers, and end customers (IBM, 2023).

Through an analysis of current industry challenges and examination of existing use cases, the opportunities and benefits that Blockchain can bring to last-mile logistics will be explored. It will also examine possible barriers to its implementation, including lack of standards, difficulty in adaptation, and the need for investment in technology.

In summary, the thesis will explore how Blockchain can be used to improve last-mile logistics, offering solutions to current challenges and enabling greater transparency, security and collaboration among stakeholders.

It will start from an analysis of the present literature on the subject and, thanks to a survey conducted by the Luiss Research Center to Italian and foreign companies regarding the use of Blockchain in the field of Last Mile delivery and more generally along the whole supply chain, it will verify whether or not the literature finds application in reality.

In this regard, the analysis will aim to answer the following research questions:

RQ_1. Does Blockchain adoption generate positive effects on a company's supply chain management?

RQ_2. What is the impact of last-mile technologies (such as drones) on the supply chain and how can it be further improved through the use of blockchain?

2. Literature review and hypotheses development

2.1 Blockchain Technology

Blockchain is a relatively new and rapidly evolving technology, and the available literature on the topic is constantly growing. In general, the literature on Blockchain focuses on its distinctive properties, i.e., the unique features that make this technology different from other similar technologies, such as decentralization, transparency, security, and immutability of data, and its potential uses in different sectors (Puthal et al., 2018).

The characteristics of Blockchain mentioned above will now be analyzed specifically:

- Decentralization: All network participants can access the distributed ledger and its immutable transaction record. Through it, transactions are recorded only once and thus any duplicate activities, typical of traditional corporate networks, are eliminated (Zarrin et al., 2021).
- Transparency: No participant can modify or alter a transaction after it has been recorded in the shared ledger. If a transaction record has an error, a new one must be added to correct it. Both transactions will therefore be visible. This allows their authenticity to be verified (Sunny et al., 2020).
- Security: the Blockchain uses advanced cryptographic algorithms to ensure that recorded data is protected from tampering and that transactions are secure (Zhang et al., 2019).
- Data immutability: all validated transactions are immutable, as they are permanently recorded. No one, not even a system administrator, can delete a transaction (Hofmann et al., 2017).

Another key element of Blockchain are smart contracts (De Giovanni, 2020). Smart contracts are digital contracts stored on a blockchain that are executed automatically when predetermined terms and conditions are met. When a condition is met, the contract is executed immediately. Because smart contracts are digital and automated, there are no paper documents to process or wasted time spent on error reconciliation (Zheng et al., 2020). Blockchain transaction records are encrypted, making them very difficult to hack. Smart contracts remove the need for intermediaries to handle transactions and, consequently, the delays and costs associated with them (Casado-Vara et al., 2019).

Considering this, we hypothesize:

H_1. The adoption of Blockchain technology for contract and transaction management has a positive impact on the management of complex supply chain contracts.

The use of blockchain in the supply chain can offer numerous benefits, including increased traceability, transparency, and security of transactions. Blockchain technology can be used to record and track the movement of goods along the supply chain, enabling various actors in the chain to verify the authenticity and origin of goods and monitor their status in real time (Helo and Shamsuzzoha, 2020).

At the enterprise level, blockchain can be used in several areas:

- Supply Chain Management: Blockchain can be used to track the origin of goods and ensure their quality, reduce transaction times, and improve supply chain transparency (Chang and Chen, 2020).

- Finance and accounting: Blockchain can be used to automate and speed up financial transactions and accounting processes, reducing costs and improving security (Demirkan et al., 2020).

- Data protection: Blockchain can be used to protect sensitive data, such as customers' personal information or financial transactions (Yu et al., 2022).

- Contract management: Blockchain can be used to automate the management of contracts, reducing the time and costs associated with their negotiation and management (Hewa et al., 2021).

- Intellectual property management: blockchain can be used to protect and manage copyrights, patents, and other forms of intellectual property (Ito and O'Dair, 2019).

For the purposes of this thesis, the implications of using blockchain to support supply chain management will be analyzed in detail, including benefits and limitations.

In general, the use of blockchain and smart contracts in the supply chain can help improve the efficiency, transparency, and security of processes, reduce costs, and improve customer satisfaction. There are many companies and start-ups that are already experimenting with this technology on different aspects of the supply chain, from product tracking to payment management and logistics:

1- De Beers, the leading diamond mining company, launched a blockchain platform called Tracr in 2018 to track the origin of diamonds from the mines to the hands of consumers. The platform is designed to ensure that diamonds sold by De Beers have been ethically and sustainably mined, thereby combating the problem of conflict diamond trading and fake diamond trading. The Tracr platform uses blockchain technology to create a unique and immutable digital ledger of diamonds, enabling supply chain participants to verify the provenance of diamonds in a secure and transparent manner. Each diamond is

assigned a unique ID on the platform, which follows the diamond throughout the supply chain, from mine to jewelry store. With Tracr, De Beers hopes to increase the transparency and traceability of diamonds, thereby helping to combat the conflict diamond trade and increasing consumer confidence in diamonds. In addition, the platform could also help create new markets for diamonds, as consumers may be willing to pay more for diamonds that have certain traceability and ethical sourcing (De Beers, 2022).

2- Atea, a Norwegian information technology company, is working with the Norwegian Seafood Association, Nova Sea, BioMar and IBM to use blockchain to establish an industry standard for seafood products. The project, called "Traceable fish from the sea to the table," aims to create a traceability system for seafood products using blockchain, which will allow consumers to verify the provenance and quality of the seafood products they purchase.

   The goal of the project is to create a blockchain platform that allows supply chain participants to record data on seafood products, such as origin, date of fishing and quality, so that consumers can easily verify this information. In addition, the project also aims to create a blockchain-based certification system that allows consumers to verify whether seafood products have been caught sustainably (IBM, 2021).

3- MediLedger is a blockchain platform for the pharmaceutical industry supply chain. It was founded by some of the world's largest pharmaceutical companies, including Pfizer and Genentech, with the goal of developing a blockchain-based supply chain solution for the pharmaceutical industry. MediLedger's supply chain system uses blockchain technology to create a distributed, immutable record of pharmaceutical product movements at the lot level. Information about the production, transportation, and distribution of drugs is recorded on the blockchain so that it can be easily verified and tracked by all authorized stakeholders, such as pharmaceutical companies, distributors, and regulatory authorities.

   The system also uses smart contracts to automate certain aspects of the supply chain process, such as verifying the authenticity of drugs. For example, when a drug is produced, a unique code is generated and recorded on the blockchain along with information such as production date, dosage and batch number. When the drug is transported to a distributor or pharmacist, they can use the code to verify that the drug is authentic and meets all safety and quality requirements.

   In summary, blockchain enables the creation of a distributed, transparent, and immutable record of drug movements, making it easier for pharmaceutical companies and regulatory authorities to monitor and verify that drugs have been transported and stored in a safe and regulatory-compliant manner. In addition, the system makes it possible to verify the authenticity of drugs, preventing counterfeiting (MediLedger, 2023).

Considering this, we hypothesize:

H_2. The adoption of blockchain technology for new platform development has a positive impact on the management of product traceability and transparency.

H_3. The adoption of blockchain technology for the development of new platforms has a positive impact on the management of quality control.

In relation to the fight against counterfeiting, blockchain makes it possible to record information about original products in a unique and immutable way, so that the authenticity of products can be verified at any time. For example, a pharmaceutical company such as the one mentioned above uses the blockchain to record information about its products, such as the place and date of manufacture, expiration date, and serial number. This information is recorded on the blockchain as "blocks" of data, which cannot be changed once recorded (Kumar and Tripathi, 2019). When a consumer purchases a product, he or she can verify the authenticity of the product using a QR code or other scanning method. The QR code tells consumers whether the product has been registered on the blockchain and whether the information recorded on it matches that of the product they purchased. In this way, consumers can be assured that the product they purchased is authentic and safe for use (Aini et al., 2020)

Counterfeiting is a significant problem in Italy. According to the Institute for the Protection of Italian Industrial Property (ITPI), the value of the black market for counterfeit products in Italy has been estimated at about 6.6 billion euros in 2019 (Ministry of Business and Made in Italy, 2023). This includes both counterfeit goods and counterfeit services. Globally, the World Trade Organization (WTO), estimates that global trade in counterfeit goods reached $1.82 trillion in 2020, accounting for 3.3 percent of global trade. China is still regarded as a major producer and distributor of counterfeit goods. Other high-risk countries are India, Hong Kong, the Netherlands, Singapore, Dubai, Turkey, and Russia. Fashion and clothing are the sectors most affected by counterfeiting, followed by food products, alcoholic beverages, and pharmaceuticals. (Ministry of Foreign Affairs, 2023) Counterfeiting can have negative consequences for the global economy, consumer health and safety, and can harm legitimate businesses and workers. Authorities around the world are working to combat counterfeiting through laws and international cooperation, and technology is also developing innovative solutions to support it.

Considering this, we hypothesize:

H_4. Integration of blockchain technology with other digital technologies enables greater control over the origin and provenance of raw materials.

2.2 Last Mile

The combination of blockchain and last mile offers many opportunities to improve supply chain traceability and security, as well as to automate and simplify delivery processes.

The "Last Mile" is a term used to describe the last stage of a product delivery, which is the transportation of the product from the last transit point to the end customer (Lim et al, 2018). The Last Mile is considered one of the most complex and costly steps in the supply chain, as it requires precise planning and logistics to ensure that products are delivered in a timely and accurate manner (Guo et al, 2019).

Last Mile logistics includes activities such as selecting the most efficient route for delivery, planning milestones, vehicle and human resource management, managing delays, and troubleshooting.

According to the literature, the most common parameters for evaluating the efficiency of last mile delivery are:

- Delivery time: the amount of time between product shipment and delivery to the recipient (Hubner et al., 2016) .
- Cost: the total cost associated with delivery, including transportation, labor, and operational costs (Mangiaracina et al., 2019)
- Accuracy: the precision in delivering packages on time and in the required quantities
- Reliability: the ability to deliver the product within an expected time frame and in good condition.
- Customer satisfaction: the customer's perception of the quality of the delivery service (Vakulenko et al., 2019).
- Environmental impact: the environmental impact of last-mile deliveries, including fuel use and traffic congestion (Bertram and Chi, 2018).
- Flexibility: the ability to adapt to changes in customer demand or product availability.
- Traceability: the ability to monitor and track delivery in real time to ensure product safety and customer satisfaction (Zhang et al., 2016).
- Logistics efficiency: the ability to optimize the delivery process in terms of cost, time and customer satisfaction.

Due to the growing demand for quick and customized deliveries, the Last Mile is becoming increasingly important for companies to meet their customers' needs and maintain a competitive advantage. This has led to the development of new technological solutions that can meet these needs (De Giovanni and Cariola, 2021), such as drone delivery, automated delivery, and real-time delivery through technologies such as blockchain (Deng et al., 2020).

2.3 Unmanned Aerial Vehicle

The "last mile" challenge in logistics is difficult since it is inefficient and expensive. Unmanned Aerial Vehicle (UAV) delivery, such as drone delivery, has been presented and widely acknowledged as a possible solution to this problem. However, the majority of present UAV delivery systems are based on Cloud Computing, which cannot match the requirements of numerous real-time services in UAV delivery systems efficiently. Meanwhile, security concerns in UAV delivery systems are raised due to the presence of numerous actors (such as the sender, middler, and receiver) who may not have a mutual trust relationship (Li et al., 2022). Blockchain, precisely because of its qualities, aids in the resolution of these issues.

Drones may already be the most convenient delivery mode under some conditions, such as in areas with insufficient road infrastructure. They are also environmentally benign, with CO_2 emissions that are typically lower than those of single-delivery electric cars and vans, and substantially lower than those of gasoline vehicles.

A study published by McKinsey & Company (2023) states, however, that an initial limitation to the potential of drones in deliveries stems from relevant regulations; In most nations, persons are only allowed to operate and monitor one drone at a time; a visual observer must also monitor the airspace in which the drone operates. As a result, labor can contribute for up to 95% of total drone delivery costs. To become really cost competitive across the board, operators must be able to change their focus from observing airspace to operating drones, and the number of drones per operator must considerably grow. This, in turn, will necessitate significant advancements in technology and legislation to allow a single operator to operate up to 20 drones in heavily populated skies.

These advancements would include autonomous drone flying, which would allow drones to fly with minimal human intervention, unmanned traffic management systems, and detection and avoidance solutions. Only after these system modifications will the potential cost savings of drone delivery become apparent (Cornell et al., 2023).

There are already several companies exploiting the potential of drones for delivery (Goodchild and Toy, 2018), including:

- Amazon Prime Air: Amazon is developing a drone delivery service called Prime Air. The service will use autonomous drones to deliver packages to customers quickly and safely.
- UPS Flight Forward: UPS has launched a drone delivery program called UPS Flight Forward. The program uses drones to deliver packages to customers in rural and remote areas.

- Alibaba: Alibaba, a Chinese e-commerce company, has begun using drones for deliveries in some rural areas of China. The company said drones can reduce delivery time and increase delivery efficiency.
- DHL: DHL, a global logistics company, is using drones for deliveries in some rural areas of northern Europe, where traditional means of transportation can be difficult to use.

Considering this, we hypothesize:

H_5. The use of Unmanned Aerial Vehicles (such as drones) in the last mile has a positive impact on delivery time and cost.

H_6. The use of Unmanned Aerial Vehicles (such as drones) in the last mile reduces logistical risks and increases the safety of deliveries.

2.4 Last Mile and customer satisfaction

There are several studies and research that explore the relationship between last mile and customer satisfaction. Studies that explore the relationship between last mile and customer satisfaction often look at factors such as timeliness of delivery, accuracy of delivery, flexibility of delivery options, and communication during the delivery process. These factors can affect customer perceptions of service quality.

A 2021 study published in the "*Journal of Business & Industrial Marketing*" analyzed the impact of the last mile on customer satisfaction in an e-commerce context. The research showed that logistics value, consisting of convenient delivery location, delivery time and flexibility, delivery tracking, and return convenience, positively affects customer satisfaction. In addition, the relationship between logistics value and customer satisfaction is stronger when transactions are made in industries with higher service levels (Kawa and Światowiec-Szczepańska, 2021)

Overall, these studies show that the last mile is a crucial factor in customer satisfaction and that efficient management of the last mile can increase customer satisfaction and loyalty toward the brand.

Regarding consumers' perceptions of last-mile deliveries made by drones, a 2020 study published in "*Journal of Air Transport Management*" analyzes consumers' preference for drone delivery over a traditional delivery service. The results show that price and type of goods influence consumer preference, which also depends on socio-demographic characteristics such as gender, age and household income.

Specifically, the younger the consumer's age, the greater the preference for drone delivery service (Kim, 2020).

Another study published in "*International Journal of Logistics Research and Applications*" shows that perceived usefulness and trust have the greatest influence on consumers' intention to adopt drones for delivery. Furthermore, it is shown that as perceived privacy risk increases, the intention to adopt drone delivery service decreases (Leon et al., 2021).

Thus, work still needs to be done on these aspects to overcome these obstacles and make the use of drones an acceptable and safe solution.

Considering this, we hypothesize:

> *H_7. The adoption of blockchain technology through the introduction of tokens for all parties involved in a transaction has a positive impact on the management of informative transparency.*
>
> *H_8. Integration of blockchain technology with other digital technologies enables successful sharing of information with consumers.*

2.5 Urban logistics and sustainability

Blockchain can be used to optimize urban logistics through asset tracking and optimal scheduling of deliveries. This can help reduce traffic congestion and pollution, as deliveries can be scheduled more efficiently and CO_2 emissions can be monitored and reduced (Caspersen and Navrud, 2021).

The amount of pollution produced by a "last mile" delivery depends on several factors, including the type of vehicle used, the distance traveled, and the load transported. In general, deliveries made by traditional vehicles such as trucks or vans may produce more pollution than deliveries made by AI-driven vehicles, as the latter are often designed to be more energy efficient and emit fewer pollutant emissions.

Autonomous vehicles or drones can make deliveries using an optimized route, avoiding traffic, and thus reducing CO_2 emissions. According to the European Environment Agency (2022), the transport sector is responsible for about a quarter of total CO_2 emissions in Europe, 71.7 percent of which is produced by road transport.

In general, combustion engine-powered transport vehicles, such as trucks and vans, are responsible for higher levels of emissions than electric or alternatively powered transport vehicles. However, it is important

to note that the efficiency of the vehicle and the amount of cargo transported can also affect the environmental impact of last mile deliveries.

A study conducted by the University of Cambridge (2020) examined how the use of autonomous vehicles for last mile deliveries could reduce CO2 emissions by 30-50%.

Blockchain technology can then be used to improve the traceability and transparency of last mile deliveries, enabling more efficient route optimization and reduced emissions. There are also several ongoing pilot projects using blockchain to track last mile deliveries in sectors such as agriculture and logistics, with the goal of improving environmental sustainability (Xiong et al., 2020).

Considering this, we hypothesize:

> *H_9. The use of route optimization system generates positive performance in terms of environmental impact.*

3. Methods

The objective of this study is to analyze the impact of blockchain and last-mile technologies on supply chain and business performance. To this end, two research questions (RQ_1 and RQ_2) were developed to guide us in this study.

The first RQ tests whether blockchain adoption generates positive effects on supply chain management.

The second RQ explores the impact of last-mile technologies (such as drones) on the supply chain and how it can be further improved through the use of blockchain.

Next, the following nine hypotheses were developed:

H_1. The adoption of Blockchain technology for contract and transaction management has a positive impact on the management of complex supply chain contracts.

H_2. The adoption of blockchain technology for new platform development has a positive impact on the management of product traceability and transparency.

H_3. The adoption of blockchain technology for the development of new platforms has a positive impact on the management of quality control.

H_4. Integration of blockchain technology with other digital technologies enables greater control over the origin and provenance of raw materials.

H_5. The use of Unmanned Aerial Vehicles (such as drones) in the last mile has a positive impact on delivery time and cost.

H_6. The use of Unmanned Aerial Vehicles (such as drones) in the last mile reduces logistical risks and increases the safety of deliveries.

H_7. The adoption of blockchain technology through the introduction of tokens for all parties involved in a transaction has a positive impact on the management of informative transparency.

H_8. Integration of blockchain technology with other digital technologies enables successful sharing of information with consumers.

H_9. The use of route optimization system generates positive performance in terms of environmental impact.

To test our hypotheses, data from a survey conducted by the Luiss Research Center were analyzed. The goal of the survey was to gather information from international companies regarding blockchain investments, last-mile management, and management of the entire supply chain. The survey was sent to companies operating along the entire supply chain: Manufacturer, Wholesaler, Distributor, Supplier, Retailer. Companies were asked to respond to the questionnaire by considering the last two years of company business. Following data cleaning, 156 valid responses emerged, which were used to conduct the analysis.

The following table shows the sample description:

Company type	#	%	Number of employees	#	%	Average turnover (millions)	#	%
Manufacturer	56	36%	< 50	14	9%	< 10	11	7%
Wholesaler	30	19%	50-99	40	26%	10-50	38	24%
Distributor	13	8%	100-200	19	12%	50-100	25	16%
Supplier	21	13%	> 200	83	53%	> 100	82	53%
Retailer	36	23%						
	156			156			156	

Table 1
Data source: LUISS Research Center survey

The original questionnaire included a section on Omnichannel, but this was not considered for the purposes of our analysis. Instead, responses from the following blocks were considered:

- Investment in Blockchain technology
- Management of supply chain challenges

- Management of operational challenges
- Last-mile management
- Management of logistics challenges
- Investment in new technologies
- Corporate performance

Each block has within it variables that the companies rated according to a seven-point Likert scale, where item 1 represents "Strongly disagree," item 4 "Neither agree nor disagree," and item 7 "Strongly agree." For the data analysis, it was decided to consider all items on the scale but clasterizing them into three levels:

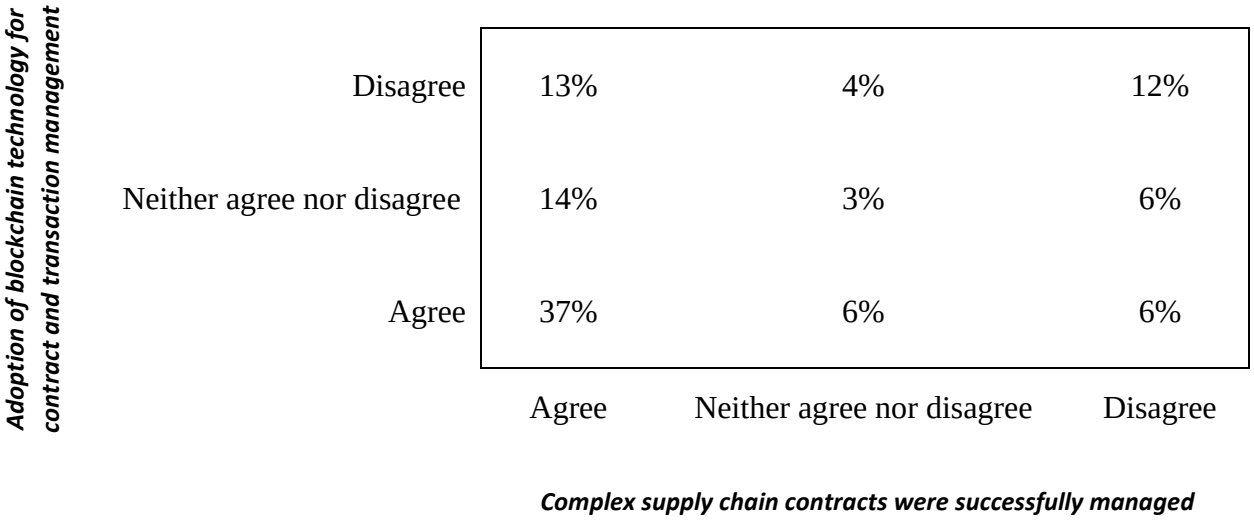
1) Disagree (within which there are items 1 to 3)
2) Neither agree nor disagree (within which only item 4 was considered)
3) Agree (within which there are items 5 to 7)

To test our hypotheses, some variables were selected from all the variables investigated in the survey. The first group of variables has as its main theme the investments in Blockchain technology made by the analyzed companies in the last two years. The second group of variables concerns some of the main aspects of the supply chain, such as product traceability, quality management, last-mile delivery and sustainability. In detail, the variables considered regarding blockchain and new technologies related to it were the following: "Modifying the management of contracts and transactions," "Developing new platforms," "Integrating blockchain technologies with other digital technologies," "Robot delivery (e.g.: drones)," "Introducing tokens for all parties involved in a transaction," and "Route optimization system."

These variables were analyzed through a correspondence analysis with the second group of variables: "Complex supply chain contracts," "Product traceability," "Product transparency," "Quality control and management," "Raw materials origin and provenance," "Delivery cost," "Delivery time," "Logistics risks and safety," "Lack of transparency," "Information sharing with consumers," and "Environmental impact." The variables chosen can be traced to different aspects of the supply chain and cover different areas of interest, corresponding to those examined in the Literature review.

4. Results

H_1. The adoption of Blockchain technology for contract and transaction management has a positive impact on the management of complex supply chain contracts.



The figure shows us that 37 percent of the total companies surveyed say they have adopted blockchain technology for contract and transaction management and have been successful in managing complex supply chain contracts. At the same time, only 13 percent of the surveyed companies decided not to use blockchain technology for contract management, but still managed to achieve good results in contract management.

As anticipated earlier, blockchain is a technology that offers greater transparency, security and immutability in contract and transaction management. This makes it easier for the various actors in the supply chain to collaborate, increasing the efficiency and speed of transactions. In addition, blockchain eliminates the need for third-party intermediaries, reducing costs and increasing trust between trading partners.

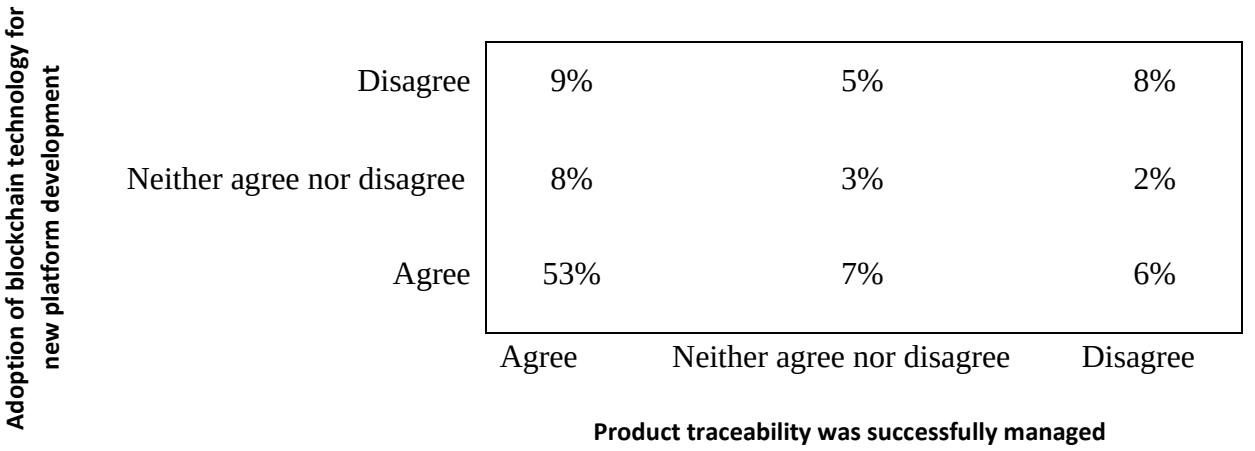
Nick Szabo, a technologist and academic known for developing the smart contract concept in the 1990s, defines smart contracts as "automated self-executing contracts with the terms of the agreement between buyer and seller being directly written into lines of code" (Szabo, 1994).

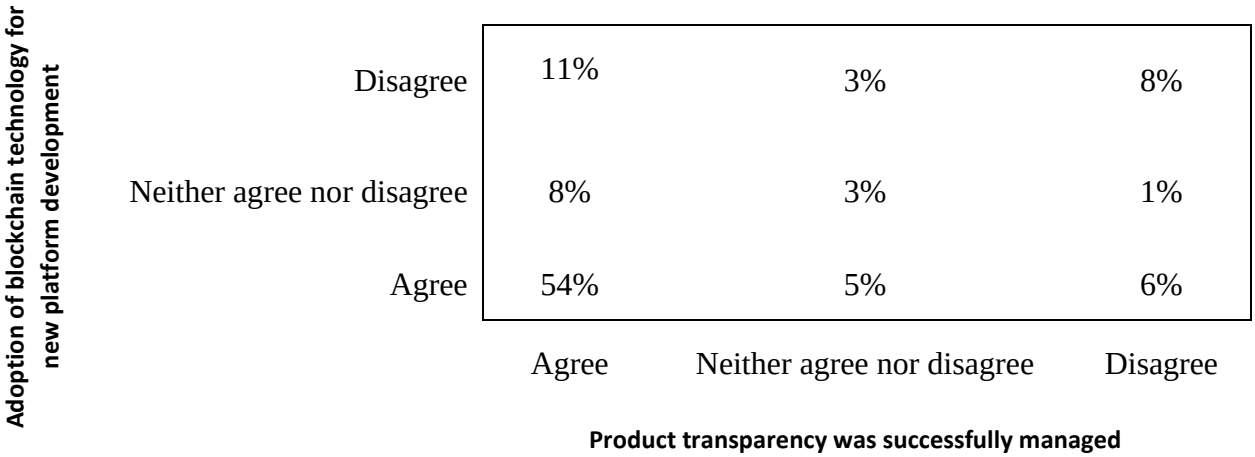
Blockchain makes smart contracts immutable, which means that once a contract has been registered, it cannot be modified or deleted. Smart contracts can be used to eliminate intermediaries in many contract activities, which means that there are lower costs and faster time for contract management.

However, there are also some difficulties associated with the use of smart contracts, such as the need for technical experts to create and manage contracts and the lack of appropriate legislation and regulation in

many countries. These could be just some of the reasons why 28 percent of the companies surveyed decided not to use blockchain technology for contract management at all.

H_2. The adoption of blockchain technology for new platform development has a positive impact on the management of product traceability and transparency.





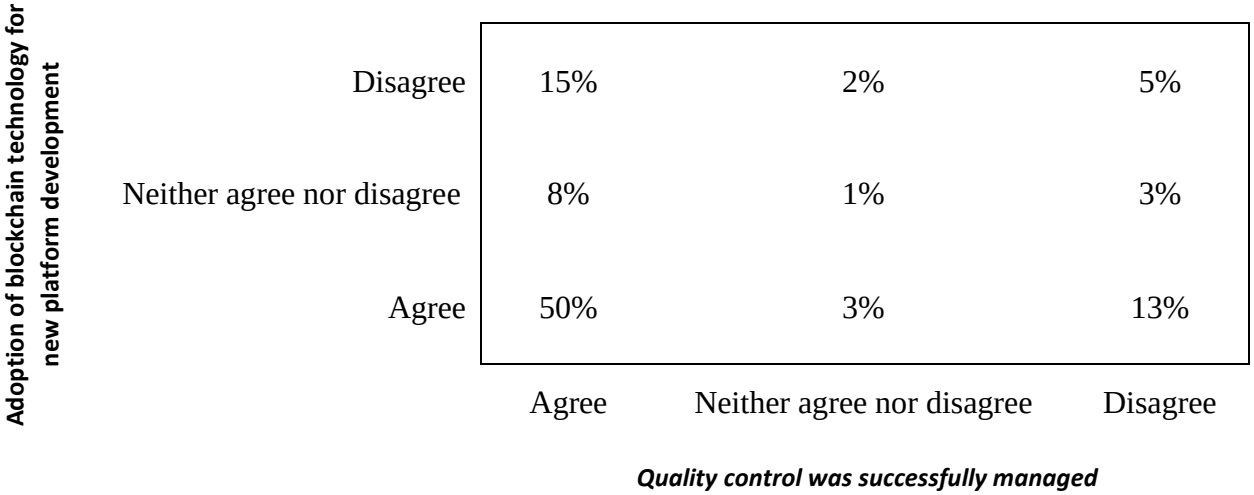
The figures show us that more than 50 percent of the total companies surveyed say they have adopted blockchain technology for the development of new platforms and have successfully managed product traceability and transparency. At the same time, only 9% of the surveyed companies that did not use blockchain technology still managed product traceability successfully, while for product transparency, only 11% of companies did.

Companies that do not use blockchain to manage product traceability can do so through traditional systems, such as a centralized database, manual recording of product information, use of barcodes and other identification systems.

Adopting blockchain technology to manage product traceability and transparency has several advantages for companies. First, blockchain is a distributed digital ledger that makes it possible to immutably record all transactions and create a complete history of products. This means that manufacturers, suppliers and customers can verify the provenance, quality and safety of products quickly and reliably.

In addition, the transparency provided by blockchain can increase consumer trust in products and improve companies' reputations.

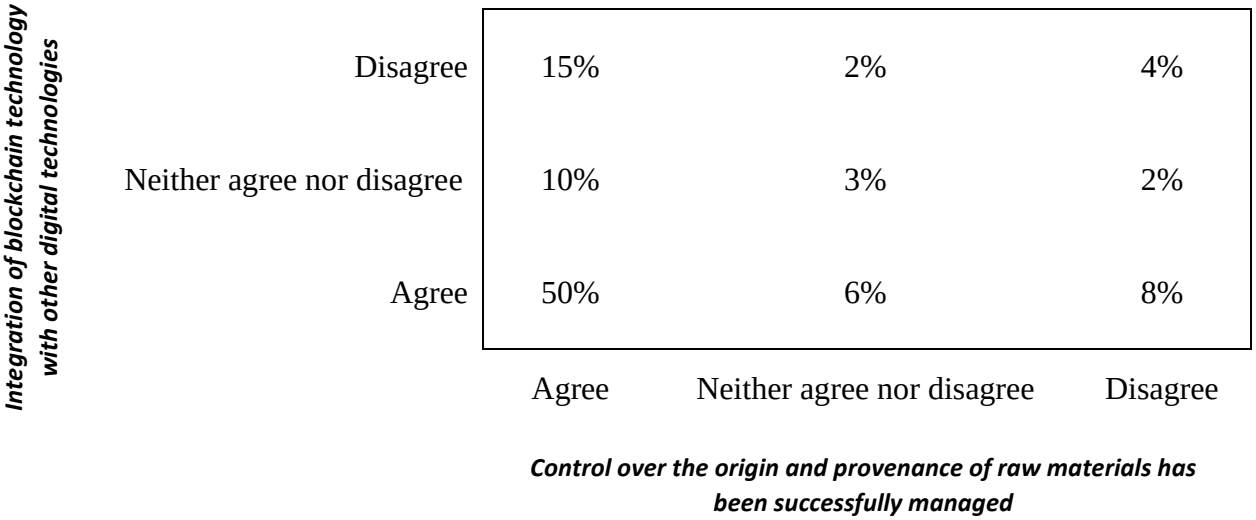
H_3. The adoption of blockchain technology for the development of new platforms has a positive impact on the management of quality control.



Quality control is a verification process that takes place throughout the life cycle of a product or service, from its design stage to delivery to the customer. Quality control can be carried out internally by company employees or by specialized external entities, and consists of a series of tests, inspections, and checks that aim to ensure that the product or service meets customer requirements and specifications. This process can be supported by various technologies, including blockchain, which can ensure the quality of the product or service. In fact, as shown in the figure, 50 percent of the companies surveyed say they have adopted blockchain technology and successfully managed product quality control. The other 50% of the surveyed companies either do not use blockchain for quality control or use this technology but this does not have positive effects on quality control. This figure can be explained by introducing the limitations there are in using blockchain for quality control. A first limitation is the difficulty in integrating blockchain with existing systems: integrating blockchain with existing IT systems can be complex and time and resource

consuming. In addition, blockchain technology is still new and its adoption is limited in many areas. This can make it difficult for companies to share data and quality control information.

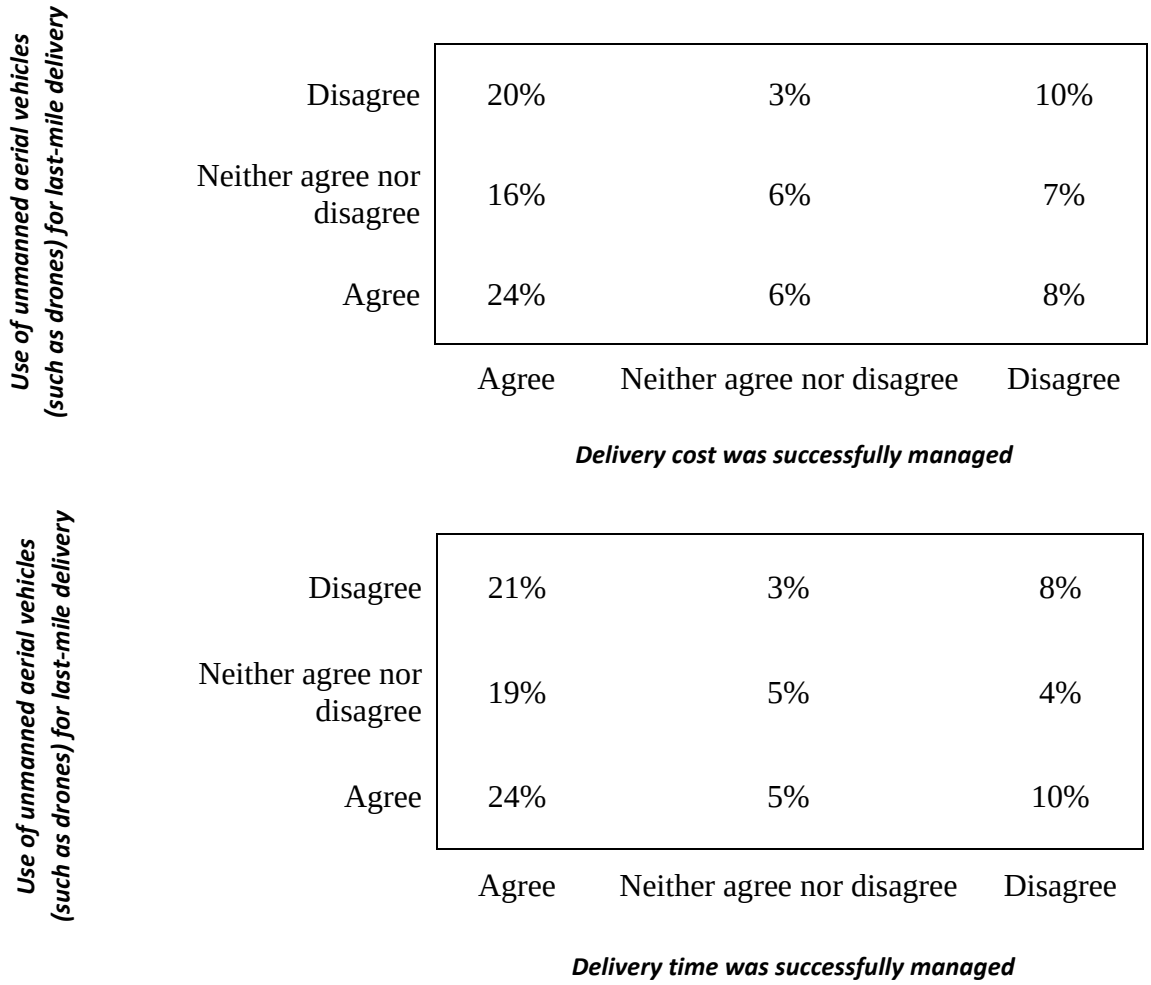
H_4. Integration of blockchain technology with other digital technologies enables greater control over the origin and provenance of raw materials.



Blockchain can be integrated with technologies such as IoT (Internet of Things) and AI (Artificial Intelligence) to monitor and track raw materials in real time, making it easier for companies to identify and verify their origin and provenance. This can be particularly useful for companies that want to ensure that the raw materials used in production meet certain quality, ethical and sustainability standards. However, integrating different technologies also brings challenges, such as system compatibility, data security and the need for standardization.

Fifty percent of the companies surveyed have integrated blockchain with other digital technologies and successfully managed control over the origin and sourcing of raw materials.

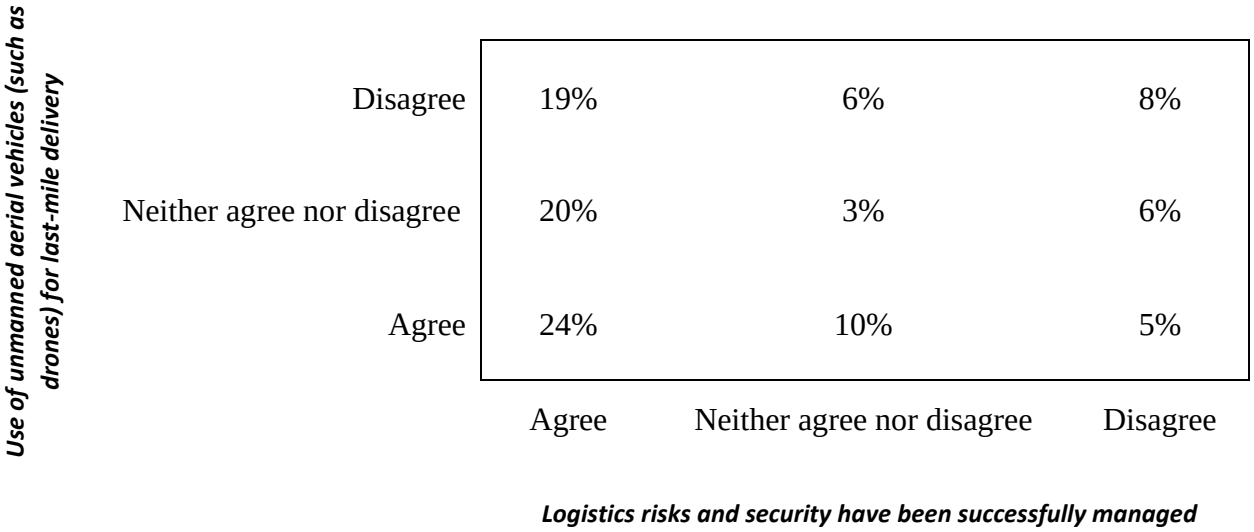
H_5. The use of Unmanned Aerial Vehicles (such as drones) for last-mile delivery has a positive impact on delivery time and cost.



Several studies have found that the use of drones can significantly reduce delivery times as they can avoid traffic congestion and the need to stop at traffic lights. In addition, drones can access areas that are difficult to reach by traditional deliveries, such as rural and remote areas. Drones help improve the accuracy of deliveries and increase the overall efficiency of the delivery process. The use of drones can also help reduce delivery costs by reducing the need for manual labor and minimizing the risk of human error. Twenty-four percent of companies surveyed say they have used drones and experienced benefits in terms of delivery cost and time. However, the use of drones for last-mile deliveries also presents some challenges, such as regulatory restrictions, privacy concerns, and limited flight range. This may explain why about 10 percent of companies, have used drones for deliveries, but have not seen cost and time benefits. Although the use of drones for delivery can potentially have a positive impact on the time and cost of shipments, there are still many challenges to overcome to make this technology fully efficient and accessible to companies. The

main challenges include Restrictive regulations and standards, lack of adequate infrastructure for charging and storing drones, and the need for accurate planning and logistics.

H_6. The use of Unmanned Aerial Vehicles (such as drones) in the last mile reduces logistical risks and increases the safety of deliveries.

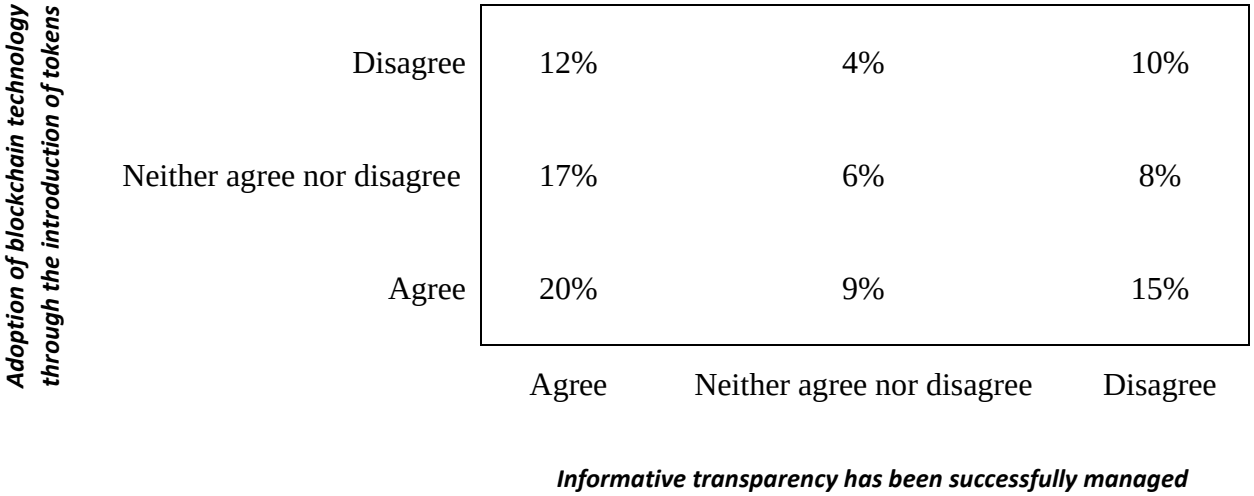


The figure that stands out the most is the fact that about 40 percent of the companies surveyed say they have successfully managed logistics risks and security without the use of drones. This is a result we expected as companies can manage logistics risks and security even without the use of drones, but through a combination of traditional and technological solutions.

Choosing reliable delivery partners, planning and managing resources, constantly monitoring shipments, and training delivery personnel are just some of the traditional methods used by companies to manage logistics risks.

Logistics risks can affect all players in the supply chain, including manufacturers, suppliers, transporters, warehouses, and retailers. The main logistics-related risks include supply disruptions, delivery delays, damage or loss of goods in transit, errors in information processing, lack of visibility into the route of goods, and uncertainty about product availability.

H_7. The adoption of blockchain technology through the introduction of tokens for all parties involved in a transaction has a positive impact on the management of informative transparency.

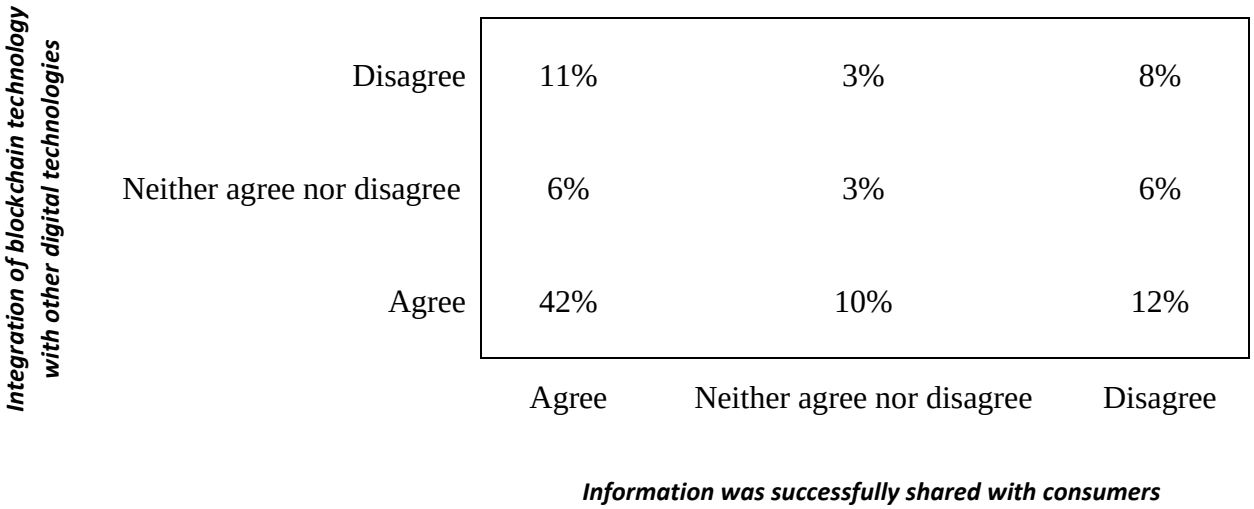


Information transparency can be defined as a supply chain mapping activity in which information is collected on, for example, the components of a product, names of suppliers, location of facilities, associated certifications, etc. Companies can develop the transparency of their supply chain through information and knowledge sharing (Narwane et al., 2020). The traceability feature of the supply chain enhances transparency (Ada et al., 2021).

Tokens are digital units that represent an asset or right in a blockchain. They can be used to represent goods and services, such as tangible property or financial services, and can be exchanged and transferred between users in a blockchain. Tokens can be used to increase the transparency and traceability of transactions, making it easier for the parties involved to verify and track the provenance and history of an asset or service. A company can use tokens to represent ownership of a product or asset, and these tokens can be transferred between different supply chain actors, providing complete traceability of transactions.

More than 50 percent of the companies interviewed say they have not managed information transparency well, and this is a very significant finding that highlights how difficult it is for companies to achieve this goal. The main obstacles in achieving information transparency could relate to the lack of a centralized data collection and management system, integration of information from different sources, data protection, and technological complexity in terms of resources and time.

H_8. Integration of blockchain technology with other digital technologies enables successful sharing of information with consumers.



Of the total number of companies surveyed, 42 percent say they have used blockchain technology and through it have successfully shared information with consumers. This figure highlights the importance of supply chain transparency.

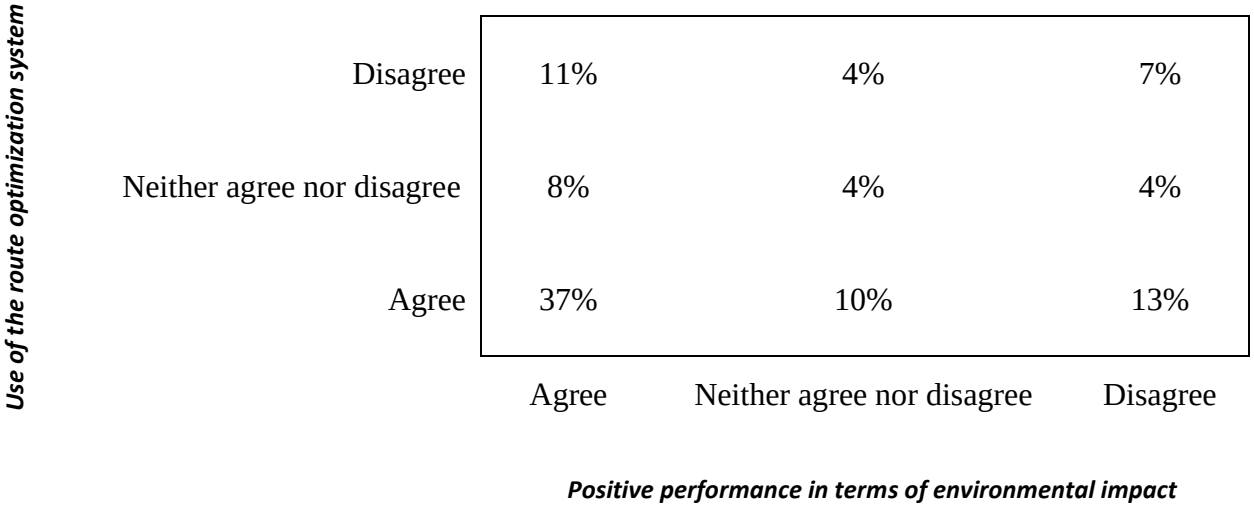
Thanks to blockchain technology, companies can share information about the provenance, quality, and safety of products with consumers. This increases trust in products and brands, as well as consumer awareness of where raw materials come from and how they have been handled.

Over time, this transparency will help develop consumers' loyalty to companies, increasing their likelihood of choosing to buy from them again in the future.

In addition, informational transparency can also help prevent the spread of fake or dangerous products in the market, as it allows consumers to verify the authenticity and origin of a product. As analyzed in the literature review, The fight against counterfeiting is an ongoing effort to prevent the production and distribution of fake products that imitate original products.

Through a blockchain, consumers can access detailed information about the production and distribution of a product, including the date of production, place of origin, and intermediate steps.

H_9. The use of route optimization system generates positive performance in terms of environmental impact.



A route optimization system allows delivery routes to be planned efficiently, minimizing distances traveled and fuel use. A route optimization system analyzes information about destinations, vehicles, load capacity, and other factors to calculate the most efficient delivery solution in terms of cost, time, and resource utilization. Using advanced technologies for route optimization can also help prevent delivery delays and improve the quality of service provided to customers.

Thirty-seven percent of companies surveyed say they use route optimization systems and are able to perform positively in terms of environmental impact.

A company's environmental impact can be calculated using several tools and methodologies. One of the most common is the greenhouse gas emissions assessment, which includes quantifying the carbon dioxide and other greenhouse gas emissions produced by the company during its production and distribution process.

Last-mile delivery significantly affects the environmental impact due to the density of vehicles and their movement in an urban area. The amount of trips made for delivery, the amount of miles driven, and the type of vehicles used can have a significant effect on the amount of greenhouse gas emissions and the amount of fuel consumption. In addition, there has been a significant increase in the number of last-mile deliveries in recent years due to the spread of e-commerce, and this is putting pressure on the capacity of urban infrastructure, increasing traffic congestion and air pollution.

Route optimization technology and more efficient route planning can reduce this negative impact by improving transportation efficiency and emission control.

5. Discussion

Blockchain is a technology that is attracting increasing attention in several industries, including logistics. Its ability to create a shared and immutable digital ledger between multiple parties allows for transparency, security, and immutability of data. This study was created with the aim of exploring the potential of blockchain and its application in last-mile delivery and, more broadly, throughout the supply chain. In particular, the study aims to verify whether what is described in the literature, finds correspondence in reality.

The last mile is the final stage in the process of delivering a product. It is a crucial stage of the logistics process, as it represents direct contact with the customer and can significantly affect customer satisfaction. However, the last mile also presents several challenges, including delivery management, traceability, security, and punctuality.

The starting point was an analysis of the literature present on the subject and, thanks to a survey conducted by the Luiss Research Center to Italian and foreign companies regarding the use of Blockchain in the field of Last Mile delivery and more generally along the entire supply chain, its correspondence with reality was verified.

The study was guided by the following two research questions:

RQ_1. Does Blockchain adoption generate positive effects on a company's supply chain management?

RQ_2. What is the impact of last-mile technologies (such as drones) on the supply chain and how can it be further improved through the use of blockchain?

Nine hypotheses were developed, allowing us to analyze Blockchain from different perspectives, enabling a greater understanding of industry dynamics and leading to the identification of new opportunities to optimize supply chain management.

The managerial implications of this study are diverse and depend on the type of company and the specific needs of its supply chain. In general, the confirmed hypotheses may suggest to company managers that adopting blockchain technology for contract management has a positive impact on managing complex supply chain contracts. Smart contracts are digital contracts stored on a blockchain that are automatically executed when predetermined terms and conditions are met. Smart contracts remove the need for intermediaries to manage transactions and, consequently, the delays and costs associated with them. This was confirmed in the analysis of data on the companies surveyed.

The use of blockchain technology has a positive impact on the management of product traceability and transparency. Blockchain technology can be used to record and track the movement of goods along the supply chain, enabling the various actors in the chain to verify the authenticity and origin of goods and monitor their status in real time. The integration of blockchain technology with other digital technologies enables greater control over the origin and provenance of commodities. All these aspects are closely related to the concept of quality control.

Quality control is a verification process that takes place throughout the life cycle of a product. Data analysis has shown that the adoption of blockchain technology for quality control has limitations, however. A first limitation is the difficulty in integrating blockchain with existing systems: integrating blockchain with existing IT systems can be complex and time and resource consuming. In addition, blockchain technology is still new and its adoption is limited in many areas.

Two other key aspects that were addressed in the study are information transparency and information sharing with consumers.

Of the total number of companies surveyed, 42 percent say they have used blockchain technology and through it have successfully shared information with consumers. This figure highlights the importance of supply chain transparency. Thanks to blockchain technology, companies can share information about the provenance, quality, and safety of products with consumers. This helps prevent the spread of fake or dangerous products in the market, thus fighting against counterfeiting.

On the topic of Last Mile, this is considered one of the most complex and expensive steps in the supply chain, as it requires precise planning and logistics to ensure that products are delivered in a timely and accurate manner. Due to the growing demand for quick and customized deliveries, the Last Mile is becoming increasingly important for companies that want to meet their customers' needs and maintain a competitive advantage. This has led to the growth of innovative delivery solutions such as drone delivery.

Through a literature review, we found that the use of drones has potential benefits in terms of delivery time and cost, delivery safety, and CO_2 emissions. Through analysis of the data from the survey, a slight discrepancy emerged between what the literature states and what is actually perceived by the companies involved. Specifically, about 10 percent of the companies stated that they have used drones for deliveries but did not see any benefits in terms of cost and time. This may stem from the fact that there are still many challenges to overcome to make this technology fully efficient and accessible to companies. The main challenges include restrictive regulations and standards, lack of adequate infrastructure for charging and storing drones, and the need for accurate planning and logistics. In contrast, at the sustainability level, the

benefits of using drones in last-mile deliveries are clear. Drones can make deliveries using an optimized route, avoiding traffic, and thus reducing CO_2 emissions.

The last aspect discussed is again about sustainability, and in particular the use of route optimization systems. A route optimization system allows delivery routes to be planned efficiently, minimizing distances traveled and fuel use. Thirty-seven percent of the companies surveyed say they use route optimization systems and are able to perform positively in terms of environmental impact. It is worth pointing out that a company's environmental impact can be calculated using various tools and methodologies. One of the most common is the greenhouse gas emission assessment, which includes quantifying the carbon dioxide and other greenhouse gas emissions produced by the company during its production and distribution process. Last-mile delivery significantly affects the environmental impact because of the density of vehicles and their movement in an urban area.

This study provides information on the actual implications of using Blockchain operationally, logistically, and in relation to the ecosystem. The actual performance of new technologies (such as drones and route optimization software) used along the supply chain of the surveyed companies is also analyzed.

However, it must be considered that this study has limitations, which can serve as an inspiration for future research in this field. First, the sample surveyed, consisting of 156 companies, represents only a small portion of the companies using blockchain technology in the supply chain, and this limits the generalizability of the results. Second, the data derived from the survey administered to companies, are the result of a self-assessment, so one must consider the tendency of companies to provide favorable responses.

Another limitation concerns the long-term effects of the technologies adopted by companies. The results obtained at this time may not be valid in the future due to any technological developments or changes in the external environment. This could make it difficult to determine the full and lasting impact of such technologies on business performance.

Finally, one must consider blockchain regulations, which can change over time. This can make it difficult for companies to implement blockchain technology and keep it in line with current regulations. In addition, if blockchain-related regulations change, the results of the study may no longer be representative of reality.

6. Conclusions

This study investigates the effects of using blockchain along the entire supply chain, with a focus on the application of this technology in last-mile deliveries and new technologies to support it. In general,

blockchain generates positive effects along the entire supply chain and enables stakeholders to manage various operations more efficiently and effectively.

The available literature on the subject was compared with data from a survey conducted by the Luiss Research Center. The survey was submitted to companies operating throughout the supply chain (Manufacturer, Wholesaler, Distributor, Supplier, Retailer) and was aimed at investigating the investments made by companies in recent years in blockchain technology, operational management challenges, logistics challenges, last-mile management and business performance.

Several hypotheses were developed and tested using data from a sample of 156 international companies.

The data analysis showed how the adoption of blockchain technology has a positive effect on product traceability and transparency, quality control, and the origin of raw materials. All of these contribute to strengthening the fight against counterfeiting.

We also discussed the importance of sharing information with consumers and the positive impact of using pathway optimization systems on sustainability. Finally, we analyzed the benefits of using drones for last-mile delivery, such as reducing the time and cost of delivery, the ability to reach remote locations, and the reduction of CO_2 emissions by companies. However, some limitations in using drones for last-mile delivery emerged, such as the need for compliance with flight regulations, the need for adequate infrastructure, and the high initial investment in resources and skills.

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Summary

1. Introduction

Blockchain is attracting increasing attention in the logistics and delivery industry due to its ability to create a shared and immutable digital ledger (IBM, 2023). This thesis will explore how Blockchain can be used to improve last-mile logistics, offering solutions to current challenges such as traceability, security, and on-time delivery. The opportunities and benefits of Blockchain for last-mile logistics will be explored, and possible barriers to its implementation, such as lack of standards and difficulty of adaptation, will be examined. The thesis will be based on literature analysis and a survey conducted by the Luiss Research Center to Italian and foreign companies regarding the use of Blockchain and will attempt to answer the following research questions:

RQ_1: Does Blockchain adoption generate positive effects on a company's supply chain management?

RQ_2: What is the impact of last-mile technologies on the supply chain and how can it be further improved through the use of Blockchain?

2. Literature review and hypotheses development

2.1 Blockchain Technology

Blockchain is a rapidly evolving technology with many distinctive properties such as decentralization, transparency, security and immutability of data (Puthal et al., 2018). Blockchain technology can be used to record and track the movement of goods along the supply chain, enabling various actors in the chain to verify the authenticity and origin of goods and monitor their status in real time (Helo and Shamsuzzoha, 2020).

Another key element of Blockchain is smart contracts (De Giovanni, 2020). Smart contracts are digital contracts stored on a blockchain that are automatically executed when predetermined terms and conditions are met (Zheng et al., 2020).

Considering this, we hypothesize:

> *H_1. The adoption of blockchain technology for contract and transaction management has a positive impact on the management of complex supply chain contracts.*
>
> *H_2. The adoption of blockchain technology for new platform development has a positive impact on the management of product traceability and transparency.*

H_3. The adoption of blockchain technology for the development of new platforms has a positive impact on the management of quality control.

In terms of fighting counterfeiting, blockchain makes it possible to record information about original products in a unique and immutable way, so that the authenticity of products can be verified at any time. For example, a pharmaceutical company could use the blockchain to record information about its products, such as the place and date of manufacture, expiration date, and serial number. This information is recorded on the blockchain as "blocks" of data, which cannot be changed once recorded (Kumar and Tripathi, 2019). In this way, consumers can be assured that the purchased product is authentic and safe (Aini et al., 2020).

Considering this, we hypothesize:

H_4. Integration of blockchain technology with other digital technologies enables greater control over the origin and provenance of raw materials.

2.2 Last Mile

The "last mile" is a term used to describe the last stage of product delivery, which is the transportation of the product from the last transit point to the end customer (Lim et al, 2018). The last mile is considered one of the most complex and expensive steps in the supply chain, as it requires precise planning and logistics to ensure that products are delivered in a timely and accurate manner (Guo et al, 2019). Due to the growing demand for fast and customized delivery, the last mile is becoming increasingly important for companies to meet customer needs and maintain a competitive advantage. This has led to the development of new technological solutions that can meet these needs (De Giovanni and Cariola, 2021), such as drone delivery, automated delivery, and real-time delivery through technologies such as blockchain (Deng et al, 2020).

2.3 Unmanned Aerial Vehicle

The "last mile" challenge in logistics is difficult because it is inefficient and expensive. Delivery by unmanned aerial vehicles (UAVs), such as drones, has been presented and widely recognized as a possible solution to this problem (Li et al., 2022). Drones may already be the most convenient delivery mode in some conditions, such as in areas with insufficient road infrastructure. They are also environmentally friendly, with CO_2 emissions typically lower than those of single-delivery electric cars and vans and substantially lower than those of gasoline vehicles. There are already several companies exploiting the potential of drones for delivery (Goodchild and Toy, 2018), including Amazon Prime Air and UPS Flight Forward.

Considering this, we hypothesize:

H_5. The use of Unmanned Aerial Vehicles (such as drones) in the last mile has a positive impact on delivery time and cost.

H_6. The use of Unmanned Aerial Vehicles (such as drones) in the last mile reduces logistical risks and increases the safety of deliveries.

2.4 Last Mile and customer satisfaction

There are several studies and research exploring the relationship between the last mile and customer satisfaction. A 2021 study published in the Journal of Business & Industrial Marketing showed that logistical value, which consists of convenience of delivery location, timing, flexibility, and traceability of delivery, positively affects customer satisfaction. Another study published in "International Journal of Logistics Research and Applications" shows that perceived usefulness and trust have the greatest influence on consumers' intention to adopt drones for deliveries. Furthermore, it has been shown that as perceived privacy risk increases, the intention to adopt a drone delivery service decreases (Leon et al., 2021). Overall, these studies show that the last mile is a crucial factor in customer satisfaction and that efficient management of the last mile can increase customer satisfaction and brand loyalty.

Therefore, more work needs to be done on these aspects to overcome obstacles and make the use of drones an acceptable and safe solution.

Considering this, we hypothesize:

H_7. The adoption of blockchain technology through the introduction of tokens for all parties involved in a transaction has a positive impact on the management of informative transparency.

H_8. Integration of blockchain technology with other digital technologies enables successful sharing of information with consumers.

2.5 Urban logistics and sustainability

Blockchain can be used to optimize urban logistics through asset tracking and optimal scheduling of deliveries. This can help reduce traffic congestion and pollution, as deliveries can be scheduled more efficiently and CO_2 emissions can be monitored and reduced (Caspersen and Navrud, 2021).

Autonomous vehicles or drones can make deliveries using an optimized route, avoiding traffic, and thus reducing CO_2 emissions. According to the European Environment Agency (2022), the transport

sector is responsible for about a quarter of Europe's total CO_2 emissions, of which 71.7 percent are produced by road transport.

Considering this, we hypothesize:

> *H_9. The use of route optimization system generates positive performance in terms of environmental impact.*

3. Methods

The objective of this study is to analyze the impact of blockchain and last-mile technologies on supply chain and business performance. To this end, two research questions (RQ_1 and RQ_2) were developed to guide us in this study. Nine hypotheses were then developed, and to test them, data from a survey conducted by the Luiss Research Center were analyzed. The survey was sent to companies operating along the entire supply chain: Manufacturer, Wholesaler, Distributor, Supplier, Retailer. A total of 156 valid responses were obtained from the survey. To test our hypotheses, a few variables were selected from all those investigated in the survey. The first group of variables has as its main theme the investments in Blockchain technology made by the surveyed companies in the last two years. The second group of variables covers some of the main aspects of the supply chain, such as product traceability, quality management, last-mile delivery, and sustainability. The variables chosen can be traced back to different aspects of the supply chain and cover different areas of interest, corresponding to those examined in the literature review.

4. Results

H_1. The adoption of Blockchain technology for contract and transaction management has a positive impact on the management of complex supply chain contracts.

Of the total number of companies surveyed, 37 percent say they have adopted blockchain technology for contract and transaction management and have been successful in managing complex supply chain contracts. At the same time, only 13 percent of the surveyed companies decided not to use blockchain technology for contract management but still managed to achieve good results in contract management.

Blockchain makes smart contracts immutable, which means that once a contract has been registered, it cannot be modified or deleted. Smart contracts can be used to eliminate middlemen in many contracting activities, resulting in lower costs and shorter contract management time. However, there are also some difficulties associated with the use of smart contracts, such as the need for technical experts to create and manage contracts and the lack of adequate legislation and regulation in many countries. These

could be just some of the reasons why 28 percent of the companies surveyed decided not to use blockchain technology for contract management at all.

H2. The adoption of blockchain technology for new platform development has a positive impact on the management of product traceability and transparency.

More than 50% of the total companies surveyed say they have adopted blockchain technology for new platform development and successfully managed product traceability and transparency. At the same time, only 9% of the surveyed companies that did not use blockchain technology still successfully managed product traceability. Adopting blockchain technology to manage product traceability and transparency has several advantages for companies. First, blockchain is a distributed digital ledger that allows all transactions to be recorded immutably and creates a complete history of products. This means that manufacturers, suppliers and customers can verify the provenance, quality and safety of products quickly and reliably. In addition, the transparency provided by blockchain can increase consumer trust in products and improve the reputation of companies.

H3. The adoption of blockchain technology for the development of new platforms has a positive impact on the management of quality control.

Quality control is a verification process that takes place throughout the life cycle of a product or service, from the design stage to delivery to the customer. This process can be supported by various technologies, including blockchain, which can ensure the quality of the product or service. In fact, as the figure shows, 50 percent of companies surveyed say they have adopted blockchain technology and successfully managed product quality control. The remaining 50 percent of the surveyed companies either do not use blockchain for quality control or use this technology but have no positive effect on quality control. This finding can be explained by introducing the limitations of using blockchain for quality control. A first limitation is the difficulty of integrating blockchain with existing systems. In addition, blockchain technology is still new and its adoption is limited in many areas. This can make it difficult for companies to share data and quality control information.

H4. Integration of blockchain technology with other digital technologies enables greater control over the origin and provenance of raw materials.

Fifty percent of the companies surveyed have integrated blockchain with other digital technologies and successfully managed control over the origin and sourcing of raw materials. Blockchain can be integrated with technologies such as IoT (Internet of Things) and AI (Artificial Intelligence) to monitor and track raw materials in real time, making it easier for companies to identify and verify their origin

and provenance. This can be particularly useful for companies that want to ensure that the raw materials used in production meet certain quality, ethical and sustainability standards.

H_5. The use of Unmanned Aerial Vehicles (such as drones) for last-mile delivery has a positive impact on delivery time and cost.

Several studies have found that the use of drones can significantly reduce delivery time, as they can avoid traffic congestion and the need to stop at traffic lights. Drones help improve delivery accuracy and increase the overall efficiency of the delivery process. The use of drones can also help reduce delivery costs by decreasing the need for manual labor and minimizing the risk of human error. Twenty-four percent of companies surveyed say they have used drones and experienced benefits in terms of cost and delivery time. However, the use of drones for last-mile deliveries also presents some challenges, such as regulatory restrictions, privacy concerns, and limited flight radius. This may explain why about 10 percent of companies have used drones for deliveries but have not experienced cost and time benefits.

H_6. The use of Unmanned Aerial Vehicles (such as drones) in the last mile reduces logistical risks and increases the safety of deliveries.

The figure that stands out the most is the fact that about 40 percent of the companies surveyed say they have successfully managed logistical risks and safety without the use of drones. This is a result we expected, because companies can manage logistics risks and security even without the use of drones, but through a combination of traditional and technological solutions. Choosing reliable delivery partners, planning and managing resources, constantly monitoring shipments, and training delivery personnel are just some of the traditional methods used by companies to manage logistics risks.

H_7. The adoption of blockchain technology through the introduction of tokens for all parties involved in a transaction has a positive impact on the management of informational transparency.

Information transparency can be defined as a supply chain mapping activity in which information is collected on, for example, the components of a product, names of suppliers, location of facilities, associated certifications, etc. Companies can develop transparency in their supply chain through information and knowledge sharing (Narwane et al., 2020). Supply chain traceability increases transparency (Ada et al., 2021).

Tokens are digital units that represent an asset or right in a blockchain and can be used to increase transparency and traceability of transactions, making it easier for the parties involved to verify and track the provenance and history of a good or service.

More than 50 percent of companies surveyed say they have not managed information transparency well, a very significant figure that highlights how difficult it is for companies to achieve this goal. The main obstacles to achieving information transparency could include the lack of a centralized data collection and management system, integration of information from different sources, data protection, and technological complexity in terms of resources and time.

H_8. Integration of blockchain technology with other digital technologies enables successful sharing of information with consumers.

Using blockchain technology, companies can share information with consumers about the provenance, quality, and safety of products. This increases trust in products and brands, as well as consumer awareness of where raw materials come from and how they have been processed. Of the total companies surveyed, 42 percent say they have used blockchain technology and successfully shared information with consumers. This figure highlights the importance of supply chain transparency. Over time, this transparency will help develop consumers' loyalty to companies, increasing their likelihood of choosing to buy from them again in the future. In addition, information transparency can also help prevent the spread of fake or dangerous products in the market, as it allows consumers to verify the authenticity and origin of a product.

H_9. The use of route optimization system generates positive performance in terms of environmental impact.

A route optimization system enables efficient planning of delivery routes, minimizing distances traveled and fuel consumption. The use of advanced route optimization technologies can also help prevent delivery delays and improve the quality of service provided to customers. Thirty-seven percent of companies surveyed say they use route optimization systems and are able to achieve positive results in terms of environmental impact. A company's environmental impact can be calculated using various tools and methodologies, and one of the most common is the assessment of greenhouse gas emissions. Last-mile delivery has a significant impact on environmental impact due to the density of vehicles and their movements in an urban area. Route optimization technology and more efficient route planning can reduce this negative impact by improving transportation efficiency and emission control.

5. Discussion

Blockchain is a technology that is attracting increasing attention in several industries, including logistics. Its ability to create a shared and immutable digital ledger between multiple parties enables transparency, security, and immutability of data. This study was created with the goal of exploring the

potential of blockchain and its application in last-mile delivery and, more broadly, throughout the supply chain. In particular, the study aims to verify whether what is described in the literature, finds correspondence in reality.

The last mile is the final stage of a product delivery process. It is a crucial stage of the logistics process, as it represents direct contact with the customer and can significantly affect customer satisfaction. However, the last mile also presents a number of challenges, including delivery management, traceability, safety, and punctuality.

The study was guided by the following two research questions:

RQ_1. Does Blockchain adoption generate positive effects on a company's supply chain management?

RQ_2. What is the impact of last-mile technologies (such as drones) on the supply chain and how can it be further improved through the use of blockchain?

Nine hypotheses were developed that allowed us to analyze blockchain from different perspectives, enabling a greater understanding of industry dynamics and leading to the identification of new opportunities to optimize supply chain management. The confirmed hypotheses may suggest to business leaders that the adoption of blockchain technology for contract management has a positive impact on the management of complex supply chain contracts.

Smart contracts eliminate the need for intermediaries to manage transactions and, consequently, the delays and costs associated with them. This was confirmed by analyzing data on the companies surveyed.

The use of blockchain technology has a positive impact on the management of product traceability and transparency. The integration of blockchain technology with other digital technologies allows for greater control over the origin and provenance of goods. All these aspects are closely related to the concept of quality control. Quality control is a verification process that takes place throughout the life cycle of a product. However, data analysis has shown that there are limitations to the adoption of blockchain technology for quality control. A first limitation is the difficulty of integrating blockchain with existing systems; In addition, blockchain technology is still new and its adoption is limited in many areas.

Two other key issues addressed in the study are information transparency and information sharing with consumers. Of the total companies surveyed, 42 percent say they have used blockchain technology and successfully shared information with consumers. This figure highlights the importance of supply chain

transparency. With blockchain technology, companies can share information with consumers about the provenance, quality, and safety of products. This helps prevent the spread of fake or dangerous products in the market, thus combating counterfeiting.

As for the last mile, this is considered one of the most complex and expensive steps in the supply chain, as it requires precise planning and logistics to ensure that products are delivered in a timely and accurate manner. Due to the growing demand for quick and customized deliveries, the last mile is becoming increasingly important for companies that want to meet their customers' needs and maintain a competitive edge. This has led to the growth of innovative delivery solutions, such as drone delivery.

Through a literature review, we found that the use of drones has potential benefits in terms of delivery time and cost, delivery safety, and CO_2 emissions. Analysis of the data from the survey revealed a slight discrepancy between what was stated in the literature and what was actually perceived by the companies involved. Specifically, about 10 percent of the companies stated that they have used drones for deliveries but have not experienced any benefits in terms of cost and time. This could stem from the fact that there are still many challenges to overcome to make this technology fully efficient and accessible to companies. The main challenges include restrictive regulations and standards, the lack of adequate infrastructure for charging and storing drones, and the need for careful planning and logistics. At the sustainability level, however, the benefits of using drones in last-mile deliveries are clear. Drones can make deliveries using an optimized route, avoiding traffic, and thus reducing CO_2 emissions.

The last aspect discussed again relates to sustainability, specifically the use of route optimization systems. A route optimization system allows delivery routes to be planned efficiently, minimizing distances traveled and fuel consumption. Thirty-seven percent of companies surveyed say they use route optimization systems and are able to achieve positive results in terms of environmental impact. Last-mile delivery significantly affects the environmental impact due to the density of vehicles and their movement in an urban area.

This study provides information on the real implications of using Blockchain operationally, logistically, and in relation to the ecosystem. The actual performance of new technologies (such as drones and route optimization software) used along the supply chain of the companies surveyed is also analyzed.

However, it must be considered that this study has limitations, which may serve as inspiration for future research in this field. First, the sample analyzed, consisting of 156 companies, represents only a small portion of the companies using blockchain technology in the supply chain, and this limits the generalizability of the results. Second, the data derived from the survey administered to companies are

the result of a self-assessment, so the tendency of companies to provide favorable responses must be considered. Another limitation concerns the long-term effects of technologies adopted by companies. The results obtained at this time may not be valid in the future because of any technological developments or changes in the external environment. This could make it difficult to determine the full and lasting impact of such technologies on business performance. Finally, one must consider blockchain regulations, which can change over time. This can make it difficult for companies to implement blockchain technology and keep it in line with current regulations. Also, if blockchain-related regulations change, the results of the study may no longer be representative of reality.

6. Conclusions

This study investigates the effects of using blockchain along the entire supply chain, with a focus on the application of this technology in last-mile deliveries and new technologies to support it. In general, blockchain generates positive effects along the entire supply chain and enables stakeholders to manage various operations more efficiently and effectively. The available literature on the subject was compared with data from a survey conducted by the Luiss Research Center. The survey was submitted to companies operating throughout the supply chain and was aimed at investigating the investments made by companies in recent years in blockchain technology, operational management challenges, logistics challenges, last-mile management and business performance.

Several hypotheses were developed and tested using data from a sample of 156 international companies.

The data analysis showed how the adoption of blockchain technology has a positive effect on product traceability and transparency, quality control, and the origin of raw materials.

We also discussed the importance of sharing information with consumers and the positive impact of using pathway optimization systems on sustainability. Finally, we analyzed the benefits of using drones for last-mile delivery, such as reducing the time and cost of delivery, the ability to reach remote locations, and the reduction of CO_2 emissions by companies.

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