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Blockchain across Operations and Finance: Enabling Role for Non-Possessory Revolving Pledge

Tesi di Laurea Magistrale in

Management Engineering

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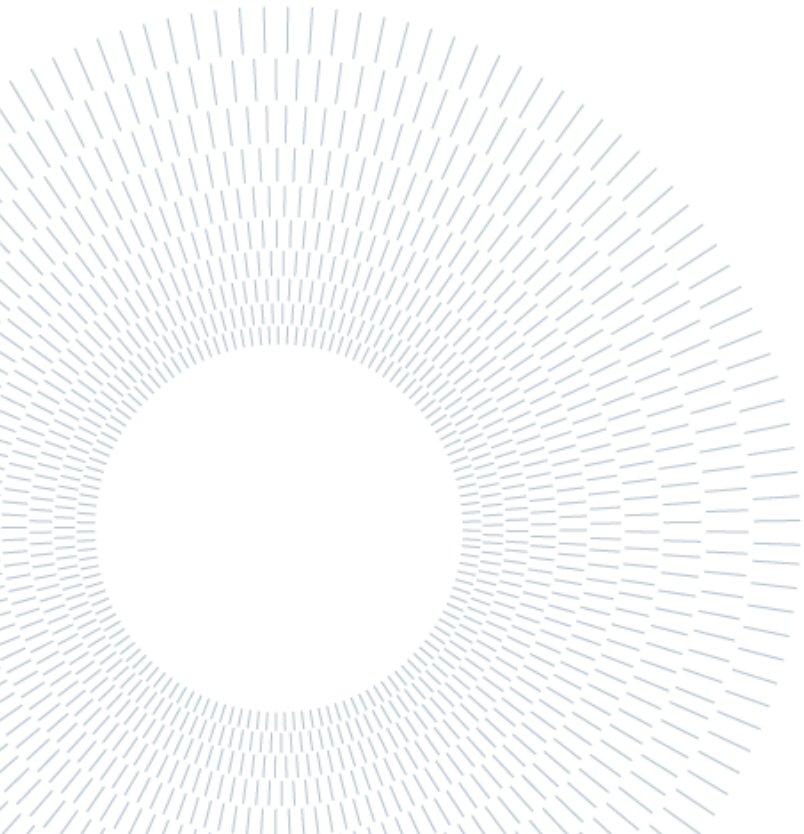


Abstract

In today's ever-evolving digital landscape, blockchain technology has triggered a significant transformation, particularly in the way finance and supply chain dynamics have been reshaped. One area of notable focus has been inventory management. This shift in the paradigm has had a widespread impact on the financial industry, acting as a powerful catalyst for the concept of non-possessory revolving inventory pledges. This thesis embarks on an extensive exploration of the profound influence of blockchain technology on the relationship between lending institutions and businesses, specifically in the context of non-possessory revolving collateral. The study aims to unravel the multitude of advantages brought about by blockchain-based financing and emphasize the resulting improvement in collaboration between finance and supply chain sectors. The research methodology relies on a qualitative exploratory single case study, delving deep into the various stakeholders involved in non-possessory revolving inventory financing. The study meticulously uncovers the practical benefits offered by blockchain technology, with a particular focus on enhancing operational efficiencies and increasing transparency in processes.

The findings of this research present a dual narrative of transformation. Firstly, the thesis highlights the crucial role played by blockchain technology in enabling lending institutions to autonomously monitor collateral values in real-time. This groundbreaking innovation has significantly reduced the financial burden associated with non-possessory revolving collateral, making this financing method more appealing and cost-effective for both businesses and financial institutions, thereby boosting their competitiveness. Secondly, the research reveals the profound impact of

blockchain technology on the intricate relationship between finance and supply chain operations.

Key-words: Blockchain; Operations; Finance; Pledge; Inventory

Abstract in italiano

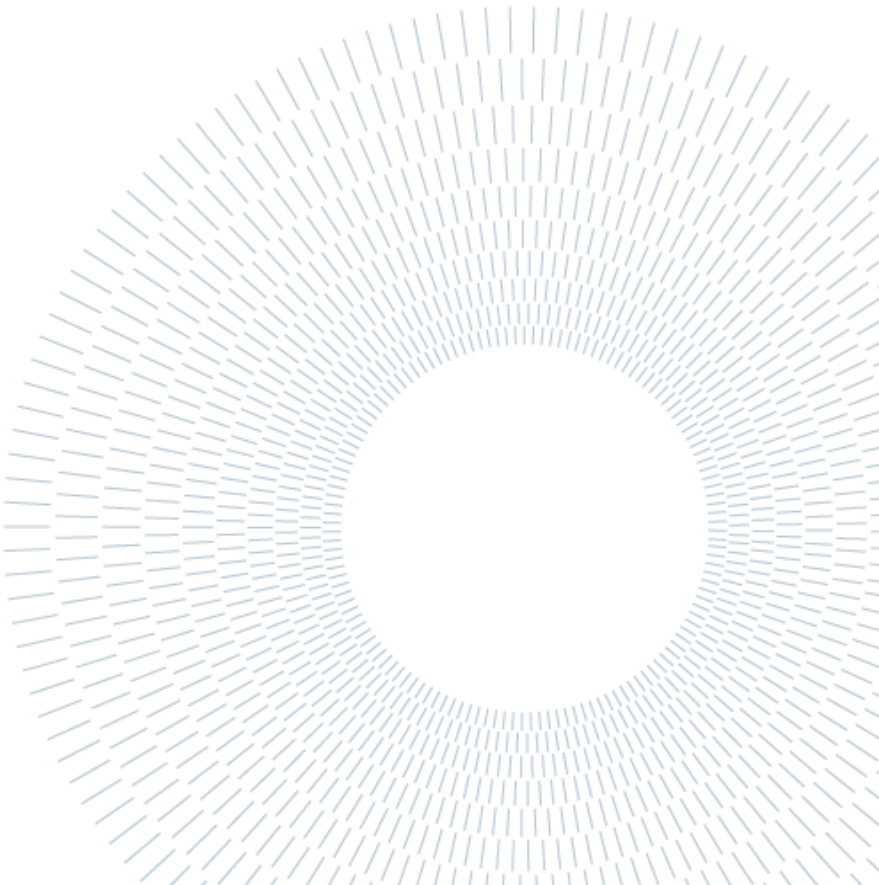
Nell'attuale panorama digitale in continua evoluzione, la tecnologia blockchain ha innescato una trasformazione significativa, in particolare nel modo in cui sono state ridisegnate le dinamiche della finanza e della supply chain. Un'area di notevole interesse è stata la gestione delle scorte. Questo cambiamento di paradigma ha avuto un impatto diffuso sull'industria finanziaria, fungendo da potente catalizzatore per il concetto di pegno di inventario rotativo non possessorio. Questa tesi intraprende un'ampia esplorazione della profonda influenza della tecnologia blockchain sul rapporto tra istituti di credito e imprese, in particolare nel contesto delle garanzie rotative non possessorie. Lo studio mira a svelare la moltitudine di vantaggi apportati dal finanziamento basato sulla blockchain e a sottolineare il conseguente miglioramento della collaborazione tra i settori della finanza e della supply chain. La metodologia di ricerca si basa su uno studio qualitativo esplorativo su un singolo caso, approfondendo i vari attori coinvolti nel finanziamento delle scorte rotative non possessorie. Lo studio scopre meticolosamente i vantaggi pratici offerti dalla tecnologia blockchain, con particolare attenzione al miglioramento dell'efficienza operativa e all'aumento della trasparenza dei processi.

I risultati di questa ricerca presentano una duplice narrazione della trasformazione. In primo luogo, la tesi evidenzia il ruolo cruciale svolto dalla tecnologia blockchain nel consentire agli istituti di credito di monitorare autonomamente i valori delle garanzie in tempo reale. Questa innovazione innovativa ha ridotto in modo significativo l'onere finanziario associato alle garanzie rotative non possessorie,

rendendo questo metodo di finanziamento più attraente e conveniente sia per le imprese che per gli istituti finanziari, aumentandone così la competitività.

In secondo luogo, la ricerca rivela il profondo impatto della tecnologia blockchain sull'intricato rapporto tra finanza e operations.

Parole chiave: Blockchain; Operations; Finanza; Pegno; Magazzino



Executive Summary

Abstract

The article discusses how blockchain technology has transformed the finance and supply chain industries, particularly in the area of inventory management. The focus is on non-possessory revolving inventory pledges, and the advantages that blockchain-based financing brings to collaboration between finance and supply chain sectors. The study uses a qualitative exploratory single case study to uncover the practical benefits of blockchain technology, including enhancing operational efficiencies and increasing transparency. The research reveals the crucial role played by blockchain technology in enabling lending institutions to autonomously monitor collateral values in real-time, which has significantly reduced the financial burden associated with non-possessory revolving collateral. The study also highlights the profound impact of blockchain technology on the intricate relationship between finance and supply chain operations.

Introduction

Digital technologies have transformed how people interact with their environment, including industrial manufacturing. This shift, known as Industry 4.0, has improved operational processes by leveraging data analysis(Yang & Gu, 2021, p. 4). The supply chain has also been impacted, with collaborative management seeking innovation and partnerships. Supply Chain Finance has emerged as a trend, focusing on managing financial flows and working capital(Du et al., 2020). The supply chain can provide insights into the health of companies. The flow of goods,

information, and finance has become interconnected, emphasizing the importance of optimizing working capital and cost distribution. Supply chains must prioritize transparency, cooperation, and adaptability to navigate regulatory requirements. Blockchain technology shows promise in revolutionizing financial instruments like the non-possessory revolving pledge in Supply Chain Finance.

Literature Review

In light of the rapid digital transformation, blockchain technology stands out as one of the most disruptive and promising innovations. It has evolved from its initial application in the financial and banking sector to making significant inroads in various fields, including healthcare, manufacturing, and transportation (Manzoor et al., 2022). This evolution primarily centers on enhancing the digital management of vast data volumes and transforming the landscape in which this digital data is generated and stored.

A fundamental aspect of blockchain technology that instils confidence among its participants is the immutability of data registers. Once the blockchain network accepts data, it becomes untouchable and unchangeable, resistant to alteration or manipulation. This immutability underpins the development of an information-sharing platform that enables virtual aggregation and scheduling of distributed information, allowing for high-quality, low-cost peer-to-peer services (Xue et al., 2021).

However, integrating blockchain technology into Company operations presents several challenges. These include limitations in data processing capacity, the delicate balance between transparency and privacy, the management and control of decentralized blockchain networks, high implementation costs, and the absence of standardized blockchain architecture. Despite these challenges, recent advancements in regulatory frameworks, collaborative efforts, and more efficient

blockchain architectures are helping to overcome these obstacles. The forthcoming thesis aims to explore these challenges in-depth and provide strategies to address them.

Traditional business models that act as intermediaries between parties must carefully consider how blockchain technology impacts their offerings, competition, and operations (Morkunas et al., 2019). Blockchain can potentially revolutionize various industries and compel entities to reconsider their strategies and value-creation methods (Schatsky and Muraskin, 2015).

Blockchain's potential to enhance the efficiency and transparency of supply chain operations is substantial. When combined with the Internet of Things (IoT), it further improves transaction efficiency as data generated by IoT devices undergoes validation through network member consensus before being added to an encrypted blockchain.

Rijanto (2021) examines how blockchain technology simplifies intricate processes in inventory financing, purchase order financing, and receivables financing. Blockchain's transparent and secure ledger system can revolutionize these financial operations, enhancing efficiency and trust in the supply chain industry.

An essential aspect that the existing literature often overlooks is how blockchain technology integrates into both business operations and supply chain finance. Numerous studies have explored blockchain's implementation in specific domains, such as BT financing platforms (Ke, 2023; Ning and Yuan, 2023) and its implications in supply chains (Mithas et al., 2022; Ahmed et al., 2022). However, a deep exploration of the overall impact of blockchain on the interconnection between business operations and finance needs to be improved. Blockchain can potentially redefine supply chain management and financial control profoundly, yet this crucial connection is often neglected in current literature.

Blockchain can be a game-changer in this context, enabling companies to use internal resources, like warehouses, as collateral for securing financing, e.g., through non-possessory revolving pledges. This concept opens new opportunities to enhance credit access and optimize corporate resource management. Furthermore, there needs to be more literature regarding applying non-possessory revolving pledges, specifically to warehouses. This presents a promising research area requiring further investigation to fully understand the implications and opportunities of this innovative practice in supply chain finance.

Another often overlooked element is the analysis of the regulatory framework and its impact on the adoption and utilization of blockchain technology in the context of business operations and supply chain finance.

Through our research, we aim to bridge these gaps in the existing literature and provide a more nuanced understanding of the impact of blockchain technology on business operations and supply chain finance.

For this purpose, we have formulated the following research questions that guide this study:

RQ1: "How does the integration of blockchain technology impact the interconnectedness of business operations and supply chain finance, and what are the implications for these areas?"

RQ2: "To what extent does the adoption of blockchain technology influence managerial decision-making, including operational efficiency and financial choices?"

RQ3: "What are the implications and opportunities of using blockchain technology for better exploiting internal illiquid resources, such as warehouses?

RQ4: "Can technologies such as IoT and 5G support blockchain technology in developing new perspectives and horizons for inventory management and inventory finance?"

RQ5: ” What is the role of regulatory frameworks in facilitating or hindering the adoption of blockchain technology in operations and supply chain finance?”

Methodology

The purpose of this Master's thesis is to evaluate the influence of blockchain technology on inventory financing, management, and decision-making processes within the supply chain. This study seeks to explore the intricate interactions between Supply Chain and Finance practices, technologies, and associated challenges.

The Literature review has uncovered significant research voids, leading to the formulation of five distinct research inquiries that will guide the direction of this

Master's thesis. The proper methodology to be adopted to address the research question has been picked among qualitative research methods as the study attempts to describe and interpret some complex human phenomenon, in the words of informants. Indeed, as the knowledge in the domain is still limited, it is critical to collect data from those who are experiencing the phenomenon under investigation (Gioia et al., 2013) “within its real-life context” (Yin, 2013). Although existing research has explored the potential application of blockchain technology (Chang and Chen, 2020; Hofmann et al., 2017), there is a lack of evidence-based studies that investigate the challenges of adopting this novel technology (Babich and Hilary, 2019). Besides, Eisenhardt and Graebner (2007) indicated that, compared to multiple case studies, single-case research can investigate more in-depth evidence with a greater focus, which is appropriate considering the exploratory nature of this study.

The lack of previous research in this area is addressed through the proposal of a formal definition for this relatively new topic and a research framework that is based on an adaptation of concepts from the literature, notably Lambert et al. (1998).

Figure 1. shows the main characteristics of the interviewed companies, which are named with a code (from letter A to D) to protect their identity for privacy issues.

	Contextual Factors		Interviewed
Case Study Code	Size	Role	Role
Company A	Large-sized Enterprise	Dairy	Administrative Director
Company B	Large-sized Bank	Financial Institution	Manger
Company C	Large-sized Bank	Financial Institution	Manager
Company D	Very Large-sized Enterprise	Technology Providers	Manager

Figure 1. Interviewed companies.

To address the research gap, we derived a research conceptual framework shown in Figure2.

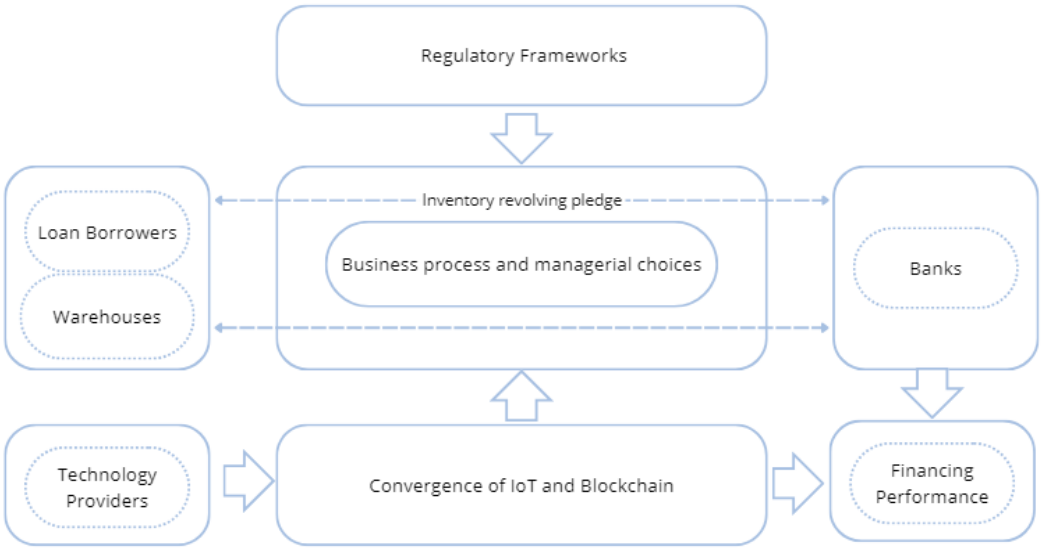


Figure2. Conceptual Framework

The conceptual research framework is composed of the individual constructs and the relationships between the constructs are based on an adaptation and extension of the model proposed by (Blackman et al., 2013).

The theoretical framework expounded above serves as the backbone upon which the conceptual structure of this research is erected, acting as the masterful pillar to articulate a circumscribed context and unveil a gap necessitating bridging. Within this framework, three distinct analytical approaches (Resource Dependence Theory, Institutional Theory, Dynamic Capabilities) emerge, meticulously chosen to probe the multifaceted dimensions of the thesis results.

One of the pivotal decisions in the course of conducting case study research lies in the judicious selection of the case. To best meet the exigencies of the research, it is advisable to opt for a singular case, which functions as a representative sample.

Besides, Eisenhardt and Graebner (2007) indicated that, compared to multiple case studies, single-case research can investigate more in-depth evidence with a greater focus, which is appropriate considering the exploratory nature of this study.

In the context of a comprehensive case study, the imperative is to meticulously scrutinize every facet of the selected subject. The case that has been chosen for this research pertains to Company A, a dairy cooperative that undertook an operation in collaboration with two distinguished financial institutions, namely Company C and Company B, employing the revolving inventory pledge financing, fortified by the transformative capabilities of blockchain technology. This analysis explores the perspectives of the two financial institutions, Company A, and the technology provider, Company D.

The study relied on a combination of primary and secondary data sources, each serving a distinct purpose in the research. The primary data collection phase centered on structured interviews conducted between September 2023 and October 2023. These interviews were semi-structured, allowing for flexibility while maintaining a standardized framework. Four key actors central to the case under examination were individually interviewed, ensuring a well-rounded perspective on the subject matter. Complementing the primary data, a comprehensive collection of secondary data was undertaken. These secondary data sources included whitepapers, reports, websites, and blogs. This information was instrumental in providing context and background for the study.

Findings

The adoption of blockchain technology in the agri-food sector has brought about a profound transformation in the way finance and supply chain interact and collaborate. It has revolutionized traditional methods of securing loans, particularly

in cases like Company C and Company B, where non-possessory revolving collateral has emerged as an innovative solution.

One of the critical aspects that blockchain technology has addressed is the control and monitoring of collateral in non-possessory pledges, which lending institutions greatly depend on. Without the innovative use of blockchain, lending institutions would be reluctant to embrace non-possessory pledges as a viable financing option.

Blockchain technology emerged as the perfect solution to address these challenges. It introduced a digital transaction ledger that securely and transparently recorded every movement of assets within warehouses. This transformation empowered lending institutions to continuously monitor collateral values in real-time, providing a transparent and secure environment for financial transactions.

Furthermore, the ease of accessing financing at a lower cost has been a game-changer for companies, especially when compared to traditional financing methods. Non-possessory revolving collateral, empowered by blockchain, has made securing loans more accessible and affordable for businesses. The reduction in costs is attributed to several factors, including the elimination of the need for physical asset transfer, the removal of notarial fees, and the improved efficiency in the monitoring and management of collateral values. These factors collectively contribute to the lower cost of financing, making it a more attractive option for companies in need of financial support.

Blockchain technology has ushered in a new era of adaptability and flexibility within business models. This transformation has broadened financial institution’s portfolio of guaranteed agri-food products. By leveraging their clients' existing facilities, the necessity of constructing new warehouses has been obviated, consequently reducing operational expenses and streamlining their operations.

For the company, the conventional approach would have necessitated pledging the cheese physically as collateral, rendering it inaccessible for their production processes and exposing it to risks. However, blockchain technology has presented an innovative solution to this conundrum. It has enabled the company to embrace non-possessory revolving pledges, obviating the need to physically deliver goods. With the efficiency and transparency proffered by blockchain, securing financing for cheese aging has become more facile, optimizing their cash flows and resource allocation. The company is now contemplating the extension of blockchain utilization to multiple warehouses, promising even greater transparency, accuracy, and security across all their operations.

Nonetheless, the successful integration of blockchain technology is inherently intertwined with the regulatory landscape in which it operates. The efficacy of regulatory frameworks can either facilitate or impede the utilization of blockchain in the context of financial operations. Blockchain's capacity to underpin secure and transparent recording and monitoring of non-possessory revolving collateral curtails the susceptibility to fraudulent activities and defaults. Blockchain technology, by its very nature, has the potential to mitigate transaction costs, reduce processing timelines, and rectify information asymmetry between financial institutions and client organizations. A lack of unambiguous and supportive regulatory guidelines may lead to compliance quandaries and dissuade financial institutions and businesses from embracing innovative blockchain-based solutions. The obscurity or restrictiveness of these regulations can hinder the interconnectivity and scalability of blockchain solutions across international borders or diverse sectors.

Traditionally, warehouses were seen as a financial burden, tying up valuable capital that could otherwise be invested in other critical aspects of the business. However,

with the integration of blockchain technology, warehouses have undergone a remarkable transformation, evolving from being viewed solely as a cost to becoming a powerful source of financing. The ability to utilize movable assets as collateral for obtaining loans or lines of credit can offer significant benefits to a wide range of businesses, particularly those with seasonal or capital-intensive operations.

Discussion

In this section discusses the empirical findings in the prior literature to answer the research question. The adoption of blockchain technology has significantly transformed the dynamics between finance and supply chain particularly evident in the case study under analysis. Adopting non-possessory revolving collateral, as Company C and Company B demonstrated, introduced an innovative solution. This approach minimized the need for physical transfer of assets, streamlining the lending process and enhancing efficiency. Businesses could now use their assets as collateral without surrendering possession, ensuring uninterrupted production processes. It must also be said that controlling and monitoring collateral in non-possessory pledges were significant concerns for lending institutions. Without innovative solutions, such as blockchain technology, lending institutions hesitated to embrace non-possessory pledges due to the lack of control over pledged assets. Blockchain technology emerged as the perfect solution to address these challenges. The successful adoption of BT necessitates the active involvement of all stakeholders in the supply chain. However, some stakeholders may need more resources to embrace technological innovations (Saberi et al., 2019; Ghode et al., 2020). Companies spearheading BT projects can inspire other partners with limited resources to participate by offering both technical and financial support (Min, 2019). The integration of blockchain technology into their existing operations transcends

mere technological enhancement; it has the potential to redefine the way they conduct their business affairs. In blockchain adoption, participants with limited resources must reach a consensus on risk allocation and benefits distribution with leading firms to manage dependencies effectively. This agreement aligns interests and fosters the adoption of blockchain technology (Santos & Eisenhardt, 2005). Considering the role of boards of directors in strategic priorities and digital transformation (DT), RDT's central proposition aligns with the findings. Boards can use DT to reduce uncertainty, lower transaction costs, and increase the flow of essential resources (Bainbridge, 2012). Inter-organizational relationships, enhanced by digitally savvy board members, contribute to acquiring and allocating resources to reduce uncertainty (Auster & Choo, 1994). The integration of blockchain technology into the business models of Company C and Company B has ushered in a transformative era of adaptability and flexibility, aligning with the tenets of Resource Dependence Theory (RDT). As highlighted by RDT, companies often grapple with dependencies on external entities for crucial strategic resources (Hillman et al., 2009). Firms seek to manage dependencies by forming inter-organizational arrangements (Casciaro & Piskorski, 2005). Blockchain technology provides a dependable and verifiable collateral source, mitigating risks associated with erroneous valuations.

Institutional theory perspective posits that organizations operating in comparable environmental conditions tend to converge on similar structures and operational approaches to secure legitimacy and ensure survival. In the agri-food sector, where the ageing or maturation of products plays a pivotal role, the integration of blockchain technology and the shift towards non-possessory pledges can be understood as strategic responses to this industry's specific challenges and dynamics. The institutional theory is a theoretical perspective that studies how organizations adapt and respond to the pressures and expectations of the

environment in which they operate. According to this theory, organizations tend to conform to their sector's dominant norms and values to gain legitimacy and survival. In this way, organizations facing similar environmental conditions tend to adopt similar structures and modes of operation, creating a phenomenon of institutional isomorphism (DiMaggio & Powell, 1983).

The transformation of warehouses, with the introduction of blockchain, from traditional static storage facilities into dynamic sources of financing is a testament to the evolving landscape of business operations. Traditionally, warehouses were viewed as a financial burden, tying up capital that could be invested elsewhere in the business. However, with the implementation of blockchain, these warehouses have become integral components of financial strategies. This newfound trust and transparency have strengthened the relationship between financial institutions and agri-food businesses and contributed to increased efficiency and competitiveness in the financial sector (Teece et al., 1997). Integrating dynamic capabilities into the transformed warehouse landscape aligns with the idea that decision-making becomes paramount in the face of uncertainty. Knight (1921) highlighted that making the right investments is crucial when uncertainty is present. Dynamic capabilities, therefore, become the primary function in navigating a rapidly changing business environment, with the execution of activities being a secondary consideration (Knight, 1921).

However, the success of blockchain integration is intricately interwoven with the regulatory landscape that governs its operations. Resource dependency theory provides a theoretical lens to identify resource interdependencies that can inform the formulation of standards and regulations. The thesis findings underscore the critical importance of regulatory clarity in fostering blockchain adoption. Including regulatory and standards organizations is important in supporting and promoting

blockchain adoption in the supply chain (Ahmed & MacCarthy, 2022). Regulatory frameworks address challenges related to industry-specific regulations and practical issues associated with traditional collateral methods. This aligns with the normalization process theory from the literature, which addresses the successful deployment and integration of technologies, elucidating the practical challenges highlighted in the interviews and the subsequent alleviation achieved through blockchain integration.

Conclusion

In conclusion, this study has delved into the underexplored realm of non-possessory revolving collateral in inventory financing, shedding light on the transformative impact of blockchain technology. The research gap identified in existing literature has been addressed by examining the intricate dynamics between supply chain and finance practices, revealing how blockchain technology has revolutionized inventory financing, management, and decision-making processes. The case study has exemplified the revolutionary solution offered by non-possessory revolving collateral, minimizing the need for physical asset transfer and providing a more streamlined and efficient approach. Blockchain integration has played a pivotal role in addressing critical aspects, such as control and monitoring of collateral, which lending institutions heavily depend on. The immutability and verifiability of blockchain data have eliminated the need for periodic manual signatures, ensuring accuracy and real-time information. The ease of accessing financing at a lower cost has been a game-changer for businesses, making loans more accessible and affordable, especially when compared to traditional financing methods. However, the successful integration of blockchain is contingent upon the regulatory landscape. Regulatory frameworks can either facilitate or impede the utilization of blockchain in financial operations. Furthermore, the perception of

warehouses has undergone a paradigm shift from being viewed solely as illiquid resources to becoming powerful sources of financing.

It is of utmost importance to provide a detailed account of how this thesis has significantly contributed to advancing the understanding and scope of the current literature. Thanks to this research, the discourse on Business Operations and Supply Chain Finance has transcended the paradigm of separate entities and embraced a more interconnected perspective, notably facilitated by the implementation of cutting-edge technologies like blockchain. The specific focus has been on employing blockchain to optimize inventory management in companies, such as the one examined in our case study, where non-possessory revolving pledges enable innovative and efficient resource utilization. It has clarified the role of regulations in the context of blockchain, especially in relation to bureaucratic elements that persist to some extent, albeit minimized. This research underscores the ongoing tension between the revolutionary potential of blockchain and the persistent bureaucratic elements within regulatory frameworks, emphasizing the need for continued exploration and refinement in this transformative landscape.

Despite the significant contributions made by this thesis in the field of business operations and supply chain finance through the adoption of Blockchain Technology, it is crucial to highlight the most important limitations present in this research.

Firstly, the thesis focuses on a specific case study, making it highly specific and oriented towards the analysis of a single company. The limitation lies in the generalizability of the conclusions, as the dynamics of this particular company may not fully represent the broader implications on the global landscape of businesses. It can be also useful to analyze the results of this research with an awareness of how they might vary between Italian legislative contexts and international legal

frameworks. Comparing companies across different sectors and organizational complexities in managing supply chains could reveal common trends, patterns, and challenges, offering opportunities for segmentation based on the adoption of blockchain technology. In conclusion, future research could explore these avenues to address the limitations identified in this thesis, contributing to a more comprehensive understanding of the implications of blockchain technology in the realms of business operations and supply chain finance.

Contents

Introduction

In the contemporary landscape, digital technologies have risen to paramount importance, instigating a profound transformation in the way individuals interact with their environment. These technological advancements, often referred to as Industry 4.0, have catalyzed a comprehensive metamorphosis across various sectors, including industrial manufacturing, empowering businesses to harness the potential of data aggregation and analysis (Lu, 2021). This transformative wave has expedited decision-making processes, imbued them with efficiency, and steadfastly focused on cost-effectiveness and the enhancement of quality standards (Yang & Gu, 2021, p. 4). The supply chain, a pivotal component of contemporary business dynamics, is no exception to this transformative tide (Ho et al., 2020).

The contemporary era witnesses an unprecedented deluge of data from supply chains, marking a pivotal juncture where supply chain collaborative management seeks innovation from suppliers in processes and products, fostering mutually advantageous partnerships (Attaran & Attaran, 2007). These inflection points represent unique opportunities to propel the supply chain into a forward-thinking realm, skilfully integrating it with the central forces of the digital revolution. This constructive collaboration equips supply chain specialists with the capacity to decipher the intricate tapestry of information flows, sculpting a vision for the future supply chain.

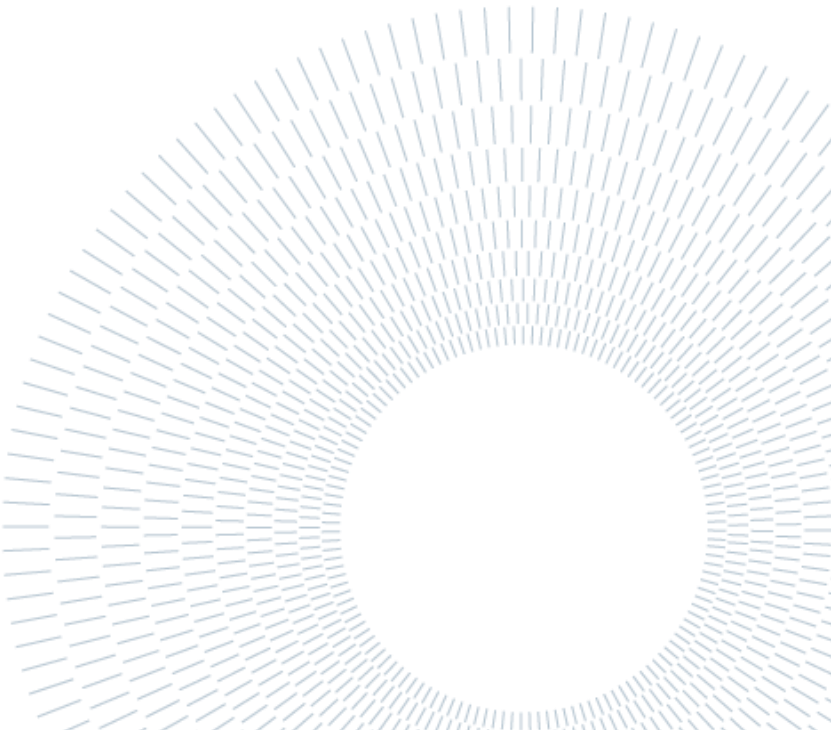
Over the past decade, Supply Chain Finance has emerged as a prevailing trend within the intricate tapestry of the business environment. Originally conceived as an extension of Supply Chain Management, it swiftly evolved into a self-contained discipline replete with its own distinctive practices, stakeholders, and body of research

(Zhou et al., 2022). Supply Chain Finance encompasses an array of solutions designed to facilitate the management of financial flows, with a particular emphasis on working capital. This focal point extends its reach beyond a company's specific business operations, encompassing its role within the larger supply chain framework. While it remains challenging to pinpoint an all-encompassing definition of SCF or to delineate its precise boundaries, a guiding principle does emerge: "SCF solutions encompass those measures designed to augment working capital along the entirety of the supply chain."

The breakneck pace of innovation in today's business landscape exerts its influence across all industries, compelling stakeholders to continually seek avenues for profit generation and the augmentation of enterprise value. If explored methodically, the supply chain can yield fundamental insights that offer a barometer for the overall health of the companies constituting the supply chain.

Concomitant with the ongoing digitalization of operational processes, the flow of goods, information, and finance has transcended their once-disjointed trajectories, permeating through multiple functions and stakeholders. The importance of optimizing Working Capital utilization and curbing the Cost of Capital is underscored by the ever-expanding adoption of supply chain finance solutions (Rijanto, 2021), particularly the non-possessory revolving pledge. This innovative financial instrument allows the pledgor to retain possession and utilization rights of the pledged assets, such as inventory, while concurrently granting a security interest to the pledgee. In practical terms, SCF is poised to facilitate mutually beneficial solutions for both buyers and suppliers, enhancing liquidity and cost distribution along the value chain (Du et al., 2020). Moreover, the imperatives of transparency and disclosure have become common knowledge, necessitating supply chains to fortify their operational ethos, guarantee cooperative partnerships, elevate global trade performance, and enhance adaptability in navigating a labyrinth of regulatory mandates.

The fundamental premise set forth here lays the groundwork for bridging the chasm between speculative conjecture and tangible contributions. The demand for supply chains to cultivate transparency, accountability, and trust forms the core impetus for this research endeavour. A profound exploration of one of the most promising and disruptive technologies, Blockchain Technology (BCT), has been undertaken to develop a practical solution for SCF. Blockchain technology, with its attributes of transparency, immutability, and traceability, stands as a powerful enabler of the non-possessory revolving pledge, holding the potential to revolutionize this financial instrument.



1 Literature Review

1.1. Background

Blockchain technology has transformed the ways of operation and the financial sector bringing a new era of transparency, efficiency, and faithfulness in many business sectors. In fact, disruptive technologies have significantly altered the way industries and businesses operate nowadays (Tan et al., 2023). Blockchain integration in these areas is motivated by the fact that these issues have been prevalent in global supply chain management and global supply chain finance for long. The intricate endeavour in organizing and coordinating organizational operations has always challenged organizations across time, with the challenge being to reconcile multiple contradicting stakeholder interests and incentives.

In the context of supply chain management, governance mechanisms that are strong enough to help to overcome disputes and achieve consensus are needed. Such friction happens as a result of disparate incentives and interests, something which in the past plagued the traditional supply chain systems with various problems surrounding visibility and accountability. Therefore, the issue of supply chain governance has become one of the main challenges encountered by companies operating in the complex network of global supply chains.

At the same time, supply chain operations, especially within the supply chain finance have undergone a change. The challenges faced by banks and companies are overcome through the use of blockchain technology (Song et al., 2023). Businesses could not obtain financing for their supply chain operations due to the opacity and inefficiency

of traditional financial systems. These issues have been with us forever, forcing us to seek an alternative solution using this new technology – the blockchain.

Initially developed as an underlying infrastructure for cryptocurrencies such as Bitcoin, blockchain technology has demonstrated huge potential in transforming different business sectors by building trust and accountability through decentralized and permanent ledger systems. Blockchain can be termed as one of the most disruptive technologies that can potentially reformat the old concepts of supply chain management and supply chain finance. Information asymmetry reduction, security enhancement and transacting process streamlining have fuelled exploration in its adoption.

1.2. Blockchain

Given the rapid digital transformation, blockchain technology can be considered one of the most disruptive and promising innovations. Indeed, considered a true game changer, it initially gained ground in the financial and banking sector, eventually achieving significant results in various fields such as healthcare, manufacturing, transportation, and many others (Manzoor et al.;2022). Initially discussed as a fundamental component for cryptocurrencies, nowadays it plays a significant role in various sectors. Indeed, due to its qualities and features, such as decentralization, it enables the exploration of new possibilities in managing digital data and information, not to mention new security techniques and transaction verification. The innovative advancement of digital technology leads to increased complexity in data management systems. Therefore, qualities like security, integrity, and transparency of information are of utmost importance. The role of blockchain is increasingly focused on enhancing the digital management of vast amounts of data and transforming the world in which this digital data is generated and stored. The inefficiencies of traditional centralized systems are eliminated by its decentralization capabilities and the creation of a single

distributed ledger that is stable, immutable, and accessible to all users for the purpose of verifying and managing digital data.

This technology, previously known solely for digital financial transactions and digital currencies, has proven to be a fundamental element for innovation in the industrial and banking sectors. It has thus transcended the boundaries of the financial world and the modern economy that existed for years. Blockchain is leading industries and banks not only towards secure and efficient transactions but also offering opportunities to improve interactions within companies, between companies, and between companies and the financial landscape.

1.2.1. Blockchain History

It was in 2008 that the talk of this technology began when Satoshi Nakamoto invented Bitcoin. Bitcoin, a digital currency or cryptocurrency, has its roots in peer-to-peer technology and decentralization, representing a significant innovation in the realm of digital financial transactions (Sapra, R. et al., 2018). However, it was in 2012 that a new challenge arose concerning uncertainties linked to the adoption of cryptocurrencies worldwide. This conflict between regulators and cryptocurrencies is exemplified by some nations declaring the use of Bitcoin illegal or discouraged.

Beyond the numerous challenges, around 2014, the focus shifted towards the emergence of other platforms built on similar principles, like Ethereum. These new technologies propelled further evolution of blockchain technology, extending its applications beyond digital financial transactions. Consequently, in 2016, Bitcoin

began to be discussed as a "disruptive technology" capable of revolutionizing multiple sectors and reshaping the future of technology.

However, in 2019, a phenomenon known as the "Cryptowinter" began, marking a period of stagnation in the cryptocurrency market. It was characterized by price declines and increased regulatory issues, prompting the need to stabilize and secure the market through clear and consistent regulation over the years.

So, in 2020, a growing number of central banks began exploring the possibilities presented by Central Bank Digital Currencies (CBDCs) (Bhawana et al., 2021). Simultaneously, in an effort to regulate cryptographic assets, the European Commission sought to regulate the digital transaction market through a financial digital package.

In 2021, the markets for DeFi (Decentralized Finance) and NFTs (Non-Fungible Tokens) steadily and prominently expanded. This heralded a new era of financial innovation with some banks embracing cryptocurrencies.

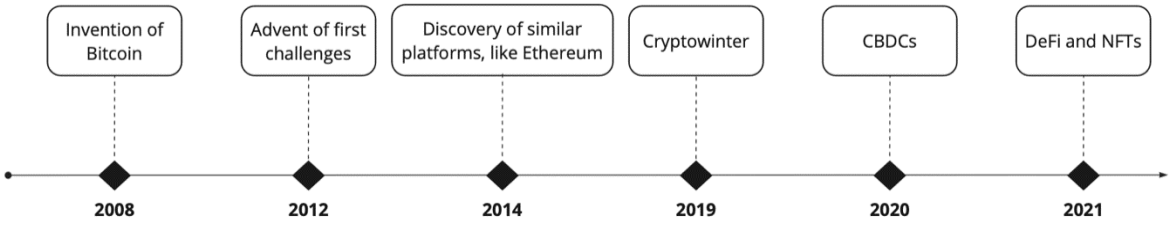


Figure 1. Evolution of blockchain

The question arises as to why Satoshi Nakamoto wanted to invent a virtual currency like Bitcoin. The answer lies in the fact that nobody trusted each other. In the years prior to this invention, there was a need for a single source of truth along the supply chain. Two methods were employed: the Trusted Third Party (TTP), where an authority verified the truth of transactions, and the Supply Chain Leader who was responsible for verifying each transaction. The primary limitation of these solutions was the trustworthiness of the authority or leader, which might not be believed by all.

This is where blockchain technology comes into play, aiming to eliminate ambiguities and wrongdoing during transactions. It offers an immutable and distributed ledger among all participants in the blockchain. It revolutionized the entire management of digital data along the supply chain, based on a transparent and secure system, and notably, without intermediaries.

This paves the way for a future without intermediaries, where trust becomes an intrinsic quality of digital transactions.

1.2.2. Features

In the context of a blockchain network, the crucial element is the renunciation of the need to trust each other among participants or to involve a third party for collaboration. Instead, dynamic online networks can easily create opportunities for sharing resources such as data and computing power, as well as enabling interactions for a variety of purposes within a peer-to-peer network.

One of the key pillars for confidence-building among participants in a blockchain is the immutability of data registers. This means that once data has been accepted by the blockchain network, it becomes untouchable and unchangeable, unable to be altered or manipulated.

The elimination of the need to rely on others is made possible thanks to the technological principles behind the blockchain. The basis of the decentralized management model is information sharing. By building an information sharing platform, virtual aggregation and scheduling of distributed information can be realized, and high-quality, low-cost services can be directly provided to each other in a peer-to-peer manner (Xue et al.,2021). The information is stored in a chain of data blocks, each of which refers to the previous block via an alphanumeric string derived, usually via a hash function. This makes any attempt to manipulate data contained in

a block without being discovered extremely unlikely, as references to previous blocks would no longer be consistent with the data itself.

The introduction of new data into the blockchain requires widespread consent and the achievement of an accepted state. In the case of the Bitcoin blockchain, this means that each participant who creates blocks of data selects the longest and most valid chain of blocks to connect the new blocks.

It should be noted that the immutability of the data recorded in a blockchain can be questioned in exceptional circumstances, such as bugs in the code. However, such situations of violation of immutability are highly unlikely, especially when considering the mathematical principle of "collision resistance", which makes it extremely difficult to find two blocks with the same hash value. Although a user has an incredible amount of computational power, the probability of succeeding in such an attack remains extremely low.

Blockchain technology has revolutionized trust and security in digital transactions, enabling collaboration and resource sharing securely and reliably between participants without the need for trusted brokers. Its immutable structure and resistance to mathematical collisions play a fundamental role in ensuring the security of information in the network.

Decentralization is a foundational principle of blockchain technology, representing its fundamental essence. Blockchains operate in the absence of a central authority, effectively distributing data across a vast network of interconnected nodes. This decentralized architecture stands as a formidable bulwark against the consolidation of undue power within a single entity, thereby significantly enhancing the security of the system while simultaneously cultivating a deep well of trust within the ecosystem.

One of the defining attributes of blockchain systems is their unwavering commitment to transparency. These systems often take the form of public ledgers, open for scrutiny by anyone with an interest. This transparent framework allows for the comprehensive

examination of the entire historical tapestry of transactions and data records. By opening the door to such transparency, blockchain engenders a culture of accountability and integrity. Participants can independently verify the veracity of the system, creating an environment where trust becomes an organic byproduct of this transparency.

Furthermore, blockchain introduces a fascinating and innovative juxtaposition of transparency and privacy. While transaction details are meticulously recorded on the ledger, the personal identities of participants remain securely concealed behind cryptographic keys (Liang et al., 2021). This novel approach not only ensures a degree of anonymity but also functions as a shield protecting sensitive information and personal privacy. It's this careful balance that makes blockchain technology uniquely adept at safeguarding the confidentiality of individual data while upholding transparency at the broader level.

These characteristics collectively contribute to the appeal and utility of blockchain technology across various applications. Whether it's in finance, supply chain management, healthcare, or identity verification, these attributes ensure that blockchain can deliver secure, transparent, and private solutions that reduce the need for intermediaries, enhance trust, and provide resilient data management and authentication.

1.2.3. Infrastructure

The cryptocurrency and Dapps ecosystem is built upon a well-defined foundation, which is that of Blockchain Technology. It possesses a highly complex infrastructure upon which an unlimited number of business applications can be created. This robust platform is comprised of five fundamental pillars:

- Network: This serves as a cornerstone for this technology, as it operates in a decentralized and trustless nature, eliminating the need for any intermediaries. A distributed network connects an enormous number of users to the same platform. The decentralization aspect makes this technology secure, as no single entity can exert undue power over others. During each transaction, the involved parties need not necessarily establish trust.

- Algorithms: Cryptographic algorithms and consensus mechanisms ensure the security of this platform. Through them, every piece of information within the system is verified and validated, guaranteeing data integrity.

- Ledger: All transaction and digital asset details are enclosed within this ledger, considered the core of the blockchain platform. It is accessible to anyone for information verification, offering transparency and immutability. Transparency allows anyone to access and verify the information recorded within, and immutability means that once information is recorded, it cannot be altered. This provides a higher level of security for all platform participants.

- Transfer: As mentioned earlier, this technology enables the exchange of digital currencies. Transaction security is ensured by a traceability system that records all usernames and addresses of the involved parties, reducing the possibility of fake users. The transfer can be enhanced through the application of smart contracts, which enable digital transactions to occur if certain conditions are met.

- Asset: This extends beyond just Bitcoin to a variety of different cryptocurrencies based on tokens and digital assets. These are necessary to represent the value of physical or digital assets, facilitating their use in transactions within the

blockchain platform. Digitizing an asset enables efficiency and increased transparency in various markets, including the financial one.

It's important to discuss different categories of blockchain platforms:

- Application-Specific Platforms: These platforms have a specific scope and purpose, such as insurance contracts or supply chain tracking.

- General-Purpose Platforms: In this case, the platforms are designed to be flexible and versatile for adoption in various sectors, with a wide range of purposes and applications.

Furthermore, blockchain platforms can have different modes of access:

- Private: Access to all information is restricted to a limited group of users, ensuring higher levels of security and privacy for authorized users.

- Public: In this scenario, anyone is authorized to access the information within the blockchain, characterized by high transparency and accessibility.

- Permissionless: This model allows all users to modify and access the data within the network and the network itself, offering high levels of freedom. However, it requires careful security management to ensure optimal system integrity.

- Permissioned: Participation in the network and data modification are permitted only to select users. This provides greater control but demands efficient management of access for authorized users.

There exists a highly complex and diversified digital ecosystem, offering various opportunities in various application fields and use cases. Its characteristics of transparency, decentralization, and security underscore its importance for the future digital world, where numerous industrial sectors are being completely revolutionized.

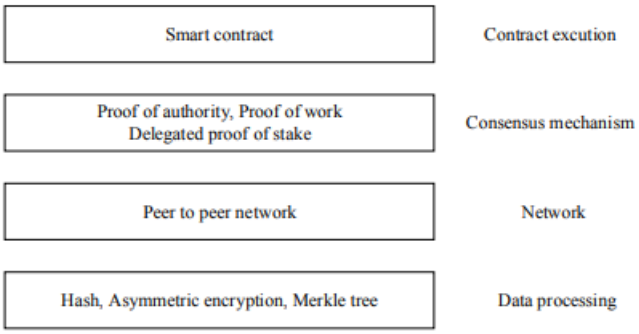


Figure 2. Blockchain Infrastructure

1.2.4. Smart contracts and TimeStamp

Blockchain applications can take various forms:

- TimeStamp: Within blockchain platforms, timestamping plays a crucial role in certifying the timing of all documents and actions taken. Through Blockchain Technology, a unique digital footprint of every action can be created. This footprint represents tangible proof of what has occurred, and the timestamp ensures a chronological record. This is particularly valuable in legal and business contexts, providing evidence of temporal integrity.

- Smart Contracts: Considered one of the most innovative technologies in the blockchain realm, smart contracts are computer protocols designed to simplify and verify the execution of contracts or negotiations, leading to their automation and the elimination of intermediaries. Smart contracts find

applications in various domains, such as financial transactions and the automation of complex business processes. They offer crucial advantages, including automation, contract execution assurance, transparency, efficiency, and intermediary elimination.

- DApp (Decentralized Application): DApps are decentralized operations that leverage blockchain technology's features. They function differently from traditional applications, relying on peer-to-peer technology, being censorship-resistant, transparent, and decentralized. An important feature is immutability, reducing the risk of external manipulation. This opens new frontiers where DApp users have full control over their data and information without the interference of large, centralized companies.

- Token: In the context of blockchain, there is a need to digitally represent physical assets like real estate or digital assets like multimedia content. Tokens can also be used to represent a participant's share in a project. Their ease of exchange makes the world of transactions within the blockchain a realm built on transparency and security.

- Cryptocurrency: Earlier, we briefly mentioned tokens. The most common form of these tokens is cryptocurrencies, which are based on cryptography to ensure security and the creation of new units. They facilitate global and instantaneous financial transactions, without the need for intermediaries. They are decentralized, so there is no need for the intervention of any authority, giving users ultimate control over their funds. The supply of cryptocurrencies is

limited, and their adoption is continually growing. For this reason, they are considered a store of value, much like gold.

These applications represent the essence of blockchain innovation. The expansion of unique solutions based on transparency, security, and efficiency for various types of digital transactions and interactions is underway.
It is significant to delve into the details of Timestamp and Smart Contracts, as they play a fundamental role in understanding the entire analysis that will be conducted during the thesis.

1.2.4.1. Timestamp

Living in an incredibly complex digital world, there is a need to keep a temporal record of events, especially within certain business and financial contexts. The introduction of timestamps within Blockchain Technology has made this possible, revolutionizing the way certain information and critical data are managed.

It is important to ensure the reliability and security of corporate data so that they remain consistent and tamper-proof. Data recorded within the blockchain is encrypted to make the information immutable once entered, preventing retroactive operations when the timestamp records the date of an event. The financial sector is the one most concerned with the immutability of transactions.

In today's world, especially the financial one, even a slight temporal shift in transactions can change the fate of the global market. Through blockchain technology and timestamps, it is not only possible to record user transactions temporally but also to make them transparent and accessible.

This can simplify legal and financial processes. Timestamps are used to record contracts to ensure their validity and reliability. This opens up new opportunities, especially in the Fintech sector.

Despite the numerous advantages, several obstacles need to be overcome, such as standardizing timestamping protocols, ensuring interoperability between different blockchains, and addressing cybersecurity concerns. The adoption of blockchain is hindered by varying levels of acceptance between countries, so standardizing these processes would help reduce this geographical gap. Cyberattacks are particularly dangerous, especially when pinpointing the exact moment of an event in the legal or financial sector.

Successfully overcoming these challenges is necessary to harness the immense potential offered by timestamps and blockchain technology in general. Only by doing so can we achieve an unprecedented level of efficiency and trust in the digital world.

1.2.4.2. Smart Contracts

"Smart contracts" are at the heart of the digital revolution that has transformed the world of contracts. Until the advent of blockchain technology and smart contracts, contracts required complex steps, paper documents, and often costly involvement of intermediaries. However, Nick Szabo foresaw the digital evolution and predicted that the era of global connectivity would require new forms of contracting better suited to the digital environment.

A smart contract is a form of self-executing, incorruptible contract encoded in a blockchain, a decentralized network of computers that share the same database. Once a smart contract is created, its code is immutable, ensuring that the contract rules are fixed and cannot be altered without public agreement.

This immutability is extremely important as it provides an unprecedented level of security. Since the code is public and accessible to anyone, smart contracts are transparent and verifiable. Anyone can review the code to ensure that the contract is as written. Furthermore, thanks to the cryptographic technology underlying the

blockchain, transactions made through smart contracts are secure and nearly impossible to manipulate. However, it's not just security that makes this revolutionary.

Smart contracts eliminate the need for traditional intermediaries. For example, traditional contracts may require the involvement of a notary or a lawyer to ensure that all parties adhere to the contract's terms. Smart contracts, on the other hand, automatically execute transactions when the conditions defined in the code are met. This means that parties don't need to trust each other or third parties; they only need to trust the code and the mathematics behind the smart contract. Moreover, smart contracts significantly reduce operational costs. Transactions become more efficient and cost-effective because there's no need to pay intermediaries to confirm and execute contracts. This will have a positive impact on a wide range of industries, from international trade to supply chain management, from finance to insurance.

Smart contracts are essential for the execution and formalization of commercial transactions, and their introduction eliminates intermediaries, simplifies the contract conclusion and execution process, and paves the way for a new era of trust and security in the digital world.

Smart contracts form the cornerstone of blockchain technology, thanks to their immutability and certainty.

Once a smart contract is created and distributed on the blockchain, its code and associated data are immutable. This means it cannot be altered or tampered with by anyone, ensuring the integrity and security of transactions. This immutability is the foundation of the reliability of smart contracts. Stakeholders can be certain that the contractual terms will not change after implementation.

Smart contracts operate deterministically. This means that when you execute a smart contract, all nodes on the network always produce the same result. This specificity is ensured by the inherent nature of the blockchain, and the rules defined in the contract's code. The outcome of a smart contract depends solely on its code, the input data

provided during the transaction, and the current state of the Ethereum blockchain. All this information is public and accessible to all network nodes, so the result is the same for everyone, regardless of who is fulfilling the contract or where they are physically located.

The immutability and determinism of smart contracts guarantee their reliability and security. These characteristics make them ideal for a wide range of applications, from the automatic execution of complex financial transactions to the management of complex contract processes in various sectors.

Smart contracts form the foundation of blockchain technology, ushering in a new era of trust and security in digital transactions. Their power stems from two key features: self-execution and transparency.

Smart contracts are designed to be entirely self-executing. This means that when the conditions specified in the contract code are met, the smart contract activates automatically and carries out the programmed actions without human intervention. This automated process eliminates the risk of human error and ensures that transactions proceed without delays or issues. Furthermore, smart contracts run on a public blockchain, making the code accessible to anyone who wants to examine it. This transparency is crucial for building trust in the transaction. Anyone can review the smart contract's code and understand exactly how the code works and what conditions apply to its activation. This open access to the underlying code removes secrecy and ambiguity in the operation of smart contracts, increasing trust between parties.

Smart contracts function similarly to traditional contracts in the real world, with one important difference. Instead of being stored as physical documents or digital files in a specific location, smart contracts are stored and replicated on a decentralized blockchain network. This allows you to access and verify them from anywhere in the world, removing geographical barriers and increasing accessibility.

Smart contracts eliminate the need for trusted intermediaries such as lawyers and notaries, thanks to their self-execution, transparency, and reliability. The terms are programmed into the contract and guaranteed by the blockchain network, enabling parties to have complete confidence in the outcome of the transaction.

We can say that smart contracts represent a milestone in the development of digital contracts, as they bring greater efficiency, security, and reliability to digital transactions, paving the way for a new era of contractual relationships in the digital environment.

Applications of Smart Contracts

In the industrial sector, smart contracts are revolutionizing supply chain management and production. Companies can use smart contracts to automate agreements with suppliers and ensure automatic payments when specific conditions, such as material delivery, are met. This not only simplifies business transactions but also eliminates cumbersome bureaucratic steps and reduces operational costs. Moreover, smart contracts can be used to trace the origin of products along the entire supply chain, ensuring the quality and authenticity of goods. Production departments can utilize smart contracts to manage agreements with service providers, such as transportation and maintenance companies. These contracts are automatically triggered when certain conditions are met to ensure that services are provided efficiently and on time. Additionally, transaction automation reduces the risk of errors and disputes, improving collaboration among parties involved in the production chain.

In the banking and financial sector, smart contracts are employed in various scenarios. For instance, in the insurance sector, they can simplify policy management. Smart contracts can automatically monitor insurance terms and trigger payments in the event of an insured occurrence, reducing claims processing times and ensuring a prompt response to policyholders.

In the world of financial transactions, smart contracts can manage complex financial agreements between institutions and ensure that payments occur only when all agreed-upon conditions are met. This reduces the risk of fraud and ensures transaction integrity. Additionally, smart contracts facilitate the creation and management of complex financial instruments, such as derivatives, making it easier to monitor and enforce contracts between counterparties.

The use of smart contracts in the industrial and banking sectors enhances operational efficiency, reduces costs, and improves transaction security. These implementations will radically transform the management of industrial and financial transactions, paving the way for a future in which transactions and financial operations are more reliable, transparent, and secure, thanks to blockchain technology and smart contracts.

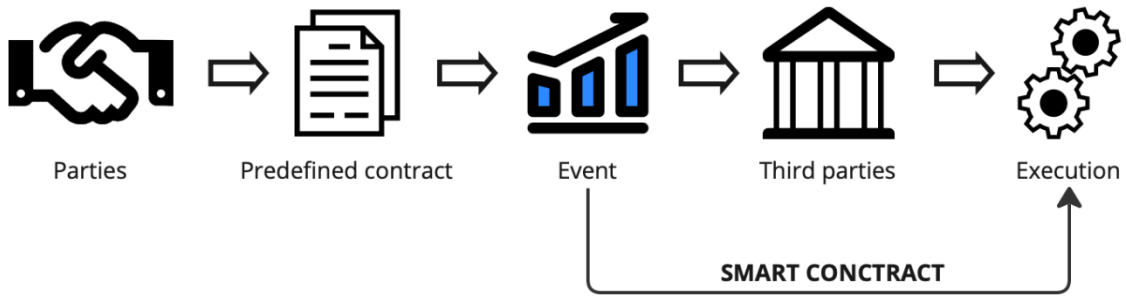


Figure 3. Implementation Smart Contract

1.2.5. Limitations of Blockchain in Enterprises

In a world where blockchain technology is constantly changing, companies face many challenges when deciding to use this new technology in their daily operations. These restrictions may vary in nature and complexity and may impact the Company's ability to leverage the full potential of the blockchain.

All of these challenges represent potential barriers to blockchain adoption and understanding them is crucial to making informed decisions and creating effective solutions (Morkunas et al., 2019).

- Data Processing: Major Challenges Current blockchain technology has limited the ability to process large amounts of data. For example, the maximum size of a Bitcoin block is fixed at 1 megabyte (MB). This means the blockchain can only handle a certain number of transactions at a time, reducing access and increasing transaction confirmation time.

  This limitation in data processing power could have a major impact on companies looking to use blockchain for their operations. Since blockchain technology is designed to make information secure and immutable, its decentralized nature and information about all transactions throughout the network will lead to large overhead, especially when the data is very large.

  This means that while blockchain has security and traceability benefits, businesses will face real limitations in their ability to do business effectively. This may result in longer transaction confirmation times and higher transaction costs. Companies should be aware of this limitation and consider it carefully when deciding to adopt blockchain as part of their business, while looking for solutions and other ways to manage data.

- Impact of transparency and privacy: The deployment of blockchain ensures transparency and open information, but it also makes it difficult to guarantee the confidentiality of information. Since changes are visible to all network participants, additional steps must be taken to protect

sensitive data. The tension between transparency and privacy can be problematic in situations where greater privacy is required.

- Management and control issues: The decentralized and anonymous nature of Blockchain can cause significant problems in management and control. Because blockchain nodes operate globally and are often anonymous, it is difficult for regulators to detect and prevent illegal or illicit behavior online. If some nodes collude to add false information to blocks, authorities will not immediately notice such behavior and it will be difficult to prosecute the offender later.

- Cost remains high: Blockchain applications designed for specific customers require expensive developers and require complex integration. One of the main problems companies face when considering implementing blockchain solutions is the cost incurred throughout the process. The main reason for this problem is that the development of custom blockchain applications requires a dedicated team of developers whose salaries will be higher than traditional programmers. Additionally, integrating these blockchain solutions into existing businesses requires hard work and additional resources, which leads to additional costs. Although blockchain technology brings long-term benefits, high startup costs may prevent many small and medium-sized businesses from using blockchain technology.

- Blockchain architecture is not yet standardized. The lack of design of blockchain architecture is another limitation that needs to be further analyzed considering the problems companies will face when using this

technology. Since there is no integration in the blockchain business, trying to establish business connections between different companies through this model will encounter major problems. Integrating different blockchain architectures can be a complex and difficult task.

Lack of standards can lead to many problems, such as difficulties in ensuring interaction between different blockchains. Different companies using different standards may encounter problems in maintaining exchange rates or ensuring secure communication between them. Additionally, the process of verifying and recording transactions can vary between blockchains, making it difficult for companies to develop consistent processes.

The absence of a standard will further hinder blockchain adoption at the market level and require additional efforts to ensure interoperability between different platforms. Businesses face this limitation when they decide to use blockchain as part of their business.

It is important to say that these restrictions represent significant but manageable challenges. However, these obstacles to blockchain adoption are being overcome by recent developments in regulatory easing, collaborations between organizations, as well as new development in more efficient blockchain architectures(«Blockchain and the Five Vectors of Progress» , 2018).

Challenges	Advancements/Strategies
Data processing limitations	Improved blockchain architectures
Transparency vs. privacy balance	Advances in regulatory frameworks
Management of decentralized networks	Collaborative efforts for network control
High implementation costs	Cost-effective solutions and collaborative funding
Lack of standardized architecture	Ongoing development of standardized blockchain frameworks

Figure 4. Challenges and Advancements in Blockchain Integration

In the thesis we will examine these problems in more detail, their impact on the use of this technology, and solutions and strategies to solve these problems.

1.2.6. Recent developments and Technology Enabler

Barriers to blockchain adoption are slowly being overcome due to recent advances in management flexibility, collaboration between organizations, and the development of better blockchain architectures.

A significant part of this development is in Hyperledger, Stellar, R3 and Ripple, increasing the capacity and efficiency of blockchains. This leads to processing times falling from minutes to milliseconds (Androulaki et al., 2018).

We also worked well in the design process to create a more integrated and integrated system for different blockchain applications.

Other issues with blockchain usage are decreasing complexity and cost. Leading companies such as Amazon, IBM and Microsoft offer cloud computing solutions and pre-designed models at a lower cost than construction. This model simplifies the installation process, reducing delivery time from months to days, allowing organizations to reduce the cost of initiatives.

An important step is to strengthen management. In the United States, many states have passed laws to encourage the adoption of blockchain in healthcare. This represents a major change in the behavior of this technology and leads to new ways of using it. New technologies enable greater efficiency and lead to greater changes in business. However, the window to enjoy this benefit is only open for a short period of time.

The evolution and progress of blockchain technology does not happen alone; but they are linked to various technological supports that will help improve its future. The Internet of Things (IoT) and 5G technology are an example of a significant technology integration that is key to unlocking the full potential of blockchain.

The combined use of IoT and 5G can increase the efficiency, security and efficiency of blockchain applications. However, these technologies do not necessarily solve important problems such as limited data processing capabilities, trade-offs between transparency and privacy, and governance and control issues. Therefore, it is necessary to consider these challenges when making significant improvements and pay attention to solutions to solve them in blockchain deployments.

The term "Internet of Things" (IoT) was coined by IoT pioneer Kevin Ashton. British Technology, 1999. Used this to describe the physical theory that real-world physical objects can be connected to the internet using sensors. Although the idea of connecting devices and networks to monitor and control things has been around for decades, early solutions relied on closed communication and standards rather than using the Internet Protocol (IP) standard.

The idea of using IP to monitor and control things has been around for decades. Connecting devices other than traditional computers to the internet is nothing new. Seminal examples include vending machines at Carnegie Mellon University in the United States and even the coffee machine in the Troy Room at the University of Cambridge in the United Kingdom, which was still connected to the Internet until 2001 (Rose et al.,2015).

The Internet of Things (IoT) refers to a vast network of physical devices, vehicles, homes, and other devices equipped with electronics, software, sensors, and connectivity capabilities. It allows them to connect and exchange information. “Smart things” are at the heart of the Internet of Things and are simply a term used for embedded systems connected to the Internet. These devices range from everyday life devices, such as thermometers and smart devices, to appliances, medical devices, and even entire buildings.

Overall, IoT has the potential to change the efficiency and productivity of many industries, such as improving people's quality of life through the use of solutions in smart home. However, it should also be noted that it brings serious concerns about security and privacy and requires attention and care. These features will need to be paid attention to in the future because the increased use of IoT will bring with it new problems and opportunities for technology and people.

Advanced communications are needed for the Internet of Things to be effective. Here comes 5G, wireless communications that promises to revolutionize the interaction between connected devices and their environments.

5G is a wireless communications technology that promises to make a huge impact on the Internet of Things, a world where physical devices can communicate with any device. Other and digital networks for various purposes. This revolutionary change in communications technology is redefining the capabilities of IoT devices to be more efficient and effective.

One of the advantages of 5G is that its speed and bandwidth are higher than previous generations. This means IoT devices can send and receive data faster, paving the way for a variety of new applications. Consider self-driving cars that need high-speed data exchange to make quick decisions on the road, or medical monitoring equipment that needs to instantly send important data to monitor a patient's health.

Reducing latency is another important feature of 5G. This means that the delay between the IoT device sending the command and the actual execution of the command is eliminated. This is important for applications such as remote control of robots or mechanical systems, where even slow movements can have large consequences.

In addition, 5G can provide higher connectivity and wider coverage even in remote areas. This is important for IoT devices in creative environments, such as agricultural devices in remote areas or remote monitoring devices in sparsely populated areas.

There is no doubt that the Internet of Things (IoT) brought by 5G will bring great benefits, but to ensure its progress and growth, it is important to consider some important aspects. Current centralized architectures cause many significant problems, including the risk of single failure, security, privacy, transparency, interoperability, scalability, and cost issues (Atlam et al. 2020).

The concept of "single failure" is a significant threat because the failure of the central server of the IoT infrastructure will negatively affect the availability and quality of all applications and IoT services. Additionally, since IoT devices are connected to the internet, they are vulnerable to cyber-attacks. As the number of connected devices increases, it becomes increasingly difficult to maintain adequate control over data collection and sharing.

Privacy management is a very important issue. The Internet of Things generates a lot of data, creating entry points for hackers looking to access sensitive information for organizations and users. The fact that third-party service providers do not provide assurances about responsible use and data protection raises concerns.

However, blockchain technology is emerging as a promising solution to these challenges. The integration of blockchain and IoT is called "Blockchain for IoT" (BCoT) (Dai et al., 2019). Adopting the decentralized and decentralized nature of blockchain technology provides a solution to one of the problems associated with centralized IoT

architectures. In a blockchain network, there is no need for a central server to manage IoT devices and communications because each part of the network facilitates data sharing.

In addition, blockchain provides greater security and privacy by using advanced encryption, hash functions and timestamping. These tools help reduce privacy and security concerns in IoT by keeping data safe and ensuring accurate tracking of transactions.

And thanks to the combination of the Internet of Things (IoT) and 5G technology, significant improvements in the efficiency and speed of blockchain application projects can be achieved. 5G connectivity provides incredible data, allowing you to speed up the process of recording transactions on the blockchain. This advantage is especially important in real-time applications such as tracking medical supplies or tracking shipments via mobile phone. However, it is important to note that the use of 5G can improve data collection efficiency but cannot solve the challenge of managing large amounts of data. This is a problem that some blockchains still face.

The security integration of blockchain, IoT and 5G can make a huge impact on protecting data generated by IoT devices. The combination of advanced encryption and security protocols provided by 5G can increase the stability of data stored on the blockchain. However, it should be emphasized that despite this development, cyber threats still remain a constant problem and the correct management of security keys is still the main problem to be solved.

Automation of IoT devices work through 5G can improve the efficiency and accuracy of the work. In this case, blockchain plays an important role by recording these changes transparently and securely, ensuring the complete security of the transaction. However, it should be noted that this performance cannot solve the scalability problem. Blockchain, by its very nature, still has limitations on processing multiple transactions simultaneously.

Finally, the ease of microeconomic operations of IoT devices represents another key point for IoT and blockchain integration. The ability of electronic devices to make small changes in instantaneous speed could be useful in situations such as charging an autonomous car or managing road resources. However, it is also worth noting that the simplicity of this change cannot solve the problems of business management, it also requires deep thinking and special solutions.

1.3. Blockchain adoption by Enterprises

Blockchain technology has many opportunities to create new jobs and directly impact the workforce. Organizations using traditional business models based on the idea of being an intermediary between two parties now need to carefully consider how blockchain technology affects their offerings, how they compete, and how they operate(Morkunas et al., 2019).

Currently, many experiments have been carried out in various areas, including the use of blockchain to track the movement of goods on the market, the use of smart contracts for safe, faster and cheaper real estate transactions, and the use of the Blockchain space. Let customers make deliveries. foreign currency without delays or high exchange rates. These pilot projects got businesses thinking about how rapidly growing blockchain applications could impact their business models.

Blockchain technology can impact value to consumers by providing products or services that did not previously exist or were only available at a certain price. More time or money. In addition, blockchain technology can provide faster and cheaper transactions compared to transactions made in the traditional environment. For example, the buyer value of the acceptance document for home buyers is based on the

promotion of the transfer of property from the seller to the buyer through contract document review. But working with a real estate agent to buy or sell is time-consuming and often costly. Here blockchain technology can reduce transaction costs and time for all parties. This can be done using smart contracts.

It is worth noting that the big milestone for blockchain technology has not been reached yet. Only a limited number of blockchain projects have moved from inception to full implementation. A recent Gartner study found that only 1% of CIOs surveyed reported using any form of blockchain, and only 8% of CIOs are currently engaged in short-term planning and testing processes (Gartner, 2018).

Blockchain applications have surpassed the financial sector and promise to increase efficiency in many sectors. Manufacturing companies need reliable and fast tracking of products from purchase to worldwide shipping. Physicians are committed to creating irreplaceable and searchable medical records to reduce drug and insurance fraud and improve data exchange in clinical trials. Public projects include not only land ownership but also digital projects that will facilitate travel, manage public information and facilitate the voting process.

Blockchain has the opportunity to create benefits beyond digital currency and is having a positive impact on all business activities, leading to a major change in the transfer and management of information. Businesses must always be careful and analyze carefully how to integrate this new technology into their business models in order to be competitive and up to date in the developing world.

1.3.1. Blockchain-based Supply Chain

Given that the ultimate goal of every Company is to become competitive in the global market, it is essential to understand what the Supply Chain is, how its boundaries are structured, and how it represents the cornerstone of the global economy.

By definition, the Supply Chain is a network of activities, organizations, information, and resources. Their interconnection ensures the production and distribution of goods and services. Various actors can participate in a Supply Chain, but the most important ones are suppliers, manufacturers, distributors, retailers, and end customers. It can be considered as the path taken by a good or service, from its creation to reaching the end consumer. It is not just a collection of components but a dynamic ecosystem based on planning, coordination, and resilience to address the numerous challenges that arise in the global market.

As mentioned earlier, the Supply Chain is a dynamic network composed of various actors performing different activities crucial for the production and distribution of goods and services. At the beginning of this maze of activities are the "suppliers," who are essential for obtaining components and raw materials. They are represented as companies playing a central role in the Supply Chain. Then there are the "manufacturers," who are referred to as modern alchemists capable of transforming raw materials into finished products through experience and technology. Companies that create these products or services, which are intangible goods, reflect their innovation in them. Of course, the discussion does not only revolve around suppliers and manufacturers, as the good or service must be distributed through intermediaries called "distributors." They ensure that the final product reaches the end consumer through various distribution forms ranging from wholesalers to retailers and distribution agents. They play a crucial role in optimizing costs and logistics processes to enable optimal product distribution. At the end of the Supply Chain, there are "customers," who are at the center as the raison d'être of the Supply Chain. Its entire architecture is focused on finding products and services that satisfy the customer. They can be end consumers using the final product or service, or other companies using the product as input for further production. Regardless of the type of customers, they represent the ultimate goal of every effort along the Supply Chain.

Along the supply chain, it is not just physical goods and services being discussed, but also invisible yet crucial flows of money and information. Demand forecasting information guides the strategic decisions of each actor in the Supply Chain. These pieces of information, in the form of data, can transform simple decisions into strategic ones, increasing the efficiency level of activities such as production and distribution. On the other hand, the flow of money is essential to keep the entire supply chain alive, starting from the sale of products to economic transactions with other actors in the chain. To ensure the economic continuity of the involved parties, accurate financial management becomes increasingly necessary.

1.3.1.1.Supply Chain Relationships inside and outside

Today's global trade is held together by relationships that emerge within the same supply chain and also between different supply chains. The ultimate goal is to support the entire structure of the global market. Below, we will analyze how these relationships, which today form a true connective tissue, influence the supply chain.
It is essential to talk about a synchronized and efficient system. For this reason, the interconnection between various actors in the chain such as suppliers, manufacturers, distributors, retailers, and customers come into play. As introduced earlier, the foundation of everything is collaborative, transparent, and above all open communication, capable of permeating throughout the entire supply chain.

This collaboration is not based solely on a mere exchange of goods and services. There is involvement of all actors in sharing their knowledge, perspectives, and strategies. This spirit of collaboration allows each actor to implement more meticulous planning and optimize production according to demand fluctuations. For example, suppliers

can adapt to the needs of manufacturers, ensuring the required items are provided at the right time and place.

This is where trust among various actors comes into play, acting as a glue for relationships within the supply chain. Inside it, not only timelines and contracts need to be respected, but accurate and particularly sensitive data are exchanged. Transparency must be ensured, starting from the quality of materials to production timelines and clear data regarding inventory levels. Transparency does not only extend to this but encompasses every phase of the supply chain, including ethical actions and sustainability. Nowadays, customers demand the highest level of transparency from companies providing products or services. They have increased awareness regarding political and environmental actions. Hence, companies need to move towards meeting these customer demands.

In today's global market, supply chains extend beyond national borders. This happens due to the need to search for resources outside one's own country, increasing opportunities for various supply chains but also bringing along challenges such as increased competitiveness within diversified markets that require more skills.

In other countries, different cultures, regulations, and challenges can be found. Each company’s task is to adapt its structure and way of thinking and operating to the cultural diversity due to its expansion. Collaboration with partners comes into play here. As mentioned earlier, the key to good relationships among different actors is clear communication. Indeed, correct translation of crucial data and deep knowledge of diverse regulations that could compromise product or service compliance in that specific country are necessary.

It is essential to remember that one of the major advantages of this type of communication between various supply chains is sharing best practices and optimizing processes, perhaps by adopting successful strategies from other countries. This exchange of information thus fosters continuous improvements to reduce waste, production and delivery times, and increase competitiveness.

Even within the same country, maintaining high levels of transparent communication between different supply chains is fundamental to promote economic stability and operational efficiency.

In a world where supply chains are global, ensuring operational consistency, collaboration, and transparency is of paramount importance. All of this is ensured by an environment based on technology and communication, acting as a breeding ground for prosperity and business growth.

Technologies serve to enhance the quality of relationships both within the same supply chain and between different supply chains. Relationships with suppliers are managed through Supplier Relationship Management (SRM) systems, monitoring supplier performance and sharing sensitive information. This is necessary for companies to assess supplier performances in terms of delivery times, resource quality, and regulatory compliance.

Enterprise Resource Planning (ERP) systems are also fundamental for managing activities within the Company and monitoring inventory levels but also for managing sales and customer contacts. Through these technologies, companies can have a unified view of operations, facilitating planning activities and greater coordination among various actors in the supply chain. This way, there is increased reactivity and response times.

There are also platforms that enable online collaboration among various actors in the supply chain, ensuring instant and real-time communication. This allows quick and informed decisions, reducing downtime and ensuring that all actors have access to necessary data. It is thanks to this technological foundation that shared goals and greater consistency can be established. Collaboration among various actors is thus facilitated by the advent of new technologies.

It is very important to adopt a Company culture focused on the most advanced technologies to ensure a better flow of information and resources along the supply chain.

1.3.1.2.Blockchain and its advantages in Supply Chain

We are in the midst of the fourth industrial revolution, and it is within this context that the fundamental role of Blockchain Technology emerges. This cornerstone of our technological innovation era was initially designed to support cryptocurrencies, but it has now found its place in enhancing efficiency, security, and transparency in all activities carried out within a Company. The most significant area where this transformation has occurred is in the Supply Chain.

Throughout this thesis, it is essential to highlight features such as production traceability, secure certification, monitoring and maintenance, identity management, and access.

Aspect	Description
Blockchain Application	Fundamental role in enhancing efficiency, security, and transparency in all company activities, with a focus on the Supply Chain.
Traceability	- Records all stages of a product's production cycle immutably and transparently.
	- Applicable to products, raw materials, production processes, and financial transactions.
	- Motivations include reducing counterfeiting and fraud, avoiding non-compliant products, and promoting consumer trust.
Secure Certification	- Ensures a higher level of security in businesses with numerous certifications and regulations.
	- Records certifications immutably, simplifying compliance verification processes.
	- Particularly crucial in food and pharmaceutical sectors for customer protection and trust.
Monitoring and Maintenance	- Real-time monitoring of goods during transportation using IoT.
	- IoT sensors upload critical data to the blockchain for immutable and transparent ledger information.
	- Enables proactive interventions based on real-time data, reducing damages and increasing efficiency.
Identity Management and Access	- Blockchain ensures decentralized data protection and secure identity management.
	- Actors in the Supply Chain can create verified and unique digital identities immutably.
	- Cryptographic authentication using private and public keys enhances data security.
	- Prevents malicious access to sensitive data, fostering a reliable working environment for collaborations.

Figure 5. Features overview

TRACEABILITY

At the core of optimal product quality and safety lies the feature of traceability made possible through blockchain technology. All stages of a product's production cycle are recorded immutably and transparently. This ledger is always up-to-date and immune to external tampering. This result extends not only to products, raw materials, and production processes but also to any type of financial transaction.

Consider a food supply chain: every step, from raw material collection to processing, is recorded. This recording includes crucial details for traceability, such as precise locations, products used in processing, processing times, weather conditions, and so on. These data are made available to all stakeholders in the supply chain, including end consumers.

The main motivations for the proliferation of traceability in businesses include a drastic reduction in counterfeiting and fraud. Traceability also helps avoid the introduction of non-compliant or counterfeit products into certain markets. Consumers gain not only awareness but also trust in companies introducing products to meet their needs.

Companies can also use this technology to track raw materials, enabling better resource management. This helps identify waste through monitoring processes along the supply chain. Once inefficiency, such as waste, is identified, direct intervention can significantly reduce costs and increase overall efficiency. This leads to a more sustainable resource management.

SECURE CERTIFICATION

In today's business landscape, which demands numerous certifications and regulations, a technology like blockchain serves to ensure a higher level of security. It

allows recording all required certifications immutably to ensure that products or services meet the required standard specifications. This is especially crucial in the food and pharmaceutical sectors, where consumers must be safeguarded more than ever.
Thanks to this technology, immutable, transparent, and accessible records can be obtained. Authorized access simplifies compliance verification processes and minimizes the time and resources needed. Authorized access also ensures that this information is not counterfeited or altered, ensuring greater authenticity.

This is not just operational security; it's customer protection and trust among all stakeholders along the Supply Chain, enhancing ethics and values in various internal relationships and between different chains.

MONITORING AND MAINTENANCE

Today, it is possible to monitor all types of goods in real-time during transportation, a crucial step to dramatically improve supply chains. In this case, the Internet of Things (IoT) plays a significant role in ensuring more effective monitoring and maintenance.
Manufacturers equipped with IoT sensors can control critical data, such as environmental conditions. These data are directly uploaded to the blockchain as ledger information. As mentioned earlier, this information is immutable and transparent. This way, the condition of goods is always available and monitorable. Monitoring, for example, a shipment of medications to verify its temperature and potentially flag it and recall it from the market, becomes significantly important in the food and pharmaceutical sectors.
Automation comes into play when, for example, the temperature drops below a certain threshold, and a signal is automatically sent to operators. With timely interventions, it is possible to reduce or eliminate damages to transported products.

Maintenance is also a consideration because the data within the blockchain can be used as a historical data registry. By analyzing them, trends can be identified, and potential risks can be prevented in the future. This not only reduces damages related to resources and raw materials but also increases the efficiency of overall resource management.

Manufacturers can therefore make use of these data records guaranteed by blockchain technology and, with the help of technologies like artificial intelligence, predict potential breakdowns along the production chain. Automation, as in the previous case, allows notifying operators when certain thresholds are exceeded, preventing critical values. This reduces downtime, optimizing overall business productivity.

IDENTITY MANAGEMENT AND ACCESS

To manage issues such as cyber threats and security breaches, it is necessary to build a vital barrier such as secure identity and data access management. Data security is fundamental and is guaranteed by the blockchain, as it advocates modern technological innovation, capable of decentralized data protection for users, whether more or less sensitive.

Due to this crucial decentralization feature, any actor in the Supply Chain can create a verified and unique digital identity, registered immutably. Cryptography through cutting-edge protocols comes into play when protecting user data from malicious entities.

It is cryptographic authentication, through private and public keys, that is the most distinctive feature of this technology. Indeed, only through these keys can access be gained to specific data one intends to view. Eluding such security practices is almost impossible without possession of the aforementioned access keys.

This security serves not only to prevent malicious individuals from accessing sensitive data but also to allow and facilitate greater security during collaborations between

partners within the same and between different supply chains. This creates a reliable working environment for all involved parties.

1.3.1.3. Automation of Contracts through Smart Contracts along the Supply Chain

One of the most significant and revolutionary developments concerning how businesses manage their operations is the introduction of Smart Contracts along the Supply Chain. Like all technologies inherent to blockchain, this brings about improvements in terms of efficiency and transparency.

Smart Contracts, which are based on blockchain technology, are protocols in the digital world that are automatically executed as contractual clauses once certain predefined conditions are met, and once executed, they cannot be stopped. In the realm of the Supply Chain, this innovation has greatly simplified contract management and overall negotiation times. There is no longer a need for any intermediary, leading to streamlining of the entire process and reduction in total costs.

Smart contracts serve to streamline the possibility of anything negative happening, thus reducing any risks associated with operations that can now be performed through smart contracts. Manual contract management, for example, is characterized by human errors and incorrect interpretations. This manual management poses various issues when it comes to commercial transactions. To avoid the possibility of fraud, advanced encryption, as mentioned earlier, is employed.

Smart Contracts make the management of orders, payments, deliveries, and so on, much more agile. They are also used within a continually evolving financial

ecosystem. Indeed, they can enhance the management of loans for companies, enabling them to access credit more easily and securely.

Banks today can automatically grant loans through smart contracts. The system verifies that the requirements are met and that the provided information aligns with the reality of the situation. This tends to eliminate all the lengthy bureaucratic processes of credit approval and evaluation.

Not only is the loan approval process automated, but also the repayment of installments with corresponding interests, avoiding situations where deadlines are not met without any human intervention. Transparency and punctuality are the foundation of the results achieved in the financial world thanks to blockchain technology. Undoubtedly, automating these processes drastically reduces operational costs for both banks and companies. Extensive personnel and paper documentation are no longer necessary.

Companies can now access credit in a simple, fast, and effective manner, enabling them to have the necessary funds to invest in their own development and business innovation, expanding and competing globally.

1.3.1.4.Supporting Technologies impact

To address the limitations arising from the adoption of Blockchain Technology and fully leverage opportunities within the increasingly complex ecosystem of global supply chains, two key technologies play a crucial role: IoT and 5G.

IoT as Support

This technology manifests as interconnected physical devices designed to collect, process, and exchange various types of data. This allows businesses to monitor every

element of the supply chain. For instance, by placing sensors on packages or products, companies can have real-time tracking of the product's location and condition from the beginning of the chain to the end consumer.

Every movement can be monitored and traced in real-time. Each item can be uniquely and instantly tracked, and the gathered data is constantly updated and digitally visible to authorized users. Movements, stops, and transactions are visible to operators, ensuring greater transportation efficiency.

The sensors used not only provide information about the object's location but also monitor the physical state of the products to ensure higher quality. Temperature sensors, for example, can be used for medicines that must be stored within specific temperature limits. Humidity sensors can be installed to prevent damage to certain materials during transport or storage.

Moreover, IoT is utilized to prevent damages, theft, and losses. All steps in the supply chain are recorded, so if an item were to go missing, the last recorded point along the chain could be traced to locate it.

The integration of IoT into the application of Blockchain Technology serves to ensure a more secure and transparent management of the supply chain and achieve higher levels of operational efficiency.

5G as Support

Compared to previous generations of wireless networks, 5G offers significantly enhanced performance. This allows for the simultaneous, fast, and seamless connection of multiple devices, including the IoT sensors adopted along the supply chain. Often, companies have a large number of IoT sensors providing real-time data, and the presence of 5G ensures faster data transfer, enabling users to access blockchain information with greater reliability as it's updated in real-time.

Thanks to minimal latency, this supporting technology enables super-fast communication between different nodes of the same supply chain. For example, if an IoT device like a sensor detects a temperature fluctuation in a pharmaceutical product, the information, in the form of an alert, is swiftly sent to the relevant stakeholders.
Stakeholders in the supply chain consistently collaborate to achieve the best possible outcomes. Critical data, such as inventory data, is crucial and must be shared instantly and securely. This modus operandi allows for greater efficiency in planning and, most importantly, in decision-making.
Therefore, it is evident that 5G is crucial as a supporting technology for blockchain to ensure fast, reliable, and secure connections. This enables the implementation of more complex, real-time blockchain applications.

1.3.1.5.Warehouse

Thanks to blockchain technology, the way companies view warehouses within their operations and the entire supply chain has undergone a revolution. Levels of security, transparency, and efficiency have increased compared to the management methods used before this technological innovation.
The first thing that has been positively changed is the traceability of goods, as every movement along the supply chain is recorded permanently and immutably on the blockchain. This type of traceability is entirely real-time today, thanks in part to supporting technologies.
With the introduction of smart contracts, many processes have been automated. Indeed, if certain conditions are met, operations such as order management, compliance checks, and all types of billing no longer require any human intervention, significantly reducing errors and improving their efficiency.

A high area of improvement due to this technology is the security of the data present on the blockchain, as it is a network based on decentralization and the use of advanced cryptography to protect all stored information. This information cannot be modified or manipulated.

Furthermore, a higher level of collaboration is promoted among all actors within the supply chain. Therefore, the advent of this innovative technology allows for increasingly effective management of traditional warehouse management processes, laying the groundwork for the evolutionary path of the logistics sector.

It will be described later how these advantages are currently strengthening trust relationships between supply chain actors and banks.

1.3.2. Blockchain-based Finance

Blockchain technology is reshaping conventional concepts of business transactions, offering new opportunities for the reconfiguration of value. It has the potential to disrupt various industries and organizations, compelling these entities to reconsider their strategies and value creation methods (Schatsky and Muraskin, 2015). While blockchain application is growing across various industries, from supply chains to public services, it has been more rapidly adopted in the banking and financial sector (Hughes et al., 2019).

Blockchain technology is eagerly anticipated to transform and innovate the functioning of the banking and financial sector. Its decentralized nature, interorganizational trust through distributed ledger technology, and the reduction of information asymmetry and counterparty risk have profound implications for business models and processes, attracting the attention of relevant scholars. Oh and Shong (2017) studied real-world applications of blockchain in South Korea in 2017, discovering that blockchain could potentially improve the management of existing

information processes and establish partnerships with businesses linked to financial institutions.

For startup financing, a blockchain-based financing system can address issues of information asymmetry and transaction costs inherent in startup funding, leading to a more decentralized and efficient entrepreneurial financing process (Ahluwalia et al., 2020). Additionally, blockchain-based initial coin offerings (ICOs) can provide startups with a new form of financing.

In the securities and derivatives market, blockchain can enhance investor control and increase systemic risk distribution. It can also develop permissioned platforms for the clearing and settlement of derivatives and manage liquidity shortages (Avgouleas & Kiayias, 2019). In credit systems, a blockchain-based credit analysis framework can be highly useful in gathering customer information from other financial sectors, analyzing customer creditworthiness, and calculating their credit scores, potentially making the process much more efficient and transparent.

For trade finance, blockchain has the potential to disrupt the centralized operational model governing trade finance and business processes, such as payment through letters of credit. In global health financing, blockchain has the potential to disrupt traditional mechanisms of global financing through four significant modes: universal access to financing through direct transactions without intermediaries, new multilateral financing mechanisms, increased security and reduced fraud and corruption, as well as opportunities for open markets for health data that promote discoveries and innovations.

Financial digitalization and disintermediation

The inherent trust element in blockchain technology allows for disintermediation in certain banking and financial sectors. The study conducted by Elghaish, Abrishami, e Hosseini (2020) utilized blockchain technology to propose a decentralized, automated,

and secure financial platform in integrated delivery projects, enabling all participants to control and monitor financial transactions without authorizing modifications. A blockchain-based financial product management platform constructs a distributed network architecture for managing financial product information and provides tamper-proof, information transparency, and secure information sharing. For example, blockchain could serve as a platform for companies to voluntarily disclose short-term information and could effectively reduce errors in disclosure and earnings management, enhance the quality of accounting information, and mitigate long-term information asymmetry. Kabra et al. (2020) proposed an automated framework for check settlement called Mudra Chain, where settlement operations are managed by the blockchain network rather than the existing check truncation system. Yoo (2017) examined the dynamics of the financial sector and related services using blockchain in the Korean market and found that the most actively applied blockchains in the financial sector are expanding into settlement, remittances, securities, and smart contracts. Moreover, the transition to a private distributed ledger that bypasses the central bank is accelerating interbank payments.

Financial inclusion

Financial inclusion means that low-income earner or business is able to acquire affordable and sustainable financial services. Based on the World Bank almost 2 billion adults are without bank accounts or only partly served by banks. However, with blockchain technology, a single coherent, transparent, and responsible digital economy can be created that is intended to resolve global poverty and encourage urban trade. Blockchain has a promising ability of addressing unbanked and underbanked issues, contributing to financial inclusion and poverty eradication. Blockchain is actually an answer for reducing financial exclusion in a context of sustainable development especially for developing countries. As a case for instance,

Schuetz and Venkatesh (2020) highlight blockchain as a means of addressing financial exclusion in rural India and providing solutions of connecting rural villages to the world by responding to the chain linking.

(Norta et al., 2019) introduced a blockchain-based capital transfer system aimed at reducing barriers to financial inclusion and providing financial services to those without a bank account. Blockchain-based fintech technology and cryptocurrencies have been introduced to enhance access and availability of financial services for populations without bank accounts or with limited access. These solutions are meant to enhance the availability of financial services among the low-income earners.

Financial Regulation

Blockchain technology enhances the flow of information between public agencies and stakeholders as it can facilitate transparency and transaction traceability. Consequently, it has the potential to impact financial regulation Collomb, Filippi, e Sok (2019) explored the use of blockchain technology as regulatory technology by incorporating specific rules and constraints into the technological structure of initial coin offerings to comply with fundamental principles of financial regulation. The study conducted by Ducas e Wilner (2017) examined the regulatory role of blockchain technologies in combating money laundering and terrorism financing. A blockchain-based database could potentially offer a feasible solution to combat financial fraud in the public sector and leverage the unique capabilities of blockchain.

However, blockchain technology also challenges existing regulatory approaches, and the challenge lies in determining a new balance between technological innovation and regulation. This implies that financial regulation and private law should set the boundaries of blockchain technology to protect market participants and companies as a whole while allowing the necessary space for innovation.

Aspect	Description
Financial Digitalization and Disintermediation	- Disintermediation in banking and financial sectors. - Use cases include decentralized, automated, and secure financial platforms. - Blockchain-based financial product management for tamper-proof information.
Financial Inclusion	- Addresses issues of unbanked and underbanked - Promotes financial inclusion and poverty eradication. - Blockchain as a solution for sustainable development in developing countries.
Financial Regulation	- Enhances information flow and transparency for regulatory - Uses in regulatory technology for compliance with financial - Potential in combating money laundering and terrorism - Challenges existing regulatory approaches, requiring a new balance for innovation and protection.

Figure 6. Overview of Aspects Affected by Blockchain Adoption.

1.3.2.1.Blockchain potential usage in financial services domain

In the financial services sector, blockchain is effectively redefining how financial institutions operate and provide services to their clients. This technology offers a wide range of applications that go far beyond the mere management of cryptocurrencies(*Blockchain Adoption in Financial Services*, 2019). Let's explore these possibilities in detail.

- Commercial Banking

Commercial banks are harnessing blockchain technology to introduce new competitive products and services. A notable example is the tokenization of financial products. As Don Tapscott, author of "Blockchain Revolution," puts it, "Blockchain is an open platform where anyone can build. It's a shared platform that will change the way we do just about everything." Cryptocurrencies like Bitcoin and Ethereum were just the beginning; now we see the creation of financial tokens representing stocks, bonds, and even structured products.

Blockchain is also an excellent ally for asset and real estate traceability. Recording property ownership, such as houses, land, and cars on the blockchain, simplifies the ownership verification process and reduces the risk of fraud. For instance, Propy, a blockchain-based real estate buying and selling platform, offers a solution for secure and intermediary-free transactions.

Peer-to-peer markets are becoming more accessible thanks to blockchain. Startups like Ripio offer blockchain-based peer-to-peer lending services that enable individuals to borrow money from others without the involvement of a traditional bank. Additionally, smart contracts on the blockchain automate loan management, allowing for automatic profit and collateral sharing.

Personal financial management is simplified through blockchain. Applications and services like Chain, which securely manage cryptocurrency wallets, are gaining popularity. Customers can track their investments in one place, with a clear view of all their financial assets.

Even liquidity management, cash reserves, and intrabank transactions are becoming more efficient thanks to blockchain. Transactions can be executed in real-time without the need to go through intermediaries, speeding up processing times and reducing costs. According to Accenture's study on blockchain-based payments, this technology could save banks up to $12 billion annually by 2025.

Blockchain is also an invaluable asset for customer acquisition and loyalty management. The traceability of transactions on the blockchain allows financial institutions to recognize and reward loyal customers more accurately and efficiently. Private enterprise blockchains, such as Hyperledger Fabric, enable businesses to create customized blockchain-based loyalty programs, offering real-time benefits to customers.

- Payment Systems

Blockchain technology has revolutionized transactions, foreign exchange and corporate transactions by making them faster and more convenient. According to Circle CEO, Jeremy Allaire, blockchain enables cost effective payments eliminating the need, for slow and expensive transaction methods. This advancement has the potential to reduce trade costs while expediting the trade process.

Moreover, peer to peer payment services like BTC Jam, Codius and BitBond have made borrowing money from individuals worldwide much simpler. These platforms eliminate the necessity of banks. Promote a more inclusive lending environment where credit becomes accessible to all regardless of their location.

The adoption of blockchain has also enhanced payment transactions in general. Companies like Coinbase and BitPay offer to use solutions for cryptocurrency payments to merchants. This not ensures cryptocurrency transactions but also allows consumers to utilize digital currencies for everyday purchases both in physical stores and online services.

Furthermore, virtual exchanges and wallets have transformed currency exchange. Transfer on a scale. Platforms such as BitPesa and Bitreserve facilitate currency conversions with swift processing times. By reducing transaction costs and processing time these advancements, in remittance systems benefit communities that heavily rely on these funds.

- Capital Markets

Blockchain has significantly accelerated the execution of trades. Real-time matching and automated payment delivery systems reduce trading times, resulting in faster financial transactions, increased efficiency, and reduced risk of errors. The use of blockchain in trading operations has the potential to significantly shorten settlement times, which can sometimes take days.

After trade execution, reconciliation, reporting, market monitoring, and surveillance become much more efficient. Blockchain transactions are permanently recorded and shared among the involved parties, reducing the risk of errors and fraud. Additionally, data is available in real-time, enabling greater transparency and the ability to promptly detect anomalies.

Custody and security services are becoming more effective thanks to blockchain. Trustee services, asset documentation, and record-keeping are simplified and made more secure. Blockchain enables the immutable recording of all data related to the custody of financial assets, reducing the risk of loss or misappropriation of such assets.

Blockchain enhances the security of derivative-related transactions. The transparent and secure nature of blockchain reduces the risk of fraud and disputes in derivative contracts. This is particularly relevant in an industry where contract complexity and the need to monitor counterparty obligations are critical.

Asset records become more reliable through the use of blockchain. The technology ensures that the origin and history of a financial asset are clearly traced, helping to strengthen investor confidence and enhance regulatory compliance. As Larry Fink, CEO of BlackRock, states, "Blockchain offers greater transparency and reduces risks associated with asset custody, providing a new level of security for investors."

- Risk Management

Revision and risk assessment are simplified thanks to blockchain. The use of smart contracts allows involved parties to automate and standardize the review and risk assessment processes. This means that contract terms and guarantees can be managed transparently and immutably, minimizing the possibility of errors and disputes. Blockchain eliminates the need for manually processing contract documentation, speeding up risk assessment times.

Counterparty risk management and fraud prevention significantly improve with blockchain. The storage of immutable records shared among involved parties increases trust in counterparty-related information. Financial transactions and contracts are permanently and transparently recorded, reducing the risk of fraud or fraudulent activities. Blockchain offers complete traceability, enabling the verification of historical data and the timely detection of suspicious behavior.

Liquidity and capital management become more precise thanks to blockchain. Financial institutions can use blockchain to track real-time transaction and liquidity position. This allows them to have a clear and instant view of their financial status, facilitating resource management and capital planning.

Blockchain provides a real-time global view of systemic risks. Sharing financial data on a blockchain network allows institutions to continuously monitor systemic risks across the financial sector. This enables a timely response to threats and better prevention of financial crises. Blockchain can also help institutions comply with regulations and ensure transparency in financial operations.

Operational risk management has significantly improved with blockchain. The technology enables the automation of critical processes, improving efficiency and reducing the risk of human errors. Data recorded on blockchain is highly reliable, contributing to the quality of information used in operational risk management.

- Regulatory Compliance

Blockchain automates compliance activities, making complex processes such as Comprehensive Capital Analysis and Review (CCAR) requirements more efficient. The use of smart contracts ensures that financial operations are executed in compliance with applicable regulations. These contracts can be designed to automatically adhere to regulatory constraints and report violations in real-time, reducing the risk of human errors and enabling better compliance management.

Regulatory constraints are applied more accurately through blockchain-based smart contracts. These contracts are programmed to automatically comply with current regulations, ensuring that financial operations adhere to the laws. This reduces the possibility of regulatory violations and simplifies compliance with complex regulations.

Optimization of regulatory processes, such as Anti-Money Laundering (AML) and Know Your Customer (KYC) compliance, is made more efficient through blockchain. Sharing data on a blockchain network among financial institutions allows for faster and more accurate customer identity verification, reducing duplication of efforts and bureaucratic burden associated with collecting customer information.

Blockchain simplifies sanction enforcement. Financial transactions recorded on the blockchain can be easily traced and analyzed to identify potential sanctions violations. This enables regulators to respond promptly and enforce sanctions more effectively.

Blockchain provides advanced tools for regulators. They can monitor the activities of financial intermediaries in real-time by accessing data on the blockchain. Furthermore, blockchain enables a detailed audit trail verification for compliance, simplifying the monitoring and review of financial operations.

Figure 7. Compliance Concerns

- Trade and Supply Chain Finance

Blockchain enables real-time tracking and management of financial documents, such as letters of credit and bank payment obligations. This eliminates the need for intermediaries and reduces the risk of errors, allowing all parties involved to transparently track transaction information.

Debt financing, insurance, and factoring services are becoming more efficient thanks to blockchain. Financial institutions can use blockchain to automate processes that would otherwise require days or weeks of manual work. Smart contracts can automatically execute payments based on preset criteria, simplifying the financing process and reducing costs. This makes faster and more accessible financing possible for businesses involved in the supply chain.

Blockchain also facilitates invoice financing. Companies can convert their invoices into tradable digital financial assets on the blockchain, allowing them to obtain liquidity in advance and improve working capital management. This is particularly advantageous for small and medium-sized businesses that often have to wait a long time for invoice payments.

Commodity trade financing is simplified through blockchain. Companies can use blockchain to track the origin and authenticity of raw materials, reducing the risk of

fraud and improving regulatory compliance. Furthermore, the execution of decentralized contracts on the blockchain allows for direct trade between parties, eliminating the need for costly intermediaries.

Real-time document preparation and approval are made more streamlined thanks to blockchain. Documentation errors are minimized, and processes become more efficient. Interaction between importing and exporting banks becomes more direct, eliminating the need for correspondent banks and reducing transaction processing costs.

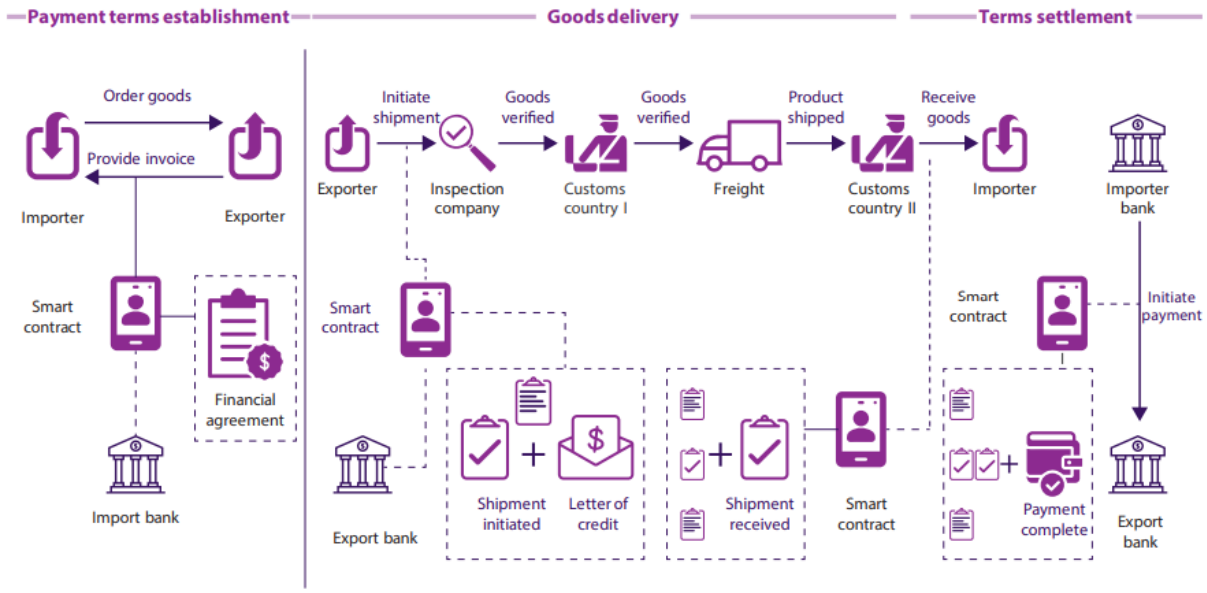


Figure 8. SCF process

1.3.2.2. Blockchain adoption in SCF

Supply Chain Finance (SCF) is a strategy to optimize working capital in the supply chain involving many stakeholders. Stakeholders within SCF include logistics, supply chain management, distribution networks and financial institutions, all working together to create value through collaboration. The SCF process is carried out by planning, monitoring and managing the revenues of the relevant organizations.

Working Capital Management aims to improve the cash-to-cash (C2C) cycle to easily save money for the Company. This practice allows the business to release unused financial resources and make money useful, thereby improving internal finances and thus having a positive impact on the Company value of the department.

Individuals engaged in the supply chain have the opportunity to enhance business management leading to a situation, for all parties involved. Previous studies on the chain have primarily focused on two aspects; one pertaining to finance, which encompasses measures for debt and credit management and the other relating to logistics with an emphasis, on optimizing efficiency of the supply chain.

SCF involves the use of delivery methods to finance, create results and manage projects for the benefit of stakeholders and third parties.

SCF's solutions include providing alternative financing options, such as refunds, to suppliers in the trade flow to resolve issues related to payment delays. Supply chain finance is considered an essential part of the supply chain and results in the creation of value through planning, directing and controlling the flow of financial capital during the placement of goods on account. Trade credit plays an important role in managing inventory in the market because delaying payment with trade credit causes buyers to increase the order quantity and consume the total value of the money for the period.

From a financial perspective, the functions of financial instruments include:

(1) Capital optimization
(2) Long-term financial decision making
(3) Capital management

Increasing shareholder value with the aim is the ultimate goal. Financial chain's decisions can affect the financial structure, costs, benefits, risks and business value of the Company, affecting the entire delivery process and its stakeholders. SCF can be

considered as a product and service strategy supported by technological solutions in which financial institutions participate as financiers.

Most of today's supply chain management (SCF) problems stem from information overuse, staff shortages, printing difficulties, and business closures due to the multiplication of closures. Reliance on correspondence and the need for physical information creates a vulnerability in the supply chain that requires time and efficiency.

Legal issues related to checking the accuracy of documents and the decision to ink signatures for payment and delivery documents represent more grassroots paths. These issues raise questions about the industry's ability to cope with unprecedented global impacts that often lead to delays, conflicts and supply uncertainty.

In this context, product chain financing (SCF) technology is used to create trust and ensure that suppliers of these products manage their production and transportation operations well. Over the past 5 years, there has been much research, initiatives and discussions surrounding blockchain as a way to digitize supply chains. Blockchain has great potential to improve the efficiency and transparency of supply chain operations. Progress is being made in this field and the problems are gradually being overcome. Digitalization of the supply chain leads to better information and financial information throughout the supply chain, from origin to destination. This not only improves traceability and control performance, but also helps reduce costs and increase occupational safety throughout the physical supply chain. Blockchain has the capability to ensure data security and translucency, playing an important part in perfecting the quality of supply chain operation.

Blockchain technology represents a revolutionary way to record and dissect fiscal deals and information. This invention is grounded on a decentralized, translated tally that all members of the network have access to for a certain period of time. The transaction verification process is based on distribution involving a large number of

participants and verification of the accuracy of signatures and records by agreement. The authentication process serves the essential purpose of guarante-eing the utmost safety and security of data, while also preventing any unauthorize-d access or manipulation.

The blockchain's unique feature lies in its capability to eliminate the necessity for external intermediaries. Transactions no longer rely on external authorities like banks or lawyers, as they are verified and authorized by the network itself. This not only decreases transaction costs but also accelerates the process, enabling users to interact directly.

Additionally, this approach allows full traceability of business activities, making information auditable.

Another advantage of blockchain is the ability to create smart contracts, which are self-executing processes that can perform many tasks. For example, smart contracts can manage the entire lifecycle of transactions by accepting payments without the need for human intervention. These agreements can lead to actions such as payment, delivery authorization, or confirmation of receipt. This process is based on algorithms and predefined rules that can speed up the process for products and facilitate digital payments.

Blockchain's decentralized architecture provides secure, irreversible and transparent access to supply chain information. Each block of data is defined by network members through consensus, ensuring that no party has exclusive ownership over the data. Additionally, data integrity is maintained by majority or consensus. This approach ensures that data is always validated and updated.

When combined with the Internet of Things (IoT), blockchain technology can further enhance transaction efficiency. Every data generated by IoT devices is validated through network member consensus and then added to an encrypted blockchain. After being added to the blocks, transaction-related data can be traced and verified at

any time. The use of this blockchain technology in synergy with IoT opens the door to faster transactions and significantly reduced costs. The promise of expediting transaction processes and lowering overall financing costs provides substantial benefits to all parties involved in a supply chain financing transaction. Hofmann argued that the combination of blockchain and the Internet of Things (IoT) can maintain device connectivity and offer material flow traceability along the supply network to regulate risk premiums throughout the entire shipping process. IoT allows the blockchain to be fed with real-time information via sensors, rather than relying on human "oracles" to transmit data related to the physical movement of goods.

Rijanto (2021) analyzes how blockchain technology simplifies the intricate processes of inventory financing, purchase order financing, and receivables financing. Blockchain's transparent and secure ledger system has the potential to revolutionize these financial operations, providing greater efficiency and trust in the supply chain industry.

Financial Operations	Traditional Approach
Inventory Financing	Manual, time-consuming processes
Purchase Order Financing	Dependency on intermediaries
Receivables Financing	Lack of transparency and delays

Figure 9. Traditional approach

Inventory Financing

Inventory financing simplifies the process of handling funds for goods and assets during their transport and storage. In this system, third parties, like banks, step in to provide financial support. Its primary aim is to enhance a Company’s credit and debit management throughout its operations. As a result, businesses no longer need to carry these assets on their balance sheets; instead, they can use them in their production processes.

When the stored goods get sold, the bank or lender receives the money they provided. If these products don't sell, the banks may request the return of the assets from the owners of the financial resources. Blockchain technology introduces a novel approach to this process by enabling the creation of a system that records assets through digital certificates or "tokens" representing financial institutions' members.

Financial institutions acting as creditors can assert their ownership rights through these digital tokens, even if the payment isn't received, allowing them to continue selling financial resources. These processes are securely recorded on the blockchain, ensuring the transactions' legitimacy.

Financial products are riskier than loans since they involve early investors. Businesses heavily rely on equipment. The main concerns pertain to sales issues and the longevity of items in inventory.

Blockchain technology offers a potential solution to mitigate the risks associated with financial products. It facilitates the comprehensive recording of all production and products, involving producers, sellers, and buyers. Utilizing blockchain technology in manufacturing operations brings together a wide network of users to guarantee the integrity of products and invoices. This, in turn, helps prevent issues like misinformation or double usage during operations.

Order Financing

In the realm of purchase order (PO) financing, the financial transactions take place prior to the actual shipment of goods. This unique financial arrangement places the third party providing the financing in a potentially riskier position, as the purchase order signifies the very inception of the intricate supply chain process. Purchase order financing extends to cover a broad spectrum of expenses, ranging from raw materials procurement to production and ultimately the transportation of the goods. Given the complexity of this process, blockchain technology emerges as a compelling solution,

promising enhanced transparency and data integrity at every stage, including production, packaging, and shipment. This newfound transparency equips the third parties responsible for financing with the data required to make well-informed assessments of the progress and integrity of the process.

The blockchain-based network not only fosters transparency but also ushers in novel business opportunities for the banks participating in the financial ecosystem. Moreover, it operates as a remedy for the inefficiencies prevalent in the current exchange procedures, endowing all transaction stakeholders with a secure and dependable wellspring of data.

Within this blockchain system, financial institutions find themselves empowered to record and appraise financing decisions with greater insight. Banks involved in the transactions gain precise insight into the invoicing status, thereby obtaining a comprehensive understanding of the Company's exposure to each partner bank. This depth of knowledge equips these institutions to make more informed and judicious financing decisions, strengthening the overall financial ecosystem.

Receivables Financing

Receivables Financing, also known as credit financing, plays a pivotal role in commercial transactions, aiming to bolster the credits extended by suppliers. This practice, deeply ingrained in the business landscape, centers on invoices as its linchpin. In credit financing, the evaluation of risk intricately intertwines with the supplier's financial stability and reliability. As a result, when the supplier's creditworthiness falls short of the buyer's, it is deemed a riskier investment, and the associated financing costs tend to rise. Typically, financial institutions, such as banks, act as intermediaries, purchasing these supplier credits.

Yet, within the credit financing realm, the financier must meticulously scrutinize both the financial well-being of the suppliers and the buyers to gauge the cost and extent of

necessary financing. Enter blockchain technology, offering an ideal remedy to boost transparency, authenticate data, expedite assessments, and streamline transactions.

A concrete illustration of blockchain-based credit financing can be found in Komgo, a platform on a mission to digitize and optimize commodity trade processes, with a strong emphasis on raw material financing. Komgo seeks to harness blockchain to simplify agreement procedures and hasten raw material trade, ushering in more efficient commercial transactions for investors and other parties.

Komgo introduces a smart contract system using the letter of credit (L/C) format, complete with an automatic matching feature that expedites the issuance of letters of credit. This feature is a significant boon to credit financing, offering an integrated credit discounting solution bolstered by insurance. Blockchain technology affords real-time monitoring for all involved parties, facilitating data verification, reducing the risk of fraud, and shortening the cash cycle. This technological leap not only elevates efficiency but also fosters trust and security within the credit financing ecosystem, yielding benefits for all stakeholders in the process.

1.4. Literature GAP

The existing literature lacks an exploration of how blockchain technology can be integrated into both business operations and supply chain finance. Rather than treating these two areas as entities there is a need to understand their interconnectedness. Numerous studies have focused on the implementation of blockchain technology in specific domains, Ke, (2023); Liu et al., (2023); Ning & Yuan, (2023) talk about the construction of a BT financing platform, Ahmed et al., (2022; Mithas et al., (2022) analyze the implication of adopting blockchain in their supply chains. Even if Du et al. (2020) and Bai et al. (2022) talk about how blockchain impact supply chain finance (SCF), they don't explore deeply the overall impact of blockchain on the interconnection between business operations and finance.

Blockchain has the potential to profoundly redefine supply chain management and financial control, yet this vital connection is often overlooked in existing literature. We would investigate how blockchain adoption influences managerial decisions, both in terms of operational efficiency and financial choices, to understand how this technology revolutionizes business management.

Another often overlooked aspect is the potential impact of blockchain on the use of internal resources already present within companies. Many times, resources such as warehouses are viewed as costs. Rijanto (2021) introduce the impact of blockchain in inventory financing but the focus is about digital ownership certificates or "tokens" of assets financed by financial institutions without a deep analysis of how the warehouse became really a liquid resource for firms. Blockchain could represent a turning point in this context, allowing companies to use internal resources, such as warehouses, as collateral to secure financing, for example, through non-possessory revolving pledges. This concept opens new opportunities to improve access to credit and optimize the management of corporate resources.

Furthermore, in the literature, there is a significant gap concerning the application of non-possessory revolving pledges specifically to warehouses. This represents a potential research area that requires further investigation to fully understand the implications and opportunities of this innovative practice in supply chain finance. In the literature, improvements in supply chain management, specifically in warehouse management, have been discussed through the use of supporting technologies such as IoT and 5G in the application of Blockchain Technology. As written by Tan et al.,(2023), Rampur et al.(2023) and Han et al. (2023), the main features include transparency, increased security, reduced errors during transactions, traceability, decentralization, and many others. However, the literature address how these new technologies can just improve the current conditions of warehouse management, such as inventory information sharing among supplier and retailer as written by Omar et al. (2022), do not mentioning the possible generation of a new vision of what the warehouse itself is. Thus, it is no longer seen as a cost but as an opportunity to obtain greater liquidity. What has been said is especially suitable for companies producing goods that need to go through a maturation period in the warehouse and have a reduced or absent risk of obsolescence.

Another frequently neglected element is the analysis of the regulatory framework and its impact on the adoption and use of blockchain technology in the context of business operations and supply chain finance. Regulatory frameworks can significantly influence the dissemination and scalability of blockchain adoption, yet this aspect is often underestimated in academic debates.

Understanding how regulations can either facilitate or hinder blockchain implementation is a critical component in the context of technological innovation and its adoption in the business environment.

This table provides a comprehensive overview of the identified gaps in existing literature, summarizing key insights from relevant research papers and highlighting the critical areas where further investigation is needed to enhance our understanding of the integration of blockchain technology.

Title	Year	Authors	Gap
The construction of enterprise's financial supply chain management under blockchain technology	2023	Ke, W.	Lack of exploration on the interconnectedness between blockchain technology, business operations, and supply chain finance
How blockchain impacts the supply chain finance platform business model reconfiguration	2023	Ning e Yuan	Limited understanding of how blockchain impacts the synergy between operations and finance.
How will artificial intelligence and Industry 4.0 emerging technologies transform operations management?	2022	Mithas, S., Chen, Z.-L., Saldanha, T.J.V., De Oliveira Silveira, A.	Focus on specific domains (BT financing platform) without addressing the comprehensive impact on managerial decisions.
Why, where and how are organizations using blockchain in their supply chains? Motivations, application areas and contingency factors	2022	Ahmed, MacCarthy, e Treiblmaier	Analysis of blockchain implications in supply chains but lacks in-depth exploration of relevant sector characteristics for blockchain adoption.
Supply Chain Finance Innovation Using Blockchain	2020	M. Du, Q. Chen, J. Xiao, H. Yang and X. Ma	Lack of a holistic understanding of its influence on operational efficiency.
Supply chain finance: What are the challenges in the adoption of blockchain technology?	2022	Bai, Liu, e Yeo	Lack of a comprehensive analysis of its influence on financial choices.
Blockchain Technology Adoption in Supply Chain Finance	2021	Rijanto	Lack of analysis of how financial institution partners can contribute to the successful implementation of the blockchain in SCF.
Nexus among blockchain visibility, supply chain integration and supply chain performance in the digital transformation era	2023	Tan, C.L., Tei, Z., Yeo, S.F., Lai, K.-H., Kumar, A., Chung, L.	Discusses technological features but overlooks the potential transformation of internal resource perception.
Systematic review of adopting blockchain in supply chain management: bibliometric analysis and theme discussion	2023	Han, Y., Fang, X.	Lack of exploring the integration of blockchain with other emerging technologies

Figure 10. Gaps overview

Through our research, we aim to bridge these gaps in the existing literature and provide a more nuanced understanding of the impact of blockchain technology on business operations and supply chain finance.

For this purpose, we have formulated the following research questions that guide this study:

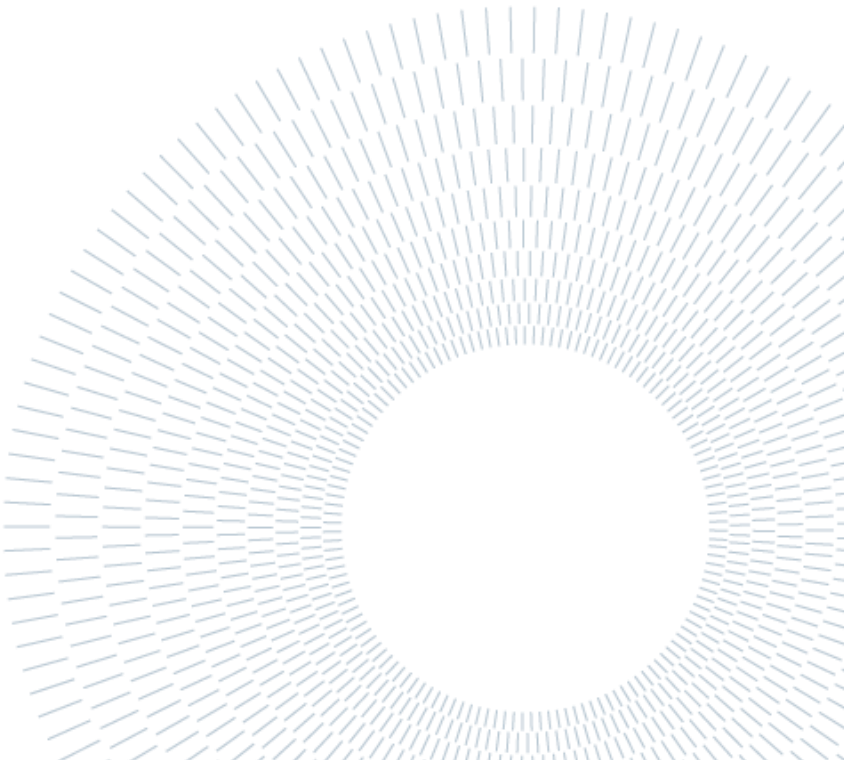
RQ1: "How does the integration of blockchain technology impact the interconnectedness of business operations and supply chain finance, and what are the implications for these areas?"

RQ2: "To what extent does the adoption of blockchain technology influence managerial decision-making, including operational efficiency and financial choices?"

RQ3: "What are the implications and opportunities of using blockchain technology for better exploiting internal illiquid resources, such as warehouses?

RQ4: "Can technologies such as IoT and 5G support blockchain technology in developing new perspectives and horizons for inventory management and inventory finance?"

RQ5: " What is the role of regulatory frameworks in facilitating or hindering the adoption of blockchain technology in operations and supply chain finance?"



2 Methodology

2.1. Approach

The purpose of this Master's thesis is to evaluate the influence of blockchain technology on inventory financing, management, and decision-making processes within the supply chain. This study seeks to explore the intricate interactions between Supply Chain and Finance practices, technologies, and associated challenges. The ultimate objective is to present a comprehensive examination of these elements and their interconnectedness. To ensure the validity of our analysis, we conducted a thorough literature review, extensively documented and discussed in Chapter 1. This review has uncovered significant research voids, leading to the formulation of five distinct research inquiries that will guide the direction of this Master's thesis. The proper methodology to be adopted to address the research question has been picked among qualitative research methods as the study attempts to describe and interpret some complex human phenomenon, in the words of informants. Indeed, as the knowledge in the domain is still limited, it is critical to collect data from those who are experiencing the phenomenon under investigation (Gioia et al., 2013) "within its real-life context" (Yin, 2013). Although existing research has explored the potential application of blockchain technology (Chang and Chen, 2020; Hofmann et al., 2017), there is a lack of evidence-based studies that investigate the challenges of adopting this novel technology (Babich and Hilary, 2019). Besides, Eisenhardt and Graebner (2007) indicated that, compared to multiple case studies, single-case research can investigate more in-depth evidence with a greater focus, which is appropriate considering the exploratory nature of this study. Therefore, an exploratory case study would be a reasonable choice for this research.

Figure 1. shows the main characteristics of the interviewed companies, which are named with a code (from letter A to D) to protect their identity for privacy issues.

	Contextual Factors		Interviewed
Case Study Code	Size	Role	Role
Company A	Large-sized Enterprise	Dairy	Administrative Director
Company B	Large-sized Bank	Financial Institution	Manger
Company C	Large-sized Bank	Financial Institution	Manager
Company D	Very Large-sized Enterprise	Technology Providers	Manager

Figure 11. Interviewed companies.

The lack of previous research in this area is addressed through the proposal of a formal definition for this relatively new topic and a research framework that is based on an adaptation of concepts from the literature, notably Lambert et al. (1998).

To address the research gap, we derived a conceptual framework shown in Figure2.

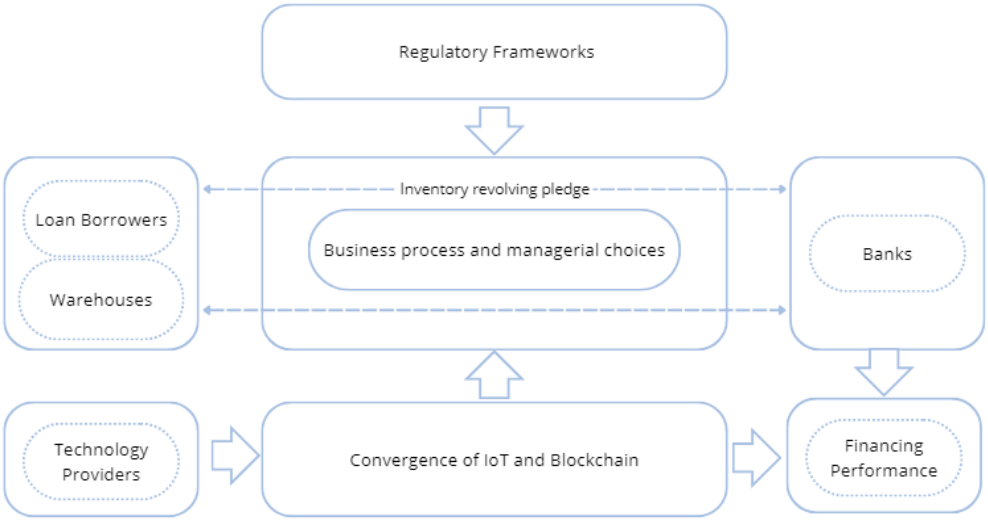


Figure 12. Conceptual Framework

The conceptual research framework is composed of the individual constructs and the relationships between the constructs are based on an adaptation and extension of the model proposed by (Blackman et al., 2013). There is a two-way influence where the operation activities place demands on the financial systems, and in turn the financial activities enable the functioning and operation of the supply chain. Changes in the operational chain, such as the increased globalization of operations, and the optimization of business processes, have significant impacts on the structure and management of the financial supply chain (Levitt, 1983; Dicken, 2007).

The theoretical framework expounded above serves as the backbone upon which the conceptual structure of this research is erected, acting as the masterful pillar to articulate a circumscribed context and unveil a gap necessitating bridging. Within this framework, three distinct analytical approaches emerge, meticulously chosen to probe the multifaceted dimensions of the thesis results.

The first of these, firmly rooted in Resource Dependence Theory, underscores that organizations draw from external entities, such as trading partners, to acquire resources vital to their ongoing existence. The need to secure these resources engenders interdependence among organizations (Chavez et al., 2015; p.158). This analytical tool will prove valuable in excavating the intricate connections between the involved actors and the diverse disciplines implicated in the research context. RDT suggests that companies often lack complete self-sufficiency in crucial strategic resources, resulting in dependencies on other firms. These dependencies create uncertainties linked to a diminished sense of control and power over the business environment (Hillman et al., 2009). The successful adoption of BT necessitates the active involvement of all stakeholders in the supply chain. However, some of these stakeholders may lack the necessary resources to embrace technological innovations (Saberi et al., 2019; Ghode et al., 2020). Leading companies, spearheading BT projects, can inspire other partners with limited resources to participate by offering both technical and financial support (Min, 2019). According to RDT, firms seek to manage

dependency and reduce uncertainties by forming inter-organizational arrangements and increasing the extent of coordination with their partners (Davis and Cobb, 2010; Drees and Heugens, 2013).

The second adopted method draws from Institutional Theory, proclaiming that organizations confronted with similar environmental conditions tend to adopt similar structures and modes of operation, compelling a unit in a population to resemble others facing the same set of environmental conditions (Moyano-Fuentes et al., 2012; p. 6). In this context, it translates into the development of specific capabilities, behaviors, or forms of innovation in particular sectors. In the context of this research, the application of this theory becomes relevant as it is oriented toward analyzing sectors with specific characteristics, in this case, those related to aging or seasoning. Its adoption is justified by the contingent conditions that have favored such specificity.

The third method of analysis, rooted in Dynamic Capabilities, emphasizes that organizations possess strategically identifiable processes that integrate, build, reconfigure, acquire, and release internal and external resources and competencies to address rapidly changing environments or ecosystems (Glover et al., 2015; p. 4069). This approach is particularly apt in exploring the internal dynamics of the organization, especially in contexts where the adoption of blockchain impacts existing paradigms.

Connection with Research questions

RQ1 delves into the effects of blockchain technology on the interconnectedness of business operations and supply chain finance. In the integrated framework, it can be related to various components. Given the multifaceted nature of RQ1, it highlights the

interconnectedness of these constructs within the integrated framework, emphasizing that technology adoption doesn't occur in isolation. Instead, it has a profound impact on multiple facets of the domain, including business processes, managerial choices, and financial performance.

RQ2 is directly linked to the framework's elements concerning managerial decision-making and technology adoption. The components related to "Business process and managerial choices" are pivotal in understanding how the adoption of blockchain technology influences decision-making processes. It can also relate to "Financing Performance" as financial choices may be influenced by the efficiency gains offered by blockchain.

RQ3 is closely tied to the framework's element of "Warehouses." It examines how blockchain technology can provide opportunities to optimize the utilization of internal resources, particularly warehouses, making them more efficient and potentially reducing illiquidity issues.

RQ4 explicitly connects the integration of IoT and 5G technologies, represented by the "Convergence of IoT and Blockchain" in the framework, with the use of blockchain for inventory management and finance. It explores the synergies between these technologies and how they might collectively open up new possibilities in inventory management and finance.

RQ5 focuses on the influence of regulatory frameworks, which directly corresponds to the "Regulatory Frameworks" component within the framework. It investigates how these regulations can either enable or inhibit the adoption of blockchain technology within operations and supply chain finance, shedding light on the role of legal and regulatory factors in shaping technology adoption.

2.2. Case Selection

One of the pivotal decisions in the course of conducting case study research lies in the judicious selection of the case. To best meet the exigencies of the research, it is advisable to opt for a singular case, which functions as a representative sample. Besides, Eisenhardt and Graebner (2007) indicated that, compared to multiple case studies, single-case research can investigate more in-depth evidence with a greater focus, which is appropriate considering the exploratory nature of this study.

In the context of a comprehensive case study, the imperative is to meticulously scrutinize every facet of the selected subject. The case that has been chosen for this research pertains to Company A, a dairy cooperative that undertook an operation in collaboration with two distinguished financial institutions, namely Company C and Company B, employing the revolving inventory pledge financing, fortified by the transformative capabilities of blockchain technology. This analysis endeavors to explore the perspectives of the two financial institutions, Company A, and the technology provider, Company D.

The choice of this case is germane to the overarching theme this research, as it aptly addresses all the research inquiries formulated. In particular:

RQ1: The case eloquently elucidates the transformative influence of blockchain technology on the interconnectivity of business operations and supply chain finance. By enabling real-time visibility, traceability, and verification of inventory data among multiple stakeholders, it augments operational efficiency and transparency.

RQ2: The case provides insights into how the adoption of blockchain technology influences managerial decision-making, by ameliorating operational efficiency and mitigating financial risks and costs for both lenders and borrowers.

RQ3: This case underscores the ramifications and potentialities inherent in leveraging blockchain technology to optimize the utilization of internal illiquid resources, such as warehouses. These resources are effectively transformed into collateral assets, readily accessible and monetizable through the instrument of smart contracts.

RQ4: The case meticulously explores the potential synergies between blockchain technology, IoT, and 5G, as they coalesce to usher in new vistas in inventory management and inventory finance. This fusion enhances data quality, fortifies security measures, and augments scalability.

RQ5: The case delves into the role of regulatory frameworks in the adoption of blockchain technology in operations and supply chain finance. It underscores the legal and compliance challenges and opportunities that surface in the wake of this innovative solution, shedding light on the facilitative or inhibitory roles of such regulatory frameworks.

The universal applicability of this case study is discernible, as it represents a microcosm of a broader phenomenon that transcends different contexts and industries. The model of revolving inventory pledge financing, fortified by blockchain technology, transcends the confines of the dairy sector and can be readily applied to any sector entailing inventory management and financing. Consequently, the insights and findings gleaned from this case study possess the inherent potential to be extrapolated and applied to analogous scenarios.

The salience of this case study is underscored by its alignment with contemporary trends and challenges in the domain of operations and supply chain finance. The COVID-19 pandemic has laid bare the vulnerabilities and inefficiencies of conventional supply chain finance models, hinging on manual processes, paper-based documentation, and intermediaries. In this tumultuous landscape, blockchain technology emerges as a beacon of hope, promising resilience, transparency, and

enhanced collaboration among the stakeholders in the supply chain. Additionally, blockchain technology augments the repertoire of financing instruments, thereby unlocking latent liquidity and value from underutilized assets, including inventory. Consequently, this case study stands as a pertinent and timely example of how blockchain technology can revolutionize operations and supply chain finance.

2.3. Data Collection

In order to conduct a comprehensive data collection process for this thesis, a meticulous and multi-faceted approach was employed to ensure the acquisition of high-quality data while mitigating potential biases. The study relied on a combination of primary and secondary data sources, each serving a distinct purpose in the research.

Primary Data Collection

The primary data collection phase centered on structured interviews, which were conducted between September 2023 and October 2023. These interviews were semi-structured, allowing for flexibility while maintaining a standardized framework. Four key actors central to the case under examination were individually interviewed, ensuring a well-rounded perspective on the subject matter. In the interest of data validation, some interviews were repeated, enhancing the reliability and credibility of the findings.

The interview process was a vital element of this study, offering a direct and firsthand perspective on the integration of Blockchain Technology (BCT) with Supply Chain and Finance. The primary data gathered through these interviews provided invaluable insights into various aspects, including the Company's operations, the characteristics of the blockchain solution they employed, and the implications of this integration. By engaging with the actors involved, this approach ensured the collection of authentic, irrefutable, and influential information.

Secondary Data Collection

Complementing the primary data, a comprehensive collection of secondary data was undertaken. These secondary data sources included whitepapers, reports, websites, and blogs. This information was instrumental in providing context and background for the study.

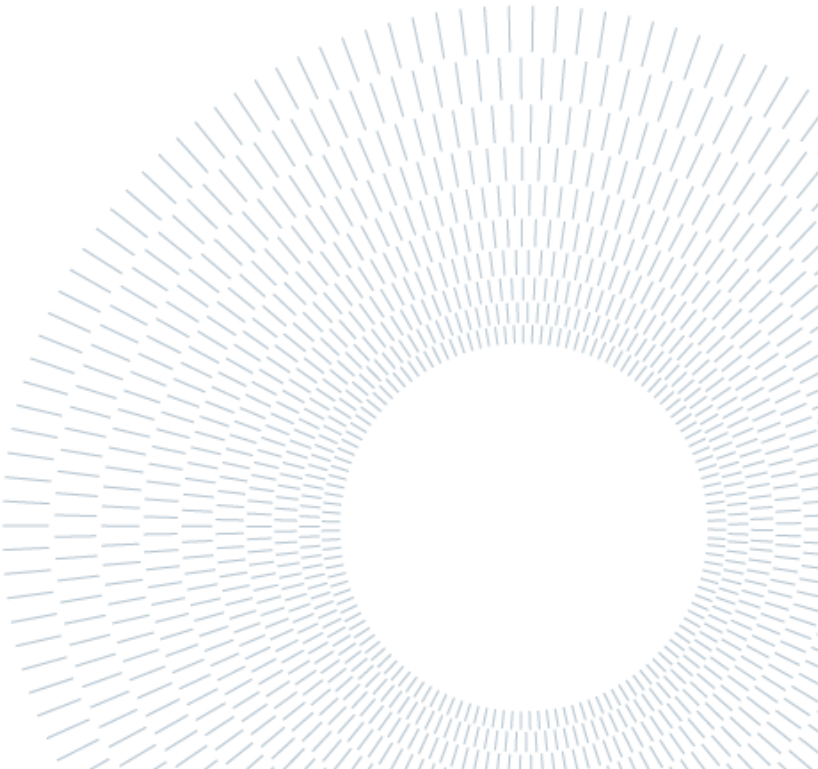
However, it is essential to acknowledge that secondary data, while informative, has certain limitations. As these data were available online, they may exhibit a lack of accuracy, and, in some cases, critical features may not have been fully elaborated upon. Nevertheless, the secondary data served as a valuable point of reference for understanding the broader landscape of BCT.

Data Collection Strategy

Given that this dissertation project was fundamentally qualitative in nature, the decision was taken to prioritize the collection of primary data. This approach allowed for a deeper exploration of the subject matter and a more nuanced understanding of how companies integrate the unique advantages of BCT with SCF. The primary data collection process was executed through various means, such as conducting interviews, taking structured notes, recording interviews.

An interview prototype was meticulously crafted to guide the data gathering process. This interview framework was thoughtfully designed to extract essential information, encompassing details about the Company, the specific characteristics of their chosen blockchain solution, and the implications of this integration on their Supply Chain Finance operations. These inquiries were strategically crafted to unearth valuable insights and provide a solid foundation for the emerging theoretical findings.

In conclusion, this multifaceted approach to data collection, incorporating both primary and secondary sources, ensures that this research project is grounded in a robust and comprehensive dataset. The primary data, in particular, provides a firsthand and authoritative account of how companies leverage Blockchain Technology to enhance their Supply Chain Finance processes, contributing significantly to the theoretical framework and overall depth of the study.



3 Case Study

Company A, the world's leading producer of Grana Padano cheese, achieved a significant milestone on December 20, 2021, by securing its first financing guaranteed through the Inventory Chain platform (ICP), which utilizes Blockchain technology. This marks the beginning of a process aimed at extending the use of this technology throughout the entire Grana Padano supply chain.

A distinctive feature of the ICP, in addition to its use in the Grana Padano supply chain, is its readiness to also handle collateral for Parmigiano Reggiano, following the same rotating technique used for Grana Padano (non-possessory collateral).

The flexibility of the ICP has made it possible to approve new transactions that can be easily executed on the new supply chain, thanks to the development of a specific algorithm for calculating the value of the pledged forms, taking into account the specific characteristics of Parmigiano Reggiano, which is produced in the first ten days of June.

Company C Group, one of Italy's leading banking institutions and among the most solid in Europe, recently successfully concluded a €20 million financing deal for Company A. This financing is based on a non-possessory rotating collateral and is, for the first time in Europe, supported by shared digital ledger technology, known as Blockchain. This operation was carried out in collaboration with Company D and will enable the producer to support their investments while simultaneously reducing operational costs, ensuring the security of the assets used as collateral for the bank. This security is ensured through constant real-time monitoring of the value of the collateral, linked to the Milan Chamber of Commerce's value.

In this transaction, the bank will provide Company A with a line of credit, receiving Grana Padano forms as collateral. The producer will retain these forms in their warehouse (non-possessory collateral) and can replace them over time with other forms of equal value (rotating collateral). What makes this operation innovative is the ability to continuously monitor the pledged goods through a system of shared digital databases between the producer and the bank, leveraging Blockchain technology.

Company C strengthens its historical commitment to supporting businesses in their development and growth journey, ensuring their financial well-being and innovation in the range of products and services offered. This financing is part of a broader project to support the country's businesses, which Company C consistently pursues and has been further enhanced during this pandemic crisis period.

Furthermore, also Company B Banca has issued a €15 million line of credit for Company A, based on the same non-possessory rotating collateral model and supported by shared digital ledger technology (Blockchain). This innovative operation, carried out in collaboration with Company D, represents one of the first of its kind in Europe for Company B. It will enable the producer to support their investments, reduce operational costs, and ensure the security of the pledged assets through the use of shared digital databases, allowing real-time control of the collateral's value.

Both of these financing operations represent a leap forward in financial innovation and digitalization, offering new tools to support companies like Company A, which require liquidity for their production cycle and investments, especially when dealing with long-aged products stored before sale. These initiatives demonstrate how digitalization and new technologies, such as Blockchain, are essential tools for promoting development and improving the competitiveness of businesses.

3.1. Company A

Company A, located in the picturesque region of the Po Valley, is a wonderful example of a successful cooperative in the Italian dairy industry. Founded in the distant year of 1900, the history of this company is a perfect blend of tradition and innovation. Over the decades, it has been able to adapt to the changing market demands and challenges of the dairy industry, maintaining a solid reputation for the quality and reliability of its products.

The company boasts over 200 farmer members who collaborate closely by providing high-quality fresh milk. The freshness and purity of the milk are fundamental for Company A, and suppliers must adhere to strict quality and animal welfare standards. The milk is collected daily from the farmers' barns, ensuring the freshness and purity of the primary ingredient for the company's products.

The extensive range of dairy products offered by Company A includes cheeses, butter, milk, cream, and yogurt. This variety of products is essential to meet the needs of consumers and maintain a strong presence in both the domestic and international markets. The company is committed to following efficient, safe, and sustainable production processes to create high-quality products that meet the tastes and expectations of customers.

Among the most representative and beloved products of Company A is the Grana Padano PDO, a refined cheese of extraordinary quality, with a perfect granular texture and a unique straw-yellow color. This cheese has a fragrant aroma and a delicate yet full-bodied flavor. The Grana Padano PDO is a controlled and certified product in every aspect, available in various formats, from whole wheels to pre-packaged slices, with various aging options. Company A is even the world's leading producer of this cheese, ensuring quality for all customers who choose it.

The strategy of Company A for Grana Padano is based on product differentiation and enhancement, aiming to satisfy the needs of discerning and quality-conscious customers. The company constantly invests in research and development to improve product quality and innovate production processes. Furthermore, the company handles product promotion and communication through advertising campaigns, events, sponsorships, and public relations activities. Grana Padano from Company A is distributed both in the domestic and international markets, where it has captured a significant market share thanks to its ability to adapt to diverse consumer cultures and preferences.

The supply chain for Grana Padano from Company A follows the same stages as the general supply chain of the company: milk collection, milk processing, product distribution, and product sales. However, there are specific details related to Grana Padano that require special attention and care. The milk for Grana Padano is collected only from farms located in specific provinces, the protected origin areas of the cheese. The milk is then transported to the Company A production facility, where it is processed according to the traditional recipe that includes natural rennet, sea salt, and natural lactic ferments. The transformation of milk into Grana Padano involves several stages, including breaking the curd, cooking, pressing, salting, and aging. The aging phase is crucial to give the cheese its organoleptic characteristics and is available in various aging periods, from a minimum of 9 months to over 24 months. Grana Padano undergoes periodic inspections by the Grana Padano Protection Consortium, which verifies compliance with production standards and certifies the product's quality with the PDO label. Grana Padano is packaged in various forms and formats, including whole wheels, slices, portions, and grated, to ensure preservation, hygiene, and to enhance its image and identity. Grana Padano is then distributed through retail, traditional stores, and e-commerce channels, both in Italy and abroad. The sale of Grana Padano is based on the needs and preferences of consumers, who can choose

from various aging periods and formats. Grana Padano is a versatile product suitable for various occasions, from direct consumption to cooking.

The warehouse of Company A is a key element in the supply chain, as it allows the management of product inflows and outflows, ensuring their storage and traceability. The warehouse is equipped with automated and computerized systems to optimize space, time, and storage costs. It is divided into different areas based on product type and temperature requirements, including room temperature areas, refrigerated areas, and frozen areas. It is connected to the production facilities through conveyor belts or forklifts, simplifying the transfer of finished products between the packaging department and the shipping department. The warehouse is also connected to distribution vehicles through loading and unloading ramps, allowing for quick and secure loading and unloading of products. Finally, the warehouse is equipped with an integrated computer system with that of the production facilities and retail points, enabling real-time monitoring of the quantity, quality, and location of products in the warehouse.

3.1.1. Interview with Administrative Director

Introduction, Regulatory Aspects, and Implementation of Blockchain Technology

The interview with the Administrative Director of Company A has shed light on a strategic corporate decision: the adoption of blockchain technology in the production of the prestigious Grana Padano cheese. This choice is motivated by two fundamental perspectives: regulatory considerations and financial implications of this innovation.

On one hand, it's essential to note that the decision to embrace blockchain was driven by the desire to comply with new regulations. In particular, the opening to non-possessory revolving pledges by the authorities represented a crucial step towards accessing more flexible financing. This regulatory move eliminated the need to physically pledge the prized Grana Padano, allowing easier access to credit. However,

it brought challenges related to physical records and the lack of direct control over the goods by lending institutions. In this context, blockchain technology emerged as a key solution to overcome this dilemma.

Blockchain, a digital platform that securely and transparently records every movement of cheese forms within the warehouse, enabled constant monitoring of collateral values for financing. This significantly bolstered the confidence of financial institutions, as they could observe the real-time trend of collateral values and make lending decisions with unprecedented precision. This created an environment of increased security and transparency for all parties involved in financial transactions, greatly simplifying the non-possessory pledge process. Moreover, blockchain made the process more adaptable and responsive to evolving regulatory requirements.

Another benefit arising from the implementation of blockchain relates to the company's consolidation and enhanced regulatory compliance. Blockchain technology, with its immutable and verifiable ledger, facilitated compliance with regulations concerning non-possessory revolving pledges, providing regulatory authorities with access to accurate and easily verifiable data. This had a positive impact on the company's reputation with financial institutions and regulatory authorities, contributing to the consolidation of its image as a reliable and transparent entity.

Blockchain-Based System and Its Benefits

The integration of blockchain technology into the existing corporate system has brought significant advantages to Company A. Blockchain was not merely a technological upgrade but played a pivotal role in transforming and optimizing business operations. This innovation was adeptly tailored to interact synergistically with existing operational systems. Its ability to record and share data made it possible to automate aging warehouse management and achieve more efficient and precise cheese management securely and transparently.

The synergy between blockchain technology and business operations established a direct link between the Company's daily activities and the finance department. This greatly simplified access to financing, making it more adaptable to the evolving demands of the market. Before blockchain adoption, rigorous physical monitoring and surveillance of cheese forms were necessary to ensure their integrity as collateral for loans. This required considerable human efforts, along with paperwork. However, thanks to blockchain, this process could be digitized, making cheese forms a more adaptable and cost-effective source of financing.

Blockchain allowed for smoother financial management, as the value of collateral could be monitored in real-time. This created a new level of trust between the Company and financial institutions. Lending decisions could be made based on up-to-date and accurate data, significantly reducing risks, and simplifying the non-possessory pledge process. This improved the company's financial stability and helped ensure that cash flows were optimized, allowing for more strategic resource allocation, and adaptability in addressing changing market conditions.

Impact on Business and Warehouse Management

The adoption of blockchain has revolutionized business and warehouse management in significant ways. The technology has enabled real-time tracking of goods in the warehouse. Every movement and change in the status of cheese forms is securely and immutably recorded, providing a complete and accurate view of every aspect of the production and storage process.

This has significantly simplified warehouse management, eliminating the need for costly and complex physical monitoring systems. Furthermore, it has reduced the risks of human errors or fraud, as the data recorded in the blockchain is immutable and easily verifiable. This has contributed to more efficient cost management, as the

expenses associated with physically monitoring cheese have been significantly reduced.

The company is now carefully considering the possibility of expanding the use of blockchain to multiple warehouses, making the system even more adaptable to growing demands. This could lead to further improvement in overall business operations' efficiency, with increased transparency, accuracy, and security in all warehouses. Blockchain has proven to be a powerful tool for linking access to financing to the company's physical resources, significantly enhancing its financial flexibility and opening new opportunities for growth and development. The adoption of blockchain has had a profound and positive impact on business management, making Company A a more competitive and resilient entity in the agri-food sector, and more adaptable to the changing landscape of finance and regulation.

3.2. Company C

Company C is a prominent Italian banking institution with a history tracing back to 1910. This establishment has grown to become a cornerstone in the Italian banking landscape, offering a range of banking, financial, and insurance services to individuals, families, as well as businesses and professionals. The Company C group's extensive presence is marked by a network of nearly 600 branches spread across the entire Italian geography, all made possible by the dedication of over 6,000 employees who work tirelessly to provide high-quality service to customers.

Company C's corporate approach sets itself apart through its strategy of product and market diversification, maintaining an unwavering focus on service quality and customer satisfaction. The group's primary objective is to create value for shareholders, employees, and the broader community, guided by a stringent risk

management approach, strong capitalization, and continuous innovation. The company's vision is to be a beacon for customers seeking personalized, simple, and transparent financial and life solutions. On the other hand, Company C's mission is to deliver high-quality banking, financial, and insurance products and services with a competent, professional, and community-rooted approach.

Among the innovative financial solutions offered by Company C, inventory financing stands out. They employ an approach that facilitates businesses in securing a line of credit backed by the goods they produce or purchase. This strategy enables businesses to have readily available liquidity to support their production and commercial cycles, avoiding the need to sell inventory at reduced prices or resort to alternative guarantees.

The true innovation introduced by Company C in this regard is the use of blockchain technology for continuous oversight of the goods used as collateral. The system relies on shared digital records between the producer and the bank, ensuring greater transparency, security, and efficiency in the realm of financing. This new system is capable of reducing operational costs and disbursement times and is designed to be flexible, allowing multiple businesses, banks, and supply chain actors to access it, thereby expanding credit access opportunities for businesses.

The first blockchain-based inventory financing operation in Europe took shape at the beginning of 2022 in collaboration with Company A. In this initiative, the bank provided the dairy with a 20-million-euro line of credit, guaranteed by the PDO (Protected Designation of Origin) Grana Padano cheese stored in the producer's warehouses and monitored through the blockchain system.

For this pioneering project, Company C received the prestigious ABI Award for Banking Services Innovation 2022 in the "Digital Transformation" category. This annual award, promoted by the Italian Banking Association, aims to promote and valorize innovation culture in the banking, insurance, and financial sectors. The jury

expressed admiration for Company C ‘s ability to create a platform that allows for complete digitization of non-possessory collateral management for goods, ensuring rigorous asset monitoring through the use of blockchain technology.

The Company C Group has proven to be a stable and dynamic banking institution, capable of achieving excellent economic and financial results, while also offering innovative and competitive solutions to its customers. Some significant data reflecting the group's performance in 2022 include:

- The Company C Group closed 2022 with a net profit of 312 million euros, an increase of 9.7% compared to 2021, and a net worth of 3,038 million euros, a 6.6% increase. The group recorded a return on equity (ROE) of 10.5%, one of the highest in the Italian banking sector.

- The Company C Group holds a 2.8% market share in the Italian banking sector, with a direct collection of 36,708 million euros and an indirect collection of 28,614 million euros. The group has a 3.5% market share in the Italian insurance sector, with a total premium of 1,461 million euros.

- The Company C Group has a strong commitment to supporting Italian businesses, with a credit portfolio of 28,144 million euros, 76% of which is dedicated to businesses. In 2022, the group disbursed over 8 billion euros in new business loans, with an annual growth rate of 9%. The group also has a low incidence of non-performing loans, accounting for 3.4% of the total.

- The Company C Group has a solid reputation in the international financial market, with a long-term rating of A from Standard & Poor's and A2 from

Moody's. The group also boasts good liquidity, with a Liquidity Coverage Ratio (LCR) of 230% and a Net Stable Funding Ratio (NSFR) of 121%. The group also has robust capitalization, with a Common Equity Tier 1 (CET1) ratio of 14.4% and a Total Capital Ratio of 18.3%.

3.2.1. Interview with Company C Manager

Introduction and Regulatory Aspects

The interviewee works at Company C, an Italian bank renowned for its extensive experience with revolving collateral, particularly in the agri-food sector. Company C is known for managing one of Italy's largest cheese warehouses, containing a staggering 500,000 wheels of Parmigiano Reggiano cheese. This famous Italian cheese is renowned worldwide for its quality and significant economic value. As a result, Company C offers its clients the opportunity to secure their loans by pledging the cheese wheels stored in its warehouses.

Before the introduction of non-possessory revolving collateral, Company C operated with the traditional collateral method, which required the physical delivery of the collateral. This approach imposed constraints on both the bank and its clients. The bank had to manage dedicated warehouses and adhere to strict regulations concerning the Protected Designation of Origin (PDO) of Parmigiano Reggiano. This designation dictated that the cheese had to be produced in specific geographical areas within the Emilia-Romagna region and the province of Mantova. For clients, this meant parting with the custody of their assets and relinquishing the ability to use them in their production processes.

The introduction of non-possessory revolving collateral has radically transformed the situation, bringing advantages to both the bank and its clients. For Company C, this

innovation has allowed the expansion of its range of guaranteed agri-food products, including, for instance, Grana Padano, a cheese similar to Parmigiano Reggiano but with a broader designation encompassing various Northern Italian regions. Moreover, it enabled the management of non-possessory revolving collateral without the need to construct new warehouses, instead making use of their clients' existing facilities. For clients, this has enabled them to retain custody of their assets and use them within their production processes, increasing efficiency and profitability.

Non-possessory revolving collateral emerges as an innovative solution particularly suited for businesses operating in the agri-food sector, especially dairies that require substantial investments in milk processing. Thanks to this option, dairies can use the stored asset as collateral to obtain advantageous financing from Company C, a bank specialized in the sector.

Blockchain-Based Platform

The interview proceeds to examine Company C's use of blockchain technology to manage non-possessory revolving collateral. Blockchain technology allows for the creation and sharing of a digital transaction ledger, which is maintained and updated by a network of distributed and independent nodes. This ledger is composed of a chain of blocks, each containing a set of transactions and a cryptographic reference to the previous block. The blockchain ensures the immutability, transparency, and traceability of recorded transactions, eliminating the need for intermediaries or central authorities.

According to the interviewee, this choice has brought significant advantages compared to the traditional approach used by other banks. Non-possessory revolving collateral operations often relied on manual records, requiring signatures from both parties and storage at the dairy or bank. This method proved to be inefficient, costly, and susceptible to errors or fraud. In contrast, the blockchain allows for the creation of

a digitized and immutable record, eliminating the need for periodic manual signatures from dairies and streamlining the verification process for all involved parties.

A crucial additional benefit is the direct integration of the blockchain platform with the dairy warehouses' management system. This ensures that information is consistently updated in real-time. Real-time communication between the blockchain platform and the warehouse management system facilitates the efficient compilation of commitment inventories and their digital signing, without causing inconvenience to customers or counterparties.

It's interesting to note that there are other applications of blockchain in the agri-food sector. For example, the TE-FOOD platform uses blockchain to trace the origin and quality of food products throughout the value chain. This platform enables consumers to verify the origin, composition, and conditions of the products they purchase, enhancing trust and food safety. Although the blockchain platform used by Company C serves a different purpose, it shares the same principles of data transparency and traceability.

The adoption of blockchain has significantly improved the efficiency and security of the non-possessory revolving collateral process, ensuring accurate recording of transactions and greatly simplifying collateral management.

Impact on Business Model

Blockchain has allowed Company C to offer an innovative and competitive service in the non-possessory revolving collateral sector, achieving remarkable results beyond initial expectations.

The interviewee reports that the company had originally planned a five-year business plan, but in just over a year and a half, they nearly doubled their objectives. This extraordinary success prompted them to expand into other product lines, beyond

Grana Padano, including Parmigiano Reggiano, Trentingrana, and Pecorino Romano, all products with DOC and IGT certification. These certifications attest to the origin and quality of Italian agri-food products, enjoying recognition at the European level. The company has expanded its offering to high-value products that require traceability and security assurance.

The interviewee highlights how the use of blockchain has made their business model more efficient and opened up new financing opportunities. Furthermore, blockchain technology could find similar applications in other sectors, such as wine and ham, and could play a significant role in inventory financing. Inventory financing is a form of financing based on using movable assets as collateral to obtain loans or lines of credit, particularly beneficial for businesses that need to purchase products for later sale without having the necessary capital. This form of financing can also assist businesses in cash flow management and offer flexibility, especially for seasonal activities.

In conclusion, the adoption of blockchain has transformed Company C's business model, leading to exceptional results and driving the Company to explore new business opportunities in Italian agri-food sectors and potentially in other areas of the agri-food industry.

3.3. Company B

Company B is a prominent Italian banking group that offers a wide range of traditional banking services to a diverse clientele, including individuals, businesses, professionals, and public entities. With over 1,300 branches both in Italy and abroad, the group has established a strong presence in the financial sector. Managing assets of approximately 150 billion euros, they demonstrate a robust and stable financial position in the market. Company B's philosophy revolves around being a "customer-

centric" bank, committed to providing personalized and innovative solutions while strictly adhering to principles of sustainability, transparency, and social responsibility. Their mission is to create value for shareholders, customers, employees, and the communities in which they operate, through efficient management, balanced growth, and a strong local presence.

One noteworthy aspect of Company B 's activities is the implementation of inventory financing. This form of short-term financing or revolving credit line is designed for businesses that need funding for the purchase of products that will be sold later. These products themselves serve as collateral for the loan, which is granted based on the value of the company’s inventory or warehouse. Inventory financing enables businesses to manage liquidity more efficiently, cope with seasonal demand fluctuations, and increase sales volumes. Company B offers various options for inventory financing, including unsecured loans, mortgage loans, and factoring.

Another area where Company B has distinguished itself is through innovative use of blockchain technology. Blockchain is a data structure that allows the creation of secure, ever-growing lists of records known as blocks, linked together through encryption. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data. Blockchain is a distributed, shared ledger synchronized among multiple participants in different locations, eliminating the need for centralized authorities or intermediaries. It offers an immutable record and complete transaction traceability.

Company B has initiated significant blockchain-based projects, including a platform based on the Ethereum blockchain. This platform enables Company B customers to make instant, secure, and low-cost payments to each other or to other parties participating in the network. Company B Chain uses a digital currency called Company B Coin, which is pegged to the value of the euro and can be converted into euros at any time. Furthermore, Company B Chain supports the creation and

management of smart contracts, which are self-executing agreements based on predefined rules and verifiable by the network.

Company B is also involved in the Spunta project, promoted by the Italian Banking Association (ABI) and involving over 100 Italian banks, including Company B. This project utilizes the Corda blockchain to enhance the efficiency and transparency of interbank reconciliation for accounting operations. Spunta allows banks to exchange information in real time, resolve any discrepancies, and record transactions in an immutable and shared manner. This has significantly reduced the time and costs associated with the reconciliation process, moving from days to just a few minutes.

Company B's commitment to innovative financial solutions extends to its partnership with Company A, mirroring a successful approach taken previously with Company C. In a move that highlights Company B's dedication to supporting the growth of local businesses, they have collaborated with Company A. Company B, in collaboration with Company D, has carried out one of the first financing operations in Europe based on blockchain technology, providing a credit line of 15 million euros to Company A, the world's first producer of Grana Padano. This transaction is part of inventory financing, a form of short-term financing or revolving credit line for companies that must buy products to sell at a later date. These products act as collateral for the loan, which is granted based on the value of the inventory or warehouse of the enterprise.

3.3.1. Interview with Company B Manager

Introduction and Regulatory Aspects

In this interview, a manager from Company B shares an experience similar to that of Company C in the field of non-possessory revolving collateral. Specifically, the interviewee discusses Company A, the first Company in Italy that needed significant financial support for its core business, which is the production and commercialization of Grana Padano cheese. Company A faces the challenge of financing a robust warehouse necessary for aging the cheese for periods ranging from 9 to 18 months.

To address this challenge, Company B followed the example of Company C. Company A had already implemented automation and digitalization in warehouse management. Using a platform, they had constant access to information about the warehouse's status and could record incoming and outgoing goods in real time through this platform. This technological approach significantly simplified the non-possessory revolving collateral process for Company B.

The interviewee emphasized that if this type of tool were regulated at the European level, banks could require less capital, thereby reducing costs. This regulatory perspective is of vital importance because the widespread adoption of this blockchain-based solution could open new opportunities for businesses and financial institutions across Europe.

Blockchain-Based Platform

With the introduction of blockchain, all processes have become more efficient. The interviewee has access to the same platform used by Company A to monitor the value of collateral in real time. Furthermore, Company A can autonomously manage its assets, a significant change from the previous process. The blockchain provides the

interviewee with an alert system that notifies them when the collateral value falls below a certain threshold, and Company A does not renew the collateral.

The interviewee noted that integration with the blockchain was smooth. Additionally, the data recorded on the blockchain platform is reliable, allowing Company B to offer larger loans at lower costs. The blockchain has greatly simplified the process, providing greater security for both the bank and the client.

The adoption of blockchain has had a positive impact on high-capital businesses, such as Company A, which require substantial financing to support their operations. Access to credit has been facilitated by the increased security and efficiency offered by blockchain. Furthermore, the blockchain contributes to greater transparency in financial operations, enhancing trust between the parties involved.

Impact on the Business Model

The interviewee highlighted that companies requiring substantial investments, like Company A, often struggle to obtain sufficient financing to cover the costs associated with the warehouse, which represents a significant portion of the company's value. The blockchain has simplified the non-possessory revolving collateral process, allowing banks to provide more substantial loans at more favorable rates.

The collateral provided by the blockchain is reliable and verifiable, enabling banks to grant larger loans, thereby improving access to credit for these high-capital businesses. Moreover, the process is significantly more efficient than traditional methods, reducing operational costs and the risk of incorrect evaluations.

Blockchain technology offers significant advantages to companies with long-aging goods in their warehouses and is suitable for further applications in sectors such as long-maturing wine production. Additionally, the ability to access real-time data and

autonomously control collateral represents a significant step toward greater ease of credit access for similar businesses. This new blockchain-based business model is proving highly advantageous for all parties involved, from the bank to the client company, contributing to increased efficiency and competitiveness in the financial sector.

3.4. Company D

Company D, a prominent player in the European digital transformation landscape, stands out for its extensive range of services, including high-level consultancy, cutting-edge digital solutions, and custom software development. The guiding vision of this company is to create a better world for all by fully harnessing the myriad opportunities presented by future technologies. Its primary mission is to assist its clients in achieving their business objectives by providing innovative and sustainable solutions.

Among its areas of expertise, Company D excels in the application of blockchain technology solutions, which are revolutionizing supply chain management. Blockchain is a decentralized and immutable digital ledger that securely and transparently records transaction information. This innovative tool significantly enhances visibility, traceability, and operational efficiency throughout the entire supply chain, reducing the risk of errors, fraud, and disputes.

A concrete example of the use of blockchain technology in supply chains is the project carried out by Company D in collaboration with Company A, one of Italy's leading dairy cooperatives. This project resulted in the creation of a platform based on Blockchain Transparent Supply, which enables tracking the entire journey of milk, from milking in the barn to the consumer's refrigerator. This process ensures the quality and origin of the product. Thanks to a QR code printed on the packaging, consumers can easily access vital information about the milk's supply chain, including the date and location of milking, transportation, processing, and packaging. This approach significantly boosts consumer confidence and enhances the Latteria Soresina brand.

Another important aspect is Company D’s contribution to the financing operation of Company A’s warehouse. This innovative operation, based on a non-possessory revolving pledge system supported by blockchain technology, represents a significant step forward, as it is the first of its kind for Company B and one of the first in Europe. Company D’s involvement was crucial, allowing the producer to support their investments while simultaneously reducing operational costs. This operation ensured Company B's security of the pledged asset through a real-time merchandise control system that updates the collateral's value.

To achieve this goal, Company D provided its expertise and a solution based on Blockchain Transparent Supply, enabling continuous monitoring of the pledged goods through a shared digital database system between the producer and the bank. This same solution was previously used to trace the milk's journey from the barn to the consumer's refrigerator, guaranteeing the quality and origin of the product. All of this serves as a clear example of how Company D can offer innovative and customized solutions that perfectly align with the needs of its clients, fully leveraging the potential of blockchain technology.

3.4.1. Interview

The interviewee provided a detailed analysis of the impact of blockchain technology on the interconnection between finance and business operations, with a particular emphasis on the implementation of non-possessory revolving pledge in the context of financial operations involving Company A. The blockchain platform provided by Company D played a key role in the success of this operation, enabling the establishment of a secure and immutable digital ledger for monitoring information related to the value of Company A's products stored in warehouses. This is of particular importance given the application of non-possessory revolving pledge, which requires rigorous data and financial guarantee control.

The interviewee clarified the concept of "non-possessory revolving pledge" and explained its functioning, emphasizing the importance of maintaining the value of assets above a specific threshold to avoid notifications to companies. These notifications alert companies when the value of goods in storage is not met. Blockchain has emerged as a fundamental tool for certifying the warehouse date and managing the ledgers, greatly simplifying the evaluation process by involved financial institutions, such as Company C and Company B. This has minimized the risk of fraud or data discrepancies and made the financing process more efficient and transparent.

Despite the crucial role of blockchain in the non-possessory revolving pledge in Company A's financial operation, the interviewee identified a persistent challenge: the need for periodic verification of goods in warehouses by a notary. However, this situation has significantly improved compared to the past when, without blockchain, the non-possessory revolving pledge supporting the financial operation would have been a challenging task due to the lack of control by the financier, requiring a constant presence of a notary. This step, traditionally crucial for ensuring the integrity of financial operations, could be further enhanced through the implementation of the

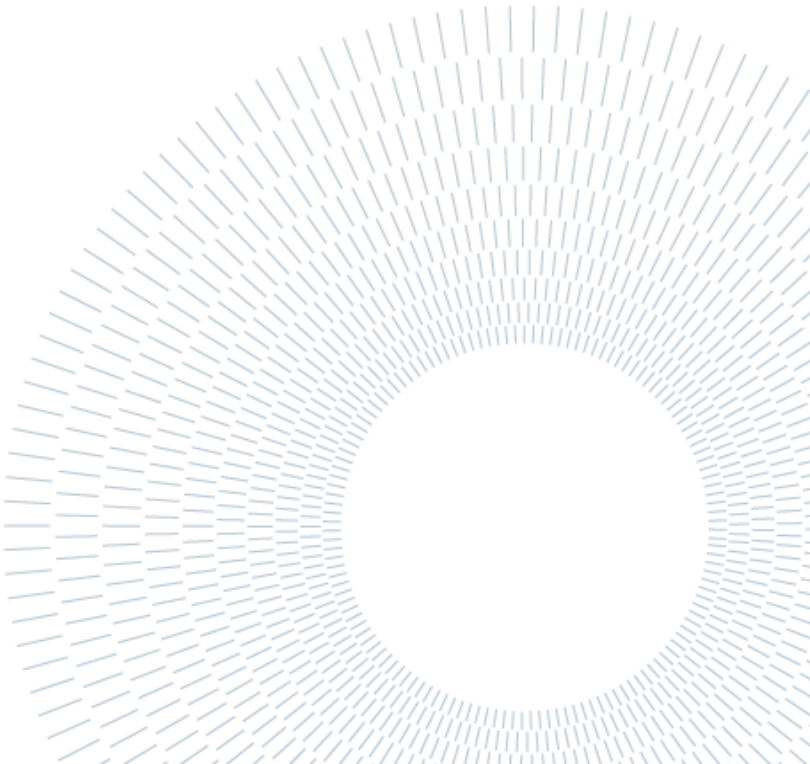
Internet of Things (IoT) and 5G technology in the specific blockchain platform used in this case study.

The interviewee highlighted that, although blockchain ensures accurate and immutable recording of data related to goods in storage, physical verification of goods remains a necessary legal practice. However, this practice requires significant resources and introduces potential delays in operational and financial processes. The adoption of IoT and 5G technology offers a promising solution to address this challenge. The use of weight sensors, environmental monitoring devices, and other advanced IoT tools would enable real-time monitoring and precise control of goods in warehouses. Data collected by these sensors could be immediately integrated into the blockchain platform, ensuring the continuity of traceability and certification of goods.

Furthermore, the interviewee shared a futuristic vision in which IoT and 5G could be used to expedite blockchain regulation and reduce the need for intermediaries. They suggested the use of weight sensors and other devices to monitor and certify the content of financial warehouses, enabling blockchain operations without the need for intermediaries. The speed and reliable connectivity offered by 5G technology would further enhance this solution, with sensor data transmitted in real-time to the blockchain, eliminating the need for periodic manual checks by a notary. This would significantly improve the efficiency and transparency of the process, minimizing delays and associated costs.

The interconnection between finance and business operations has been greatly enhanced by this technology, making the non-possessory revolving pledge more reliable and easily manageable, reducing the need for human intervention or intermediaries in verifying goods in storage. This transformation has helped reduce bureaucratic timelines and associated costs, improving the company's operational performance.

In addition to optimizing relationships with the involved financial institutions, the implementation of this technology has led to significant cost savings in operational and transportation costs. Company A has been able to minimize the transportation of goods, reducing costs and overall environmental impact. This has significantly contributed to the overall efficiency of business operations.



4 Findings

4.1. Interconnected Relations

The adoption of blockchain technology in the agri-food sector has brought about a profound transformation in the way finance and supply chain interact and collaborate. It has changed traditional methods of securing loans, particularly in cases like Company C and Company B, where non-possessory revolving collateral has emerged as an innovative solution.

"The act of moving the product elsewhere solely because I have to place it under possessory pledge is a disturbing factor." (Company A)

In the traditional finance system, the possessory pledge method had its fair share of challenges. It heavily relied on the physical possession of collateral by the lending institution, requiring businesses to physically surrender their assets. This approach could disrupt normal operations and impact production processes, causing inefficiencies and disruptions. Furthermore, businesses often needed to release and re-pledge the same assets for multiple loans, incurring additional transaction costs and administrative burdens. It was a system that was neither flexible nor cost-effective.

Non-possessory revolving collateral, as illustrated by the cases of Company C and Company B, introduced a revolutionary solution to these problems. It minimized the necessity for the physical transfer of assets, offering a more streamlined and efficient

approach. Businesses could now use their assets as collateral without surrendering possession, ensuring that their production processes continued uninterrupted. This innovation not only simplified the lending process but also significantly enhanced the efficiency and security of asset-backed loans within the financial sector.

"The goal of keeping the product in our warehouses while providing a higher level of security to the credit institution willing to finance us is the ultimate objective of implementing blockchain technology." (Company A)

"With non-possessory pledge without blockchain, when the Company needed to move pledged goods, it had to call the bank, request authorization, and have the appraiser come out because the ledger needed to be updated, as it's a physical paper ledger. Therefore, the appraiser had to approve the release of the pledged items and, most importantly, ensure that a quantity and quality were reloaded to maintain the bank's pledged amount."(Company B)

One of the critical aspects that blockchain technology has addressed is the control and monitoring of collateral in non-possessory pledges, which lending institutions greatly depend on. Without the innovative use of blockchain, lending institutions would be reluctant to embrace non-possessory pledges as a viable financing option. This hesitation primarily stems from their lack of control over the assets pledged, which remain securely within the warehouse of the borrowing company. In the absence of blockchain, lending institutions typically had to rely on notaries to monitor the inventory under pledge, a process that required daily oversight and verification. This approach resulted in a substantial and recurring cost, making it less appealing for financial institutions to engage in non-possessory pledges.

"With traditional revolving non-possessory pledge, the Company , in case of bad faith, could easily not call the bank, take the items, and sell them."(Company B)

Blockchain technology emerged as the perfect solution to address these challenges. It introduced a digital transaction ledger that securely and transparently recorded every movement of assets within warehouses. The immutability and verifiability of blockchain data eliminated the need for periodic manual signatures, ensuring that data was always accurate and up-to-date.

This transformation empowered lending institutions to continuously monitor collateral values in real-time, providing a transparent and secure environment for financial transactions. The blockchain technology fostered trust between all parties involved, simplifying the non-possessory revolving collateral process and making finance and supply chain operations more interconnected than ever before.

Lending institutions now had the ability to continuously and autonomously monitor the collateral in real-time, eliminating the need for costly notarial services. This transition significantly reduced the financial burden associated with non-possessory pledges, making them a more attractive and cost-effective financing solution.

The adoption of blockchain has not only streamlined the lending process but has also had a significant impact on how businesses manage their assets within their supply chains. It has made asset management more efficient, transparent, and secure, allowing businesses to use their assets as collateral without hindering their day-to-day operations. This increased flexibility and security have made it easier for businesses to access financing while ensuring the continuous flow of their supply chain activities.

"The blockchain allows us to have the real-time status of the items and enables us to generate reports daily when there are movements of items or even just relocations. This is somewhat the genesis of the operation and, above all, what has brought together the needs of the dairies, which were to obtain credit on favorable terms, with facilitated access, and low administrative operational intensity." (Company C)

"So, for them, it was easier to access a larger amount of financing because we provide a greater guarantee."(Company B)

Furthermore, the ease of accessing financing at a lower cost has been a game-changer for companies, especially when compared to traditional financing methods. Non-possessory revolving collateral, empowered by blockchain, has made securing loans more accessible and affordable for businesses. The reduction in costs is attributed to several factors, including the elimination of the need for physical asset transfer, the removal of notarial fees, and the improved efficiency in the monitoring and management of collateral values. These factors collectively contribute to the lower cost of financing, making it a more attractive option for companies in need of financial support.

Blockchain technology has not only revolutionized finance but has also reshaped the way supply chain and finance collaborate. It has made the agri-food sector more agile, efficient, and competitive by streamlining the lending process, enhancing transparency, and fostering trust among all parties involved. This innovation represents a significant step toward a more interconnected and responsive financial system that benefits both businesses and financial institutions alike.

4.2. Managerial Decision-Making

Blockchain technology has ushered in a new era of adaptability and flexibility within business models, heretofore unattainable.

The adoption of blockchain technology has triggered a revolutionary transformation in their business model. The implementation of a non-possessory revolving collateral system has granted clients the ability to retain custody of their valuable assets, including the esteemed Parmigiano Reggiano cheese wheels. This transformation has not only optimized their production processes but has also broadened company's portfolio of guaranteed agri-food products. By leveraging their clients' existing facilities, the necessity of constructing new warehouses has been obviated, consequently reducing operational expenses and streamlining their operations.

"The results are well beyond expectations. We had created a 5-year business plan, and in a year and a half, we have nearly doubled the goal we had set for ourselves in five years."
(Company C)

Furthermore, during the Company C interview, it was notable that the initial business plan was designed with a five-year horizon. Nonetheless, the results achieved within a mere year and a half vastly exceeded expectations, nearly doubling their initial objectives. The efficiency and security offered by blockchain have not only expedited the realization of Company C's goals but have also paved the way for new avenues of business expansion.

"Now we are also starting to focus on other sectors of Italian excellence in the agri-food industry, such as wine and cured meats." (Company C)

Their diversification of product offerings now encompasses not only Parmigiano Reggiano but also high-value products like Trentingrana and Pecorino Romano, all boasting DOC and IGT certifications attesting to their quality and provenance. This expansion into various product lines and the prospective application of blockchain technology in sectors like wine and ham further underscore the adaptability and flexibility inherent in these enterprises' business models.

A comparable transformation was witnessed at Company B as well. The integration of blockchain technology has facilitated businesses dealing with long-aging goods, such as Company A and their Grana Padano cheese, to secure more substantial loans at favorable rates. The blockchain technology has provided a dependable and verifiable source of collateral, mitigating the risks associated with erroneous valuations and enabling companies to finance the significant costs linked to aging their products, becoming an integral component of their business model.

The embrace of blockchain technology has indeed wrought a transformation in Company A's business model, fundamentally altering the manner in which they oversee their prestigious Grana Padano cheese production and financing. For Company A, a company deeply rooted in the traditional art of cheese-making, the challenge of securing substantial financing for the aging of their Grana Padano cheese, requiring periods ranging from 9 to 18 months, was particularly distinctive. The conventional approach would have necessitated pledging the cheese physically as collateral, rendering it inaccessible for their production processes and exposing it to risks.

However, blockchain technology has presented an innovative solution to this conundrum. It has enabled the company to embrace non-possessory revolving pledges, obviating the need for the physical delivery of their prized Grana Padano. This transformation has not only streamlined the accessibility of credit but has also preserved the capacity to employ the cheese as a vital component of their production.

This metamorphosis has significantly heightened efficiency and profitability, rendering Company A's business model more adaptable to the evolving dynamics of the market.

"Let's say that it's more of an additional incentive for us to spread the technologies we have in this warehouse to other storage facilities, particularly because the main advantage is warehouse management automation." (Company A)

The integration of blockchain technology into their existing operations transcends mere technological enhancement; it has the potential to redefine the way they conduct their business affairs. Blockchain's real-time tracking and secure, immutable recording of cheese movements within their warehouse have streamlined the entirety of their cheese management procedures. This automation has not only curtailed expenses but has also eliminated the necessity for intricate physical monitoring systems. The data recorded within the blockchain has emerged as a dependable and verifiable source of collateral, notably reducing the risks associated with errors or fraudulent activities.

This evolution in their business model has rendered Company A more competitive and resilient within the agri-food sector. With the efficiency and transparency proffered by blockchain, securing financing for cheese aging has become more facile, optimizing their cash flows and resource allocation. The company is now contemplating the extension of blockchain utilization to multiple warehouses, promising even greater transparency, accuracy, and security across all their operations.

4.3. Regulatory Framework's Impact on Blockchain

Blockchain technology, a distributed ledger system, serves as a vehicle for multiple stakeholders to partake in the dissemination and verification of data without the involvement of intermediaries. Its transformative potential extends across various facets of operational and supply chain finance, encompassing invoice financing, trade finance, and supply chain management. Nonetheless, the successful integration of blockchain technology is inherently intertwined with the regulatory landscape in which it operates. The efficacy of regulatory frameworks can either facilitate or impede the utilization of blockchain in the context of financial operations.

"The ideal situation would be for these tools, like blockchain, to be considered at the European level, enabling us to have a lower capital absorption" (Company B)

This sentiment underscores a pivotal regulatory factor that can amplify the embrace of blockchain technology, namely, the reduction of capital requisites for financial institutions. Capital requirements, which constitute the minimal capital holdings mandated for risk mitigation, are established by international and national regulatory bodies such as the Basel Committee and the European Central Bank. The Company B manager expounded upon how the implementation of blockchain technology at the European level can effectively diminish the capital necessities for banks. Blockchain's capacity to underpin secure and transparent recording and monitoring of non-possessory revolving collateral curtails the susceptibility to fraudulent activities and defaults. In light of these observations, the Company B manager posits that the harmonization of non-possessory revolving collateral regulation at the European level could serve as a catalyst for greater blockchain adoption in the realm of operations and supply chain finance.

Blockchain technology, by its very nature, has the potential to mitigate transaction costs, reduce processing timelines, and rectify information asymmetry between financial institutions and client organizations. It also cultivates trust and enhances collaboration among distinct stakeholders within the supply chain. The testimony of the Company C manager further elucidates the merits of blockchain technology in enhancing access to credit for businesses. The expedited and streamlined verification of invoices, contracts, and payments engendered by blockchain engenders a more efficient and transparent financial ecosystem. Furthermore, blockchain has the capacity to enhance the rapport between banks and businesses, as well as among businesses and their suppliers and customers. It is imperative to acknowledge that regulatory frameworks buttressing the use of blockchain for non-possessory revolving collateral function as enablers of its adoption by amplifying these manifold benefits.

Nevertheless, the potential of blockchain technology may be stifled by regulatory frameworks that are nebulous or overly restrictive. A lack of unambiguous and supportive regulatory guidelines may lead to compliance quandaries and dissuade financial institutions and businesses from embracing innovative blockchain-based solutions. The obscurity or restrictiveness of these regulations can hinder the interconnectivity and scalability of blockchain solutions across international borders or diverse sectors. Furthermore, the tardiness or reluctance of certain regulatory bodies to adapt to emergent technologies creates a quagmire of uncertainty or barriers for prospective adopters.

Another salient consideration is the variability of regulatory frameworks contingent upon the industry or sector in which blockchain technology is employed. The interviews underscored the significance of sector-specific regulations, particularly those pertaining to the Protected Designation of Origin (PDO) for select products. The PDO, a designation that denotes products with specific attributes tied to their geographical origin, exemplified by Parmigiano Reggiano cheese and Prosecco wine, is subject to stringent quality criteria and oversight by authorized bodies. The

Company C manager elucidated that blockchain technology, when applied to PDO products, can engender heightened traceability and authenticity, consequently enhancing their market value and reputation. However, it is essential to ensure that regulatory stipulations relating to product origins, quality, and geographical designations are attuned to blockchain-enabled processes to ensure a seamless transition.

The interviews also unveiled practical challenges intrinsic to the establishment of non-possessory revolving collateral through traditional methods. The Company C manager expounded upon the cumbersome and protracted procedures that this form of collateral necessitates, including preliminary assessments by appraisers, notary visits, manual record-keeping, and bureaucratic intricacies. Additionally, pledging a portion of the warehouse effectively encumbers these assets in favor of the bank, rendering it arduous for companies to transport or divest them without bank authorization and the involvement of appraisers. These processes, with their dependencies on availability, coordination, and trust, posed significant constraints for both parties.

The integration of blockchain technology ameliorates these challenges by simplifying and automating the non-possessory revolving collateral processes. Blockchain technology permits real-time monitoring and valuation updates of collateral, negating the need for appraisers and notaries. This grants companies greater flexibility and control over their assets, enabling them to release or replenish them without the necessity of bank intervention or approval. Furthermore, blockchain technology insulates against bad faith and fraud by assuring the secure registration and verification of pledged assets on the distributed ledger.

"The possibility of using the non-possessory revolving pledge has initiated a development action with blockchain." (Company C)

The adoption of blockchain technology for non-possessory revolving collateral was precipitated by a regulatory amendment in August 2020. The Italian Ministry of Economy and Finance issued a decree that introduced the non-possessory revolving pledge as a novel form of collateral for loans. This decree, a watershed moment, extended permission for banks and companies to harness blockchain technology for the registration and management of non-possessory revolving collateral without necessitating the physical possession or transfer of assets. This regulatory change inaugurated fresh avenues for financial institutions and businesses to leverage blockchain technology in the spheres of operations and supply chain finance, especially within the agri-food sector.

The Company C manager's account highlights how this regulatory evolution empowered Company C to broaden its operational horizons, affording financing options to more dairies engaged in the production of Grana Padano cheese. Grana Padano, a PDO product akin to Parmigiano Reggiano but originating from a distinct geographical region and consortium, presented a unique set of challenges. Company C had consistently operated within the Parmigiano Reggiano context, possessing its own warehouses situated within the PDO area for the storage and surveillance of cheese as collateral. However, the absence of warehouses within the Grana Padano area posed a substantial hurdle to offering financing to dairies specializing in this cheese. The regulatory framework governing non-possessory revolving collateral allowed Company C to exploit blockchain technology to monitor and track the cheese stored in the dairies' proprietary warehouses without the necessity of constructing or leasing new storage facilities. This strategic adaptation enabled Company C to cater to the financial needs of an expanded array of dairies engaged in capital-intensive production and aging processes.

Regulatory frameworks exert a pivotal influence in either facilitating or impeding the integration of blockchain technology within operations and supply chain finance. Insights gleaned from interviews with Company B and Company C managers underscore regulatory factors that expedite this adoption, including the abatement of capital requirements for financial institutions, heightened operational efficiency and transparency, and the simplification and automation of non-possessory revolving collateral processes. Conversely, impediments to this adoption may arise from regulatory ambiguities, industry-specific regulations, and practical challenges associated with the traditional methodologies for establishing non-possessory revolving collateral. A fertile avenue for future research endeavors could encompass a comparative analysis of disparate regulatory frameworks across regions or nations and their consequential impact on blockchain adoption within the domain of operations and supply chain finance.

4.4. IoT's Role

Diving into the intricate dance of technology, it becomes evident that the fusion of IoT and 5G is not merely a support beam for blockchain; rather, it's a harmonious symphony, with each note playing a crucial role in enhancing the capabilities of the other. Imagine the technological landscape as a collaborative canvas where the strokes of IoT and 5G paint a vivid picture, unlocking the true potential of blockchain.

Picture the evolution of blockchain as a collective effort, not a solo performance. It leans on the crutches of various technological allies, and among them, the dynamic duo of the Internet of Things (IoT) and 5G stands out as a testament to seamless integration. These two technological juggernauts aren't just supporters; they are the key that turns the lock, opening doors to a future where blockchain can truly thrive.

The marriage of IoT and 5G doesn't just add a layer of efficiency and security to blockchain applications; it transforms them into robust, interconnected ecosystems. It's like giving wings to a fledgling idea, allowing it to soar to new heights. The amalgamation of IoT and 5G brings about a revolution, enhancing the efficiency, bolstering the security, and elevating the overall performance of blockchain applications.

Security, the guardian of data integrity, experiences a formidable alliance in this trio. Blockchain, IoT, and 5G come together as the guardians of a digital realm, especially when it comes to safeguarding the deluge of data emanating from IoT devices. The advanced encryption and security protocols offered by 5G act as a knight in shining armor, fortifying the stability of data stored on the blockchain. It's not just about protection; it's about creating an impenetrable fortress for the data generated by the ever-expanding network of IoT devices.

A real-world case study featuring Company A's financial operations serves as a poignant illustration of blockchain's pivotal role in non-possessory revolving pledges. This isn't a mere theoretical concept; it's a practical demonstration of how blockchain is actively shaping financial landscapes.

However, as with any technological stride, challenges persist. The periodic verification of goods in warehouses remains a persistent hurdle. In the absence of blockchain, this task was arduous, and although blockchain improves the situation, it doesn't eliminate it entirely. Physical verification still looms, devouring valuable resources and injecting delays into operational and financial processes.

In steps IoT and 5G as the dynamic duo of solutions. Picture weight sensors, environmental monitoring devices, and cutting-edge IoT tools acting as digital guardians, offering real-time monitoring and precise control over goods in warehouses. The data they collect seamlessly integrates into the blockchain, ensuring a continuous flow of traceability and certification. It's not just about tackling the

challenge of periodic physical verification; it's about infusing efficiency and transparency into the veins of financial operations.

Peering into the future, the vision stretches beyond mere enhancement. The integration of IoT and 5G emerges as a potential game-changer in blockchain regulation, lessening dependence on intermediaries. Weight sensors and other devices become the architects of a new era, monitoring and certifying the contents of financial warehouses, enabling blockchain operations without the need for intermediaries. The rapid transmission of sensor data in real-time via 5G to the blockchain platform obliterates the need for manual notary checks, promising heightened efficiency and reduced operational costs.

The revelations from this case study echo the symbiotic relationship between IoT, 5G, and blockchain technologies. Challenges persist, but the integration of these enablers presents not just a solution to hurdles but a transformative potential. It's a narrative of overcoming obstacles, reshaping the future landscape of blockchain applications, and offering a tapestry woven with enhanced efficiency, transparency, and a diminished reliance on intermediaries. It's not just a technological evolution; it's a digital revolution, redefining how we perceive and utilize blockchain in our ever-evolving world.

4.5. Warehouse

The shift in the perception of warehouses from illiquid resources to sources of financing has had a profound impact, particularly in the context of agri-food companies dealing with products that require extended aging, such as cheese. Traditionally, warehouses were seen as a financial burden, tying up valuable capital that could otherwise be invested in other critical aspects of the business. However, with the integration of blockchain technology, warehouses have undergone a

remarkable transformation, evolving from being viewed solely as a cost to becoming a powerful source of financing. This transformation is particularly pronounced in agri-food companies that depend on prolonged aging processes.

"In our case, it's part of our daily operations because we need to finance a cheese aging warehouse, a value that is cyclical, repetitive, and recreated every day. Since we sell cheese every day and produce it daily, the stock in the warehouse, which is technically called current assets, but is effectively a fixed asset, regenerates daily. Therefore, there is a continuous need for financing." (Company A)

Historically, companies faced a significant challenge when it came to financing their warehouses, which represented a substantial portion of their overall value. These warehouses were not merely static storage facilities; they were integral components of the production process, playing a vital role in the quality and value of the products. Acquiring loans for warehouse management often presented a formidable hurdle, as traditional financing methods were not only cumbersome but also costly. This challenge was especially acute for agri-food companies handling products like Grana Padano cheese, Parmigiano Reggiano, or similar items, which require extensive aging to achieve their premium quality.

The implementation of blockchain technology has revolutionized this age-old paradigm. The real-time tracking and recording capabilities of blockchain have turned the warehouse into a dynamic and efficient part of the business. Now, agri-food companies have the ability to use their aging products as collateral for loans, all while retaining direct control over their valuable assets. This newfound flexibility has streamlined the financing process and significantly improved access to credit, empowering companies to secure larger loans at more favorable terms.

"So, in fact, we are adding value or trying to make the most of the value that this cheese already has while it rests in the warehouses during the aging process."(Company A)

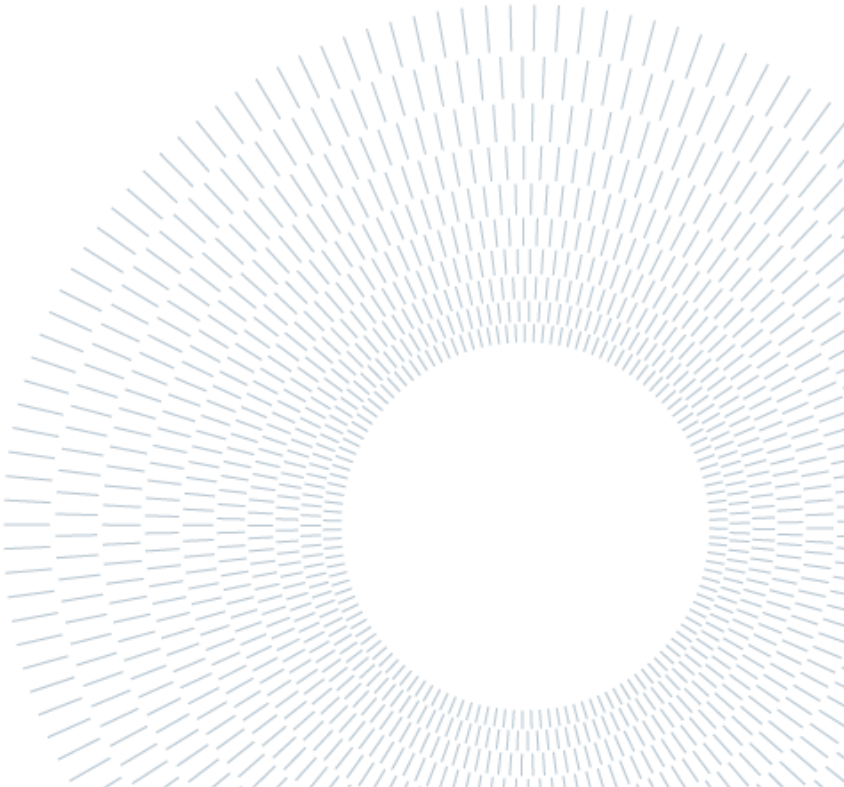
One of the key advantages of blockchain is its unmatched reliability and verifiability. The data recorded on the blockchain platform is tamper-proof, ensuring the integrity of the collateral. This high level of security has given banks the confidence to provide larger loans, as they have a high degree of certainty in the value of the assets used as collateral. It has also significantly reduced the risk of incorrect evaluations, further strengthening the relationship between financial institutions and agri-food businesses.

However, the impact of blockchain extends far beyond just access to credit. It has ushered in a new era of transparency in financial operations, enhancing trust among all parties involved. Businesses can now enter financing arrangements with greater confidence, while banks can operate with reduced risks. This trust and transparency have contributed to increased efficiency and competitiveness within the financial sector, benefiting both the banking institutions and the client companies.

Furthermore, it's essential to recognize that blockchain's impact is not limited to the agri-food sector alone. It has the potential to revolutionize inventory financing in various industries. The ability to utilize movable assets as collateral for obtaining loans or lines of credit can offer significant benefits to a wide range of businesses, particularly those with seasonal or capital-intensive operations.

In conclusion, the adoption of blockchain technology has not only simplified warehouse management but has also redefined the way businesses perceive their warehouses. No longer seen as a financial burden, warehouses have transformed into valuable sources of financing, particularly for agri-food companies dealing with long-aging products. This transformation has ushered in a new era of financial flexibility and efficiency, contributing to the growth and competitiveness of businesses in the

agri-food sector and beyond. Blockchain has truly been a game-changer, turning what was once an illiquid resource into a powerful financial asset.



5 Discussion

This section discusses the empirical findings in the prior literature to answer the research question. The adoption of blockchain technology has significantly transformed the dynamics between finance and supply chain, particularly evident in the cases of Company C, Company B, and Company A. This transformation has changed traditional methods of securing loans, fostering trust between all parties involved, simplifying the non-possessory revolving collateral process and making finance and supply chain operations more interconnected than ever before.

In the traditional finance system, possessory pledges relied on the physical possession of collateral, causing disruptions in business operations and incurring additional transaction costs. Adopting non-possessory revolving collateral, as Company C and Company B demonstrated, introduced an innovative solution. This approach minimized the need for physical transfer of assets, streamlining the lending process and enhancing efficiency. Businesses could now use their assets as collateral without surrendering possession, ensuring uninterrupted production processes. This transformation simplified the lending process and significantly enhanced efficiency and security.

Controlling and monitoring collateral in non-possessory pledges were significant concerns for lending institutions. Without innovative solutions, such as blockchain technology, lending institutions hesitated to embrace non-possessory pledges due to the lack of control over pledged assets. Traditional methods relied on notaries for monitoring inventory under pledge, incurring substantial and recurring costs.

Blockchain technology emerged as the perfect solution to address these challenges. It introduced a digital transaction ledger that securely and transparently recorded every movement of assets within warehouses. The immutability and verifiability of blockchain data eliminated the need for periodic manual signatures, ensuring accurate and up-to-date information. The successful adoption of BT necessitates the active involvement of all stakeholders in the supply chain. However, some stakeholders may need more resources to embrace technological innovations (Saberi et al., 2019; Ghode et al., 2020). This empowered lending institutions to continuously monitor collateral values in real-time, fostering trust between all parties involved and simplifying the non-possessory revolving collateral process.

The integration of blockchain technology into the lending process not only streamlined operations but also profoundly impacted how businesses manage their assets within supply chains. It made asset management more efficient, transparent, and secure, allowing businesses to use their assets as collateral without hindering day-to-day operations. This increased flexibility and security facilitated easier access to financing, ensuring the continuous flow of supply chain activities.

The adoption of blockchain has reshaped the collaboration between supply chain and finance. The agri-food sector has become more agile, efficient, and competitive thanks to the streamlining of the lending process, enhanced transparency, and the fostering of trust among all involved parties. Companies spearheading BT projects can inspire other partners with limited resources to participate by offering both technical and financial support (Min, 2019). This innovation represents a significant step toward a more interconnected and responsive financial system that benefits businesses and financial institutions. The integration of blockchain technology into their existing operations transcends mere technological enhancement; it has the potential to redefine the way they conduct their business affairs.

Examining these findings through the Resource Dependence Theory (RDT) lens, it becomes evident that the adoption of blockchain technology addresses the dependencies and uncertainties inherent in the agri-food sector. RDT suggests that companies often depend on other firms for crucial resources (Casciaro & Piskorski, 2005). The successful adoption of blockchain technology requires active involvement from all stakeholders in the supply chain, with leading companies playing a crucial role in inspiring and supporting partners with limited resources (Davis and Cobb, 2010).

External dependencies from increased product market competition and limited credit supply have driven organizations to seek measures to restore control over their environments (Pfeffer & Salancik, 2003). In blockchain adoption, participants with limited resources must reach a consensus on risk allocation and benefits distribution with leading firms to manage dependencies effectively. This agreement aligns interests and fosters the adoption of blockchain technology (Santos & Eisenhardt, 2005).

Considering the role of boards of directors in strategic priorities and digital transformation (DT), RDT's central proposition aligns with the findings. Boards can use DT to reduce uncertainty, lower transaction costs, and increase the flow of essential resources (Bainbridge, 2012). Inter-organizational relationships, enhanced by digitally savvy board members, contribute to acquiring and allocating resources to reduce uncertainty (Auster & Choo, 1994).

The integration of blockchain technology into the business models of Company C and Company B has ushered in a transformative era of adaptability and flexibility, aligning with the tenets of Resource Dependence Theory (RDT). As highlighted by RDT, companies often grapple with dependencies on external entities for crucial strategic resources (Hillman et al., 2009).

The results from Company C's experience demonstrate a remarkable deviation from the conventional five-year business plan, doubling their goals within a mere year and

a half. Company C's success in exceeding expectations indicates that managing dependencies and fostering collaboration, as suggested by Davis and Cobb (2010) and Drees and Heugens (2013), is instrumental in navigating the uncertainties associated with resource dependencies.

Moreover, the diversification of products financed by Company C, expanding beyond Parmigiano Reggiano to include Trentingrana and Pecorino Romano, echoes the RDT notion that firms seek to manage dependencies by forming inter-organizational arrangements (Casciaro & Piskorski, 2005). This expansion underscores the adaptability and flexibility ingrained in the business models of these enterprises, a characteristic emphasized in their successful integration of blockchain technology.

Like Company C, Company B's experience with blockchain in the context of long-ageing goods, exemplified by Company A and their Grana Padano cheese, aligns with RDT's emphasis on managing dependencies and uncertainties through inter-organizational arrangements. Blockchain technology provides a dependable and verifiable collateral source, mitigating risks associated with erroneous valuations.

The transformative impact on Company A's business model, particularly in securing substantial financing for ageing Grana Padano cheese, attests to the effectiveness of blockchain in addressing resource dependencies. The shift from physical collateral to non-possessory revolving pledges reflects the innovative solutions presented by blockchain technology, aligning with the RDT concept of setting boundaries to maximize strategic control over external forces (Santos & Eisenhardt, 2005).

The adoption of non-possessory revolving collateral, particularly in the agri-food sector, can be illuminated through institutional theory. This theoretical perspective posits that organizations operating in comparable environmental conditions tend to converge on similar structures and operational approaches to secure legitimacy and ensure survival.

In the agri-food sector, where the ageing or maturation of products plays a pivotal role, embracing blockchain technology and non-possessory pledges can be seen as a response to industry needs. Organizations within this sector navigate a landscape shaped by market characteristics, regulatory frameworks, longstanding traditions, evolving consumer expectations, and competitive pressures. Adopting innovative financial instruments, such as non-possessory revolving collateral, aligns with the established practices and expectations within the agri-food industry.

The unique conditions of the agri-food sector, characterized by the need to manage the ageing or maturation of products, create a distinct environment that influences the choices and adaptations made by organizations within it. The integration of blockchain technology and the shift towards non-possessory pledges can be understood as strategic responses to this industry's specific challenges and dynamics. These adaptations enhance the legitimacy of organizations within the agri-food sector by aligning with prevalent industry practices and demonstrating a capacity to respond effectively to environmental demands.

The institutional theory provides valuable insights into why adopting non-possessory revolving collateral is not a universal phenomenon but is instead prominent in specific industries like agri-food. By acknowledging the influence of industry norms and environmental conditions, organizations in the agri-food sector position themselves strategically to navigate the complexities of their unique operational landscape, ensuring both legitimacy and survival in the face of evolving challenges.

The institutional theory is a theoretical perspective that studies how organizations adapt and respond to the pressures and expectations of the environment in which they operate. According to this theory, organizations tend to conform to their sector's dominant norms and values to gain legitimacy and survival. In this way, organizations facing similar environmental conditions tend to adopt similar structures and modes of

operation, creating a phenomenon of institutional isomorphism (DiMaggio & Powell, 19831).

The institutional theory can be used as an analysis method to examine how organizations develop specific capabilities, behaviors, or forms of innovation in particular sectors. In particular, this theory can be applied to the context of this study, which concerns sectors related to the ageing or maturation of products. Adopting this theory is justified by the contingent conditions favoring such specificity, such as market characteristics, regulations, traditions, consumer expectations, and competitive pressures (Moyano-Fuentes et al., 20122).

The transformation of warehouses with the introduction of blockchain from traditional static storage facilities into dynamic sources of financing, particularly in the context of agri-food companies dealing with products requiring extended ageing, is a testament to the evolving landscape of business operations. This shift in perception has been fueled by the integration of blockchain technology, a transformative force that has redefined the role of warehouses in the financial ecosystem.

Traditionally, warehouses were viewed as a financial burden, tying up capital that could be invested elsewhere in the business. However, with the implementation of blockchain, these warehouses have become integral components of financial strategies, especially for agri-food companies engaged in producing long-aging products like cheese. Cheese production's cyclical and repetitive nature necessitates continuous financing, turning warehouses from mere storage spaces to valuable assets in daily operations.

The adoption of blockchain technology has addressed historical challenges in financing warehouses. Historically, agri-food companies handling products like Grana Padano cheese, faced obstacles in acquiring loans for warehouse management due to the cumbersome and costly nature of traditional financing methods. Blockchain's real-

time tracking and recording capabilities have revolutionized this paradigm, allowing companies to use aging products as collateral for loans, thereby streamlining the financing process and enhancing access to credit.

The impact of blockchain extends beyond mere access to credit, delving into the realms of reliability and transparency. The tamper-proof nature of blockchain data ensures the integrity of collateral, instilling confidence in banks to provide larger loans with a high degree of certainty in asset value. This newfound trust and transparency have strengthened the relationship between financial institutions and agri-food businesses and contributed to increased efficiency and competitiveness in the financial sector (Teece, Pisano & Shuen, 1997).

The concept of dynamic capabilities, as expounded by Teece, Pisano, and Shuen (1997), comes into play in this context. Dynamic capabilities are strategically identifiable processes that enable firms to integrate, build, reconfigure, and release resources to address rapidly changing environments. This approach goes beyond the traditional VRIN (valuable, rare, inimitable, and non-substitutable) resource model, emphasizing the organization's ability to adapt to evolving markets. The 'dynamic capabilities' approach underscores the importance of exploiting existing competencies to address changing environments (Nedzinskas et al., 2013).

Integrating dynamic capabilities into the transformed warehouse landscape aligns with the idea that decision-making becomes paramount in the face of uncertainty. Knight (1921) highlighted that making the right investments is crucial when uncertainty is present. Dynamic capabilities, therefore, become the primary function in navigating a rapidly changing business environment, with the execution of activities being a secondary consideration (Knight, 1921).

Theoretical foundations, such as the resource-based view and core competency theory (Barney, 1996; Prahalad and Hamel, 1990), underpin the evolution of warehouses into dynamic financing assets. The resource-based view posits that an organization's

performance depends on its capabilities and unique, valuable, and non-substitutable resources. Core competencies developed through collaboration become sources of competitive advantage. This aligns with the capability of warehouses, enabled by blockchain, to serve as collateral for loans, creating a unique and valuable financial asset for businesses.

The integration of blockchain technology has not only transformed warehouse management but has redefined the perception of warehouses as sources of financing for agri-food companies. This transformation, coupled with dynamic capabilities, emphasizes the adaptability and strategic significance of warehouses in the face of changing business environments. The combination of blockchain and dynamic capabilities has turned what was once an illiquid resource into a powerful financial asset, contributing to the growth and competitiveness of businesses in the agri-food sector and beyond.

Incorporating blockchain technology into operations and supply chain finance is a transformative force, fostering seamless data dissemination and verification among stakeholders while eliminating the need for intermediaries. This distributed ledger system, explored in the thesis, exhibits versatile applications, spanning invoice financing, trade finance, and supply chain management. However, the success of blockchain integration is intricately interwoven with the regulatory landscape that governs its operations.

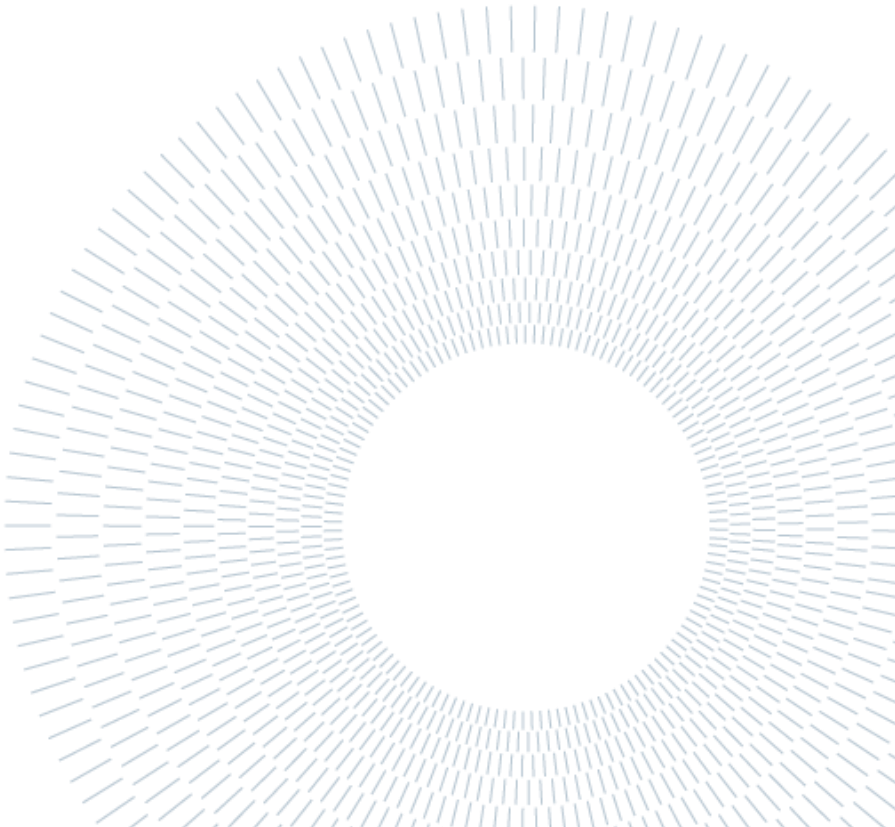
Within this regulatory context, as the interviews with industry managers illuminated, a pivotal factor influencing the adoption of blockchain technology is the reduction of capital requisites for financial institutions. The sentiments echoed by the Company B manager underscore the significance of considering tools like blockchain at the European level to achieve a lowered capital absorption.

This resonates with the lack of standards, regulations, and legal frameworks as major impediments to blockchain adoption. Resource dependency theory provides a theoretical lens to identify resource interdependencies that can inform the formulation of standards and regulations.

The participation of regulatory bodies in blockchain consortia, such as the Pharmaledger consortium (IMI, 2020), aligns with the thesis findings, indicating that regulatory frameworks significantly influence blockchain integration. Network effect theory emphasizes the necessity of compliance with existing standards for sustainable network growth. This parallels the observations from the industry managers, affirming blockchain's potential to reduce processing timelines and transaction costs, thereby enhancing operational efficiency and transparency.

Furthermore, the proposal in the literature to combine social network theory for investigating key aspects desirable for users in a blockchain solution design corresponds with the industry managers' testimonials. They emphasize how blockchain fosters collaboration and trust among stakeholders in the supply chain.

The thesis findings underscore the critical importance of regulatory clarity in fostering blockchain adoption. Including regulatory and standards organizations is important in supporting and promoting blockchain adoption in the supply chain (Ahmed & MacCarthy, 2022). Regulatory frameworks address challenges related to industry-specific regulations and practical issues associated with traditional collateral methods. This aligns with the normalization process theory from the literature, which addresses the successful deployment and integration of technologies, elucidating the practical challenges highlighted in the interviews and the subsequent alleviation achieved through blockchain integration.



6 Conclusion and future developments

In conclusion, this study has delved into the underexplored realm of non-possessory revolving collateral in inventory financing, shedding light on the transformative impact of blockchain technology. The research gap identified in existing literature has been addressed by examining the intricate dynamics between supply chain and finance practices, revealing how blockchain technology has revolutionized inventory financing, management, and decision-making processes.

The case study has exemplified the revolutionary solution offered by non-possessory revolving collateral, minimizing the need for physical asset transfer and providing a more streamlined and efficient approach. Blockchain integration has played a pivotal role in addressing critical aspects, such as control and monitoring of collateral, which lending institutions heavily depend on. The immutability and verifiability of blockchain data have eliminated the need for periodic manual signatures, ensuring accuracy and real-time information.

Blockchain technology has fostered trust among all involved parties, simplifying the non-possessory revolving collateral process and creating a more interconnected relationship between finance and supply chain operations. The ease of accessing financing at a lower cost has been a game-changer for businesses, making loans more accessible and affordable, especially when compared to traditional financing methods.

However, the successful integration of blockchain is contingent upon the regulatory landscape. Regulatory frameworks can either facilitate or impede the utilization of blockchain in financial operations. Reducing capital requisites for financial institutions

is identified as a pivotal regulatory factor that can amplify the embrace of blockchain technology. Nevertheless, regulatory frameworks that are nebulous or overly restrictive may stifle the potential of blockchain, leading to compliance challenges and discouraging its adoption by financial institutions and businesses.

The perception of warehouses has undergone a paradigm shift from being viewed solely as illiquid resources to becoming powerful sources of financing. This transformation, particularly noteworthy in the agri-food sector dealing with products requiring extended ageing, has been facilitated by the integration of blockchain technology. Warehouses are now recognized as valuable assets, contributing to the interconnectivity and scalability of blockchain solutions across international borders and diverse sectors.

6.1. Research Contribution

It is of utmost importance to provide a detailed account of how this thesis has significantly contributed to advancing the understanding and scope of the current literature. Thanks to this research, the discourse on Business Operations and Supply Chain Finance has transcended the paradigm of separate entities and embraced a more interconnected perspective, notably facilitated by the implementation of cutting-edge technologies like blockchain.

This study delves into novel facets that extend beyond the confines of the technology's conventional applications, as covered in existing literature. The transformative impact is evident in the reevaluation of supply chain management, particularly in addressing one of its most intricate core processes—inventory management. Through the lens of blockchain technology, we have redefined the discourse on inventory, especially in companies dealing with highly mature goods possessing minimal or no risk of obsolescence. The specific focus has been on employing blockchain to optimize inventory management in companies, such as the one examined in our case study,

where non-possessory revolving pledges enable innovative and efficient resource utilization.

Crucially, this thesis has shed light on the regulatory landscape surrounding the application of blockchain in domains like supply chain and financial institutions. It has clarified the role of regulations in the context of blockchain, especially in relation to bureaucratic elements that persist to some extent, albeit minimized. The inherent contradiction arises from the fact that blockchain technology aims at complete disintermediation among various actors, while bureaucratic processes, although reduced, still linger. This research underscores the ongoing tension between the revolutionary potential of blockchain and the persistent bureaucratic elements within regulatory frameworks, emphasizing the need for continued exploration and refinement in this transformative landscape.

6.2. Limitations and future research

Despite the significant contributions made by this thesis in the field of business operations and supply chain finance through the adoption of Blockchain Technology, it is crucial to highlight the most important limitations present in this research.

Firstly, the thesis focuses on a specific case study, making it highly specific and oriented towards the analysis of a single company. The limitation lies in the generalizability of the conclusions, as the dynamics of this particular company may not fully represent the broader implications on the global landscape of businesses. A more extensive number of case studies could have provided broader, more exhaustive, and diversified perspectives on possible strengths and challenges associated with blockchain adoption.

Another noticeable limitation is the reliance on a purely Italian research context. This raises concerns about the applicability of the technology in a global context. The

regulatory aspects, despite being a significant contribution to the current literature, may face adaptability issues in international contexts with different regulations. It is essential to analyze the results of this research with an awareness of how they might vary between Italian legislative contexts and international legal frameworks.

There are several opportunities for future research within this emerging field, aiming to deepen the understanding of the interaction between business operations and financial institutions.

One potential avenue is to extend the research beyond Italy, allowing for a global comparison of regulations and challenges linked to blockchain technology and non-possessory revolving pledge. Exploring how different geographical areas may influence dynamics and outcomes could provide valuable insights.

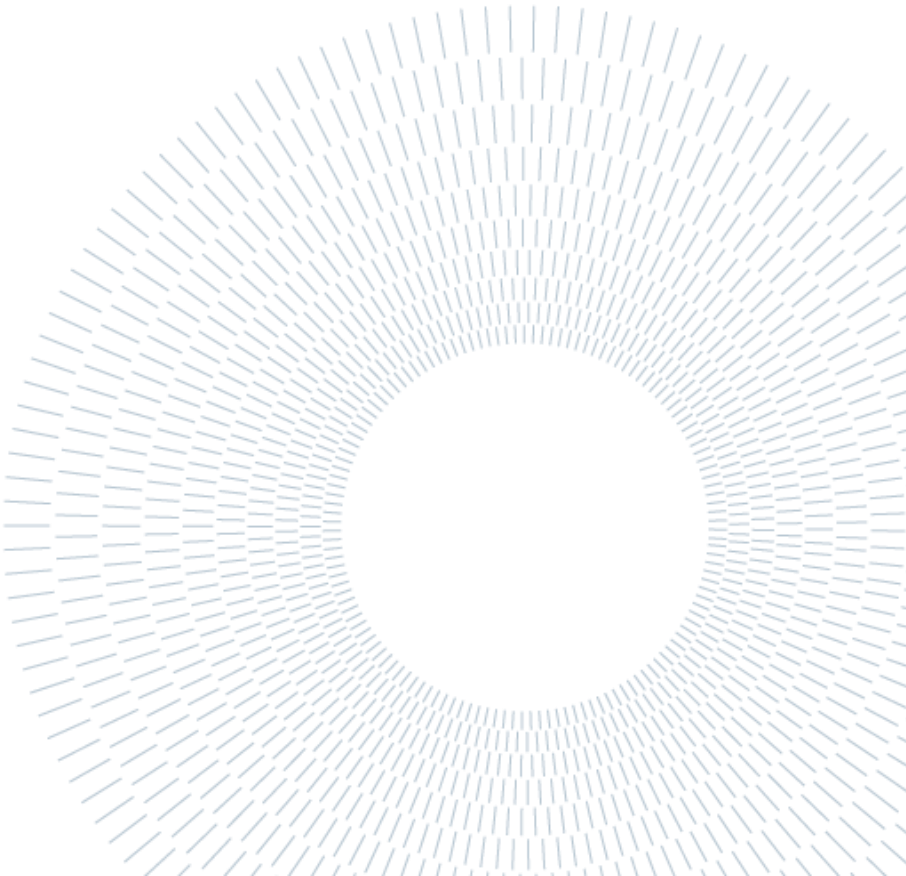
Another avenue for research involves studying multiple case studies instead of a single one. Comparing companies across different sectors and organizational complexities in managing supply chains could reveal common trends, patterns, and challenges, offering opportunities for segmentation based on the adoption of blockchain technology.

Additionally, further research on supporting technologies for blockchain, such as IoT and 5G, could enhance performance aspects and address regulatory challenges. Investigating how these technologies complement blockchain adoption would be a crucial aspect of future research.

Recognizing the importance of understanding the adoption of blockchain based on the type of asset produced is essential. Exploring how blockchain technology adapts to the diverse needs of companies in different sectors could enhance its efficiency in each specific industry, especially in operational and relational practices between financial institutions and companies.

In conclusion, future research could explore these avenues to address the limitations identified in this thesis, contributing to a more comprehensive understanding of the

implications of blockchain technology in the realms of business operations and supply chain finance.



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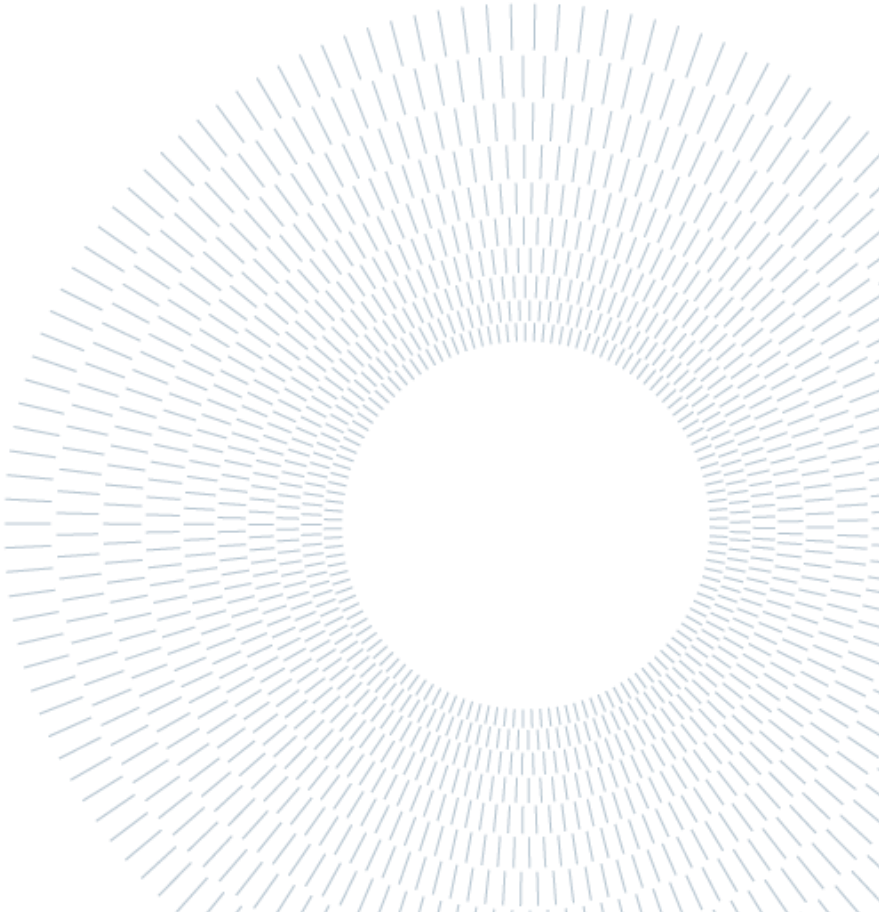
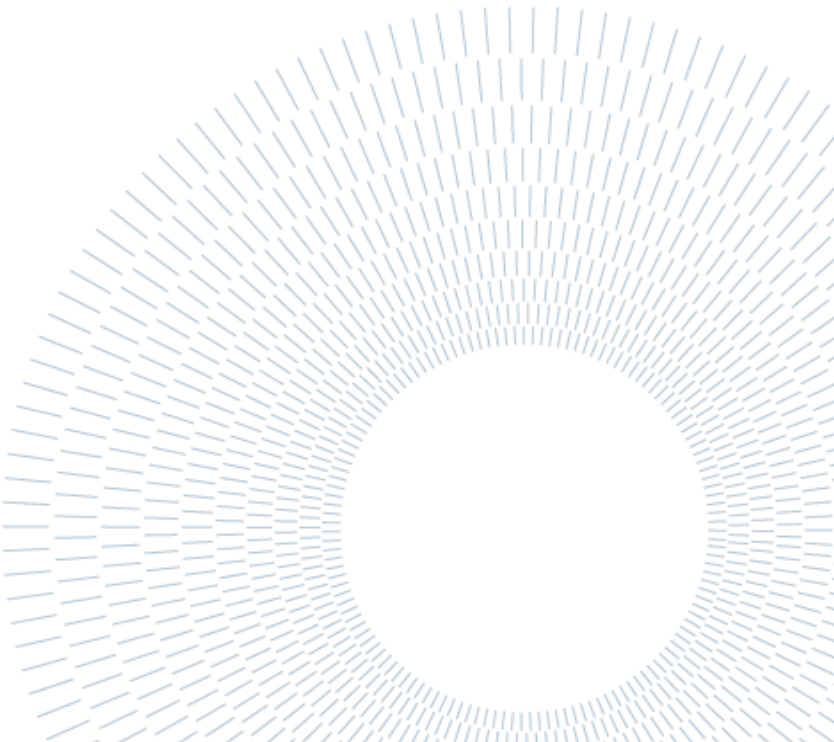


List of Figures



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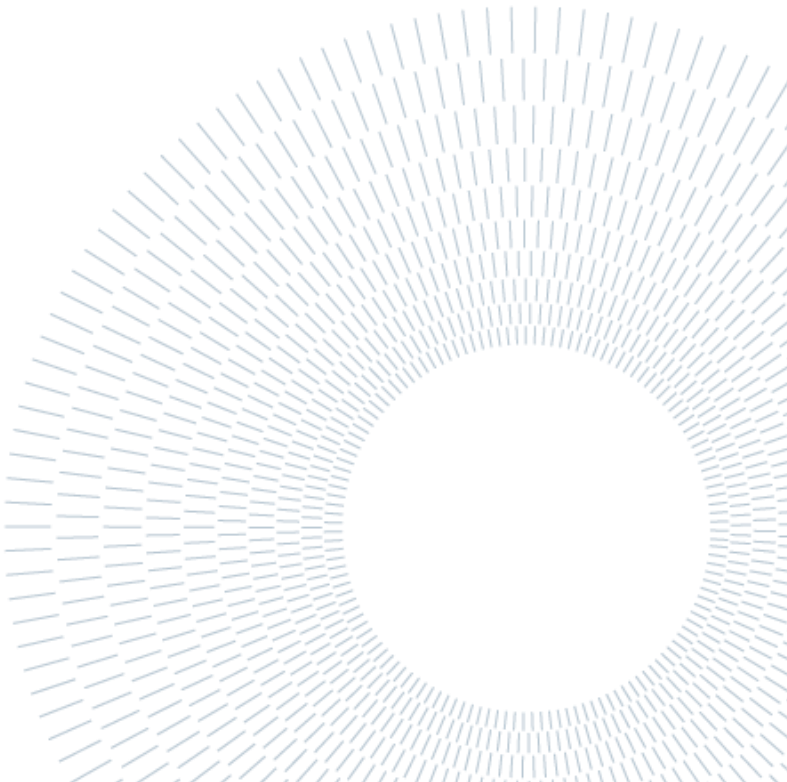

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