POLITECNICO
MILANO 1863

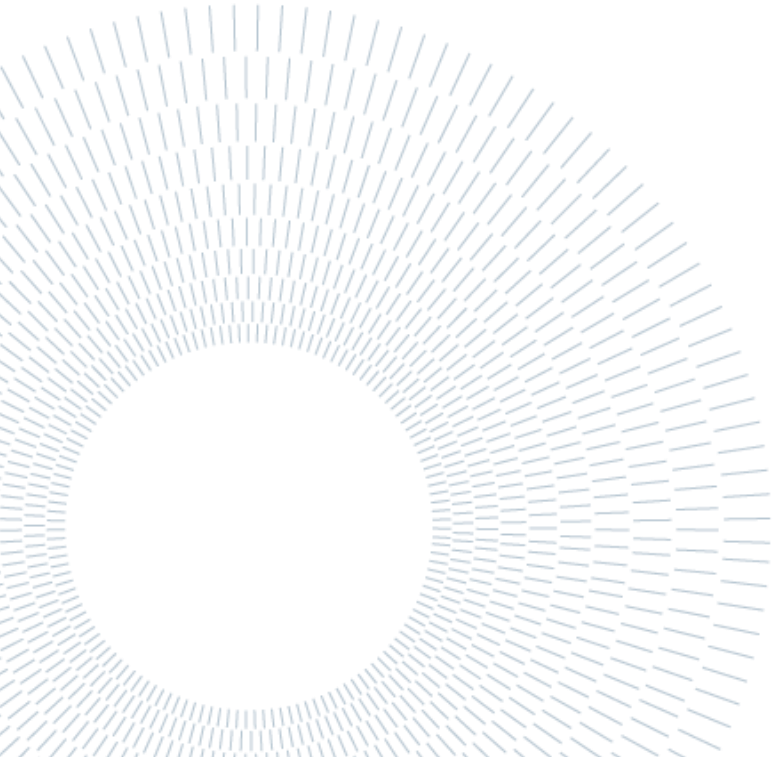
SCUOLA DI INGEGNERIA INDUSTRIALE
E DELL'INFORMAZIONE

Token and Business Ecosystems: A Multiple Case Study Analysis

TESI DI LAUREA MAGISTRALE IN
MANAGEMENT ENGINEERING
INGEGNERIA GESTIONALE

Author: **Tommaso Patti**
Federico Benini

Student ID: 10705820 10937970
Advisor: Luca Gastaldi
Co-advisor: Giacomo Vella
Academic Year: 2023-24



Abstract

The increasing adoption of tokenization and blockchain technology is reshaping business ecosystems by introducing new models for governance, ownership, and value exchange. This thesis investigates how companies integrate token-based mechanisms into their business strategies, analyzing the benefits and challenges associated with their adoption. The research focuses on the role of tokens in enabling modularity, interoperability, and traceability within decentralized business ecosystems, providing a structured evaluation of their strategic implications.

A multiple-case study methodology was employed, combining semi-structured interviews with industry professionals and secondary data analysis. The selected cases cover various industries, including luxury goods, automotive, financial services, and technology, where tokenization is applied for product authentication, asset ownership transfer, and digital identity verification. Findings reveal that tokens enhance ecosystem coordination by facilitating trust, enabling composable digital interactions, and streamlining asset transferability. However, challenges such as regulatory uncertainty, market adoption barriers, and technological integration complexities remain critical obstacles.

This study contributes to the academic discourse by offering a conceptual framework for evaluating tokenized business models and their role in modular ecosystem dynamics. In addition to the framework, the research formulates four key propositions that summarize the strategic implications of token adoption within business ecosystems. The outcomes of this research provide a foundation for future studies and offer practical insights for companies seeking to leverage tokenization to enhance value creation, improve transparency, and foster decentralized interactions within their ecosystems.

Keywords: tokenization, blockchain, business ecosystems, modularity, digital assets, decentralized governance, interoperability.

Abstract in Italiano

L'adozione crescente della tokenizzazione e della tecnologia blockchain sta ridefinendo gli ecosistemi aziendali, introducendo nuovi modelli di governance, proprietà e scambio di valore. Questa tesi analizza come le aziende integrano meccanismi basati su token nelle loro strategie di business, valutando i benefici e le sfide associate alla loro adozione. La ricerca si concentra sul ruolo dei token nel favorire la modularità, l'interoperabilità e la tracciabilità all'interno di ecosistemi aziendali decentralizzati, fornendo una valutazione strutturata delle loro implicazioni strategiche.

È stata adottata una metodologia di studio multi-caso, combinando interviste semi-strutturate con professionisti del settore e analisi di dati secondari. I casi selezionati coprono diversi settori, tra cui beni di lusso, automotive, servizi finanziari e tecnologia, in cui la tokenizzazione è applicata per l'autenticazione dei prodotti, il trasferimento di proprietà di asset e la verifica dell'identità digitale. I risultati evidenziano come i token migliorino il coordinamento dell'ecosistema, facilitando la fiducia, abilitando interazioni digitali componibili e semplificando la trasferibilità degli asset. Tuttavia, permangono sfide significative, tra cui incertezze normative, barriere all'adozione di mercato e complessità nell'integrazione tecnologica

Questo studio contribuisce al dibattito accademico offrendo un framework concettuale per la valutazione dei modelli di business tokenizzati e del loro ruolo nella dinamica modulare degli ecosistemi. Oltre al framework, la ricerca formula quattro proposizioni chiave, che sintetizzano le principali implicazioni strategiche dell'adozione dei token negli ecosistemi aziendali. Gli esiti di questa ricerca forniscono una base per studi futuri e offrono spunti pratici per le aziende che desiderano sfruttare la tokenizzazione per migliorare la creazione di valore, aumentare la trasparenza e promuovere interazioni decentralizzate all'interno dei loro ecosistemi.

Parole chiave: tokenizzazione, blockchain, ecosistemi aziendali, modularità, asset digitali, governance decentralizzata, interoperabilità.

Contents

1 Introduction

1.1. Context and Theoretical background

Over the past decade, blockchain technology and tokenization have emerged as transformative forces in modern business ecosystems, reshaping economic models and fostering digitally interconnected industries. By enabling the representation of physical and digital assets as blockchain-based tokens, tokenization has unlocked new opportunities for innovation, particularly in supply chain management, digital finance, and customer engagement. The transparency, programmability, and immutability of blockchain technology position tokens as key enablers of coordination, automation, and efficiency in complex business environments.

The integration of tokenized systems within business ecosystems could allow enterprises to surpass conventional industry boundaries, facilitating more efficient and scalable business processes. The Blockchain & Web3 Observatory (Blockchain & Web3 Outlook, 2025) at the Politecnico di Milano reported a 43% increase in "*Blockchain for Business*" projects in 2024 compared to 2023, reflecting a shift towards operational and scalable solutions. The number of live projects in this area has surged by 122%, with financial asset tokenization emerging as a dominant trend. Meanwhile, non-financial applications, such as Digital Product Passports (DPPs), are gaining traction, particularly in European markets. These developments highlight the potential of blockchain technology to modernize industries, modularity, interoperability within business ecosystems and lay the foundation for innovative business models (Schneider et al., 2020).

As tokenization continues to expand, its influence on business ecosystems, stakeholder coordination, and governance structures becomes increasingly evident. Tokens facilitate frictionless transactions, automate compliance, and foster decentralized decision-making, redefining firm interactions within modular and interconnected ecosystems. These developments emphasize the need for firms to rethink their strategic and operational models to effectively integrate tokenization, ensuring competitiveness in an increasingly digital and decentralized business environment. As businesses transition towards decentralized digital infrastructures, the principles of modularity gain increasing relevance, providing a structured approach to managing interdependencies, ensuring scalability, and enhancing coordination within tokenized ecosystems. This shift raises critical questions about how firms can leverage tokenization not only as a financial instrument but also as a governance and coordination mechanism, enabling new forms of modular organization in business ecosystems.

This transformation aligns with a broader reconfiguration of business ecosystems, where modularity plays a fundamental role in structuring decentralized coordination and value exchanges. The increasing complexity of business ecosystems has led firms to rethink interactions and decision-making structures (Schneider et al., 2020). Over the past two decades, economic activity has increasingly shifted toward interdependent networks of firms, where value is co-created and distributed among multiple stakeholders (Adner, 2017; Jacobides et al., 2018). In this context, business ecosystems have emerged as an essential framework for analyzing inter-firm collaboration, highlighting the interplay between platforms, modularity, and governance structures (Baldwin & Clark, 2000; Moore, 1999). Central to this transformation is the concept of modularity, which enables firms to design business architectures that balance adaptability and control, allowing for scalable innovation while ensuring operational efficiency. Modularity facilitates the decomposition of complex systems into independent yet interoperable components, enhancing

efficiency and flexibility in dynamic environments. Traditionally, modularity has been studied in firm-led environments, where governance is concentrated within a dominant entity that orchestrates interactions among participants (Gawer & Cusumano, 2014). However, emerging digital technologies have redefined modularity, shifting from centralized governance models to distributed coordination frameworks, where interactions, value exchanges, and operational processes are increasingly structured through decentralized infrastructures rather than controlled by a single entity.

One of the most transformative technologies driving this shift is blockchain, which has gained increasing attention for its ability to enable transparent, immutable, and trust-minimized coordination (Iansiti & Lakhani, 2017). By leveraging distributed ledger technology (DLT), blockchain removes reliance on intermediaries, allowing transactions, asset exchanges, and stakeholder coordination to occur in an automated, verifiable, and tamper-resistant manner. Within this landscape, tokenization has emerged as a key enabler of blockchain-based modular ecosystems, allowing firms to represent assets, rights, and governance structures in the form of programmable digital tokens (Sockin & Xiong, 2023). These tokens facilitate automated transactions, smart contract execution, and peer-to-peer exchanges, introducing novel mechanisms for data traceability, ownership verification, and cross-platform integration within business ecosystems (Wilson et al., 2022). As tokenization becomes increasingly integrated into business models, scholars have begun to explore its implications for value exchange mechanisms, decentralized governance, and digital asset interoperability (Van Haaren-van Duijn et al., 2022). While prior research on modularity has primarily focused on structuring interfirm interactions and optimizing product and service design architectures (Baldwin & Clark, 2000; Sanchez & Mahoney, 1996), recent studies suggest that blockchain-based tokenization extends these principles by embedding modular coordination mechanisms directly into digital assets (Lamberty et al., 2020). However, despite its growing adoption, the role of

tokenization in shaping modular business ecosystems remains underexplored, particularly regarding its implications for data traceability, asset transferability, and composability across decentralized networks. While tokenization enhances transparency, automation, and stakeholder coordination, its impact on ecosystem scalability, secondary market efficiency, and cross-platform interoperability requires further investigation. While prior research has examined modularity in business ecosystems (Baldwin & Clark, 2000; Sanchez & Mahoney, 1996) and blockchain governance (IT University of Copenhagen et al., 2018), the role of tokenization in modular structures remains insufficiently examined. Specifically, its influence on traceability, asset transferability, and ecosystem interoperability lacks empirical validation. This dissertation addresses this gap by analyzing how firms leverage tokenized mechanisms to restructure coordination, governance, and value exchanges.

1.2. Research Objectives and Contribution

Building on this evolution, scholars have increasingly explored the role of modularity and tokenization in structuring decentralized business ecosystems. While blockchain and tokenization have been widely discussed in financial applications, their role in facilitating modular coordination within decentralized business ecosystems remains underexplored. Specifically, its influence on traceability, asset transferability, and ecosystem interoperability lacks empirical validation.

This dissertation addresses this gap by analyzing how firms leverage tokenized mechanisms to redefine governance structures, reshape asset ownership models, and enhance stakeholder interactions in decentralized networks. By examining how firms implement tokenized frameworks, this study investigates their impact on modular coordination, system interoperability, and secondary market efficiency. The research highlights both the opportunities and challenges associated with token-based architectures, contributing to ongoing discussions on the transformation of business

interactions in digital ecosystems. To achieve these objectives, this dissertation adopts a multiple-case study approach, analyzing firms that have integrated tokenization within their business models. The research employs qualitative methods, including semi-structured interviews, industry reports, and document analysis, to assess the impact of tokenization on business coordination, ownership verification, and system interoperability. By leveraging a case study methodology, the research provides empirical evidence on how firms navigate the complexities of blockchain-based modularity, offering insights into the real-world applications of tokenized ecosystems.

The increasing reliance on tokenized business models introduces new complexities in ecosystem coordination, extending beyond traditional governance models. As firms develop strategies to manage asset exchanges, composability, and secondary markets, it becomes essential to explore new theoretical perspectives that address traceability, ownership transfer, and system interoperability within modular architectures. This dissertation contributes to this discussion by presenting a conceptual framework that captures the interplay between traceable token lineage, unconstrained transfer ownership, and autonomous ownership verification. These elements enable the development of efficient secondary markets, seamless cross-platform asset exchanges, and decentralized governance structures. While the framework itself is introduced in the discussion chapter, the empirical findings throughout this study illustrate how firms navigate tokenized modularity in practice, offering insights into the real-world implications of traceability, transferability, and composability in digital ecosystems.

To structure this investigation and provide a comprehensive understanding of tokenized modularity, the dissertation follows a structured research approach. The study is organized as follows: This chapter (Introduction) introduces the research context, objectives, and significance of the study. Chapter 2 presents a literature review, examining the theoretical foundations of modularity, business ecosystems, and blockchain tokenization. The chapter synthesizes existing research, establishing a conceptual framework for the study. Chapter 3 details the research methodology,

outlining the case selection process, data collection techniques, and analytical approach. Chapter 4 provides an empirical analysis of selected case studies, illustrating how firms implement token-driven projects. Chapter 5 discusses the findings, linking empirical insights to theoretical perspectives and identifying the key contributions of the study. Chapter 6 presents the discussion, where the research findings are analyzed in relation to the existing literature, addressing the research question and introducing the conceptual framework developed in this dissertation. Finally, Chapter 7 concludes the dissertation by summarizing its main contributions, discussing limitations, and proposing directions for future research on tokenized ecosystems.

By integrating insights from modularity theory, blockchain governance, and tokenization, this research advances the understanding of token and business ecosystems. Through its empirical contributions, this dissertation provides a structured perspective on the role of tokenization in modular business ecosystems, offering new insights into its implications for governance, interoperability, and value coordination among stakeholders.

2 Literature Review

2.1. Business Ecosystem

2.1.1. Definition

The concept of business ecosystems has emerged as a pivotal framework for analyzing the interconnected and dynamic nature of modern economic and organizational structures.The term, which was introduced by Moore (1993), denotes a "economic community that is sustained by a foundation of interacting organizations and individuals." In this community, a variety of entities, including suppliers, customers, competitors, and regulatory bodies, work together to generate and distribute value to end users. This viewpoint underscores the importance of cooperative relationships and interdependence in the context of modern business.

Moore also delineates the evolutionary stages of a business ecosystem, which progress through four phases: Birth, Expansion, Leadership, and Self-Renewal. Each stage presents unique cooperative and competitive challenges, as depicted in Figure 1 below:

The Evolutionary Stages of a Business Ecosystem

	Cooperative Challenges	Competitive Challenges
Birth	Work with customers and suppliers to define the new value proposition around a seed innovation.	Protect your ideas from others who might be working toward defining similar offers. Tie up critical lead customers, key suppliers, and important channels.
Expansion	Bring the new offer to a large market by working with suppliers and partners to scale up supply and to achieve maximum market coverage.	Defeat alternative implementations of similar ideas. Ensure that your approach is the market standard in its class through dominating key market segments.
Leadership	Provide a compelling vision for the future that encourages suppliers and customers to work together to continue improving the complete offer.	Maintain strong bargaining power in relation to other players in the ecosystem, including key customers and valued suppliers.
Self-Renewal	Work with innovators to bring new ideas to the existing ecosystem.	Maintain high barriers to entry to prevent innovators from building alternative ecosystems. Maintain high customer switching costs in order to buy time to incorporate new ideas into your own products and services.

Figure 1: The Evolutionary Stages of a Business Ecosystem

Source: Moore (1993)

Building upon Moore's foundational work, Adner (2017) defines ecosystems as structured networks where partners align their activities to fulfill a shared value proposition. This alignment is essential for the efficient and adaptable management of the intricate interdependencies that define ecosystems. This coordination is particularly apparent in digital ecosystems, where modularity and interoperability are critical enablers of scalability and innovation. This is a direct extension of Moore's insights into the evolutionary stages of ecosystems, as the transition between phases is frequently determined by the alignment of stakeholders.

One of the defining features of business ecosystems is their modular structure, which allows participants to operate semi-independently while contributing to the system as a whole. By allowing individual components to evolve without disrupting the broader network, this modularity promotes innovation. Jacobides et al. (2018) introduce the concept of ecosystem health, which they quantify by evaluating dimensions such as robustness, productivity, and niche creation. Robustness is the capacity of the ecosystem to maintain functionality in the presence of external shocks, while productivity assesses the efficiency of transforming inputs into valuable outputs..

Niche creation emphasises the ecosystem's ability to cultivate opportunities for new participants, thereby fostering sustained innovation and diversity. These characteristics are indispensable for ecosystems that intend to flourish in environments that are both competitive and rapidly evolving.

Inspired by biological ecosystems, business ecosystems highlight the co-evolution and adaptability of their participants. Business ecosystems, in contrast to conventional organizational models that are restricted to industry boundaries, surpass these constraints by integrating a diverse array of stakeholders from various sectors. This adaptability is further bolstered by their modular nature, dynamic system in which roles and relationships evolve in response to internal and external changes, fostering continuous innovation and resilience (Gao, 2021). The interplay between adaptability and modularity guarantees the resilience of ecosystems while simultaneously fostering the development of innovative solutions.

The significance of business ecosystems in confronting modern challenges, including technological disruption and globalisation, is rooted in their adaptability. By fostering collaboration and facilitating continuous innovation, business ecosystems provide a robust model for understanding and leveraging the complexities of modern economic interactions. This integrative perspective emphasises the role of modularity, as defined by Adner and Jacobides, in the resilience and scalability of ecosystems in a world that is becoming more interconnected.

2.1.2. Exploring Modularity in Business Ecosystem

The principle of modularity has been extensively explored as a key mechanism for managing complexity in both organizational systems and product designs. Although Simon (1962) initially presented the concept of modularity in his theory of "nearly decomposable systems", Baldwin and Clark (2000) were instrumental in formalising its application to the design of complex systems through their book, *"Design Rules: The Power of Modularity"*. Modularity refers to the degree to which a system's components

can be separated and recombined. This ability allows ecosystems to maintain coherence and efficiency while adapting flexibly to change. Modularity is essential in the context of business ecosystems, as it promotes innovation, supports scalability, and guarantees resilience to disruptions.

Modularity emerged as a response to the increasing complexity of systems. Baldwin and Clark (2000) underscore the fact that modularity offers a collection of "design rules" that partition a system into smaller subsystems or modules, each of which is defined by standardised interfaces. These design rules enable various modules to operate independently while simultaneously interacting seamlessly within the overarching system. Sanchez and Mahoney (1996) provide additional detail on this topic by elucidating how modularity in product design facilitates the development of "*loosely coupled*" systems, which allow for the modification or development of individual components without requiring changes to the entire system. This loose coupling is fundamental to the application of modularity in ecosystems, as it reduces coordination costs and improves strategic flexibility. This concept has emerged as a fundamental principle for balancing adaptability and complexity in dynamic environments. This principle enables organizations to maintain overall coherence by delegating tasks to specialised units while utilising shared standards and interfaces (Jacobides et al., 2018). In this way, modularity allows companies to effectively manage complexity, thereby promoting collaboration and autonomy among ecosystem participants.

Business ecosystems leverage modularity to align interdependent activities across diverse participants. This is exemplified by platforms such as Android and iOS, which allow third-party developers to innovate independently while adhering to predefined standards. Yoo (2013) emphasises that modularity is essential for the effective integration of resources and competencies in digital ecosystems, which in turn facilitates the rapid adoption of new technologies and reduces barriers to entry (Temple University & Yoo, 2013). Modularity enables ecosystems to evolve

organically, responding rapidly to technological advancements and market demands, by promoting decentralised innovation. The influence of modularity in ecosystems is not limited to technical architecture; it also encompasses organizational structures. Jacobides et al. (2018) suggest that modularity contributes to ecosystem health by improving three critical dimensions: robustness, productivity, and niche creation. The efficiency of converting inputs into valuable outputs is reflected in productivity, while the system's ability to withstand disruptions is measured by robustness. Niche creation encourages the inclusion of new participants, thereby promoting innovation and diversity. Together, these dimensions are the foundation of modular ecosystems' competitive advantage and sustainability. Modular ecosystems are also essential for the preservation of a balance between competition and collaboration, which enables firms to innovate without compromising system coherence.

Jacobides et al. (2018) further introduce the concept of supermodularity, which underscores the potential of the ecosystem's value to be enhanced by the interdependencies between modular components. The system's overall functionality and efficiency are improved beyond the sum of its parts when specific modules are combined. This is known as supermodularity. This concept is especially pertinent in digital ecosystems, where network effects are facilitated by complementarities between technologies or participants, thereby bolstering the ecosystem's competitive advantage.For example, the integration of software applications with hardware modules in mobile ecosystems demonstrates how supermodularity fosters innovation and scalability.

The benefits of modularity are particularly pronounced in industries characterized by rapid technological change and global interconnectivity. This ability is indispensable for the promotion of collaborative innovation and the management of intricate supply chains. Baldwin (2008) examines the impact of modularity on organizational boundaries, contending that firms can utilize modular structures to balance internal capabilities with external partnerships (Baldwin, 2008). Studies highlight how

modular designs have transformed industrial organization, particularly in the mobile device sector, enabling firms to better adapt to changing consumer demands and technological advancements (Thun et al., 2022). Strategic experimentation is also facilitated by the adaptability that modularity provides. Thun (2022) illustrates how modular designs in the mobile device industry have enabled companies to rapidly test and iterate on new configurations. This experimental flexibility has been essential for navigating the complexities of global supply chains and adapting to changing consumer preferences. Additionally, Thun emphasises that modular ecosystems frequently serve as a foundation for the integration of emerging technologies, including blockchain and artificial intelligence, thereby improving their competitive advantage. Baldwin and Clark (2000) also underscore the importance of modularity in that it provides firms with "real options" which enables them to postpone decisions until uncertainties are resolved. This is essential for successfully navigating unpredictable markets.

While modularity offers significant advantages within the business ecosystem, its implementation is not without challenges. Yoo (2013) observed that the capacity of modular frameworks to preserve coherence can occasionally be exceeded by the escalating complexity of digital ecosystems. This issue is especially pertinent in systems that are highly interconnected, as the dependencies between modules can become opaque, which can complicate governance and coordination. Additionally, the persistent challenge of striking the appropriate balance between standardisation and flexibility persists, particularly in ecosystems that involve a variety of participants with varying objectives. In addition, Yoo (2013) suggested that the interplay between modularity and innovation may experience diminishing returns as ecosystems expand in size and diversity. This is due to the potential for excessive modularisation to restrict creativity by imposing overly strict rules. This underscores the necessity of conducting regular assessments of modular structures to guarantee that they continue to be consistent with the ecosystem's changing objectives and complexities.

Jacobides et al. (2018) underscore the importance of modularity in the development of sustainable and adaptive ecosystems, as it guarantees their continued relevance in a constantly changing economic environment. As businesses confront the challenges of technological disruption and globalisation, modularity functions as a natural bridge for investigating the ways in which digital technologies, including blockchain and tokenization, improve ecosystem structures by promoting decentralised coordination and increased adaptability.

2.2. Digital Technologies in Business Ecosystems

2.2.1. Evolution of Business Ecosystem with the Advent of Digital Technologies

The advent of digital technologies has profoundly reshaped the landscape of business ecosystems, transforming traditional value chains into interconnected networks. The way in which businesses collaborate, compete, and deliver value has been revolutionised by technologies such as blockchain, the Internet of Things (IoT), artificial intelligence (AI), and cloud computing. Subramaniam et al. (2019) emphasise the transformation of digital ecosystems from isolated industry structures to dynamic networks, where a variety of actors, such as firms, customers, and suppliers, interact seamlessly to generate new growth opportunities.

Digital transformation has expanded the scope and significance of ecosystems, enabling unprecedented levels of integration and scalability. For example, the music industry has transitioned from a product-based model (physical media) to an ecosystem-driven approach, which includes streaming platforms, social media, and AI-driven personalisation. In a similar vein, the healthcare sector is currently experiencing a digital transformation, as traditional pharmaceutical companies are collaborating with technology giants like IBM Watson and Alphabet's Verily to provide innovative health solutions. These examples demonstrate the widespread

influence of digital technologies on the ability of ecosystems to adapt, co-evolve, and confront the complex nature of modern markets (Parker et al., 2016; Subramaniam et al., 2019).

Additionally, the retail industry offers another striking example of this transformation. Logistics, artificial intelligence, and cloud computing have been integrated by e-commerce platforms such as Amazon to improve the customer experience and streamline operations, thereby revolutionising consumer interactions. For instance, Amazon's sophisticated AI-driven recommendation system analyses customer data to offer personalised recommendations, thereby boosting user engagement and sales. Furthermore, platforms like Alibaba employ predictive algorithms and real-time analytics to optimise inventory management, guaranteeing that products are readily accessible to satisfy fluctuating consumer demands. These capabilities not only meet the diverse needs of the market but also enable the rapid adoption of new technologies, thereby allowing businesses to remain competitive in an era of constant change. The dynamic and resilient marketplace is fostered by these ecosystems, which ensure value creation for both businesses and consumers by utilising data analytics, automation, and personalised services.

2.2.2. Production and Consumption Ecosystems

The relation between production and consumption within business ecosystems has been significantly redefined by digital transformation. Subramaniam et al. (2019) emphasise that these ecosystems are no longer isolated, but rather intricately linked, with digital technologies serving as the connective tissue. The emergence of production and consumption ecosystems has facilitated the seamless flow of value, transforming processes that were previously linear and siloed into interconnected and dynamic systems. Innovations such as digital envelopes and product-in-use information facilitate this transformation by bridging the operational gaps between creation and consumption. Subramaniam et al. (2019) emphasise that this integration

not only promotes efficiency but also innovation, as organizations utilize real-time data and cross-ecosystem collaborations to provide superior value.

- **Production ecosystems:** These focus on the creation and distribution of goods. Subramaniam et al. (2019) describe them as intricate networks of suppliers, manufacturers, and distributors collaborating to optimize efficiency and innovation. For instance, the automotive industry, where firms like Tesla have integrated IoT sensors and real-time analytics into their supply chains, exemplifies production ecosystems that enhance efficiency and reduce costs.
- **Consumption ecosystems:** These are the result of the interdependencies that arise during the use of products, which generate value by enhancing user experiences and adding new functionalities. The role of IoT and connected devices in the transformation of traditional products into smart, adaptable tools is underscored by Subramaniam et al. (2019). For example, a smart bulb can be integrated with platforms such as Amazon Echo to offer energy management and security features, thereby expanding its functionality beyond basic lighting.

Digital envelopes and product-in-use information have emerged as critical mechanisms that facilitate seamless integration and promote innovative value creation strategies, leveraging the interactions between production and consumption ecosystems.

- **Digital Envelopes**: These are digital representations of physical products that capture real-time usage data to enhance performance and informed decision-making. Subramaniam et al. (2019) underscore their responsibility for the seamless integration of production and consumption processes. For example, Rolls-Royce has implemented IoT sensors into its aviation engines to facilitate predictive maintenance and monitor performance, thereby reducing downtime and improving operational efficiency. This application is a prime example of

how the Internet of Things (IoT) can revolutionise conventional industries by offering real-time data insights.

Product-in-Use Information: This includes the data that is gathered during the operation of a product, which is used to enhance the delivery of services, customisation, and efficiency. Subramaniam et al. (2019) provide an example of General Electric's aviation engines, which demonstrate how real-time performance tracking improves operational efficiency and minimises unplanned downtime.

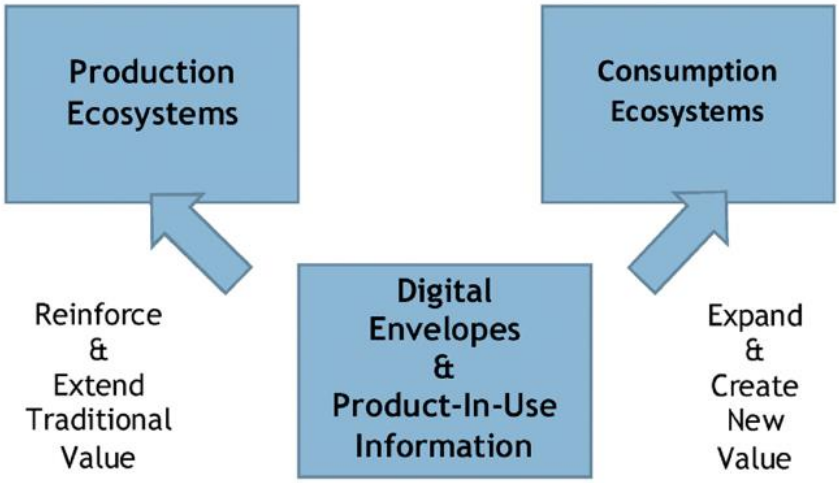


Figure 2: Framework for digital ecosystems

Source: Subramaniam et al. (2019)

2.2.3. Strategic Importance and Competitive Advantages of Digital Ecosystem

The way businesses operate has been significantly altered by digital ecosystems, which have established a foundation for collaboration and innovation across a variety of industries (Parker et al., 2016). Companies can reduce transaction costs and improve interoperability by aligning a diverse range of stakeholders through standardised interfaces, which can be achieved by utilising digital platforms. Ecosystems facilitate collaboration by enabling businesses to integrate diverse participants, while

simultaneously fostering innovation and scalability, as exemplified by platforms such as Apple's App Store and Amazon's marketplace. Subramaniam et al. (2019) emphasise the importance of these ecosystems in navigating the intricacies of digital transformations, as they offer the necessary adaptability to rapidly changing markets.

The capacity of digital ecosystems to serve as orchestrators, which facilitates the alignment of participants and generates collective value, is one of their most strategic attributes. Platforms generate opportunities for the development of complementary products and services, which subsequently enhance network effects (Jacobides et al., 2018). These effects enhance ecosystem sustainability and scalability, as observed in platforms like Microsoft Azure and Google Cloud, where seamless integration of third-party applications drives both innovation and growth.

Modular architectures are essential for the flexibility and resilience of digital ecosystems. For example, the App Store of Apple serves as an illustration of how modularity enables independent developers to innovate while maintaining adherence to ecosystem standards, thereby promoting scalability and resilience. This modularity, as it is said in the previous chapter, is especially advantageous in the context of disruptions, as it prevents the system from malfunctioning by isolating malfunctions within specific components. Furthermore, the modular framework facilitates the rapid integration of emerging technologies, as evidenced by the seamless integration of artificial intelligence and blockchain. Modular architectures enhance firms' ability to adapt to disruptions and facilitate seamless interoperability within digital ecosystems (Baldwin & Clark, 2002). Additionally, interdependencies are leveraged by digital ecosystems to create distinctive value opportunities. Platforms such as Alibaba's ecosystem integrate e-commerce, digital payments, and logistics to provide comprehensive value to both consumers and businesses by capitalising on network effects and interconnectedness. Subramaniam et al. (2019) underscore that these interdependencies not only create efficiency but also open new market opportunities, enabling firms to innovate and expand their reach.

Platforms also facilitate the development of trust and transparency within ecosystems. For example, blockchain technology facilitates decentralised applications (dApps) that guarantee secure and transparent interactions among participants. These capabilities are utilized by platforms such as Ethereum to promote collaboration and mitigate risks, thereby establishing a strong foundation for long-term innovation and competitiveness.

The strategic significance of digital ecosystems is anticipated to increase in the future as a result of the integration of advanced technologies such as artificial intelligence (AI). Predictive analytics and machine learning are employed by AI-powered platforms. These technologies enhance operational efficiency and provide participants with the capacity to anticipate and respond to market trends. Ecosystems can facilitate continuous innovation, optimise resource allocation, and create highly personalised consumer experiences by employing AI. Furthermore, the proliferation of generative AI tools, including OpenAI's GPT models, has facilitated the automation of intricate processes and the provision of improved value propositions for businesses. These developments further substantiate the function of digital ecosystems as catalysts for adaptability and growth in interconnected markets.

So digital ecosystems are becoming increasingly important in competitive strategies as they continue to develop. Ecosystems are capable of adapting to changing market dynamics and promoting innovation by incorporating emerging technologies such as blockchain, AI, and IoT. For instance, platforms such as Siemens MindSphere utilize the Internet of Things (IoT) to establish connections between industrial equipment, thereby offering operational insights and predictive maintenance. This demonstrates how digital ecosystems are redefining traditional industries by establishing new opportunities for collaboration and value creation.

2.3. Blockchain and Tokens

2.3.1. Overview

Blockchain technology has emerged as a revolutionary innovation, disrupting conventional systems and facilitating the development of new paradigms for digital interactions and value transfer. At its core, is a distributed ledger, a decentralized peer-to-peer system constituted of shared and distributed time-stamped documents (Di Pierro, 2017). Blockchain was initially developed as a decentralised ledger for financial transactions, as evidenced by Satoshi Nakamoto's Bitcoin whitepaper in 2008. However, the transformative potential of distributed ledger technology has been demonstrated by the fact that its applications have since been extended to a diverse array of industries (Nakamoto, 2008). The impact of blockchain has been further augmented by the integration of tokens, which are digital assets that are created and managed on blockchain networks. Tokens fulfil a variety of functions, including the facilitation of transactions, the representation of ownership, access rights, or governance within digital ecosystems. This chapter explores the development of blockchain technology, the classifications and concepts of tokens and their applications.

2.3.2. The Evolution of Blockchain Technology

The Evolution of Blockchain Technology Blockchain technology, introduced by an anonymous entity known as Satoshi Nakamoto in 2008, revolutionized the concept of a decentralized ledger through the publication of the Bitcoin whitepaper, "*Bitcoin: A Peer-to-Peer Electronic Cash System.*" This innovation marked the introduction of the first cryptocurrency and underscored the importance of secure, transparent transactions in the absence of a centralised authority (Nakamoto, 2008). The fundamental innovation of blockchain was its capacity to preserve immutable records across distributed nodes, thereby promoting trust in a trustless environment.

Blockchain technology has undergone substantial progress since its inception. The initial focus of blockchain technology was on financial transactions; however, it has since broadened to include a variety of sectors (Schneider et al., 2020). The smart contract functionality of Ethereum, which was introduced by Vitalik Buterin in 2014, is a revolutionary advancement that enables automated and self-executing contracts with terms directly encoded into code (Buterin, 2014). This capability enabled the development of decentralised applications (dApps), which operate without intermediaries, so increasing efficiency and decreasing expenses.

A wide range of blockchain platforms have emerged, each with unique capabilities that are specifically designed for different applications, in addition to Ethereum. For example, Hyperledger Fabric, which was developed by the Linux Foundation, prioritises enterprise solutions and provides a modular architecture that simplifies the installation of plug-and-play components. Another noteworthy development is the emergence of blockchains that prioritise privacy, including Monero and Zcash, which offer improved anonymity capabilities.

The emergence of Decentralised Autonomous Organizations (DAOs) is another significant development in the blockchain ecosystem. Decentralised Autonomous Organizations (DAOs) have emerged as a transformative concept in blockchain governance. These organizations employ blockchain technology to facilitate transparent and decentralised decision-making processes, eliminating the necessity for centralised authority (Wang et al., 2019).

Finally recent advancements include the emergence of layer-2 solutions, such as the Lightning Network, which address scalability issues, and multi-chain ecosystems that enable interoperability between different blockchains. These advancements guarantee that blockchain technology continues to develop, thereby satisfying the requirements of progressively intricate applications.

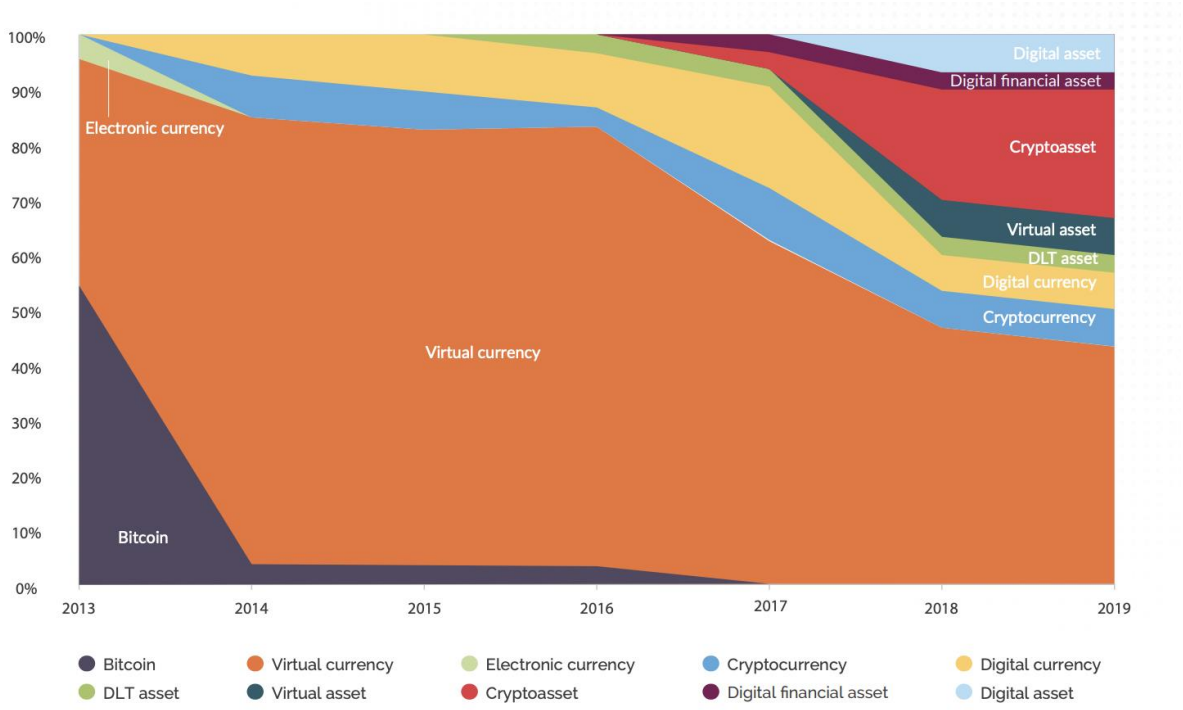


Figure 3: Evolution of Terminology Used by Regulators

Source: Global Cryptoasset Regulatory Landscape Study, University of Cambridge, 2019 (Blandin et al., 2019)

2.3.3. Blockchain Key Characteristics

Blockchain technology possesses unique characteristics that distinguish it from conventional systems. Below is an overview of its primary attributes:

- **Immutability**: Blockchain ensures that data, once recorded and verified, is incapable of being easily modified or deleted. This is accomplished by a consensus mechanism, which necessitates the agreement of multiple nodes in the network to validate a new block. The integrity of the entire system is protected by these mechanisms, which render it nearly impossible to tamper with existing blocks (Zheng et al., 2017).
- **Decentralisation**: Blockchain operates on a peer-to-peer network, where all nodes act as independent participants, in contrast to centralised systems that are subject to a single authority. The risk of single points of failure is mitigated

by assigning roles to nodes in accordance with the specific blockchain application, which reduces the dependence on central servers (Di Pierro, 2017). Decentralisation also facilitates tokenized incentives for network participants who contribute to its maintenance.

- **Transparency**: All transaction records are fully visible on public blockchains. Each transaction is recorded in a distributed ledger that is accessible to all nodes in the network. A distinctive alphanumeric address is assigned to each node, which guarantees privacy while simultaneously preserving traceability. This transparency fosters trust in the system, even among participants who do not possess pre-existing trust (Iansiti & Lakhani, 2017).
- **Consensus Mechanisms**: Consensus algorithms, including proof-of-work and proof-of-stake, are essential for the integration of new blocks into the blockchain. In order to guarantee fairness and safeguard the system from potential attacks, these mechanisms necessitate network-wide consensus regarding the validity of transactions. Security is preserved while decentralisation is preserved through the utilization of collective decision-making.

2.3.4. Tokenization: Types and Roles

Tokens have emerged as critical element of blockchain ecosystems, acting as digital representations of assets, rights, or utilities that are recorded and verified on a blockchain (Carapella et al., 2023). They can be used for a variety of purposes, such as enabling payments and providing access to specific functionalities within decentralized networks. Tokenization is the process of transforming tangible or intangible rights or assets into digital tokens that are recorded on a blockchain (Carapella et al., 2023). The purpose and functionality of tokens are the determining factors in their classification, with each type playing a pivotal role in blockchain ecosystems:

1. **Payment Tokens**: Serve as a medium of exchange that is analogous to conventional currencies. Identical to conventional currencies, these are employed as a medium of exchange. Bitcoin is the most prominent example of a payment token. Payment tokens facilitate peer-to-peer transactions by eliminating intermediaries, thereby reducing transaction costs and increasing transaction speed.
2. **Utility Tokens**: Grant users access to particular services or functionalities within a blockchain ecosystem. For example, Ethereum's Ether is employed to compensate for computational services and transactions on the Ethereum network. In order to pay for services within a particular blockchain platform or to access specific features of a decentralised application (dApp), utility tokens are frequently employed.
3. **Security Tokens**: Are subject to securities regulations and represent ownership in an underlying asset or entity. The tokens are utilized to raise capital, and the holders of the tokens receive dividends or profits. Security tokens are designed to provide investors with rights and protections that are comparable to those of traditional securities, thereby offering a unique approach to capital raising and trading ownership interests.
4. **Non-fungible tokens (NFTs)**: Uniquely identifiable tokens representing ownership of digital assets such as art, music, and virtual real estate. Distinguishing them from fungible tokens like Bitcoin or Ether, each NFT is distinct and cannot be exchanged on a one-to-one basis with another NFT. NFTs have gained significant momentum in a variety of sectors, including gaming, entertainment, and art by facilitating digital scarcity and verifying ownership (Tasca, 2019). They leverage on blockchain's capabilities to establish authenticity and provenance, generating new opportunities for digital ownership (Colicev, 2023).

Stablecoins and digital product passports (DPPs) serve as additional illustrations of the tokenization process's progression. Stablecoins are blockchain-based digital assets designed to maintain a stable value by being linked to traditional currencies or other assets (Bullmann et al., 2019). Stablecoins, including USD Coin (USDC) and Tether (USDT), provide a connection between traditional financial systems and blockchain technology by guaranteeing a consistent value (Bullmann et al., 2019). These tokens are increasingly used for payments, remittances, and decentralized finance (DeFi) applications, enhancing accessibility and reducing transaction costs. Digital product passports, on the other hand, showcase tokenization's potential in supply chain transparency and product lifecycle management (*Digital Product Passport, a Blockchain-Based Perspective - European Commission*, 2024). DPPs are digital records stored on blockchain that contain key information about a product's origin, composition, and history, ensuring traceability and compliance (Abreu et al., 2025). DPPs facilitate the verification of authenticity, traceability, and regulatory compliance by incorporating product information into tokenized records (Abreu et al., 2025). This innovation is especially significant in industries such as luxury goods, where trust and provenance are essential.

In order to enhance the functionality and interoperability of tokens within blockchain ecosystems, numerous technical standards have been established. Among all, these are the most relevant:

- **ERC-20**: The most frequently employed standard for fungible tokens, enabling seamless integration and interaction with wallets and decentralised applications (dApps) (Vogelsteller & Buterin, 2015).
- **ERC-721**: is a standard for non-fungible tokens (NFTs) that is extensively utilized in the fields of digital art, gaming, and collectibles. It facilitates the identification and ownership of unique assets (Entriken et al., 2018).

The transformative potential of tokens across sectors is underscored by their multifaceted roles. From enabling decentralized governance to fostering new economic models, tokenization continues to redefine the boundaries of what blockchain technology can achieve.

2.3.5. Applications of Blockchain and Tokens

Innovative solutions to traditional obstacles have been offered by blockchain technology and tokens, which have demonstrated transformative potential across a multitude of industries (Tasca, 2019). This section investigates their applications, with a focus on real-world use cases in order to have a clear understanding of how can be employed.

- **Financial Services**: The financial sector has been at the forefront of blockchain adoption. The decentralised architecture of blockchains has significantly improved transactional transparency, reduced costs, and enhanced security. For example, payment networks such as Ripple and Stellar facilitate cross-border transactions that are nearly instantaneous and incur lower fees than conventional systems. Tokens, particularly stablecoins, have transformed digital payments by reducing volatility and offering a viable alternative to conventional banking systems. Additionally, decentralised finance (DeFi) platforms utilize smart contracts to offer financial services, including lending, borrowing, and staking, without intermediaries, thereby democratising access to financial tools.
- **Supply Chain Management**: The immutable ledger and transparency of blockchain technology have revolutionised supply chain operations, thereby resolving issues such as inefficiency, fraud, and traceability. IBM has implemented blockchain solutions through initiatives such as IBM Food Trust, which facilitates end-to-end traceability of food products. Similarly, tokenized systems are being implemented to confirm the authenticity of products,

particularly in sectors such as luxury goods. Digital product passports (DPPs) enable stakeholders to access a comprehensive lifecycle history of products, thereby promoting regulatory compliance and trust.

- **Healthcare**: Blockchain technology improves data security and interoperability in the healthcare sector. While facilitating seamless access across various healthcare providers, decentralised records guarantee the integrity of patient data. Secure patient identification is facilitated by blockchain-based identity tokens, which enhance data privacy and administrative efficiency. Smart contracts are employed by projects such as MedRec to manage patient consent, thereby fostering trust between patients and providers and ensuring compliance with regulations (Azaria et al., 2016).
- **Digital Identity and Authentication**: The role of blockchain in digital identity management addresses critical challenges related to security and accessibility. Tokenized digital identities provide users with the ability to manage their data, thereby reducing the risks associated with centralised databases. Veramo and other platforms offer blockchain-based identity solutions that enable individuals to securely authenticate themselves while preserving their privacy. These systems are especially important for the purpose of streamlining the Know Your Customer (KYC) processes in financial institutions and combating identity fraud. Pineda et al. (2020) discuss how blockchain's layered architectures increase digital identity systems by providing users with greater control over their data and ensuring robust privacy and security (Pineda et al., 2024). Such advancements align with the capabilities seen in decentralized identity platforms like Veramo.
- **Art and entertainment**: Non-Fungible Tokens (NFTs) have disrupted the art and entertainment sectors by enabling creators to tokenize digital content. Creators are able to directly monetise their work, as each NFT is uniquely

identifiable and associated with specific digital assets, thereby ensuring provenance. NFTs have been incorporated into gaming, granting players ownership of in-game assets that can be traded or utilized across various platforms, in addition to art (Colicev, 2023).

- **Real Estate**: The real estate industry has embraced tokenization, resulting in the representation of properties as fractionalised tokens on blockchain networks. This advancement reduces the obstacles to real estate investment, thereby facilitating its accessibility to a broader audience. Real estate assets are tokenized by platforms such as RealT, which enables investors to acquire shares of properties and receive rental income that is proportional to their holdings. The tamper-proof nature of property ownership records is guaranteed by the transparency of blockchain technology, which in turn reduces administrative overhead and enhances trust.
- **Energy Sector**: Blockchain enables peer-to-peer energy trading by facilitating the decentralisation of energy markets. The secure and transparent infrastructure of blockchains enables consumers and producers to engage in direct energy trading through platforms such as Power Ledger. Tokenized energy credits encourage sustainable practices by compensating users for the production of renewable energy, thereby supporting global initiatives to combat climate change.
- **Government and Public Services**: Blockchain is being increasingly utilized by governments to provide public services, with a particular emphasis on voting and record-keeping. Immutable records of cast votes are provided by blockchain-based voting systems, which enhance election transparency and reduce fraud. Furthermore, land registries that are powered by blockchain technology guarantee secure and tamper-proof documentation of property

ownership, fostering trust in public institutions and reducing disputes (Faiz et al., 2023).

The applications of blockchain and tokens span a wide range of industries, demonstrating their versatility and transformative potential. Through the improvement of security, efficiency, and transparency, these technologies address critical challenges and unlock new opportunities for value creation. The empirical evidence of these applications will be further substantiated by the insights obtained from the interviewed companies, which will also illuminate the ways in which blockchain and tokenization drive innovation and transform traditional business paradigms.

2.4. Tokens and Their Role in Shaping Business Ecosystems

2.4.1. Impact of Tokens on Business Ecosystem Dynamics

The successful exploitation of blockchain technology necessitates an appropriate business ecosystem. Understanding the roles of various actors within this ecosystem is essential for effective blockchain implementation. This alignment promotes trust, improves collaboration, and guarantees the seamless integration of blockchain-based solutions (Ribeiro Da Silva & Angelis, 2024a). In this context, tokens are essential instruments for facilitating these dynamics, serving as catalysts for coordination and collaboration among a diverse array of stakeholders.

Tokens have emerged as pivotal instruments in shaping the dynamics of business ecosystems, as catalysts for coordination and collaboration among a variety of stakeholders. Tokens facilitate efficient interactions, align incentives, and build trust in decentralised environments by functioning as digital representations of assets or rights. The capacity of tokens to standardise processes and establish interoperable

frameworks is essential for the coordination of ecosystems (Tönnissen et al., 2020). As Wilson (2023) has emphasised, tokens facilitate the exchange of value by establishing a shared language and mechanism, thereby facilitating the seamless collaboration of participants with diverse objectives (Wilson et al., 2022). For instance, governance tokens empower users to influence decision-making processes in decentralised finance (DeFi) platforms, consequently democratising control and aligning the ecosystem's strategic objectives with stakeholder interests. This decentralised governance approach emphasises the transformative potential of tokens in promoting accountability and inclusivity.

Blockchain technology plays a key role in spanning organizational boundaries, fostering trust, and enhancing collaboration across decentralized networks (Mulligan et al., 2020). Organizations can effectively coordinate activities and establish trust within intricate ecosystems by leveraging this boundary-spanning capability to ensure seamless interactions between a variety of stakeholders.

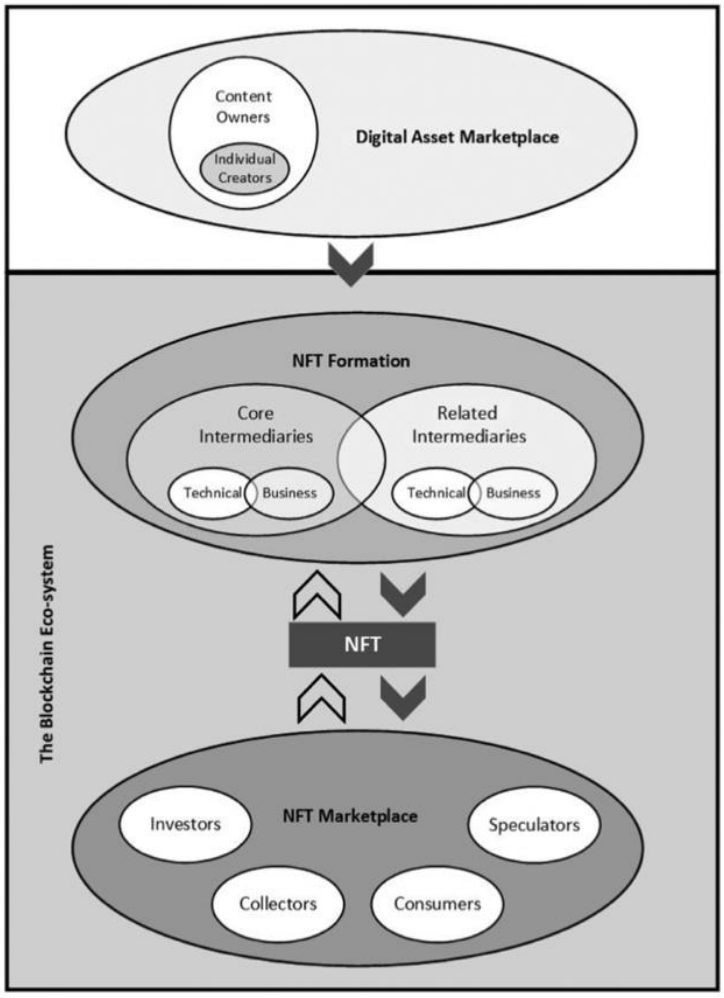


Figure 4: NFT Stakeholders and Relation Ecosystem Conception

Source: (Wilson et al., 2022)

Tokens are essential for the promotion of desirable behaviors within ecosystems, in addition to their role in governance. Tokenized reward systems have been increasingly implemented to encourage active participation and ensure conformity to shared standards. Tokens in supply chain ecosystems ensure that all participants adhere to established protocols and enhance transparency by enabling verifiable record-keeping. An illustration of this is the utilization of Digital Product Passports (DPPs), which tokenize information regarding the origin and lifecycle of products, thereby promoting regulatory compliance and sustainability. The flexibility and adaptability of tokens could enable modularity by supporting interoperability between various

platforms and applications. For instance, platforms like Ethereum utilize utility tokens such as Ether to incentivize network participation and facilitate the functioning of decentralized applications (dApps), highlighting the role tokens may play in fostering ecosystem-wide modularity. The ecosystem's adaptability to changing demands is improved by this capability. Wilson (2023) also suggests that this modularity drives the development of new value streams within ecosystems by allowing businesses to investigate disruptive innovations, such as embedding tokens into real-world assets like property and vehicles, thus expanding the scope of tokenization.

Moreover, tokens have paved the way for new business models and innovative use cases across industries. For example, tokenized access credentials can serve as a security feature that improves decentralized network security and simplifies user authentication. Tokens are utilized in the automotive sector to facilitate the management of car ownership, access permissions, and maintenance records, thereby establishing integrated ecosystems that link manufacturers, service providers, and end-users. These examples emphasize the way in which tokenization is redefining conventional relationships and facilitating more efficient and transparent interactions within business ecosystems.

While tokens play a central role in business ecosystems, the foundational blockchain technology further reinforces trust and accountability. Van Haaren-van Duijn et al. (2022) conduct an analysis of blockchain governance and underscore the importance of its immutable and transparent framework in reducing the risk of opportunistic behaviour (Van Haaren-van Duijn et al., 2022). Despite the fact that their analysis does not explicitly address tokens, the insights into blockchain's capacity to generate verifiable and tamper-proof records are highly pertinent for the building of trust in cross-border ecosystems with a variety of regulatory environments. Blockchain technology improves accountability and collaboration by allowing stakeholders to operate under a common set of rules and values. Wilson (2022) extends the discussion

on tokenization by highlighting its transformative implications for traditional ecosystem dynamics. Tokens facilitate programmable interactions and fractional ownership, thereby generating novel opportunities for value creation and distribution. For instance, the disruptive potential of token-driven models in a variety of industries has been demonstrated by the revolutionization of ownership and provenance in digital art and entertainment using non-fungible tokens (NFTs).

Tokens are essential tools for ecosystem coordination, as they facilitate value exchange, encourage collaboration, and improve modularity and trust. In order to navigate the intricacies of the digital economy, it is imperative to comprehend the role of token-driven frameworks in ecosystem dynamics as businesses continue to adopt them.

2.4.2. Modular Frameworks in Token-Driven Ecosystems

The structure and dynamics of token-driven ecosystems are fundamentally understood through the concepts of modularity, interoperability, and adaptability. These attributes facilitate the efficient operation, integration, and evolution of systems in environments that are constantly evolving and complex. Tokens and blockchain technology have the potential to revolutionise traditional business collaborations by utilising these principles, promoting resilience, innovation, and flexibility. Below are the definitions of these key concepts:

- **Modularity**: Baldwin and Clark (2000) define modularity as the decomposition of a complex system into smaller, self-contained units or modules that can be independently designed, developed, and tested while functioning as part of an integrated whole. This method enables the modification or replacement of system components without disrupting the overall functionality, thereby promoting innovation, scalability, and flexibility.
- **Interoperability**: The Institute of Electrical and Electronics Engineers (IEEE) defines interoperability as the ability of two or more systems, devices, or

components to exchange information and effectively utilize the information exchanged. This is accomplished by utilising standardised protocols and interfaces to guarantee seamless communication and integration across a variety of systems ("IEEE Standard Computer Dictionary," 1991).

- **Adaptability**: Walker et al. (2004) define adaptability as the ability of a system to adjust its processes, structures, or behaviour in response to internal demands or external changes (Walker et al., 2004). It is a reflection of the capacity of systems to maintain or enhance performance in the face of new or uncertain conditions, promoting resilience and long-term sustainability.

Modularity, as it has been said in the Chapter 2.1.2., enables ecosystems to adapt efficiently to technological and market changes. Sanchez and Mahoney (1996) underscore the fact that modular designs enable organizations to deconstruct intricate systems into manageable units, thereby fostering flexibility and innovation. Modularity guarantees that individual components can be independently developed, replaced, or enhanced without compromising the integrity of the entire system by establishing standardised interfaces. This principle is especially advantageous in dynamic environments, where scalability and adaptability are essential.

In tokenized ecosystems, this modular approach is exemplified by programmable tokens, which serve as dynamic connectors between different elements of a blockchain system. These tokens facilitate the automated execution of agreements, thereby streamlining operations and preserving adaptability. For instance, modular frameworks are employed by decentralised finance (DeFi) platforms to seamlessly integrate new financial products, thereby facilitating continuous innovation without necessitating extensive system architecture overhauls.

Additionally, modularity's adaptability is extended to cross-industry applications, where blockchain technology and tokens serve as complementary components. The inherently modular architecture of blockchain platforms facilitates a wide range of use

cases, including decentralised identity solutions and supply chain management, by guaranteeing seamless interoperability between systems. Tokens facilitate modularity by acting as connectors between diverse ecosystem components. In their 2000 study, Baldwin and Clark describe modularity as a strategy to manage design complexity, which allows the independent development and integration of system components. In blockchain-based ecosystems, tokens embody this principle by enabling seamless interaction between independent decentralized platforms.

For example, the ERC-20 and ERC-721 token standards, which were discussed in the previous chapter, serve as illustrations of how technical specifications can standardize interactions. These standards guarantee that tokens generated on various platforms are interoperable, thereby facilitating the expansion of ecosystems without any structural disruptions. Tokens facilitate the integration of participants or functionalities, such as compliance modules or transparency tools, into supply chains without disrupting the underlying blockchain infrastructure. The rapid deployment of customised solutions while maintaining scalability and coherence is made possible by the synergy between tokenization and the robust framework of blockchain technology. Sanchez and Mahoney (1996) emphasize the role of modularity in enabling systems to balance flexibility and coordination through standardized interfaces. Their concept of *'embedded coordination'* is particularly relevant to blockchain ecosystems, where the standardization of token protocols fosters autonomous yet interoperable interactions, supporting innovation and structural coherence across decentralized platforms.

The broader implications of tokenization are highlighted by the rise of NFTs (Non-Fungible Tokens), which exemplify how tokens could enable modularity within business ecosystems. Wilson et al. (2022) have shown that NFTs have the potential to serve as connectors between various ecosystem components by utilizing blockchain's ability to authenticate and manage unique digital assets. Decentralized interactions are facilitated by tokens, which maintain structural coherence by utilizing standardized

protocols and programmable features. This feature of modularity enables ecosystems to incorporate new functionalities, such as transparency tools or compliance mechanisms, without necessitating substantial architectural modifications. Indeed NFTs, exemplify adaptability and modularity by enabling the authentication and management of unique digital assets, thereby allowing systems to integrate new functionalities without disrupting existing frameworks (Li & Chen, 2023). Their capacity to connect digital and physical elements has created new opportunities for consumer engagement and community development, as brands utilize NFTs to develop exclusive, value-driven experiences (Colicev, 2023). The transformative potential of tokenization in promoting resilience, scalability, and collaboration across industries is exemplified by these developments.

In conclusion, the programmability and interoperability of tokens enhance their adaptability, enabling them to address diverse stakeholder needs across industries like art, sports, and supply chain management. Independent components can evolve and innovating without disrupting the broader system, which is consistent with the principles of modular design. These developments underscore the strategic potential of tokenized ecosystems to support innovation, scalability, and collaboration, laying the groundwork for resilient and adaptable business ecosystems.

2.5. Research Question

The literature review has highlighted that, despite the increasing interest in tokenization and blockchain technology, there are substantial research gaps in the comprehension of their strategic role within business ecosystems. Existing research frequently examines these topics in isolation, neglecting to investigate their interconnections and the collective strategic value they provide. In particular, while there is extensive research on the technical and operational aspects of tokens, a comprehensive framework examining how tokens influence characteristics, such as

modularity and adaptability, within ecosystems is lacking. An additional gap concerns the mechanisms through which tokens foster inter-organizational trust and collaboration. Although tokens are recognized for their contributions to governance and incentivisation, there is limited understanding of how they enable businesses to overcome ecosystem boundaries and barriers, particularly in decentralized and multi-stakeholder environments. This necessitates a more thorough examination of the ability of tokens to create resilient networks and facilitate seamless interactions. Lastly, despite the growing adoption of tokenization initiatives, there is insufficient practical guidance for businesses on effectively integrating tokens into their strategies. Businesses frequently lack a clear roadmap for utilising tokenization to address ecosystem-wide challenges and drive innovation, as existing frameworks are frequently fragmented or industry-specific

In order to address these gaps, the following research question has been formulated:

- **RQ**: *How can tokens enable modular ecosystem design and overcome barriers in business ecosystems?*

The objective of this research question seeks to investigate the strategic applications of tokens within business ecosystems. It aims to uncover the mechanisms through which tokens foster ecosystem transformation, identify the factors that contribute their success, and explore frameworks that businesses can utilize to leverage tokenization effectively.

The findings derived from the analysis, combined with the elaboration of a conceptual framework in the discussion, will provide a structured response to the research question. The subsequent chapters will further elaborate on the methodology employed to address this question. The methodology employed to address this question will be elaborated and explained in the following chapter.

3 Methodology

3.1. Premise

This chapter outlines the methodology adopted to conduct this thesis. The decision to employ a multiple case study methodology was guided by several considerations. Firstly, the research questions, presented in the preceding chapter 2.4, necessitate a qualitative approach to capture the complex and multifaceted dynamics of token adoption across different business ecosystems. The multiple case study method is particularly well-suited to addressing "how" and "why" questions in complex and dynamic settings, providing a rich understanding of underlying mechanisms and contextual factors (Eisenhardt & Graebner, 2007; K. R. Yin, 2018).

Moreover, the use of a multiple case design enables a comparative analysis of different contexts, offering insights into both shared patterns and unique variations. In line with the principles outlined by Eisenhardt and Graebner (2007), the methodology integrates qualitative methods aiming to capture the nuances and complexities of business ecosystems' integration dynamics. Semi-structured interviews with key stakeholders were chosen as the primary data collection method, as they allow for a flexible yet systematic exploration of participants' perspectives and experiences. These interviews are complemented by the analysis of secondary data, such as reports and technical documentation, to provide additional context and enhance the reliability of the findings. To ensure the rigor of the analysis, the information collected from the interviews were subjected to a systematic coding process, following established protocols for thematic analysis. This approach facilitates the identification of recurring

patterns and themes across cases, enabling the development of a nuanced understanding of the phenomenon under investigation.

According to the literature, represented in this case by a book published in 1984 by Yin (R. K. Yin, 1984), qualitative research is useful when the researcher has little or no control over events, and when the focus is on a contemporary phenomenon within a real-life context. These points are confirmed in this thesis, as researchers have limited control over events, being external to the organizations involved. Furthermore, the topic of this research is undoubtedly a contemporary phenomenon, given the increasing number of companies' projects with tokens.

As reported by Yin in another study published in 1981, there are two approaches to analyze case studies qualitatively: the Single-Case Design or the Multiple-Case Design. The Single-Case Design refers to situations where the research focuses on a single unit of analysis, selected for its relevance and importance to the phenomenon being studied. It enables an in-depth analysis of the topic, allowing for detailed results on the case, and is characterized by a high level of internal validity due to its focus on a single study, which permits a careful analysis of relationships between variables.

However, this methodology has some weaknesses. First of all, the results obtained are characterized by a low level of generalizability, as the results obtained from a single study can hardly be extended to a large population. At the same time, the Single-Case Design Method has a high risk of bias, as the results may be strongly influenced by certain characteristics peculiar to the case under consideration.

The second possibility is the adoption of Multiple-Case Design Method, that is the methodology selected for this dissertation. The choice of this criterion allows for an in-depth comparison between the different case studies considered, determining recurring paths and other similarities between the different situations analyzed. This is well suited to the aims of this dissertation, which seeks to examine how companies are integrating tokens into their business ecosystem, emphasizing their commonalities.

By integrating insights from literature with rich, qualitative data, this research seeks to contribute both to the academic discourse on modularity and business ecosystems and to practical strategies for organizations navigating this emerging landscape.

3.2. Data Collection

To reduce potential biases and enhance the robustness of our insights, it has been employed, as it said previously, a multi-dimensional research strategy (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). The data sources were twofold: primary and secondary. Primary data were gathered from semi-structured interviews, while secondary data comprised reports, whitepapers, posts on social networks, online news articles.

The primary data corpus was built from several semi-structured interviews. These interviews were executed over the period from May to November 2024.

As a first step, a list of potential organizations on a file Excel has been compiled by searching for companies which have developed initiatives involving blockchain-based tokens, that exploited such technical instrument to tear down ecosystem's barriers. Then, for each organization, a representative or an individual directly responsible for managing and developing the blockchain initiatives has been identified and contacted via mail or LinkedIn. A total of 15 organizations (which are described more in detail in Paragraph 3.2.1 - Interviewed Organizations) agreed to collaborate with the research.

3.2.1. Interview Design

Each semi-structured interview started with a brief introduction in order to set the stage for the interview by describing the research's overall scope. Subsequently, a predefined set of questions was designed to dissect the nuances of token and business ecosystem and to explore key aspects of the research. However, these questions were

intentionally broad, allowing respondents the flexibility to provide open-ended answers and engage in more natural discussions.

With each representative, it was utilized an online communication platform such as Microsoft Teams or Google Meet. All sessions were conducted by the authors, meticulously recorded and then transcribed word for word to preserve the integrity of the data.

3.2.2. Case Selection

The companies involved in this research were selected through a theoretical sampling based on replication, ensuring that the chosen cases would provide both diversity in token-based applications and the opportunity to observe recurring dynamics across different contexts. This approach aimed to identify common patterns in the integration of tokens within business ecosystems, particularly focusing on the concept of modularity, despite variations in industry and application.

These organizations were chosen because they represent concrete use cases that have progressed beyond the conceptual phase, offering firsthand insights into the operational realities of token integration. Their projects span a variety of applications, including improving supply chain transparency, enabling customer engagement through loyalty programs, and facilitating financial innovations such as stablecoins and asset tokenization. The inclusion of companies with diverse missions and industries ensures that the study identifies both common themes and challenges in token adoption.

The selection process involved compiling a preliminary list of potential organizations through an extensive review of industry reports, case studies and public information about blockchain projects. Organizations with completed projects that had already been fully implemented and delivered tangible results were prioritized. This ensured firsthand insights into the operational realities of token integration. Representatives

directly involved in these projects, such as innovation managers, blockchain project leads, business strategists or even CEOs/Founders in case of start-ups were contacted to participate. The study ultimately included companies from sectors such as finance, luxury goods, automotive and technology, based mainly in Italy, but also in other different regions such as France and United States. This geographic and industrial diversity adds richness to the analysis and ensures findings that are both broad and contextually nuanced.

The following table summarizes the companies which agreed to participate at the research, detailing their sectors, locations and the roles of the interviewed representatives.

Companies Interviewed				
Company	Location	Sector	Interviewed Role	Project Type
Company 1	Italy	Automotive	Head of Products	Digital Passport
Company 2	Switzerland	Fashion and Luxury	Chief Technology Officer	Digital Passport
Company 3	Italy	Fashion and Luxury	Head Of Operation Excellence & Technology	Digital Passport
Company 4	Italy	Technology	Chief Executive Officer	Digital Passport
Company 5	San Marino	Technology	Business Development Manager	Supply Chain Traceability
Company 6	Italy	Fashion and Luxury	Innovation Manager	Web 3 Experience
Company 7	Italy	Mobility and Payment Services	Product Manager and Cloud Software Engineer	Web 3 Experience
Company 8	Italy/USA	Hospitality and Tourism	Director Dev & Digital Ecosystem	Booking Tokenization
Company 9	Italy	Hospitality and Tourism	Chief Executive Officer and CO-Founder	Booking Tokenization
Company 10	USA	Finance	Head of Sales & Expansion	Stable Coin
Company 11	France	Finance	Head of Innovation	Stable Coin
Company 12	France	Finance	Business Development Manager	Stable Coin
Company 13	USA	Finance	Portfolio Manager	Assets Tokenization
Company 14	USA	Finance	Governance Liason	De-Fi
Company 15	USA	Finance	Staff Smart Contract Engineer	De-Fi

Table 1: Companies Interviewed

In the Chapter 4 each company's project is described individually and more in detail.

3.3. Data Analysis

The data analysis phase of this research followed a structured and iterative process to explore how companies exploited tokens in their business ecosystems. The primary aim was to uncover patterns and insights that could shed light on the advantages, challenges, and operational outcomes of token integration. This analysis was essential to bridge the gap between theoretical constructs and empirical evidence, ensuring a rigorous and context-sensitive approach.

An abductive methodology was adopted, combining inductive insights emerging from the data with deductive alignment to the theoretical framework established in the literature review. This hybrid approach facilitated the iterative refinement of themes, enabling the development of a coherent narrative that reflects both empirical findings and existing theories (Dubois & Gadde, 2002).

The process was divided into three key stages:

1. **Data Preparation**: Transcripts of semi-structured interviews and secondary data were reviewed to ensure completeness and consistency.
2. **Coding Analysis**: A detailed coding framework was developed to classify data into meaningful categories and themes, starting from classify the identified quotes, coming from the data preparation, and abstract them into the first orders labels.
3. **Aggregation and Proposition**: Emerging patterns were consolidated into higher-order themes and linked to the broader theoretical constructs represented by three propositions that will be properly addressed in the discussion chapter.

To support this whole process, data management tools, such as Microsoft Excel, were used to organize and analyze the qualitative data systematically. This allowed for a transparent and replicable analytical process, which was further validated through peer review and cross-referencing with literature.

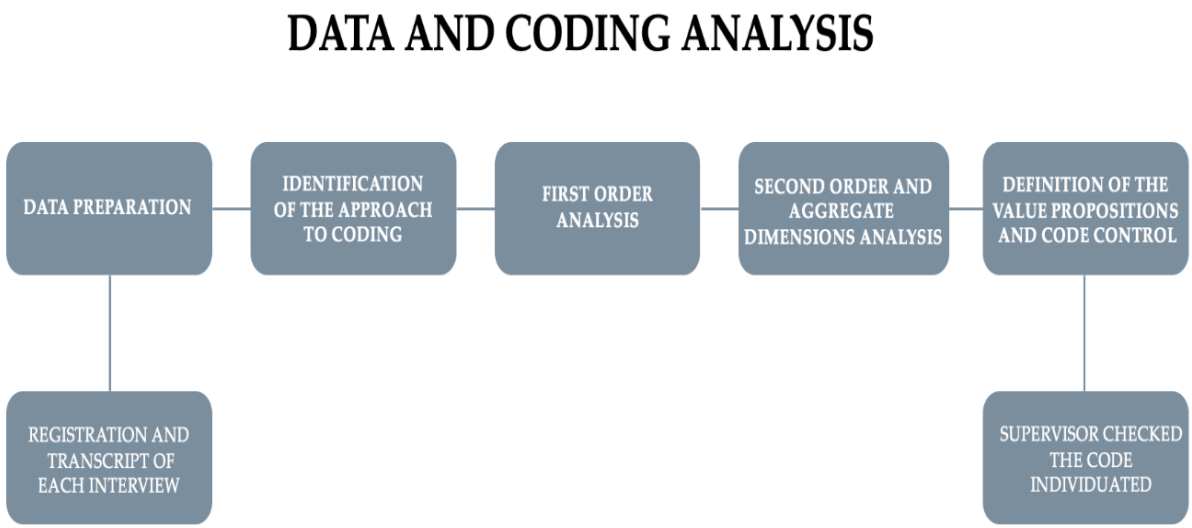


Figure 5: Coding Analysis Process

3.3.1. Coding Approach

The coding analysis represents the core of the data analysis phase, providing a systematic and detailed interpretation of the data collected. The methodology followed the approach outlined by Eisenhardt (1989) in "Building Theories from Case Study Research," leveraging a multiple case study design to build robust theoretical insights from empirical data.

The coding process was conducted in three phases:

1. **First-Order Analysis**: The first stage involved examining raw quotes from the interviews and assigning descriptive codes to capture specific concepts. At this stage, the coding remained close to the data, with minimal abstraction.
2. **Second-Order Analysis**: In the second stage, broader aggregate dimensions were first identified to capture the overarching patterns emerging from the data. These dimensions served as a foundation for further analysis, enabling the identification of more granular second-orders**.** This step required a more interpretative approach, integrating theoretical insights from the literature to connect first-order codes to the higher-level dimensions.
3. **Aggregate Dimensions**: The final stage involved synthesizing second-order themes into overarching dimensions that encapsulate the core findings of the analysis. These dimensions represent the most abstract level of interpretation, linking the empirical data to the research objectives. Finally, the entire coding analysis has been revised to ensure coherence between the coding levels.

This approach ensured that the coding structure, while tailored to the needs of this research, adhered strictly to Eisenhardt's principles for analyzing multiple case studies. Peer reviews and cross-referencing with the literature validated the coding process, ensuring coherence, reliability, and a robust theoretical contribution.

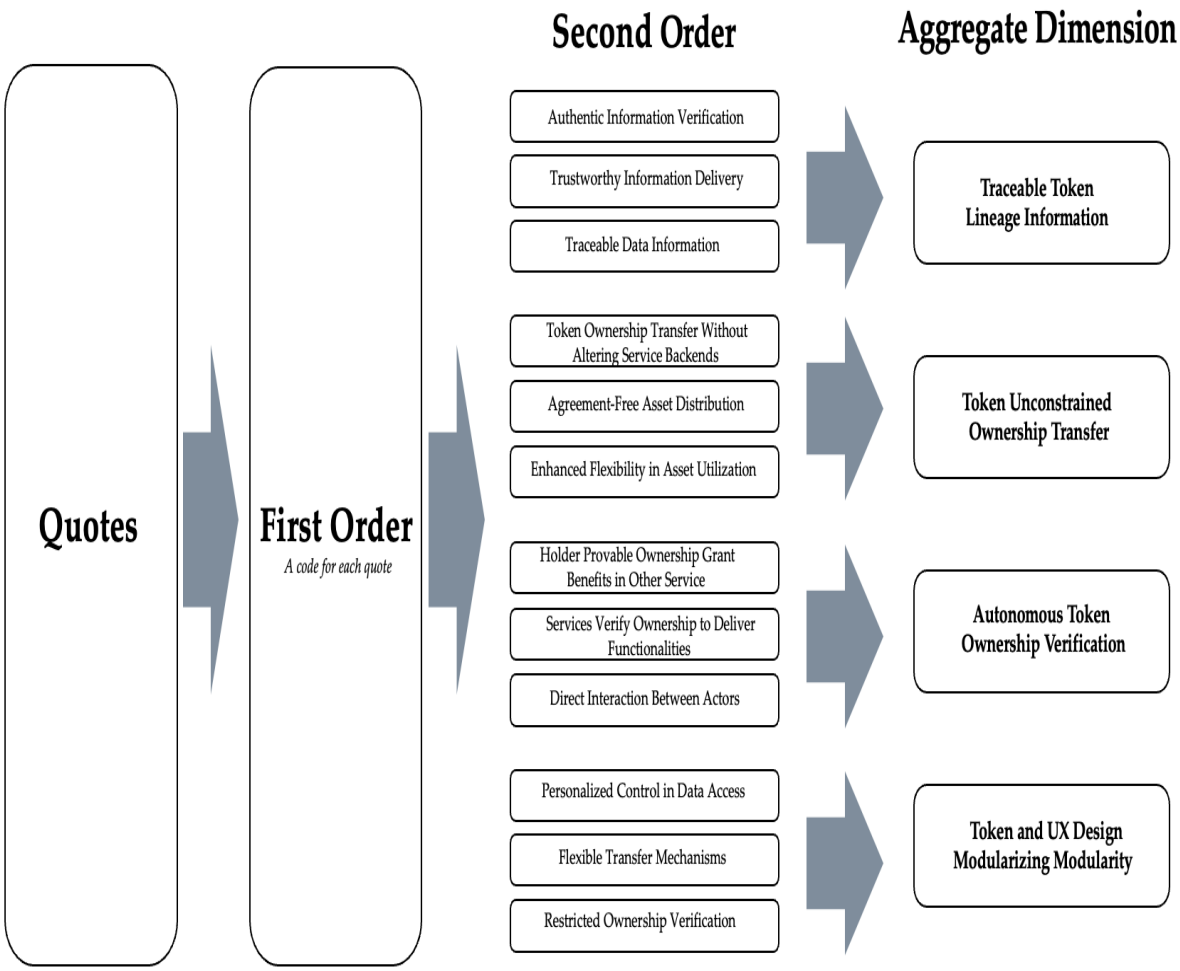


Figure 6: Coding Structure from Quotes to Aggregate Dimensions.

The visual representation of the coding structure (provided in Figure 6) illustrates the progression from raw data to theoretical abstraction, ensuring transparency and traceability in the analytical process.

To ensure reliability, the coding process was conducted iteratively, with regular discussions among the researcher's supervisor to resolve ambiguities and refine interpretations. Additionally, the coding framework was cross-validated against the theoretical framework outlined in Chapter 2.

This systematic and iterative approach to coding allowed for a detailed and nuanced understanding of the role of tokens in business ecosystems, providing a solid foundation for the findings and discussions presented in the subsequent chapters.

3.4. Ethical Consideration

All participants chose to participate in this study of their own free will and were informed about the project in advance. All data collected for this thesis will be treated anonymously, with specific codes replacing the personal names of the professionals to ensure the privacy rights of those involved, in accordance with Italian and European guidelines on personal data privacy and security (*Regolamento - 2016/679 - IT - GDPR - EUR-Lex*, 2016).

To enable participants to consent to be involved in the study without concerns about personal data appearing in the final report, they were asked to provide informed consent. This document, sent to each practitioner at the time of their initial expression of interest in the research, was completed, signed by the participant during the interview, and returned to the authors. The consent form includes the names of those responsible for maintaining the anonymity of the study, a general overview of the study's nature and objectives, a description of how the data (both written and video recordings) would be used, areas of application, and the duration of data retention necessary for completing the research. Each participant's data was stored in a shared OneDrive file, accessible only to the authors of this dissertation and the supervisors overseeing the project. All data used for study purposes will be securely disposed of at the end of the research.

Finally, to guarantee the accuracy and completeness of this study, it is declared that the results obtained from both the literature review presented in Chapter 2 and the interview process discussed in Chapter 5 have been detailed with the utmost transparency, without any omissions or intentional alterations.

4 Case Analysis

4.1. Case Study Descriptions

This section provides an overview of the token-based projects implemented by the companies interviewed, highlighting their purpose, type, and the key actors involved with their interactions in each initiative. The descriptions aim to provide context and clarity on the diversity of use cases analyzed, serving as a foundation for the results analysis presented in the next chapter. Each case description will detail the interactions between relevant actors, illustrating how tokenization is integrated into business ecosystems.

Case Study 1

Company 1, an established Italian automotive brand recognized for its expertise in performance engineering and innovation. As part of its efforts to modernize and improve vehicle lifecycle transparency through digital solutions, the company implemented a token-based certification system to enhance the traceability and residual value of its vehicles. The initiative leverages Non-Fungible Tokens (NFTs) issued directly by the company to create an immutable digital record of each car's specifications at the moment of production The token, registered on the blockchain, acts as a digital certificate storing key vehicle details, continuously updated via real-time data from the black box, including service updates, accident reports, and performance diagnostics. Unlike traditional certification documents, this digital token ensures that the car's original configuration remains tamper-proof over time. Upon purchase, customers receive the NFT, which is linked to their account and digital

wallet. The token can be updated by authorized service centers and the vehicle's onboard black box, which continuously feeds verified data to the blockchain. Service records, accident history, and performance metrics are securely stored, preventing unauthorized modifications and ensuring data authenticity. This ensures a verifiable and transparent history that follows the car throughout its lifecycle. The blockchain technology prevents unauthorized modifications, enabling transparent verification of vehicle history in secondary markets. Prospective buyers can independently confirm past ownership, maintenance history, and any modifications without relying on third-party authentication. When the vehicle changes ownership, the NFT can be transferred to the new buyer, offering an authenticated history of the car's condition. The ecosystem includes multiple actors: Company 1, which issues the NFT; first-hand buyers, who receive and manage the token; authorized service centers, which update records based on verified interventions; and secondary buyers, who can verify the authenticity of the vehicle's history before purchase. The system establishes a digital identity for the vehicle. This identity facilitate future interoperability with resale platforms, insurance providers, and mobility services, automating validation processes through on-chain proof of ownership.

Case Study 2

Company 2, a renowned Swiss luxury watch manufacturer, is recognized for its craftsmanship and technological innovation. The company introduced a Digital Product Passport (DPP) linked to its watches aimed at strengthening transparency and ensuring product authenticity. This approach utilizes Non-Fungible Tokens (NFTs) issued by the company, establishing an unalterable digital record of each watch from the point of manufacture. The token stores key information such as production details, ownership records, warranty status, and maintenance history. The DPP replaces traditional paper-based certificates by providing a tamper-proof digital record that maintains verifiable ownership history. When acquiring a watch, buyers obtain a DPP

connected to their Company 2 profile and digital asset wallet. The token can be updated by authorized service centers, which log maintenance events and repairs on the blockchain, ensuring a verifiable and transparent history of the watch. By ensuring data integrity, blockchain technology eliminates the risk of tampering, fostering greater confidence in resale markets. When the watch changes ownership, the NFT can be transferred to the new buyer, providing an authenticated record of the product's history and streamlining authentication processes in resale transactions. The ecosystem involves multiple actors: Company 2, which issues the NFT thanks to a technological provider; first-hand buyers, who receive and manage the token; authorized service centers, which update records based on verified interventions; and secondary buyers, who can verify the authenticity of the watch's history before purchase. The DPP facilitates direct communication between the company and its customers, even when products are sold through third-party retailers. Additionally, it grants exclusive access to services such as warranty extensions and membership in the Company 2 Club. The NFTs function as unique digital certificates, supporting verification processes in secondary markets and facilitating brand engagement through digital ownership. By leveraging blockchain, this system enhances product verification, market trust, and lifecycle transparency, ensuring secure and verifiable ownership records.

Case Study 3

Company 3, an Italian luxury watchmaker famous for its fusion of Swiss precision and Italian craftsmanship, distinguished by its strong maritime heritage and innovative approach to horology. The initiative utilizes Non-Fungible Tokens (NFTs) to create immutable digital records linked to each timepiece. Each watch is issued a Digital Product Passport (DPP), stored as an NFT on the blockchain, containing key details such as manufacturing specifications, ownership history, and warranty status. This digital passport ensures authenticity, prevents counterfeiting, and facilitates seamless

verification in resale markets. Upon purchase, first-hand buyers receive the DPP-linked NFT, stored in their Company 3 account. The token enables access to brand-specific services, including warranty extensions and priority servicing. When the watch is resold, the DPP is transferred to the new owner, preserving a verifiable ownership record.The ecosystem consists of multiple actors: Company 3, which issues the NFT thanks to a technological provider; first-hand buyers, who manage the digital passport; authorized service centers, which update maintenance records; and secondary buyers, who use the DPP for authentication. Additionally, the system integrates with a famous global lost and stolen timepiece registry, ensuring flagged timepieces are traceable. While the system is not yet connected to virtual ecosystems, its design allows for potential expansion into broader digital authentication networks, enhancing interoperability with emerging technologies. Through blockchain implementation, Company 3 strengthens ownership security, consumer confidence, and asset traceability, ensuring reliable and fraud-resistant certification.

Case Study 4

Company 4, a blockchain-focused startup, developed a tokenization solution designed to bridge the gap between physical products and digital assets. It had collaborated with a professional football club to implement a digital certification system for official team jerseys. Acting as the technology provider, Company 4 developed the Digital Product Passport (DPP) infrastructure, enabling secure ownership verification and traceability. Each jersey is assigned a DPP, recorded as an NFT on the blockchain and managed through Company 4's platform. This digital certificate contains key information such as production details, ownership records, and status updates. The system allows buyers to verify authenticity while preventing counterfeiting and unauthorized transfers. Beyond proving authenticity, this certification enables users to update the status of their jersey in cases of loss, theft, or resale, ensuring the record reflects real-time changes. Company 4 facilitates these updates, ensuring secure and

verified modifications. The ecosystem consists of multiple actors: the football club, which issues the NFTs; Company 4, which operates the verification system and provides wallets and the minting platform; initial buyers, who claim and manage the digital passport; official partners, responsible for status verification; and secondary buyers, who rely on the updated record for authentication. While not yet linked to virtual ecosystems, the system is designed for future compatibility with broader authentication networks. By implementing a blockchain-based framework, Company 4 establishes a verifiable mechanism for ownership authentication, product traceability, and counterfeit prevention, ensuring a transparent and tamper-resistant record for physical merchandise.

Case Study 5

Company 5, a pioneering blockchain infrastructure provider specializing in digital traceability and sustainability solutions, has developed a tokenized reward system designed to incentivize environmentally responsible behaviors. The initiative revolves around a blockchain-based rewards system, where participants earn tokens by engaging in verifiable sustainability efforts. These tokens, issued directly by Company 5, serve as proof of impact and can be redeemed for various benefits within the ecosystem. The blockchain infrastructure ensures tamper-proof tracking of actions, preventing fraudulent claims and reinforcing credibility. Each verified sustainable action grants users a token, stored in their digital wallets, which can be redeemed for services, exchanged or used for governance participation in different applications. The governance mechanism enables token holders to propose and vote on ecosystem-related decisions, including modifications to reward distribution models and sustainability project funding. Additionally, the system provides a layer of security, allowing users to report lost tokens or restrict unauthorized usage, ensuring greater control over digital ownership. The ecosystem consists of multiple actors which interact with the token. Company 5 issues and manages the token infrastructure,

ensuring security and data integrity. First-hand users participate by completing sustainable activities and claiming rewards, directly contributing to the system's impact. Applications within the system function as complementors, interacting with the token to enable new sustainability use cases. Governance participants influence the platform's evolution through decentralized decision-making. Secondary users engage with the token economy by trading, utilizing, or redeeming tokens, thereby ensuring continued circulation and participation in the ecosystem. The system integrates with carbon offsetting networks, impact verification platforms, and digital identity frameworks to enhance transparency and incentivize sustainable actions. Blockchain-based tracking ensures verifiable contributions, while decentralized governance fosters long-term engagement and ecosystem scalability.

Case Study 6

Company 6, a global fashion conglomerate managing a portfolio of renowned luxury brands, specializes in high-end apparel, accessories, and lifestyle products. The company has implemented a token-driven initiative that establishes a verifiable ownership framework for exclusive fashion collections while integrating digital innovations into its brand ecosystem. The project was developed within the group's innovation division, leveraging Ethereum's ERC-1155 token standard to link limited-edition physical apparel to Non-Fungible Tokens (NFTs), specifically for one of the group's Italian high-end apparel brands. Each NFT was associated with a specific fashion item, allowing owners to access exclusive experiences, virtual assets, and gated community perks. Holders of these tokens could participate in priority access programs, such as early invitations to fashion events, members-only product releases, and digital activations. Additionally, some NFTs were linked to digital wearables, allowing users to showcase branded items within virtual environments. Beyond authentication, the system integrated features for ownership verification and resale transparency, ensuring that product authenticity remained intact across secondary

markets.. The ecosystem comprises multiple stakeholders, including the luxury brand within Company 6, which is responsible for issuing NFTs associated with its products. Primary buyers purchase the physical items and receive the corresponding digital tokens, which are linked to their digital identities. The NFTs are seamlessly integrated into the purchasing process, ensuring the verification of digital ownership alongside the physical goods. Additionally, the system supports secondary market transactions, where subsequent buyers can authenticate the product's provenance through on-chain records before completing a purchase. Additionally, the blockchain infrastructure ensured that ownership history and product details remained immutable, mitigating risks of counterfeiting or fraudulent resales. This initiative expands the brand's digital strategy, creating a seamless connection between physical fashion and metaverse integration**.** By leveraging blockchain technology, Company 6 ensures secure authentication and interoperability with digital environments**,** positioning its brand at the intersection of luxury fashion and Web3 innovation**.**

Case Study 7

Company 7 is a leading provider of mobility and payment services, offering electronic toll collection, insurance, parking, and various digital solutions to enhance urban mobility. As part of its digital transformation strategy, the company has implemented a token-based project with the objective of improving its digital ecosystem and consumer engagement. The project revolves around a collection of Non-Fungible Tokens (NFTs) issued directly by the company on the Ethereum blockchain. By verifying their ownership, Company 7's token holders can access exclusive services and special promotions. Users acquire these NFTs through decentralized marketplaces, benefiting from seamless interoperability that allows the company to integrate easily within exchange platforms. This facilitates frictionless purchases and enables users to leverage the tokens within the company's ecosystem to unlock various benefits by proving ownership. Verification occurs through dedicated online

platforms, granting access to exclusive communities and updates on new initiatives. Additionally, the integration of these tokens extends to virtual environments, where users connecting their wallets can authenticate their ownership and access digital services. The ecosystem involves multiple actors: the company issues and sells the tokens, first-hand users acquire and store them, while transactions occur primarily through decentralized exchanges, allowing secondary users to participate. Through this new ecosystem, token holders interact within a broader digital network where blockchain technology facilitates exchanges between users, service providers, and virtual platforms. The tokens are integrated into various applications, including platforms such as Discord and OpenSea, supporting customer engagement strategies and loyalty mechanisms within the mobility sector.

Case Study 8

Company 8, a leading hospitality group managing a vast network of hotels, collaborated with Company 9, a blockchain-based travel technology startup specializing in digital asset solutions, to introduce a tokenized reservation system. This initiative transforms hotel bookings into token, allowing guests to transfer or resell reservations, enhancing booking flexibility and secondary market efficiency. Hotel reservations can be categorized into three types: refundable, non-refundable, and tokenized. The tokenized model, introduced through this initiative, links each booking to a blockchain-registered token, allowing guests to transfer or resell their reservations before check-in. Each tokenized booking is issued as an NFT on the Polygon blockchain, ensuring a verifiable and tamper-proof proof of reservation. These NFTs are managed through Company 9's dedicated platform, which facilitates booking transfers in a secure and automated manner. Guests who purchase tokenized reservations can either use them to stay at designated hotels or list them for resale on a marketplace, allowing other travelers to acquire bookings based on availability and demand. This mechanism introduces a secondary market for hotel stays, allowing

users to recover costs from non-refundable bookings. The token, based on the ERC-721 standard, encodes reservation details such as validity periods and usage conditions. It incorporates an expiration mechanism that prevents transfers after the check-in date, ensuring that once a booking is redeemed, it cannot be resold or reused. The ecosystem consists of multiple participants: Company 8, which integrates the system within its booking infrastructure and establishes hotel participation guidelines; Company 9, which provides the blockchain infrastructure, oversees the token issuance process, and manages the resale marketplace; and hotel guests, who interact with the system by either utilizing or reselling their tokenized reservations. The marketplace, operated by Company 9, functions as a dynamic trading environment, where pricing is determined based on supply and demand, offering an alternative to traditional cancellation policies. By implementing a blockchain-based framework, Company 8 and Company 9 introduce a tokenized booking model that enables reservation transfers while ensuring transaction transparency and verifiability. The structured resale mechanism allows for authenticated and secure exchanges of reservations, addressing limitations of traditional non-refundable bookings. The system operates within a controlled marketplace, where pricing dynamics are influenced by supply and demand, providing a standardized approach to reservation management.

Case Study 9

Company 9, an American regulated digital asset issuer and blockchain-focused financial startup, has developed a fully collateralized, yield-bearing digital dollar. The project leverages stablecoin, a tokenized representation of U.S. dollar reserves, issued under a strict regulatory framework and backed by a combination of U.S. Treasury securities and tokenized money market funds. This approach ensures that the asset maintains a one-to-one peg with the U.S. dollar, while offering holders direct access to risk-free yield from U.S. government-backed securities. USDM operates permissionlessly, allowing both institutional and retail users to access a stable, yield-

generating digital dollar without requiring staking or manual claims. The rewards are distributed automatically and accrue directly in users' wallets. The stablecoin is widely accepted across both decentralized and centralized financial applications, including lending protocols, decentralized exchanges (DEXs), custodial platforms, and payment networks. Participants in the ecosystem include Company 9, which issues and manages the stablecoin under regulatory oversight; liquidity providers and financial institutions, which facilitate its circulation in both DeFi and traditional finance environments; end-users, who utilize the token as a stable store of value or an alternative to traditional yield-bearing deposits; and governance participants, who contribute to ecosystem development and regulatory compliance. The use of public blockchain infrastructure enables real-time auditing of reserves, enhancing transparency and trust. Company 9's approach enables interoperability between traditional financial markets and digital asset ecosystems, providing users with a token-based alternative for value storage and transactions.

Case Study 10

Company 11, a major European financial institution, collaborated with its digital asset subsidiary, Company 12, to introduce a regulated stablecoin designed for on-chain financial transactions. The initiative aims to bridge traditional banking services and blockchain-based financial infrastructures, leveraging Company 11's institutional credibility to facilitate market adoption. The stablecoin, initially issued on the Ethereum blockchain under the ERC-20 standard, has since expanded to the Stellar network to enhance transaction efficiency. It is fully backed by cash reserves held within the institutionand ensuring transparency and it operates within a regulated framework. The token facilitates institutional financial transactions, serving as a digital cash equivalent for on-chain settlements. Institutional clients can acquire the token directly from Company 11, while secondary market access is provided through crypto exchanges and liquidity providers. The tokenized settlement mechanism enhances

efficiency, reducing transaction times compared to traditional banking infrastructure.The ecosystem consists of multiple participants: Company 11, which issues and manages the stablecoin within a regulated framework; Company 12, responsible for the blockchain infrastructure and token distribution; market makers, who facilitate liquidity provision and secondary trading; and institutional users, such as asset managers and financial institutions, utilizing the stablecoin for securities settlement and interbank transactions. The token is also integrated with regulated custodians and treasury management platforms, allowing institutional investors to securely store and utilize digital assets within compliant environments. Primarily targeted at institutional participants, the system integrates with financial infrastructure to support asset transfers, securities settlement, and interbank operations. The platform's architecture also allows for smart contract automation, enabling programmable financial transactions and facilitating controlled liquidity management within regulated digital asset markets. By leveraging blockchain's operational efficiencies while adhering to traditional financial compliance standards, Company 11 and Company 12 position the stablecoin as a structured digital instrument for institutional use.

Case Study 11

Company 13, a major U.S.-based asset management firm with a strong presence in digital finance, has introduced a token-based initiative to enhance efficiency in money market fund operations. This initiative leverages tokenized financial instruments to streamline fund transactions while integrating blockchain transparency and automation into traditional asset management practices. The project centers around a tokenized share class of a U.S.-registered money market fund, issued as a blockchain-native asset to facilitate real-time settlements and improved operational efficiency. The token, initially launched on the Stellar blockchain and later expanded to other blockchains, follows the ERC-20 standard and represents digital shares in a regulated

U.S. Government money market fund. Each token is fully backed by short-term government securities and cash equivalents, ensuring compliance with regulatory standards and investor protection. The system integrates smart contract automation to optimize fund operations, facilitating automated interest accrual, efficient liquidity management, and near-instantaneous fund transfers. By leveraging blockchain technology across multiple networks, the initiative enhances transparency, reduces administrative costs, and improves transactional efficiency in traditional asset management. Participants in the ecosystem include Company 13, which issues and manages the tokenized fund, ensuring compliance with financial regulations. Institutional and retail investors can acquire the tokens through both blockchain-native wallets and traditional financial platforms, facilitating accessibility across different investment channels. Blockchain infrastructure providers support the on-chain transaction framework, enabling seamless execution of fund-related transactions. Additionally, financial intermediaries, such as custodians and regulated exchanges, ensure liquidity, provide settlement services. This integration allows investors to engage with the tokenized fund while benefiting from both decentralized efficiencies and traditional financial security. The initiative integrates blockchain automation into regulated asset management, improving settlement efficiency while ensuring compliance and interoperability with both digital and traditional financial platforms.

Case Study 12

Company 15, a leading decentralized finance (DeFi) protocol, has pioneered automated market-making (AMM) by leveraging blockchain technology to facilitate peer-to-peer token exchanges. The platform enables users to trade digital assets directly through liquidity pools without relying on traditional order book models. This decentralized structure enhances market efficiency, providing transparent, trustless, and automated trading mechanisms. Company 14, a blockchain research and

development firm, plays a crucial role within this ecosystem by focusing on governance optimization and financial infrastructure development. The company contributes to smart contract automation, financial protocol interoperability, and governance improvements, reinforcing the decentralization principles of the protocol. At the core of its innovation, Company 15 introduced a liquidity provision mechanism where liquidity positions are represented as Non-Fungible Tokens (NFTs). This model allows liquidity providers (LPs) to create customized liquidity positions with specific price ranges, optimizing capital efficiency compared to conventional AMM structures. These NFT-based positions can be transferred, traded, or utilized as collateral in DeFi applications, expanding financial flexibility within the ecosystem. Simultaneously, Company 14 has actively participated in refining the governance framework of Company 15's protocol, introducing structured decision-making mechanisms to ensure transparent and decentralized governance. Through governance tokens, ecosystem stakeholders can propose, vote on, and implement protocol modifications, influencing economic parameters and strategic developments. The ecosystem involves various participants: liquidity providers supplying assets to pools and earning transaction fees, traders executing swaps through AMM functionalities, and governance actors influencing protocol upgrades and operational parameters. Company 14 develops governance tools and infrastructure, supporting decentralized decision-making processes. Additionally, governance participants—including large token holders and delegates—engage in voting activities that shape the protocol's evolution. External financial platforms, such as decentralized lending protocols and liquidity aggregators, integrate with the system to enhance capital efficiency, while infrastructure components like decentralized oracles and wallet services contribute to pricing accuracy and accessibility. The initiative addresses liquidity optimization while reinforcing decentralized governance models. Company 14's involvement ensures structured governance operations, enabling automated treasury management and transparent execution of proposals. The protocol's adaptability allows further

scalability, including potential integrations with layer-2 solutions to improve transaction efficiency and reduce costs. By combining governance automation, NFT-based liquidity, and decentralized coordination tools, the initiative exemplifies an advanced framework for liquidity management and governance within DeFi ecosystems.

5 Results

This section presents the findings derived from the interview data, addressing the research questions outlined in Chapter 2. The analysis organizes results by aggregate dimensions, with second-order codes serving as subsections. Direct participant quotations are presented with contextual analysis to illuminate distinct thematic perspectives. Sequential quotes demonstrate convergent viewpoints and provide deeper thematic exploration. The analysis integrates relevant literature to ground participant insights within the existing theoretical framework.

5.1. Traceable Token Lineage Information

This paragraph illustrates how stakeholders can interact with information within tokens. All data stored on the blockchain is publicly accessible and immutable, ensuring that it cannot be tampered with. Furthermore, permissions can be configured to allow specific stakeholders to transparently update token information when necessary. These characteristics influence stakeholder interactions and reshape how business ecosystems exchange information.

5.1.1. Authentic Information Verification

Using tokens involves leveraging a technology in which, once information is written and stored, it cannot be altered, ensuring data immutability and preventing any untraceable modifications—whether intentional or accidental—by any party, including manufacturers or intermediaries. Modifications are not applied directly to the original block but are recorded in a subsequent block that registers the changes.

This mechanism provides enhanced security and trust compared to traditional systems, safeguarding the integrity of the original data. Consequently, tokens enable complementors or users who read the stored information to be assured of its immutability. If any modifications occur, these changes will be transparently visible in subsequent blocks.

"I, workshop, can write potentially what I want in my databases. While using a certified token has the great value that no one, including a dealer or Company 1, can modify those numbers, neither by mistake nor by will. […] That is the great value on the original part because with blockchain you have a proof that can never be modified by anyone, […] Being blockchain and NFT, by definition they cannot be touched, this gives an additional protection unique to other systems." (Representative of Company 1)

Tokens ensure data immutability by transparently recording modifications in blocks, preventing untraceable alterations and enhancing security. The public registration of tokens facilitates product data verification, eliminating the need for additional authenticity certifications. A representative from Company 11 confirmed that the open visibility of token data allows any actor within the business ecosystem to access the information without requiring permission. This accessibility significantly reduces the time needed to transfer assets, as counterparties can instantly access and automatically verify the information, streamlining processes compared to centralized, siloed databases that require additional steps for verification and confirmation. Similarly, a representative from Company 2 reported that verifying data related to the authenticity, condition, and historical adjustments of items, such as watches, is traditionally a manual and time-consuming task. By storing this information in tokens, the process of verification is streamlined, enabling stakeholders, such as second-hand resellers, to independently access and verify the data without relying on third-party checks.

"*If you buy a traditional bond, a fund, or an equity, the settlement cycle will take two or three days. However, with on-chain settlement, it takes only about 10 minutes. You can complete a settlement in 10 minutes instead of 2-3 days because information are transparently accessed wihout spending time in intermediaries-checking activities. Transparency is one of the key benefits of blockchain.*" (Representative of Company 11)

"*As a new owner, if you want to buy a sign-in watch, it is easier to buy a used watch with a token, since I have easy and certain access to information about its previous use, including details on repairs and overall quality. In the traditional process, much effort is spent manually validating authenticity—sending the watch to a repair center for comprehensive checks. If a simple trade platform using an NFT can provide all this verified data instantly, then the process becomes much more efficient.*" (Representative of Company 2)

The full visibility of an asset's authenticated history, combined with immutable data, ensures the integrity of the information across its lifecycle. This transparency allows anyone to perform verification checks, reducing the need for clearing processes and intermediaries. Consequently, the removal of these intermediaries can lower the costs associated with such activities, enhancing operational efficiency.

As a result of these advancements, entirely new opportunities for collaboration and interaction with various stakeholders emerge. The availability of instant, verifiable data fosters a more integrated ecosystem, where entry in ecosystem can happen more seamlessly, and operations become inherently more efficient.

Moreover, as stated by a representative from Company 3, a potential buyer of a token linked to a physical object can access relevant information without needing to know or trust the counterparty in a secondary market. Token data visibility, therefore, enables authentic product verification in peer-to-peer exchanges. This point is further supported by a representative from Company 1, who highlighted that tokens exist on a public ledger, fundamentally altering how actors—such as secondary markets or complementary service providers—can access information compared to traditional

corporate databases. For instance, future car buyers can independently access the historical data regarding a vehicle's previous ownership and usage, providing greater transparency and trust in the transaction.

"That NFT has got attributes that any stakeholder can read in the metadata. [...] So basically it gives like more information about the product and makes sure that the product that is resold or gifted to another person is original." (Representative of Company 3)

"The owner of the car has not authorization to access information about his usage and car service, he can request it but is not so easy. It cannot access them automatically. In a sales process to a second customer, in case I as a second customer wanted to have these certifications from us. I could not require them a priori. With the token, being that they are put on the NFT, so he has access to that information. " (Representative of Company 1)

With full data visibility on a public ledger, buyers and sellers no longer need to rely on trusted intermediaries to validate an asset's authenticity in secondary markets. This paradigm shift reduces transaction costs, minimizes delays, and enables more secure, efficient, and direct exchanges in secondary markets, particularly within ecosystems where such transactions can occur with greater ease.

As highlighted by a representative from Company 5, data visibility allows any participant—such as complementors or buyers—to access and understand the economic value of different systems. This shared understanding makes it possible to assign a common value to loyalty points across all platforms adopting the token. Consequently, when multiple participants can attribute the same economic value to loyalty points, the logic behind the token's value can be consistently shared and transferred across the various adopters of the token.

"In the Web2 environment, integrating Decathlon loyalty points with Esselunga points is challenging because it requires converting between different economic values. For instance, Esselunga's Strawberry Points and Decathlon's vouchers follow distinct valuation mechanisms, making interoperability between loyalty systems complex. That's why instead we

used a token approach where all application could reward users with loyalty points where could be recognized evert token economic value, reconciling differences. For us blockchain, as an immutable and append-only database, blockchain allows for cross-tracking between different dApps." (Representative of Company 5)

Lastly, regarding the verification of authentic information, adopting a token that operates on a public ledger ensures that anyone can verify whether processes are correctly followed. This transparency reduces mistrust among ecosystem participants and can foster closer collaborations, thereby reinforcing trust and accountability within the ecosystem.

"Trading tokens on a decentralized network compared to an SQL database […] is different because the system is totally transparent, there aren't any back doors or hidden advantages that can be granted to some, but not others." (Representative of Company 15)

With verifiable processes in place, businesses can trust the operations of other businesses, knowing that these processes are transparent and reliable. This trust simplifies the adoption of third party services or systems, reduces skepticism, and encourages collaboration, paving the way for innovative partnerships, streamlined operations, and a more competitive marketplace where all participants operate on equal footing.

5.1.2. Trustworthy Information Delivery

While the previous discussion focused on accessing and verifying existing data to ensure authenticity, we now turn to the dynamic aspect of writing data. The public nature of tokens marks a significant departure from traditional databases, where information is typically managed and controlled by a single centralized entity. With tokens, even actors who neither own nor originally created the token can add information about a product directly to it, ensuring trustworthy and collaboratively maintained data.

For instance, in the case of Company 1, information is written not only by the company itself but also by the surrounding ecosystem of actors. A notable example is the car dealer who added details about car services directly into the token. The information provided by these complementors becomes part of the token's data, which is subsequently owned by the token holder. This data is then accessible to the car's next owner, who can review the entire usage history, including records added by both the manufacturer and its complementors.

"If then we add some other information, or the official Company 1 dealer network does, about the car services, or about the car itself that maybe got a bump, […], the NFT goes to detect from a whole series of sensors that the machines are full of […] to add other information and we decided to do there is a series of NFT concatenated in which the second NFT would also contain the photo of the first, adding a number of other details." (Representative of Company 1)

By retrieving data directly from the token, all parties gain transparent, tamper-proof insights into a product's features. This process ensures authenticity and strengthens consumer confidence, as highlighted by a representative from Company 4:

"The updating of the information within the tokens compared to […]a digital product passport on a SQL database main difference is that […], we were using a centralized system where there are certain information that could be changed over time. In our case […] whenever we create a digital twin of a physical item we actually inscribe on the blockchain the information's of that item. This information are immutable. And that's very important because we're not fetching them from the database, but we're fetching them from the NFT, where these information are actually in the metadata. And as you know, they're visible to everyone and immutable. […]" (Representative of Company 4)

Consequently, various stakeholders, from suppliers to consumers, can be actively involved in monitoring, verifying, and gaining insights into real-time changes affecting a product.

Furthermore, a company issuing a token can grant ecosystem actors access to real-time information about their products, which would otherwise only be available through quarterly manual checks. This accessibility allows third-party actors to monitor the asset more frequently and make more informed decisions, as observed in the case of the tokenized market fund of Company 13.

"Using blockchain add the benefit of seeing real time AUM, which traditionally money funds are monthly, sometimes even quarterly AUM reporting." (Representative of Company 13)

All actions related to the underlying asset, along with activities involving the use of the token, can be recorded directly within the token. This immutable information unlocks the ability to reliably demonstrate specific actions or behaviors associated with the product, as confirmed by representatives from Company 1 and Company 5.

"The token can also be used by protocols outside our ecosystem. We have integrated it with external carbon offsetting systems to reward, in some way, users who take better actions in our ecosystem and prove it in external systems that require that data."(Representative of Company 5)

" When you share data on the use of the car, imagine, now we talk about electric cars, so how did you keep the battery? It becomes important to reveal what kind of charging you did. Depending on how it is best to load, all those data are already available and therefore have an influence on the life of the battery itself and that have a consequence potentially on what then the value of the car to tend. […]. If it is connected to a token and on which, every six months has set to take a photo, after 10 years you have a very clear history of what is the mileage of the car and consequently it is very demonstrable the fact that you those 10,000 km or 100,000 km that you did actually are the real ones on the car" (Representative of Company 1)

By capturing every action of an asset in an immutable record, tokens provide indisputable evidence of its charateristics and interactions. This transparent record-keeping facilitates the modular integration of stakeholders, allowing any participant to contribute to and rely on trustworthy, valuable data.

In conclusion, the ability of any actor to seamlessly append information to a token, whether linked to a physical or digital ownership, enhances transparency, traceability, and interoperability. By eliminating centralized control, this approach cultivates a dynamic and reliable information ecosystem, where collective contributions enrich the value and integrity of tokens.

5.1.3. Traceable Data Information

Thirdly, public and immutable information stored within a token can be updated by multiple actors, creating a reliable and trustworthy digital history of a product that is useful both before and after its purchase. Tokens facilitate a multi-actor process by providing a streamlined method for tracking and sharing real-time, authentic product information throughout its lifecycle, ensuring that all stakeholders have access to the latest updates. As stated by a representative from Company 6, token-based updates and immutable information enable a secure product lifecycle tracking:

"Tokens can be used to track, streamline and digitize the supply chain. Every step, from manufacturing to delivery, can be linked to a token that verifies the physical product's origin and journey and this speeds and simplify the whole tracking process for all stakeholders" (Representative of Company 6)

A particularly interesting aspect is the real-time verification of a product's status, which token-based, upgradable, and immutable information simplifies. The process of updating a product's status does not need to be carried out exclusively by the token issuer; instead, writing and updating permissions can be granted to authorized actors. For instance, Company 3 collaborated with a third-party participant in their ecosystem to grant these permissions, demonstrating the flexibility of this approach. Similarly, Company 4 leveraged this capability to enhance their supply chain monitoring processes.

"Then the time piece with the serial number will be recorded out as lost or stolen, and in that case the digital passport that has been released with that timepiece will be stamped with it, and every single screen that you will see will notify that the piece he's frozen, in the sense that and it's been declared and the only way for the person to and put this information in the digital passport is to go through the manual process of making you know of, giving all the details that make sure that the original complaint is now." (Representative of Company 3)

"*A lot of our clients want to update the item information alongside us, their technology provider, which is quite interesting. Thanks to token technology, they can make these updates whenever needed, ensuring the data remains accurate and transparent*." (Representative of Company 4)

The information stored in a token is both tamper-proof and publicly accessible, allowing different stakeholders within the token ecosystem to access data without prior permission, add new information, and update existing records in every moment of the token lifecylce. This capability enables stakeholders to verify and deliver authentic information.

In summary, these findings lead us to formulate the first proposition:

Proposition 1. "*Publicly accessible and traceable token information simplifies modular integration of stakeholders*".

5.2. Token Unconstrained Ownership Transfer

This paragraph presents the results concerning the distinctive features of token ownership transfer, with a focus on how the underlying decentralized ledger facilitates peer-to-peer transactions. Tokens on a blockchain, much like physical objects, can be transferred directly between participants unless restricted by specific coded limitations. This characteristic has significant implications for interactions between parties, as it enables direct exchanges without intermediaries, fostering seamless collaboration and improving the efficiency of token ecosystems.

5.2.1. Token Ownership Transfer Without Altering Service Backends

In traditional systems, transferring asset ownership requires navigating through complex, often siloed infrastructures, where stakeholders maintain distinct rules, protocols, and settlement processes. These transfers are typically restricted to specific operating hours, adding further complexity. With tokens, ownership can be transferred directly between two parties—whether customers or businesses—without relying on existing ad hoc infrastructure.

Traditional infrastructures often involve multiple layers of verification, reconciliation, and manual oversight, increasing both the time and costs associated with ownership transfers. These processes can become even more cumbersome when dealing with different jurisdictions, currencies, or financial institutions. As reported by a representative from Company 11, tokens can be transferred more easily compared to traditional forms of ownership, where you must adhere to the rules and limitations of existing infrastructures. Unlike traditional systems, tokens operate on blockchain networks that function 24/7, enabling real-time transfers without the need for intermediaries. This capability reduces dependency on legacy infrastructure, lowers costs, and improves accessibility, as confirmed by Company 11 through a comparison between tokenized deposits and traditional deposit accounts.

"Comparing a traditional deposit with a deposit in a tokenised way, it is easier to transfer it for me. When you are in a traditional world, [...] if you want to move euro, for example, you will need to do it before 4:00 to be credited. So you need to deal with a the existing infrastructure with the existing cutoff time, whereas in a digital format you can do it in a real time and it's less expensive where you need to deal with the existing infrastructure and the constraints that you can have in the traditional world." (Representative of Company 11)

Company 11 adds that, in addition to the reduced constraints in ownership transfers, the integration of products from different protocols into a service no longer requires technical integration with a buyer's legacy systems. This approach enables services to

incorporate and utilize assets of other stakeholders, seamlessly integrating them and easily exchanging without restrictions. It enhances flexibility and interoperability across different protocols, all without requiring modifications to existing systems.

"In the digital world it is what you have written in your smart contract that will drive the business and that will allow to do an automatic payment of coupon. So, if it's written in the smart contract, anyone can effortlessly implement automatic payments using your token. [...] It is a smart contract that will interact with the wallet after." (Representative of Company 11)

Tokens can generally be transferred by any user, company, or application, regardless of their underlying technical architecture, demonstrating the inherent flexibility of token-based ecosystems. Company 5 provides a practical example of this in a Web3 environment, illustrating the seamless transfer of value between decentralized applications (dApps).

For instance, a token received in one application can be transferred directly to another application or to the wallet of another user, company, or service. This process abstracts the underlying infrastructure, enabling tokens, once owned by a user, to be exchanged across protocols without limitations. As a result, interoperability and ownership transfers can occur across the ecosystem with ease. This concept is further reinforced by the fact that intermediaries and aggregators, such as Decentralized Exchanges (DEXs), do not need to develop proprietary or ad hoc infrastructures to accept tokens from Company 5 or any other compatible protocol. Consequently, tokens are not only accepted but can also be utilized across different systems, enhancing their functionality and interoperability within the ecosystem.

"It's the goal of our DAO, make sure that the reward obtained from one dapp are reused in another dapp, we will launch a marketplace, so users who receive rewards from any app can spend their token to access products, services listed on this marketplace. […] But also better that come from another dapp are still better and so I can use them, say everywhere transversely. " (Representative of Company 5)

This highlights the 'opt-in' mechanism of public blockchain systems, where tokens are not confined to a specific platform but remain openly accessible and interoperable.

5.2.2. Agreement-Free Asset Distribution

In the previous section, the focus was on the ability to avoid creating ad hoc technical infrastructure for connecting and integrating companies and their databases to facilitate ownership transfers. This discussion emphasized the seamless technical interoperability enabled by shared public systems.

In contrast, the following paragraph shifts attention to the elimination of the need for agreements between parties and intermediaries when cooperating within a token-based business ecosystem. The upcoming discussion will illustrate how tokens enable transactions and interactions without requiring pre-established partnerships, coordination, or third-party involvement. This capability fosters more open and fluid business ecosystems, allowing participants to interact and exchange value directly, without the friction of negotiating terms or relying on centralized coordination. This phenomenon was highlighted by Company 7.

"To create a marketplace exchange with traditional digital records stored in a relational database and then create an internal marketplace it's a lot of work, if you had to do it from scratch. [...] A marketplace with similar features today can be Ebay, which allows users to exchange things between them, probably through the integration of its APIs, but I can't think of any other marketplace that allows private users to put anything up for sale in this way. With tokens you simply create the page on the marketplace without interacting with them and then put the contract there. It's easy [...] you just create a page, which is actually your token, and then link the contract to us for the integration part." (Representative of Company 7)

This concept of integrating tokens without formal partnerships is further supported by the case of Company 6, where several complementors interact with the token without establishing any agreement with its creator or holders. Tokens inherently

possess the capability to be freely transferred and distributed without requiring formal agreements. This portability characteristic enables various complementors—such as blockchain platforms, marketplaces, and wallet providers—to seamlessly interact with and support the token, even without official supplier status or contractual relationships. The ability of these complementors to integrate with the token, derived from its built-in transferability properties, ultimately increases the overall value of the token-based product. By expanding the token's utility and reach through a growing network of independent supporting services, the ecosystem becomes more dynamic and accessible.

"In our service we find complementors such as decentralized blockchains (e.g., Ethereum, Solana), marketplaces (e.g., OpenSea, Rarible) and wallet providers (e.g., MetaMask, Coinbase Wallet) which seamlessly interact with the token by making it accessible and visible to the costumer despite not being Company 6 brand's suppliers. Their presence on the market increases the value of our token-based product." (Representative of Company 6)

The two previously discussed token features—transferability without agreements and integration without altering back-end development—can coexist simultaneously, as demonstrated by Company 15.

Company 15 provided an example of the seamless interaction between their platform and other money markets—platforms where users can lend and borrow crypto assets—made possible precisely because tokens can freely circulate without restrictions. When a user deposits funds into a liquidity pool (i.e., pools of cryptocurrency pairs locked in smart contracts for trading) on Company 15, they receive a second token that represents a claim on their deposited funds.

These tokens, which can be transferred without requiring agreements or technical coordination, can subsequently be moved to another money market and used as collateral for a loan. This process occurs without the need for special partnerships or

additional technical integrations between the services, illustrating the inherent flexibility and interoperability of token-based systems.

"Because the Company 15 protocol is open and permissionless, other protocols can build on top of it and access the liquidity it has accumulated. Tokens in themself are a convenient common standard has emerged so every protocol can "speak the same language". This allows for easier integration and better interoperability between protocols." (Representative of Company 15)

This unrestricted flow of tokens facilitates composability across different services, unlocking new possibilities without the need for coordination between platforms.

5.2.3. Enhanced Flexibility in Asset Utilization

When users control their tokens without being constrained by traditional system limitations, they can move assets freely across platforms. In legacy systems, assets are typically tied to specific platforms, requiring users to follow rigid rules, depend on intermediaries, or accept restrictive terms. Tokens, however, empower users to transfer assets across different platforms or wallets without these constraints. This flexibility is particularly advantageous for new stakeholders, such as second-hand users, who can acquire tokens from existing participants without the need for formal agreements or custom software. By eliminating the need for ad hoc development and platform-specific restrictions, tokens enable a more streamlined and user-centric experience.

This token flexibility is exemplified by the case of Company 8, where a token represents a resellable hotel booking voucher. Typically, hotel customers must pay for bookings in advance, with limited or no reimbursement options if they decide to cancel. As a result, customers face financial losses, while hotels experience unoccupied rooms and unearned revenue. With the token-based system implemented by Company 8, the booking can be tokenized, allowing the company to register profits upfront. Simultaneously, users retain the flexibility to either use the booking

themselves or resell the token to others, depending on their preferences, as emphasized by Company 8.

"It is a technology that strategically opens to a greater flexibility for the customer, [...]The customer who has already bought from us, who has already booked, is not said to confirm if the rate is cancellable, But it is better to give them more reason to buy than less, for example with non-refundable rates. So, in this context so difficult, [...] This technology, adopted in this specific way, [...] goes in the direction of increasing conversion rates and making the customer more flexible in his consumption of the stay itself." (Representative of Company 8)

It is up to the NFT owner to decide how and where to use the token. Owners are not required to adhere to the infrastructure created by the ecosystem's orchestrator or the complementors partnered with by the orchestrator. Instead, token holders can choose to use a different marketplace that better suits their needs, thereby expanding the ecosystem without centralized control. Company 4 further reports that the token's flexibility is so extensive that owners can even decide to fractionalize an asset originally created by someone else. Once ownership is established, the owner can choose to divide the asset into smaller, tradable fractions and sell these portions to multiple buyers.

"We provide a solution to bring the physical items in the blockchain where each one has like a digital twin. So [...] once you claim that the NFT you are the owner of the NFT, so it's up to you to unlock other possibilities […] For example from the user side you could go and instead of selling the physical item, you could sell the NFT that is linked to the physical item. So you could obviously pick the marketplace you prefer. Maybe you want to trade it on, and so on or maybe you would like to fractionalize it, and because it's a very expensive item and not everyone will be able to afford it." (Representative of Company 4)

Tokens' unique flexibility is transforming how financial instruments are utilized, particularly with regard to earned interest. In traditional systems, accrued interest remains locked within investment accounts, with limited options for immediate use.

However, with tokenized assets, the yield is represented by a freely transferable token that can be instantly used for various purposes—ranging from reinvestment to making direct payments for everyday purchases. This breakdown of barriers between investing and spending is effectively illustrated by Company 13:

"So I'll give you a couple of use cases on the retail side, if I was an our token customer and Tommaso, for instance, we went out to coffee, you forgot your wallet and you're like, hey, I'm going to pay you back in some "token" because it earned something. I earned some yield that lives on chain." (Representative of Company 13)

Another perspective on token flexibility is provided by a representative from Company 14, who describes the DAI Savings Rate module, a yield-bearing system that allows users to earn interest while retaining a transferable token. Users deposit their DAI stablecoins into a smart contract and earn interest on their holdings without the involvement of intermediaries. The earned interest is represented by a separate token, which is not issued by MakerDAO (the DAI issuer). Instead, a complementor's smart contract accepts the deposits and issues 'savings DAI' tokens, representing both the principal deposit and the accrued interest. This case illustrates the flexibility of tokens, as a third-party service can create new tokens to represent the interest earned on another issuer's tokens.

"What happened was a developer who works for Maker built this contract called Savings DAI, and what it does is it tracks your balance. So what happens is this token contract ends up sitting between you and Maker. So technically this token contract owns like everything that gets deposited. [...] And so now you can go to Aave or Spark or any of these other places and say, hey, here's some sDAI, this savings DAI. I want to borrow Tether against it or something like that. And you can. It's important to note that Maker didn't give you a token. This is totally something invented as an intermediary. So, tokenization seems to occur naturally because you can rehypothecate it." (Representative of Company 14)

Tokens reduce collaboration barriers by enabling stakeholders to interact without formal partnerships or contracts, thereby eliminating time-consuming coordination efforts. Additionally, tokens negate the need for ad hoc software development, ensuring seamless integration across platforms due to their standardized nature. Furthermore, tokens provide users with flexibility, allowing them to independently decide how to utilize their digital assets without relying on intermediaries or requiring backend modifications from service providers. Collectively, these characteristics create an environment where stakeholders—regardless of their size or existing infrastructure—can easily join and operate within a tokenized ecosystem, fostering growth and innovation with minimal constraints. In summary, these findings lead us to formulate the second practice:

Proposition 2. "*Token unconstrained transfer ownership simplifies the entrance of new stakeholders* ".

5.3. Autonomous Token Ownership Verification

With distributed ledger technology as the foundation of tokens, all participants share a synchronized copy of the transaction history. This ensures that users can independently verify token ownership without requiring permission from any provider. The verification process is inherently tamper-proof, as interactions are securely recorded on the token, eliminating the risk of falsifying ownership or transfer records. This characteristic significantly impacts ecosystem dynamics by enabling users to leverage their assets or resources (e.g., data or digital products) seamlessly across multiple platforms or services. This ensures greater flexibility and autonomy regarding how and where these assets are utilized.

This approach differs from the current consumer experience with digital goods, where purchasing a song or an e-book typically only grants a license for access through a specific provider rather than actual ownership of a copy. License-based ownership in

Web 2 restricts consumers from switching platforms, as doing so results in losing access to the content. In contrast, Web3 promises a more platform-agnostic consumption experience, where token holders retain full control over their assets regardless of the underlying platform.

5.3.1. Holder Provable Ownership Grant Benefits in Other Services

Unlike traditional assets confined within a company's service or infrastructure, tokens offer unique flexibility by enabling their use across different platforms and applications. This capability arises from the interoperability of blockchain networks, where token ownership can be easily verified by any compatible service. Through tools like WalletConnect, users can link their wallets to external applications, proving ownership and accessing various services without keep ownership restricted to a specific company.

Company 10 illustrates this concept by comparing tokenized assets to traditional financial assets, such as funds held in high-yield savings accounts or certificates of deposit. These conventional assets remain liabilities on the bank's balance sheet, providing limited utility to the owner. In contrast, tokenized assets allow owners to bypass such constraints, facilitating dynamic interactions among stakeholders who can prove ownerahip and unlocking new forms of utility.

"Much of the money held in traditional banking systems is confined within their infrastructure, lacking any meaningful interoperability with broader financial markets. Assets like certificates of deposit (CDs) and high-yield savings accounts are essentially liabilities recorded on the bank's balance sheet. This setup limits the utility of these funds, as they remain inactive and cannot be leveraged for other purposes." (Representative of Company 10)

Token ownership allows users to unlock access to various services using the same token. Different protocols and services can automatically verify ownership on the blockchain, granting access without the need for additional permissions. From the

holder's perspective, a token used in one application can later be seamlessly transferred to another without requiring authorization from the ecosystem creator or token issuer.

"We have now seen that the same token can be used in multiple different protocol such as Snapshot and Tally. I mean, the same token can help you connect with different instruments." (Representative of Company 14)

Tokens are hosted on public blockchain platforms, meaning they exist within an open and transparent network accessible to anyone. This infrastructure allows users to interact seamlessly across different applications without being confined to a single company's private infrastructure, thereby enhancing utility and accessibility. This also makes tokens (e.g., assets, credentials) 'portable,' as users can, in principle, disconnect from one application and move, along with their data, to another platform whenever they choose.

Similarly, businesses that issue tokens for use on a specific platform can choose to enable those tokens to be verified and utilized across other platforms. This approach prevents companies from locking their clients or assets into a single platform, instead expanding the number of potential interaction channels and providing clients with greater reach within the ecosystem.

"It is important that this product is a token, because in any case I will be able to interact with the user again. How? Just create tools that can interact with that smartphone without the need for authorization from a third-party company. While with other technologies if it was a skin on third party platform and one day that platform fails, I lose a piece of the history I have with this client, which maybe a relationship was born. Or maybe at some point that platform throws out this client, or no longer wants to make partnerships in fashion products, or that product disappears from the marketplace. With different technologies you are always bound to third parties with whom you must enter into relations, so make agreements, contracts, partnerships and in the end, share profits" (Representative of Company 6)

Consequently, token ecosystems enable businesses to create more 'plug-and-play' interactions, allowing assets, services, and users to move seamlessly across different platforms. Companies can mix and match services or resources without restrictive contracts, ensuring operational continuity even if a platform fails or changes its strategic direction. This flexibility reduces dependency on intermediaries, fostering a more open and interconnected business ecosystem.

5.3.2. Services Verify Ownership to Deliver Functionalities

Shifting from the holder's perspective to that of a business seeking to add utility to a token, it becomes evident how companies can leverage NFTs to create exclusive experiences and foster deeper engagement. By linking specific features, rewards, or capabilities to NFT ownership, businesses can provide unique, verifiable benefits to their customers. This approach not only enhances customer loyalty but also promotes community involvement within token-based ecosystems. For instance, on Decentraland, Company 6 rewards certain users by unlocking exclusive features in the virtual world, but only for those who already own a specific NFT associated with the platform.

"On Decentraland we organize events and give wearable to those who are in possession of certain NFT that they have issued in the past. They were pants, trousers, jacking t-shirt, all with features related to powers that give you inside the platform. For example, run faster in case of shoes or dance in a strange way in case of some look that is launched for some events, always virtual events." (Representative of Company 6)

Company 6 has created another NFT collection, strategically utilizing third-party platforms such as Decentraland and The Sandbox to issue NFTs with multiple tiers, each offering progressively greater exclusivity and utility. The tiers range from tokens granting access to exclusive physical shoes to top-tier digital wearables usable across various virtual environments. Each platform independently verifies ownership of

Company 6's digital collectibles to unlock access to its respective features and functionalities.

This approach illustrates how third-party platforms can benefit from Company 6's user base while the company simultaneously leverages these platforms to provide additional utility to its customers. Notably, this arrangement does not require direct collaboration with the platforms, allowing Company 6 to integrate its products seamlessly into broader ecosystems.

Furthermore, the actors of the ecosystem can simplify partnerships to deliver joint services. Token-based infrastructure facilitates customer sharing across platforms by enabling ownership verification without complex technical integrations, making transitions between platforms more straightforward.

"If you wanted to change provider from Discord to Telegram it would take little, for the simple fact that a user who registers with his wallet, if he has the NFT of Company 7, has easy access to the dedicated channel in the other provider or any other provider that recognizes the NFT you have in your wallet." (Representative of Company 7)

Companies can expand their reach without formal agreements; however, competitors can similarly leverage the same user base, thereby reshaping competitive dynamics. The interaction between actors through ownership verification is not limited to the ecosystem's creator and its clients, which can be advantageous for businesses. For instance, just as Empoli enabled owners to prove their ownership to distribute rewards, competitors can replicate the same process. This occurs because tokens are stored on a distributed ledger, where the existence of an asset is determined by the technology itself rather than by a centralized agent. Consequently, competitors can directly engage with another company's user base in a permissionless manner. In Web3, this phenomenon is commonly known as a 'vampire attack.' However, from the token issuer's perspective, it can also be seen as an opportunity to attract users across competing services.

As highlighted by Company 6, two competing virtual worlds enabled users to verify their token ownership to grant access to exclusive virtual experiences. In this case, the two metaverses agreed to compete based on functionality; however, this interaction could also occur without formal agreements. In this context, Company 6 gained a strategic advantage by being able to sell the same digital assets across a broader range of platforms. Company 15 similarly confirmed that liquidity in tokenized protocols is accessible permissionlessly by any participant, including competitors, as no central entity is required to verify or authorize these interactions

"We gave also access to digital wearables in virtual realities such as The Sandbox and Ready Player Me, an Augmented Reality filter, and to Maison Margiela's upcoming Web3 projects, including exclusive programming, virtual experiences (gaming activations) and Web3 side projects (collaborative partnerships)." (Representative of Company 6)

"Because the Company 15 protocol is open and permissionless, other protocols can build on top of it and access the liquidity it has accumulated. Tokens in themself are a convenient common standard has emerged so every protocol can "speak the same language". This allows for easier integration and better interoperability between protocols." (Representative of Company 15)

This open and permissionless interaction allows any company, including competitors, to leverage the same token infrastructure, thereby driving both competition and ecosystem growth. While risks like 'vampire attacks' exist, token issuers can benefit from broader market exposure by selling assets across multiple platforms. Token-based partnerships represent just one outcome of a system that facilitates universal ownership verification and cross-platform integration.

Permissionless ownership verification enables any participant to join existing ecosystems, contributing to—or potentially undermining—the ecosystem's value proposition. This dynamic is exemplified by the cases of Company 10 and Company 12, which have implemented initiatives focused on creating tokenized assets. These

initiatives empower third-party providers to develop complementary services through permissionless ownership verification mechanisms. By utilizing public protocols, these tokenized assets can be seamlessly integrated into diverse ecosystems, thereby expanding both their operational scope and the value proposition for token holders.

"With stablecoins, the goal is to create a liquidity network and a flywheel of nodes that can interact with each other with your product and can use your product for their operations." (Representative of Company 10)

"It is important for us to establish partnerships with payment companies,[...]we are the products factory, we make partnerships telling people if you are big we do the KYC and sell the stablecoin, if you are small go to Bitstamp to buy the product and do what you want with it. [...]We remain mainly factory products. So we put the products, we make them available for market makers or OTC exchanges and e they are the gateways for the distribution of the product." (Representative of Company 12)

Lastly, token-based ownership verification enables new businesses to integrate into an ecosystem without the need to share user information. Unlike traditional systems, this integration is accomplished by directly verifying ownership through the token, eliminating the need for participants to exchange or authenticate sensitive data. In contrast, other technologies often require the sharing of personal information to facilitate service integration, thereby introducing potential privacy and security risks. This feature is inherent to the design of token-based ecosystems, demonstrating their ability to preserve privacy while ensuring seamless integration, as highlighted by Company 3.

"If you were to do it without the tokens, if you were to tell the second-hand marketplace, look, in my database, you find the data that this guy has this watch." (Representative of Company 3)

5.3.3. Direct Interaction Between Actors

Tokens fundamentally shift the nature of interactions among ecosystem stakeholders from indirect to direct, enabling businesses to engage with customers who were previously difficult to reach. In traditional systems, intermediaries are essential for product distribution but often limit direct contact with end customers, making it challenging to identify and interact with those who acquire the products. By leveraging tokens associated with purchased products, businesses can offer services where ownership is verifiable, creating new opportunities for direct engagement with customers. This dynamic is highlighted by the experiences of Company 6 and Company 3, where token-based solutions enable customers to prove ownership of a product purchased through a wholesaler. As a result, businesses can establish a direct connection with these customers, opening new avenues for interaction and engagement.

"Many times, it is difficult to have information about the final consumer because, by buying from a wholesaler, they never get in contact with the brand. Tokens can work as medium binding together the product, and therefore the brand, with the client." (Representative of Company 6)

"We don't know you, but we can reach out to you through the token but also tokens solve the issue we had with our existing proprietary client accounts was that many customers would register the same product. How could we identify the actual owner? [...] We had no way of knowing, so the idea here is to bring much greater clarity about who truly owns the timepiece."(Representative of Company 3)

The ability of tokens to allow data owners to prove ownership to anyone enables businesses to engage with customers directly, even when sales occur through third-party channels. This capability creates a powerful marketing strategy by providing access to information that was previously controlled by wholesalers, who often limited brands' ability to directly target their customers.

This was exemplified by Wov Labs' client, Empoli, which used tokens to interact directly with customers who purchased their football shirts—whether through the company's website or via third-party distributors. By enabling customers to prove ownership of their shirts, Empoli could identify these owners and establish a loyalty program specifically targeting football fans, fostering a direct and more personalized connection with its customer base.

"We developed a feature that we love and so basically it allows to filter out items. By filter out customers by the items that they claim so they could unlock like sort of loyalty programs for specific people or maybe reward the people that claimed a certain physical item, for example, you know, maybe. I don't know for example in the case of Empoli. Maybe they want to reward who purchased the more than three jerseys and the claim that the ownership so they can see that in our panel that that user has actually 3 jerseys and then reward them with a special disc. Or maybe even with a gift or equal to be an experience." (Representative of Company 4)

With an independent token, new services—such as the one proposed by Company 6 in the following quote—can identify token owners and directly offer new value-added services. This approach provides direct access to customers without requiring intermediation from the original platform, thereby reducing the need for coordination during the integration process.

"We as brands, if we have to invest to bring traffic somewhere we do it to take them in our ecommerce, not inside an external video game. [...]And then we don't want a massive and specific initial investment for all the development part to create an object, which has value only within that ecosystem. Over time most of the fashion brands that have developed projects on major cloud gaming platforms were seasonal projects, they launched them after six months they shut down. [...]Instead, if you work on a blockchain-based world, those tokens can take on a value that persists over time. As a brand, I can see that user still have those tokens on my platform. If you decide to leave that specific platform, I can airdrop another token that you can use in other spaces where I'm developing new experiences." (Representative of Company 6)

The automatic verification of token ownership unlocks direct interactions between various actors, from ecosystem orchestrators and customers to competitors. Additionally, it enables any ecosystem participants to reward and add utility for specific users who can prove ownership. Ultimately, token holders themselves gain the autonomy to engage with platforms and, if necessary, prove their data to other platforms. In summary, these findings lead us to formulate the third practice:

Proposition 3. *"Autonomous token ownership verification simplifies the attachment of a third-party service and holder direct interaction".*

5.4. Token and UX Design Modularizing Modularity

To conclude the results section, the following concepts, derived from interviews, will provide insights into the continuum of token design choices when companies seek to expand their business ecosystems through tokens. When designing a token, strategic decisions must be made regarding transferability and the rules for authenticating and managing assets. These decisions are enabled by the programmability of tokens, which allows specific rules and functionalities to be embedded directly into the smart contract's code. The outcomes of these design choices vary, ranging from more open ecosystems to more closed ones, depending on how openly the token's characteristics are defined. Ecosystem participants can strategically design token functionalities to support interactions across a spectrum, from open, permissionless engagement to more controlled, managed environments.

5.4.1. Personalized Control Data Access

Tokens can technically be accessed by anyone if the associated information is publicly readable, and, in some cases, anyone could add information. However, the results indicate that not every company chooses to maintain such a high level of openness. As noted by Company 4, there are applications where users do not have control over the

product's data. Instead, the entity—whether a business or a public administration—retains full control, preventing external actors from accessing or reading any data.

"Most of the system, the DPP that are out there, they just use hash and there is no information written on the blockchain and then everything is done on a centralized. System. So that makes you understand that it's still very, very early. It's going to happen." (Representative of Company 4)

Stakeholder integration and contributions to a token's history can, in principle, be designed as fully open, restricted to selected stakeholders, or limited solely to the product creator and corresponding token issuer. The case of Company 1 illustrates this design flexibility. During its pilot phase, the company chose to restrict on-chain data additions exclusively to the brand, while ecosystem participants were required to submit relevant information through an off-chain information system.

"The NFT interacts with the car's control unit that loads the information, and the user select what information he wants to share, and now you go to generate you have the possibility to choose what information you want to add. [...] there may be someone who does not like having the kilometers or have the type of battery use. And then choose if you want to put them in the NFT or not." (Representative of Company 4)

These design choices limit the modularity enabled by publicly accessible token information and writing permissions, restricting external actors' ability to contribute or integrate with the token. As a result, the ecosystem remains more centralized, reducing the flexibility of stakeholder interactions. This approach stands in contrast to fully open systems, where multiple actors can seamlessly append information and build upon existing tokens.

5.4.2. Flexible Transfer Mechanisms

Token transferability represents another crucial design choice that influences whether an ecosystem becomes more open and interoperable or remains siloed. As noted by a

representative from Company 12, the company initially decided to restrict token transfers to a predefined list of whitelisted actors. This approach allowed for greater control over who could own the asset, aligning the token's design with existing financial product mechanisms and regulatory frameworks. However, the company later opted to open token transferability, allowing their stablecoin—a cryptocurrency designed to maintain a stable value by pegging it to a reserve asset, such as fiat currency or commodities—to be exchanged with anyone. This decision enabled the stablecoin to be utilized within innovative DeFi protocols without introducing technical burdens for users.

"The big change in early July is licensing and removing whitelisting. [...] And so this frees the use of our stablecoin to anyone" (Representative of Company 12)

As previously noted, one reason for restricting token transferability is to provide a user experience that closely resembles traditional business ecosystems, thereby minimizing changes to user habits. However, such implementations are often referred to as 'Web2.5' because they do not fully leverage the potential of token transferability seen in Web3 environments.

As explained by Company 3, while an NFT may exist, the token often remains in the company's wallet and is not truly transferred or recorded on the blockchain during transactions between users. In these cases, the smart contract does not explicitly prohibit transfers. Instead, the limitation arises from the fact that users lack their own wallets, as the transfer can only be executed through Company 3's wallet.

"*Our client have two ways to claim ownership of the watch. One option is using the Arianee-built app, where users can directly claim their NFT. Alternatively, users can visit our website, register an account, and claim ownership through their profile. We primarily promote our website as it allows us to better understand and connect with our customers*." (Representative of Company 3)

5.4.3. Restricted Ownership Verification

Token owners can control and manage their tokens, enabling them to prove asset ownership to others. However, some ecosystems are designed to retain tokens within the company's wallet, thereby restricting user control and limiting interoperability. The programmable nature of tokens allows issuers to modify these control conditions over time. For instance, Company 8 initially restricted token acceptance to a single marketplace but retained the flexibility to allow other platforms to verify ownership and provide services to token holders if needed.

"At the moment you can only interact through marketplace Company 9 but I guess that anyway, having also designed in this way, with this technology, one of the possible perspectives of life, which is also to open up to other platforms, other systems that can interact." (Representative of Company 8)

When token verification is restricted to the issuer's platform rather than being directly recognized by service providers, the token's utility becomes dependent on intermediary control, limiting its interoperability. This constraint introduces friction within the ecosystem, as services must establish specific partnerships to enable token-based access, thereby reducing the token's potential for widespread adoption and seamless integration. This situation is exemplified by Company 7, where token owners cannot directly prove ownership of a ride by interacting with the provider partnered with the token issuer. Instead, they must use the issuer's application for verification and access. Consequently, any service not registered with Company 7's application cannot independently verify ownership without first establishing a formal partnership, increasing friction within the token ecosystem.

"Integrations with third-party services occur through the Company7 app, which acts as an aggregator and manages access to providers like Helbitz or Cooltra. NFTs offer benefits only within the Company 7 ecosystem and do not grant direct access to third-party services. Users can access these services via Company 7, while those with a direct account with the provider

use them independently. However, for verification, NFT users must go through the Company 7 app." (Representative of Company 7)

The token design landscape presents a nuanced continuum of ecosystem configurations, ranging from tightly controlled, company-managed interactions to more open, permissionless engagements. As blockchain and token technologies mature, companies are increasingly exploring flexible mechanisms that balance existing regulatory compliance with traditional user experiences. The programmable nature of tokens provides strategic opportunities for companies to dynamically adjust ownership, transferability, and access controls to read and update token informations.

These design choices restrict the modularity enabled by token ownership verification, limiting external actors' ability to integrate and interact. As a result, the ecosystem remains closed, reducing the flexibility for stakeholders to build services around token ownership. Ultimately, token design represents a critical strategic decision that can significantly influence interaction patterns, transparency levels, and potential value creation within a digital business ecosystem. In summary, these findings lead us to formulate the last practice:

Proposition 4. *"Token and UX design allow to manage open modular interactions, enabling the customization of ownership verification, ownership transfer and information exchange ".*

6 Discussion

This chapter explores the combinatory effects of token modularity by integrating key propositions derived from the results. Specifically, it examines how three distinct combinations of modular properties—reliable secondary markets, composable value layers, and unconstrained interoperability—align with existing literature on business ecosystems. By systematically analyzing each combination, the discussion highlights how tokens redefine traditional modularity frameworks. Ultimately, the chapter culminates in an assessment of tokens as hyper-modular instruments, synthesizing these elements into a unified perspective on their transformative role in digital ecosystems.

6.1.1. The Emergence of Reliable Secondary Markets in Token Business Ecosystems

The rise of token-based business ecosystems has been significantly influenced by the integration of publicly accessible and traceable token lineage information, coupled with unconstrained transferability. The ability to autonomously verify token ownership can be deliberately deactivated as a design choice, offering a novel perspective on modularity theory and its role in enabling reliable and dynamic secondary markets. Baldwin (2008) discusses modularity as a key mechanism for reducing transaction costs by defining standardized interfaces that facilitate specialization while maintaining interoperability (Jacobides et al., 2018).

Traditional secondary markets often face transaction frictions due to compatibility requirements and legal agreements that regulate asset transferability (Thun et al.,

2022). However, tokenization removes these barriers by embedding verifiable ownership history and authenticity directly within the asset itself (Iansiti & Lakhani, 2017). In platform ecosystems, modular structures have long been associated with competitive advantage, allowing firms to align interdependent activities without hierarchical control (Adner, 2017). Thun et al. (2022) emphasize how modular design enhances scalability through efficient coordination. Unlike previous conceptualizations of ecosystems, where firms must negotiate complementarities (Jacobides et al., 2018), token-based ecosystems introduce a more fluid and trustworthy mechanism for the exchange of ownership.

This study extends the understanding of modularity in business ecosystems by demonstrating how tokens facilitate the spontaneous emergence of secondary markets based on previously unexplored variables. Unlike earlier models that focus on centralized coordination and negotiation between market participants, token-based ecosystems decentralize authority, reducing reliance on intermediaries and enabling more efficient transactions. Jacobides (2018) describes coordination in ecosystems as spanning between markets and hierarchies. Token-enabled ecosystems challenge this paradigm by allowing secondary markets to function without centralized control. This is a crucial departure from traditional theories of modularity and value exchange, highlighting the benefits of decentralization in fostering more adaptable and resilient transactions.

Compared to traditional secondary markets, which often rely on cumbersome regulatory frameworks and contractual obligations, tokenized ecosystems offer greater transparency and accessibility. The automation of verification processes via smart contracts further enhances security and trust, creating an environment where assets can be exchanged with minimal friction. The integration of tokens within business ecosystems has profound implications for the design of secondary markets. The ability to track provenance, enforce transferability conditions, and eliminate intermediary frictions reshapes the fundamental dynamics of asset exchange. Future

research could explore how different governance models influence the stability and efficiency of these ecosystems. Additionally, industries beyond finance—such as supply chain management, intellectual property rights, and digital content distribution—could leverage tokenization to enhance interoperability and market fluidity. By challenging traditional ecosystem coordination models, token-based business ecosystems offer a novel framework for understanding how digital assets can be exchanged with minimal friction. The increased modularity not only streamlines transactions but also opens up new opportunities for innovation. For instance, in digital asset markets, smart contracts ensure compliance with pre-defined rules, further reducing transactional uncertainty.

As these ecosystems continue to evolve, their modular nature will likely drive further innovations, shaping the future of digital transactions in unprecedented ways. The shift toward token-based models presents opportunities for businesses and policymakers to rethink regulatory frameworks and market structures to better accommodate this emerging paradigm.

6.1.2. Composable Value Layers

The concept of innovation ecosystems has gained significant traction in both academic literature and managerial practice. Scholars such as Adner (2017) and Jacobides et al. (2018) have provided foundational frameworks for understanding how firms operate within ecosystems rather than in isolated competitive environments. The central premise is that firms are interdependent within a network that includes suppliers, complementors, competitors, and customers. The idea of modularity, as explored by Baldwin (2008), plays a crucial role in defining the structure of these ecosystems, enabling loosely coupled organizations to coordinate without hierarchical control. Research has categorized ecosystems into three broad types: business ecosystems, innovation ecosystems, and platform ecosystems (Jacobides et al., 2018). While business ecosystems focus on a firm's environment, innovation ecosystems revolve

around a focal innovation, and platform ecosystems highlight interactions around a platform (Gawer & Cusumano, 2014).

Adner (2017) differentiates between component and complement challenges, suggesting that technology leaders experience varying advantages based on their ability to manage these dependencies. He also highlights the importance of vertical integration in mitigating risks associated with ecosystem interdependencies. Recent research by Thun et al. (2022) further refines this perspective by introducing the concept of Massive Modular Ecosystems (MMEs), which emphasize the layered and interdependent nature of modern digital industries. Yoo (2013) critiques the emphasis on modularity, arguing that digitalization introduces a new paradigm of generativity, where innovation pathways are unpredictable and emergent (Temple University & Yoo, 2013).

Unlike Baldwin's (2008) firm-driven structures, publicly accessible token information enables permissionless service integration, reducing dependence on intermediaries. This extends beyond Jacobides et al.'s (2018) structured complementarities by encompassing decentralized ownership verification. While Adner (2017) emphasizes partner alignment, accessibility and reliability of information and ownership verification processes are shown to cut coordination costs. This autonomy contrasts with Jacobides et al.'s (2018) structured complementarity models requiring strategic alignment for interdependency management. This study demonstrates that token-based modularity enables permissionless expansion, allowing stakeholders to add services without central entity approval. Token modularity implications include lower entry barriers where third parties integrate services seamlessly, unlike traditional systems requiring negotiated platform access (Gawer & Cusumano, 2014). Moreover, the autonomous verification and protocol-native composability model enable service integration of trustworthy ownership without intermediaries. Furthermore, it reduces dependence on centralized standard-setting and governance, which typically creates

barriers for new entrants and slows the adoption of innovative solutions (Thun et al., 2022).

The emergence of token-based modularity presents profound theoretical implications for innovation ecosystem research. First, it challenges the traditional notions of firm boundaries by proposing that coordination and governance can be decentralized rather than orchestrated by a central authority. This suggests a shift from a firm-centric view of ecosystems (Jacobides et al., 2018) toward a more distributed governance model, where innovation occurs through collective participation rather than hierarchical control. Second, the findings highlight the evolution of ecosystem coordination mechanisms. Unlike prior models that emphasize structured interdependencies managed through contractual agreements and strategic alliances (Adner, 2017), token-based modularity allows for permissionless service integration. This redefines the role of complementors and intermediaries, reducing reliance on structured coordination and enabling a more fluid system of interaction among ecosystem participants. Third, the theory underscores the impact of technological infrastructure in ecosystem dynamics. The autonomy of ownership verification and protocol-native composability introduces a new layer of self-sustaining governance mechanisms. This not only lowers transaction costs but also facilitates innovation by removing barriers to entry, thus fostering a more inclusive and expansive ecosystem structure.

6.1.3. Unconstrained System Interoperability

Unconstrained System Interoperability represents a transformative approach to digital business ecosystems, integrating the principles of unrestricted token transfer and autonomous ownership verification. This paradigm fundamentally alters the dynamics of business ecosystems by enabling seamless cross-platform ownership mobility, minimizing entry barriers, and redefining access to information as a deliberate design strategy. Traditionally, modular ecosystems have been structured to

manage complexity through decomposition into interdependent modules, a concept extensively explored in the literature (Tatsumoto, 2018). However, despite their modular nature, these ecosystems have relied heavily on central platform firms to ensure compatibility, enforce governance, and dictate participation terms. Tatsumoto (2018) highlights how platform firms can drive ecosystem expansion by adopting open standards. Nonetheless, even within such frameworks, these firms maintain a regulatory role by imposing licensing restrictions or proprietary compliance measures, which ultimately shape participation dynamics.

A comparative analysis with previous theoretical frameworks, particularly those established by Baldwin and Clark (2000), reveals the limitations of traditional modularity. Baldwin and Clark argue that while modularity facilitates reduced coordination costs, this advantage is confined within predefined system architectures, which provide structural stability at the expense of broader accessibility. Consequently, this form of modularity often restricts the inclusion of new stakeholders, thereby decelerating ecosystem evolution and curbing innovation potential. Traditional theories of modularity have historically emphasized hierarchical verification mechanisms and control by centralized authorities, ensuring trust and asset authenticity through pre-established relational frameworks (Jacobides et al., 2018). These mechanisms have been pivotal in maintaining transactional security and operational efficiency within legacy ecosystems. However, such approaches inherently create bottlenecks that stifle decentralized participation and limit the adaptability of systems to evolving market dynamics. In contrast, the emergence of unconstrained token transfer introduces a fundamental shift away from firm-driven modularity. Empirical findings underscore the significance of unrestricted interoperability, particularly within cross-platform integrations where digital assets must operate fluidly without reliance on intermediaries. This transition challenges the conventional orchestration methods employed by dominant platform firms, demonstrating that modular structures can evolve autonomously through

decentralized, token-based systems. By enabling direct asset ownership verification and seamless transferability, these frameworks empower users to interact across platforms without dependence on centralized gatekeepers. The implications of this theoretical evolution extend beyond technological adaptation, influencing governance, economic participation, and competitive dynamics. By removing traditional constraints on interoperability, token-based systems facilitate a more inclusive and dynamically expanding ecosystem, fostering innovation and reducing dependency on incumbent platform governance. This shift not only democratizes access but also mitigates the risks associated with centralized control over digital assets. Additionally, it challenges existing legal and regulatory frameworks, necessitating the development of new compliance models that balance openness with security and ethical considerations. Future research must explore the long-term stability of such decentralized interoperability models, particularly in contexts requiring stringent verification protocols. Moreover, the potential for unforeseen systemic risks—such as security vulnerabilities and regulatory conflicts—warrants further investigation. In conclusion, Unconstrained System Interoperability marks a significant departure from traditional modular paradigms by prioritizing unrestricted digital asset mobility and decentralized governance. This evolution redefines the foundational principles of interoperability, positioning token-based architectures as a viable alternative to firm-regulated ecosystems. As industries continue to explore decentralized solutions, the theoretical and practical implications of USI will shape the future trajectory of digital economic structures, fostering a landscape where cross-platform interaction is no longer contingent on centralized oversight.

6.1.4. Token as Most Modular Instrument in Business Ecosystems

The evolution of business ecosystems has historically been driven by modularity, which structures interactions, reduces transaction costs, and fosters innovation. However, traditional modularity remains constrained by firm-governed mechanisms,

predefined governance structures, and intermediary-led verification processes. In contrast, token introduce a new level of modularity by integrating reliable secondary markets, unconstrained system interoperability, and composable value layers, making tokens inherently more modular than any previous system (Adner, 2017; Baldwin, 2008; Jacobides et al., 2018). Without any these features, modularity would still be limited by centralized governance, technical dependencies, or restricted market fluidity. Scholars such as Baldwin (2008) have established that modularity facilitates innovation by enabling firms to develop independently while maintaining systemic coherence through well-defined interface specifications. This perspective aligns with the broader understanding that modular systems, by minimizing dependency constraints, encourage specialization and reduce costs in product development and service delivery. Jacobides et al. (2018) further expanded this view by classifying modular ecosystems as fundamental to innovation, highlighting how decentralized structures foster adaptability and rapid technological advancement. However, traditional modularity classifications have largely been confined to firm-centric models, where control over interfaces determines competitive positioning and market power (Gawer & Cusumano, 2014).

The introduction of tokens as a modular instrument in business ecosystems represents a significant departure from these firm-centric modularity models. Tokens exhibit three fundamental dynamics that enhance modularity beyond existing frameworks: reliable secondary markets, composable value layers, and unconstrained interoperability. Unlike conventional modular structures that rely on predefined governance mechanisms and standard-setting authorities, tokens function as permissionless, decentralized components that can seamlessly integrate across multiple platforms and ecosystems. This study identifies how tokens transcend the constraints of traditional modular architectures by offering interoperability without the need for centralized coordination. Prior studies have largely confined modularity within organizational structures where interface control is crucial for maintaining

coherence and competitive advantage (Adner, 2017). In contrast, tokens operate independently of their original issuer, creating a new paradigm where modularity does not necessitate firm-based boundaries. This deviation from conventional modular systems challenges the traditional notion that firms must exert control over interfaces to sustain competitive differentiation (Adner, 2017; Baldwin, 2008).

By eliminating the necessity of firm-imposed boundaries, token-based modularity suggests a fundamental shift in how modular ecosystems are conceptualized and built. Unlike traditional modular systems where firms control the interfaces that dictate interoperability, tokens enable permissionless innovation, allowing any participant to build on existing modules without requiring authorization. This characteristic significantly enhances the scope and potential of modularity, as it reduces barriers to entry, fosters open-source development, and encourages decentralized collaboration. Baldwin's (2008) discussion on modularity influencing firm boundaries becomes particularly relevant in this context, as tokens effectively dissolve firm-based constraints, enabling an entirely decentralized form of modularity. Furthermore, the presence of reliable secondary markets ensures liquidity and value exchange independent of any central authority, while composable value layers allow for new functionalities to be built upon existing frameworks in a plug-and-play manner.

The implications of token-based modularity extend beyond theoretical contributions to business ecosystem literature. The findings of this research suggest the potential for a decentralized modular economy, where interoperability stems from open, composable systems rather than proprietary standards (Jacobides et al., 2018). This paradigm shift can alter how innovation occurs, moving from closed, hierarchical structures to open, network-based architectures where value creation is distributed across a broad array of participants. The ability of tokens to function independently of their original issuer signifies a major step toward trustless environments, where autonomous transactions and economic interactions occur seamlessly without the need for intermediaries. As the digital economy continues to evolve, token-based

modularity could become a cornerstone of future business models, enabling more inclusive and dynamic ecosystems that prioritize permissionless participation and composability over restrictive governance structures. This shift raises important questions about governance, regulatory frameworks, and the broader implications of decentralized modular ecosystems, paving the way for further research and exploration in this emerging field (Gawer & Cusumano, 2014; Baldwin, 2008; Adner, 2017; Jacobides et al., 2018).

Dimension	Key Characteristics	Impact on Business Ecosystems
Traceable Token Lineage	Publicly accessible and immutable token data Transparent verification of ownership and history	Enhances trust in transactions Reduces reliance on intermediaries for validation
Unconstrained Transferability	Tokens can be transferred peer-to-peer without restrictions Ownership changes are recorded on-chain	Eliminates settlement delays Reduces transaction costs and simplifies market entry
Autonomous Ownership Verification	Independent authentication of token ownership Direct service access without third-party approvals	Enables permissionless innovation Expands ecosystem participation and service integrations

Table 2: Key Token Dimensions and Business Ecosystem Impact

6.2. Token Modularity Framework

The following framework summarizes the key findings of the analysis, demonstrating how traceable token lineage, unconstrained transferability, and autonomous ownership verification enable more efficient interactions in business ecosystems. These insights define the Token Modularity Framework, offering a structured view of tokenization's impact on modular business interactions.

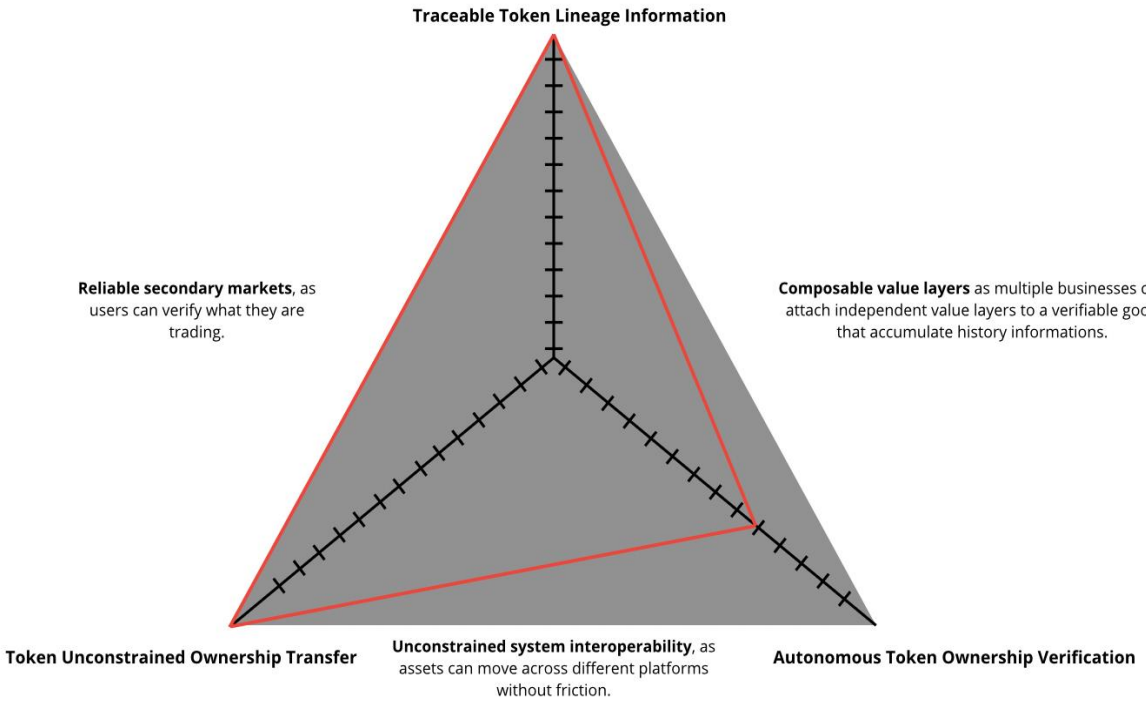


Figure 7: Token Modularity Framework

By combining these three modular dimensions, the framework establishes tokens as hyper-modular instruments that surpass traditional firm-driven architectures. This modularity fosters innovation, reduces governance bottlenecks, and encourages ecosystem scalability by lowering entry barriers for new participants. The Token Modularity Framework highlights how blockchain-based tokens reshape traditional modularity by enabling decentralized, autonomous, and composable digital ecosystems. This model directly derives from the analysis, reinforcing its empirical validity and practical applications for industry adoption.

7 Conclusion

7.1. Premise

This final chapter consolidates the study's key findings within the broader academic discourse on business ecosystems, modularity, and tokenization. The objective was to explore how token-based modularity reshapes business ecosystems by enabling greater openness, enhanced coordination, and seamless scalability. While traditional modularity relies on firm-led integration and centralized governance (Baldwin & Clark, 2000; Jacobides et al., 2018), token-based modularity introduces new coordination mechanisms characterized by permissionless participation, frictionless ownership transfers, and decentralized governance (Davidson et al., 2018; Ribeiro Da Silva & Angelis, 2024b). Blockchain technology further redefines ecosystem structures, enabling transaction automation, transparent stakeholder interactions, and decentralized economic systems (Iansiti & Lakhani, 2017).

To analyze this transformation, the study integrated foundational theories on modularity and business ecosystems with empirical insights from case studies on token adoption. Literature confirms that modularity balances innovation and control in business ecosystems (Sanchez & Mahoney, 1996). Blockchain and tokenization, however, extend modularity beyond firm-centric architectures, fostering decentralized governance, reducing transaction costs, and enhancing interoperability (Van Haaren-van Duijn et al., 2022; Wilson et al., 2022). This research examined how businesses integrate token-based modularity to streamline market participation, facilitate third-party integration, and improve secondary market liquidity.

Findings confirm that token modularity reshapes ecosystem dynamics, aligning with predictions that modular ecosystems thrive on standardization, composability, and adaptive governance (Gawer & Cusumano, 2014; Jacobides et al., 2018). Unlike traditional modular architectures requiring firm-led compatibility structures, tokens enable frictionless transactions and trust through immutable verification (Zheng et al., 2017). Tokens' interoperability without centralized oversight shifts value creation paradigms, fostering collaboration and market expansion beyond industry boundaries (Moore, 1993; Adner, 2017).

This study contributes to the discourse on digital business ecosystems by demonstrating how tokenization enhances modular coordination, reduces intermediary reliance, and promotes decentralized participation. As digital markets evolve, the role of token-based modularity in shaping business strategies, governance, and efficiency remains critical. By integrating theoretical and empirical insights, this research underscores tokenized architectures' potential to reshape economic interactions, driving a transition toward decentralized, interoperable business environments.

7.2. Theoretical and Managerial Contribution

From a theoretical perspective, this study extends modularity literature by demonstrating that tokens function as hyper-modular instruments. While prior research highlights modularity's role in innovation and industry structuring, token ecosystems introduce a more autonomous, open, and unconstrained modularity, bypassing centralized control. The findings contribute to business ecosystem theories by illustrating how tokens reduce coordination costs, expand ecosystems, and enhance service composability.

From a managerial standpoint, this study reveals how tokens redefine business ecosystems by enabling transparent secondary markets, seamless ownership transfers,

and composable service architectures. Token adoption's key advantage is its dual-feature combination: accessible and traceable token information with unconstrained transferability—two dimensions rarely examined together in academic literature. Unlike traditional modular architectures constrained by centralized governance, tokens allow stakeholders to access provenance data, transfer ownership, and trade assets with minimal intermediation, reducing transaction costs while enhancing trust and coordination. Token-based modularity also improves interoperability by removing reliance on legacy integration mechanisms. Firms can transfer ownership across platforms without backend modifications or intermediary approval. This, combined with independent ownership verification, enables token-gated access to services and functions, revolutionizing digital rights management, memberships, and access controls. By integrating ownership transferability and verification without requiring issuer approval, tokens reshape coordination dynamics in digital ecosystems.

Another critical contribution is service composability without issuer dependency. Traditional ecosystems require service providers to align with platform standards or negotiate integration contracts. In contrast, token-based architectures allow third-party developers to build services atop existing assets dynamically. This eliminates the need for issuer approval, fostering open innovation and expanding permissionless service offerings within business ecosystems.

Ultimately, token ecosystems redefine business ecosystems by lowering entry barriers, reducing coordination costs, and decentralizing governance. Firms no longer need proprietary platforms to expand services but can engage in highly modular, permissionless ecosystems leveraging existing infrastructure.

7.3. Limitations and Future Research Directions

This study acknowledges several limitations that should be considered when interpreting the findings. The investigation analyzed a restricted number of real-world tokenization implementations, which may constrain the generalizability of the results. While the multiple-case study approach provided valuable insights from 15 industry stakeholders, this sample size may not adequately represent the comprehensive spectrum of organizations utilizing tokenization technologies. A more extensive and diverse sample would potentially yield a more nuanced understanding of tokenization's effects and challenges within business ecosystems.

The research primarily concentrated on specific industry sectors—namely finance, supply chain management, and digital identity solutions—which may possess distinctive characteristics not necessarily emblematic of other domains where tokenization is being explored. The sectoral specificity of the findings suggests caution when extrapolating conclusions to alternative industries or contexts. Methodological limitations include potential bias introduced through the semi-structured interview process, as respondents exhibited varying levels of expertise and possibly held vested interests in their respective tokenization initiatives. Furthermore, the supplementation of primary data with secondary sources such as industry reports and white papers may not have provided equivalent analytical depth, potentially limiting the comprehensiveness of the investigation.

The conceptual framework centered on three token features (traceable token lineage, unconstrained transferability, and autonomous verification) in relation to modularity. While these attributes are significant, they may not encompass the full complexity and evolving characteristics of tokenization across different business ecosystem configurations. Additionally, the dynamic nature of tokenization technologies presents a temporal limitation, as rapid advancements in the field may affect the long-term applicability of the findings presented herein.

Future research should examine the long-term effects of token-based modularity on industry-wide standardization, competitive positioning, and firm adaptation strategies. Investigating cross-sectoral applications of tokens could further clarify its transformative potential. A critical avenue for future studies involves assessing how existing ecosystem roles evolve when tokenization is recognized as digital ownership, determining whether traditional structures adapt, merge, or become obsolete in response to decentralized governance models. As digital economies develop, understanding how firms navigate the intersection of modularity and decentralization will be essential for fostering resilient, efficient, and scalable business ecosystems.

7.4. Concluding Remarks

This study has explored the role of tokenization in business ecosystems, demonstrating its potential to enhance modularity, interoperability, and governance while identifying key challenges such as regulatory uncertainty and integration complexity. By bridging theoretical insights with empirical evidence, the research highlights how token-based frameworks facilitate trust, streamline asset transfers, and reshape stakeholder interactions. Token-based modularity marks a significant evolution in business ecosystem structures, eliminating traditional barriers, reducing transaction costs, and enabling seamless interoperability to create more dynamic and scalable business frameworks. However, the evolving nature of digital economies necessitates further investigation into how firms adapt to decentralized governance and emerging technological standards. As organizations continue to explore these architectures, understanding their governance, regulatory implications, and competitive dynamics will be crucial to shaping the future of digital economies. Future research should deepen the analysis of tokenization's long-term impact, ensuring that token-driven ecosystems remain scalable, efficient, and resilient to market dynamics.

Bibliography

Abreu, H., Pereira, V., & Barata, J. (2025). Blockchain-based digital product passport: Design principles and demonstration. *International Journal of Production Research*, 1–20. https://doi.org/10.1080/00207543.2025.2464161

Adner, R. (2017). Ecosystem as Structure: An Actionable Construct for Strategy. *Journal of Management*, *43*(1), 39–58. https://doi.org/10.1177/0149206316678451

Azaria, A., Ekblaw, A., Vieira, T., & Lippman, A. (2016). MedRec: Using Blockchain for Medical Data Access and Permission Management. *2016 2nd International Conference on Open and Big Data (OBD)*, 25–30. https://doi.org/10.1109/OBD.2016.11

Baldwin, C. Y. (2008). Where do transactions come from? Modularity, transactions, and the boundaries of firms. *Industrial and Corporate Change*, *17*(1), 155–195. https://doi.org/10.1093/icc/dtm036

Baldwin, C. Y., & Clark, K. B. (2000). *Design Rules, Volume 1: The Power of Modularity*. The MIT Press. https://doi.org/10.7551/mitpress/2366.001.0001

Baldwin, C. Y., & Clark, K. B. (2002). The Option Value of Modularity in Design: An Example from Design Rules, Volume 1: The Power of Modularity. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.312404

Blandin, A., Cloots, A. S., Hussain, H., Rauchs, M., Saleuddin, R., Allen, J. G., Zhang, B. Z., & Cloud, K. (2019). Global Cryptoasset Regulatory Landscape Study. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3379219

Blockchain & Web3 Outlook 2024/25. (n.d.). *Osservatori Digital Innovation del Politecnico di Milano*. Retrieved February 11, 2025, from https://www.osservatori.net/convegno/blockchain-web3/convegno-finale-osservatorio-blockchain-web3

Bullmann, D., Klemm, J., & Pinna, A. (2019). *In Search for Stability in Crypto-Assets: Are Stablecoins the Solution?* (SSRN Scholarly Paper No. 3444847). Social Science Research Network. https://doi.org/10.2139/ssrn.3444847

Buterin, V. (2014). A next-generation smart contract and decentralized application platform. *White Paper*, *3*(37), 2–1.

Carapella, F., Swem, N., & Gerszten, J. (2023). *Tokenization: Overview and Financial Stability Implications* (SSRN Scholarly Paper No. 5107878). Social Science Research Network. https://papers.ssrn.com/abstract=5107878

Colicev, A. (2023). How can non-fungible tokens bring value to brands. *International Journal of Research in Marketing*, *40*(1), 30–37. https://doi.org/10.1016/j.ijresmar.2022.07.003

Davidson, S., Filippi, P. D., & Potts, J. (2018). Blockchains and the economic institutions of capitalism. *Journal of Institutional Economics*, *14*(4), 639–658. https://doi.org/10.1017/S1744137417000200

Di Pierro, M. (2017). What Is the Blockchain? *Computing in Science & Engineering*, *19*(5), 92–95. https://doi.org/10.1109/MCSE.2017.3421554

Digital Product Passport, a Blockchain-based Perspective—European Commission. (n.d.). Retrieved March 8, 2025, from https://blockchain-observatory.ec.europa.eu/publications/digital-product-passport-blockchain-based-perspective_en

Dubois, A., & Gadde, L.-E. (2002). Systematic combining: An abductive approach to case research. *Journal of Business Research*, *55*(7), 553–560. https://doi.org/10.1016/S0148-2963(00)00195-8

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *The Academy of Management Review*, *14*(4), 532–550. https://doi.org/10.2307/258557

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory Building From Cases: Opportunities And Challenges. *Academy of Management Journal*, *50*(1), 25–32. https://doi.org/10.5465/amj.2007.24160888

Faiz, M., Wagh, D. S. K., Shahapure, R., Deb, S., & Kamble, P. (2023). *Land Registration System Using Blockchain*. *11*(7).

Gao, R. (2021). *The Theory and Development of Business Ecosystems*. https://doi.org/10.2991/assehr.k.211209.370

Gawer, A., & Cusumano, M. (2014). Industry Platforms and Ecosystem Innovation. *Journal of Product Innovation Management*, *31*. https://doi.org/10.1111/jpim.12105

Iansiti, M., & Lakhani, K. (2017). The Truth About Blockchain: *Harvard Business Review*, *95*, 118–127.

IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries. (1991). *IEEE Std 610*, 1–217. IEEE Std 610. https://doi.org/10.1109/IEEESTD.1991.106963

IT University of Copenhagen, Beck, R., Müller-Bloch, C., IT University of Copenhagen, King, J. L., & University of Michigan. (2018). Governance in the Blockchain Economy: A Framework and Research Agenda. *Journal of the Association for Information Systems*, 1020–1034. https://doi.org/10.17705/1jais.00518

Jacobides, M. G., Cennamo, C., & Gawer, A. (2018). Towards a theory of ecosystems. *Strategic Management Journal*, *39*(8), 2255–2276. https://doi.org/10.1002/smj.2904

Lamberty, R., Poddey, A., Galindo, D., de Waard, D., Koelbel, T., & Kirste, D. (2020). *Efficiency in Digital Economies—A Primer on Tokenomics* (Version 2). arXiv. https://doi.org/10.48550/ARXIV.2008.02538

Li, S., & Chen, Y. (2023). How nonfungible tokens empower business model innovation. *Business Horizons*, *66*(4), 543–554. https://doi.org/10.1016/j.bushor.2022.10.006

Moore, J. (1999). Predators and Prey: A New Ecology of Competition. *Harvard Business Review*, *71*, 75–86.

Mulligan, C., Godsiff, P., & Brunelle, A. (2020). Boundary Spanning in a Digital World: The Case of Blockchain. *Frontiers in Blockchain*, *3*. https://doi.org/10.3389/fbloc.2020.00037

Nakamoto, S. (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System* (SSRN Scholarly Paper No. 3440802). Social Science Research Network. https://doi.org/10.2139/ssrn.3440802

Parker, G., Van Alstyne, M., & Choudary, S. P. (2016). *Platform revolution: How networked markets are transforming the economy and how to make them work for you* (First Edition). W. W. NORTON & COMPANY.

Pineda, M., Jabba, D., & Nieto-Bernal, W. (2024). Blockchain Architectures for the Digital Economy: Trends and Opportunities. *Sustainability*, *16*(1), 442. https://doi.org/10.3390/su16010442

Regolamento—2016/679—IT - GDPR - EUR-Lex. (n.d.). Retrieved March 1, 2025, from https://eur-lex.europa.eu/eli/reg/2016/679/oj?locale=IT

Ribeiro Da Silva, E., & Angelis, J. (2024a). Finding Blockchain Value: A Business Ecosystem Approach. *IEEE Engineering Management Review*, *52*(2), 146–152. https://doi.org/10.1109/EMR.2024.3349629

Ribeiro Da Silva, E., & Angelis, J. (2024b). Finding Blockchain Value: A Business Ecosystem Approach. *IEEE Engineering Management Review*, *52*(2), 146–152. https://doi.org/10.1109/EMR.2024.3349629

Sanchez, R., & Mahoney, J. T. (1996). Modularity, flexibility, and knowledge management in product and organization design. *Strategic Management Journal*, *17*(S2), 63–76. https://doi.org/10.1002/smj.4250171107

Schneider, S., Leyer, M., & Tate, M. (2020). The Transformational Impact of Blockchain Technology on Business Models and Ecosystems: A Symbiosis of Human and Technology Agents. *IEEE Transactions on Engineering Management*, *67*(4), 1184–1195. https://doi.org/10.1109/TEM.2020.2972037

Simon, H. A. (1962). The Architecture of Complexity. *Proceedings of the American Philosophical Society*, *106*.

Sockin, M., & Xiong, W. (2023). Decentralization through Tokenization. *The Journal of Finance*, *78*(1), 247–299. https://doi.org/10.1111/jofi.13192

Subramaniam, M., Iyer, B., & Venkatraman, V. (2019). Competing in digital ecosystems. *Business Horizons*, *62*(1), 83–94. https://doi.org/10.1016/j.bushor.2018.08.013

Tasca, P. (2019). Token-Based Business Models. In T. Lynn, J. G. Mooney, P. Rosati, & M. Cummins (Eds.), *Disrupting Finance* (pp. 135–148). Springer International Publishing. https://doi.org/10.1007/978-3-030-02330-0_9

Tatsumoto, H. (2018). Evolution of Business Ecosystems. In T. Fujimoto & F. Ikuine (Eds.), *Industrial Competitiveness and Design Evolution* (Vol. 12, pp. 155–188). Springer Japan. https://doi.org/10.1007/978-4-431-55145-4_5

Temple University, & Yoo, Y. (2013). The Tables Have Turned: How Can the Information Systems Field Contribute to Technology and Innovation Management Research? *Journal of the Association for Information Systems*, *14*(5), 227–236. https://doi.org/10.17705/1jais.00334

Thun, E., Taglioni, D., Sturgeon, T., & Dallas, M. P. (2022). *Massive Modularity: Understanding Industry Organization in the Digital Age: The Case of Mobile Phone Handsets*. The World Bank. https://doi.org/10.1596/1813-9450-10164

Tönnissen, S., Beinke, J. H., & Teuteberg, F. (2020). Understanding token-based ecosystems – a taxonomy of blockchain-based business models of start-ups. *Electronic Markets*, *30*(2), 307–323. https://doi.org/10.1007/s12525-020-00396-6

Van Haaren-van Duijn, B., Bonnín Roca, J., Chen, A., Romme, A. G. L., & Weggeman, M. (2022). The Dynamics of Governing Enterprise Blockchain Ecosystems. *Administrative Sciences*, *12*(3), 86. https://doi.org/10.3390/admsci12030086

Vogelsteller, F., & Buterin, V. (2015). ERC-20 token standard. *Ethereum Foundation (Stiftung Ethereum), Zug, Switzerland*, *169*. https://scholar.google.com/scholar?cluster=14550551663798960314&hl=en&oi=scholarr

Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. P. (2004). Resilience, Adaptability and Transformability in Social-ecological Systems. *Ecology and Society*, *9*(2), art5. https://doi.org/10.5751/ES-00650-090205

Wang, S., Ding, W., Li, J., Yuan, Y., Ouyang, L., & Wang, F.-Y. (2019). Decentralized Autonomous Organizations: Concept, Model, and Applications. *IEEE Transactions on Computational Social Systems*, *6*(5), 870–878. https://doi.org/10.1109/TCSS.2019.2938190

Wilson, K. B., Karg, A., & Ghaderi, H. (2022). Prospecting non-fungible tokens in the digital economy: Stakeholders and ecosystem, risk and opportunity. *Business Horizons*, *65*(5), 657–670. https://doi.org/10.1016/j.bushor.2021.10.007

Yin, K. R. (2018). *Case Study Research and Applications*. SAGE Publications Inc. https://us.sagepub.com/en-us/nam/case-study-research-and-applications/book250150

Yin, R. K. (1984). *Case Study Research: Design and Methods*. SAGE Publications.

Zheng, Z., Xie, S., Dai, H., Chen, X., & Wang, H. (2017). An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends. *2017 IEEE*

International Congress on Big Data (BigData Congress), 557–564. https://doi.org/10.1109/BigDataCongress.2017.85

Annexes

Standard Questions used in the Interviews

1. Company Background

- Could you please introduce yourself and provide some background on your role within the company?
- What has been your involvement in the development and implementation of token-related initiatives?

2. Tokens and Business Ecosystem

- What were the initial motivations and strategic objectives behind the launch of your token-based project?
- Why did your company choose blockchain tokens over alternative technologies for this initiative?
- How does the process of developing token-based services or products compare to traditional digital or physical offerings?
- How does the token-based ecosystem differ from traditional product ecosystems within your industry? Are new entities or platforms involved (e.g., marketplaces, online communities)?
- What key advantages have been observed from incorporating tokens into your business ecosystem?

- Which companies or actors contribute to the value of the tokenized product or service? Who interacts with the token (e.g., consumers, applications, partner companies)?
- Have tokens facilitated new collaborations or partnerships? If so, what made these relationships valuable, and could they have been established without tokens?
- Have there been any measurable financial benefits from token implementation (e.g., increased revenue, reduced operational costs, new business opportunities)?
- Have any unexpected insights or advantages emerged from the token project?
- What has been the overall impact of tokens on your company's business ecosystem?

3. Future Outlook

- How do you see the role of tokens evolving within your business strategy?
- Are there plans to further innovate using tokens or modify their implementation in the future?
- What are the main challenges and opportunities you foresee in the long-term adoption of tokenized solutions?

List of Figures

List of Tables

Acknowledgments

We would like to express our gratitude to our advisor, Luca Gastaldi, and our co-advisor, Giacomo Vella, for giving us the opportunity to write our master thesis on such an interesting and stimulating topic. Their guidance and support throughout this research project were pivotal to bring this work to successful completion.

We would also like to extend our sincere appreciation to Ettore Zauli, whose continuous support and invaluable assistance have been instrumental throughout the development of this thesis. His insights and dedication greatly contributed to shaping our research and ensuring its successful execution.

Finally, we wish to express our sincere appreciation to the representatives of the interviewed organizations, whose insights and willingness to share their experiences contributed greatly to the depth of this study. Their collaboration provided us with essential perspectives that significantly enriched our understanding of the topic.