INATBA REPORT

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Tokenization

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Table of Contents

Key Takeaways **4**
Abstract **5**
Tokenization: Transforming Financial and Public Infrastructure through Distributed Ledger Technology **6**
Strategic Use Cases 6
Evolving Regulatory Landscape 6
Toward a Competitive Digital Economy 7
Savings and Investment Union (SIU) 7
The European Digital Capital Market Union 8
1. Introduction **10**
1.1 Why Tokenization Is Important: A Summary of Core Benefits 11
2. Distributed Ledger Technology, the Backbone of Tokenization **12**
2.1 Different Types of Tokens 13
2.1.1 Fungible and Non-Fungible Tokens 13
2.2 Asset Tokenization – Benefits and Risks 14
2.3 Hurdles and Limitations 14
3. Representation of the Token **16**
4. The Business Case for Tokenization **18**
5. Asset Tokenization and Use Cases **19**
6. The Regulatory Landscape **22**
6.1 Regulatory Frameworks for Crypto-Assets in the EU and Nationally 22
6.2 Common Principles Guiding These Regulations 23
6.3 UK and Liechtenstein: Integrating Financial and Crypto-Asset Regulation 24
6.4 Global Regulatory Landscape 25
7. The New Global Financial Landscape **26**
8. Concluding Remarks **28**
9. Appendixes **30**
9.1 The Regulatory Landscape 30
9.1.1 EU Regulatory and Guideline Timelines 30
9.1.1.1 Markets in Crypto-Assets Regulation (MiCA) – Effective 2024 30
9.1.1.2 The EU's DLT Pilot Regime 32
9.1.1.3 MiFID II / MiFIR 32
9.1.1.4 ESMA Guidelines on the Conditions and Criteria for Qualification of Crypto-Assets as Financial Instruments 33
9.1.2 National Approaches 34
9.1.2.1 Blockchain Law IV: Luxembourg's New Hub for Digital Securities 35
9.1.2.2 The Blockchain Act (TVTG) in Liechtenstein 35
9.1.2.3 New U.K. Crypto Rules Are a Big Step Forward 36

9.2 The Tokenization of Assets for a Decentralized Future in Europe 36
9.2.1 European Digital Capital Market Union 37
9.3 Selected Use Cases 38
9.3.1 Finance 38
9.3.1.1 Luxembourg's First Digital Treasury Notes 38
9.3.1.2 Supply Chain – VeChain (VET/VTHO) 39
9.3.1.3 TradeLens (IBM/Maersk) 39
9.3.2 Healthcare 40
9.3.2.1 Patientory ($PTOY) 40
9.3.2.2 Medicalchain ($MTN) 40
9.3.3 Commodities 40
9.3.3.1 Finka Token (Cattle Ranching) 40
9.3.3.2 BeefChain 41
9.4 Tokenization and Regulation 41
9.4.1 Outlook and Complexity 43

Key Takeaways

Tokenization represents a paradigm shift toward programmable, inclusive, and continuously operating financial and administrative systems. Its adoption promises enhanced efficiency, transparency, and accountability across both public and private sectors. Realizing this vision demands coordinated regulatory modernization, interoperability standards, and collaboration between policymakers, financial institutions, and technology providers. When balanced with sound governance and innovation, tokenization can form the backbone of a resilient, competitive, and citizen-centric digital economy.

The document focuses on explaining what tokenization is, why it is fundamentally important for global capital markets, and how it aligns with the policy directives and goals of Europe and other jurisdictions. The document presents use cases that have emerged in recent years on tokenization, as well as relevant national laws and regulations that both enable and, sometimes, limit the adoption of tokenized assets.

In short, the key takeaways of the document include:

1) Tokenization can enable billions of euros worth of capital market efficiencies in Europe alone.

2) Existing use cases have emerged, with the most successful ones being supported by national governments.

3) Despite regulatory advancements, both at the national and international level, regulatory fragmentation and lack of clarity persist. A common, industry-recognised taxonomy for digital assets is essential.

4) Major existing frameworks, like the DLT Pilot Regime, are limited by risk-averse limitations that make participation in the regime unattractive for major financial institutions.

5) Tokenization presents a strategic opportunity for Europe and other jurisdictions to lead in digital infrastructure modernization. Embracing the technology is key to the long term success of Europe, and the Capital Market Union should start through blockchain-enabled tokenized assets.

INATBA and its members will continue working on Tokenization policy and pushing for a global harmonized approach. The importance of this work cannot be understated - for INATBA members, tokenization may be one of the most, if not the most, important application of DLT and a highway for modernization and competitiveness for countries and regions that adopt these technology implementations.

Abstract

Distributed Ledger Technology (DLT) is rapidly emerging as a cornerstone of the global digital economy, driving innovation across financial markets, public administration, and digital services. At the center of this transformation lies tokenization—the process of representing real-world assets or services as digital tokens on a blockchain. By enabling transparent, programmable, and immutable records of ownership and transactions, tokenization is redefining how value is exchanged, governed, and regulated.

Core Benefits:
Tokenization enhances efficiency, transparency, and inclusivity. It reduces counterparty risk, automates settlement through smart contracts, and lowers transaction costs by minimizing intermediaries. Fractional ownership broadens access to traditionally illiquid or exclusive asset classes such as real estate, private credit, and commodities, increasing liquidity and democratizing investment. Tokenized systems also support 24/7 operations and real-time regulatory oversight through traceable, auditable transaction data.

Strategic Applications:
Governments, central banks, and financial institutions are already implementing tokenization. Examples include fractional real estate ownership platforms, Dirham-backed stablecoins in the UAE for regulated digital payments, and Tokenized Micro Flat Tax (TMFT) systems that embed automated tax compliance into blockchain protocols. These initiatives illustrate tokenization's potential to modernize markets, enhance fiscal governance, and support digital public infrastructure.

Regulatory Evolution:
In Europe, frameworks such as MiCA, MiFID II, and the DLT Pilot Regime are establishing clarity and harmonization for crypto-assets. National initiatives in Luxembourg, France, and Germany complement this progress, though regulatory fragmentation and interoperability challenges persist. Outside the EU, the UK and Liechtenstein integrate DLT within existing financial frameworks, while the UAE and Singapore advance regulated stablecoin ecosystems. A unified taxonomy for digital assets is essential to ensure consistency, interoperability, and investor confidence.

Strategic Implications:
Tokenization underpins Europe's ambition for a Digital Capital Markets Union—a unified, transparent, and efficient financial infrastructure powered by DLT. It supports the EU's Strategic Independence of the Union (SIU) by promoting innovation, liquidity, and competitiveness. However, successful adoption requires harmonized regulation, open standards, and incentives for market participation, alongside careful management of risks such as governance, cybersecurity, and data protection (particularly GDPR compliance).

Tokenization: Transforming Financial and Public Infrastructure through Distributed Ledger Technology

DLT is emerging as a foundational infrastructure for the global economy, accelerating innovation across finance, public administration, and digital services.

Tokenization — the representation of real-world assets and services on blockchain networks — is at the heart of this transformation. By enabling programmable, transparent, and immutable records of ownership and transaction, tokenization is redefining how value is exchanged, governed, and regulated in both financial and non-financial domains.

Tokenization reduces counterparty risk, enhances transparency, and enables 24/7 operations across interoperable platforms. It automates asset settlement, simplifies compliance, and minimizes costs by disintermediating traditional market structures. Importantly, tokenization improves liquidity by facilitating fractional ownership and lowering entry barriers, democratizing access to historically exclusive asset classes such as real estate, private credit, intellectual property, and commodities.

Strategic Use Cases

Tokenization is no longer a theoretical construct — it is being actively implemented by central banks, institutional asset managers, and governments. Use cases span a wide range of activities, for example:

- Tokenized Real Estate platforms that offer fractional ownership with automated rental income distribution.
- Stablecoin ecosystems (e.g., Dirham-backed digital currency in the UAE) designed for domestic payments under regulatory oversight.
- Public Finance Innovations such as the Tokenized Micro Flat Tax (TMFT), which automates tax compliance and collection at the protocol level using smart contracts and programmable compliance (Proof of Transaction, Proof of Compliance).

These examples demonstrate tokenization's capacity to modernize markets, tax systems, and public services.

Evolving Regulatory Landscape

The EU is building a multi-layered regulatory framework combining various directives and regulations covering several topics (e.g. MiCA, MiFID, DLT regime, AMLR).

National initiatives (e.g. Luxembourg's Blockchain Law IV, France's AMF regime, Germany's eWpG) are also advancing legal clarity and sandbox experimentation. Outside the EU, the UK and Liechtenstein have proposed models that integrate

DLT into existing financial frameworks with varying degrees of innovation and institutional emphasis.

Despite these advances, regulatory fragmentation persists. Addressing interoperability gaps, legal uncertainty, and technological neutrality remains critical. Notably, financial regulations must avoid imposing financial compliance structures on non-financial token use cases.

Toward a Competitive Digital Economy

Tokenization presents a strategic opportunity for Europe and other jurisdictions to lead in digital infrastructure modernization. A successful path forward requires:

- Adoption of technologically neutral, harmonized regulatory frameworks,
- Support for open standards and interoperable protocols, and
- Institutional incentives for liquidity providers and market makers.

By enabling transparent, programmable, and inclusive financial markets, tokenization supports both economic competitiveness and public accountability. Its integration into taxation, identity systems, and digital public infrastructure could form the foundation of a more responsive, citizen-oriented social contract.

Savings and Investment Union (SIU)

To fully realise the potential of tokenization, policymakers must address regulatory fragmentation and actively foster innovation. The following recommendations are key:

1. The report underlines the strong emphasis in the Savings and Investment Union (SIU) Action Plan and the subsequent consultation on the deployment of DLT in trading and post-trading operations.
2. Amending the DLT Pilot Regime to raise the thresholds for eligible instruments would have immediate positive impacts. Specifically, it would:
    - Stimulate greater market interest in providing DLT-based trading and settlement platforms.
    - Improve liquidity and boost trading volumes in secondary markets, especially in the direction of tokenized quotas of smaller limited companies (eg. Srl, Sarl, GmbH and so on).
3. As the financial system evolves, a greater convergence between regulations governing traditional assets is hugely welcomed (such as MiFID, EMIR, and CSDR) and those under the DLT Pilot Regime. As decentralised finance (DeFi) expands, the distinction between traditional and DLT-based ecosystems should dissolve, giving rise to a unified, integrated financial framework.

4. No position on the optimal cash-on-chain solution, however. A competitive environment — including a digital euro, MiCA-compliant stablecoins, and central bank monetary tokens (CBMTs) — would best signal Europe's openness to innovation and market-driven progress.

5. A common, industry-recognised taxonomy for digital assets is essential to standardise definitions, reduce confusion, and support interoperability across platforms. The current lack of consistent terminology creates regulatory uncertainty and contributes to market fragmentation, which in turn hampers scalable tokenization. A unified taxonomy would help align stakeholders, simplify compliance processes, and strengthen investor confidence, ultimately supporting the stability and growth of digital asset markets.

The European Digital Capital Market Union

The European Digital Single Market Vision focuses on modernizing and unifying the EU's economic infrastructure through blockchain-based technology. As previously said in this document, DLTs and digital assets can enhance capital markets by improving efficiency, transparency, and accessibility, contributing to a competitive and integrated union. The Digital Capital Markets Union aims to create an efficient, cohesive framework across Europe using digital technologies and consistent regulations.

Similarly, government efficiency also increases through digital platforms, reducing reliance on physical offices and paperwork, and enhancing convenience. Inclusive governance is promoted by making services and decision-making processes accessible to all citizens via digital platforms.

While traditional ledger systems are centralised, managed by intermediaries like banks or governments, controlling information access and transaction verification, Blockchains provide transparent, decentralized transaction recording, where network participants verify and validate transactions on a distributed ledger. Fostering a DLT based system enhances de facto trust in the system as everything could be open for easy verification. DLT technology eliminates intermediaries in DeFi, offering decentralized recordkeeping with enhanced security through automated verification and smart contracts. However, smart contracts may not constitute legally binding agreements and are limited by their code.

DLT simplifies tax processes, and enhances transparency. The Digital Single Market fosters fairer taxation, efficient reporting, transparent information, and accurate tax calculations. In blockchain networks, stakeholders like agencies, customs, and tax offices have defined roles, ensuring consensus on taxation matters. The tax offices could also rely on AI-driven mechanisms to streamline tax processes by collecting data, establishing taxpayer profiles, and automating returns. The widespread use of DLT's benefits taxation by allowing authorities to focus on core tasks, anticipate future needs, and access real-time reliable information.

However, GDPR compatibility poses challenges, especially with blockchain's immutability conflicting with data alteration and deletion requirements. Thus, GDPR must adapt to emerging technologies like blockchain, AI, and quantum tech, incorporating dynamic informed consent within the ecosystem.

The vision of creating a European Digital Single Market using DLT, including blockchain, is a forward-thinking approach to modernizing and unifying the EU's economic infrastructure. The digital single market can be created on a blockchain-based network, a DLT in which all stakeholders, including revenue agencies, customs agencies, peripheral tax offices, and other agencies, will have defined roles. Challenges of this magnitude must be tackled with unity and cohesion, as Europe has shown itself capable of doing with this historic agreement, highlighting the ability of member states to overcome differences to build a common space for the benefit of all. The member states, with their actions today and tomorrow, will increasingly influence not only the common destiny, but above all a new European way of thinking characterized by a policy of confrontation and growth in facts. Digital technologies can play a transformative role in developing a digital capital markets union within the EU.

By leveraging digital tools, the capital markets union can enhance efficiency, transparency, and accessibility, leading to more integrated and competitive capital markets. Digital technologies have the potential to significantly enhance the efficiency, transparency, and accessibility of the EU's capital markets. By embracing these technologies, the EU can accelerate the development of a digital capital markets union, fostering a more integrated, competitive, and innovative financial ecosystem that benefits both businesses and investors. Integrating digital technologies into physical infrastructures can lead to leaner, more efficient systems[1].

[1] The Interplay Between Tax and Financial Regulations in a New Digital World.

1. Introduction

Asset tokenization is the process of creating a digital representation of real-world assets (both tangible and intangible) or services on a distributed ledger, such as blockchain, achieving consensus amongst stakeholders. This digital representation is qualified as a "token". Throughout this paper, the term "real-world asset" refers to the real-world physical assets and the real-world services. This paper focuses on asset tokenization even if some of its considerations can expand to other types of tokenizations.

This transition to blockchain-based ledgers offers the potential for significant risk mitigation and operational efficiencies through the inherent properties of decentralized, immutable, and transparent transaction records.

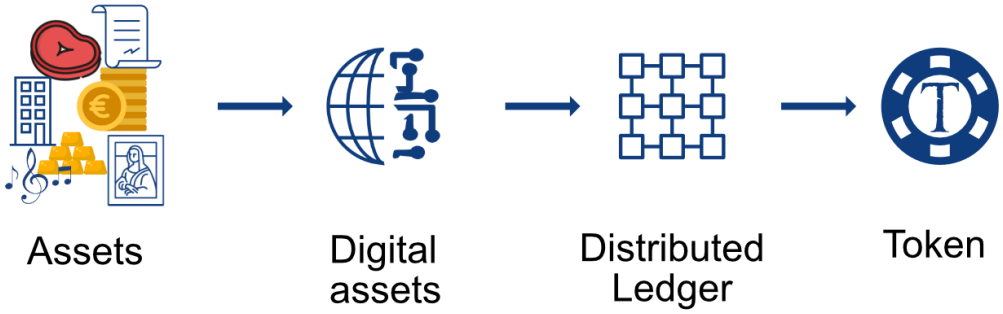

Figure 1: The process of asset tokenization.

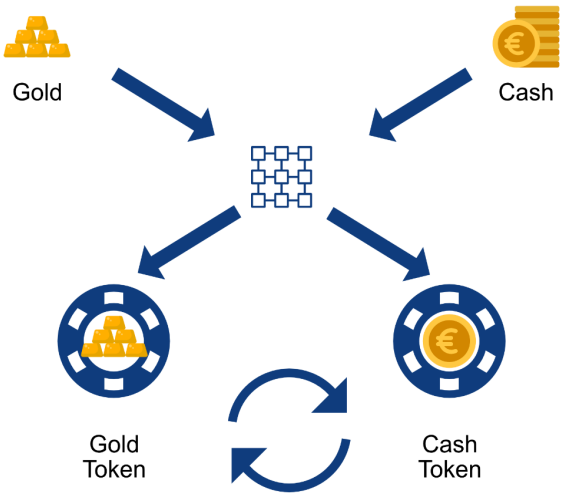

Figure 2: Tokenization of gold.

1.1 Why Tokenization Is Important: A Summary of Core Benefits

Tokenization leverages blockchain technology and smart contracts to transform how assets are issued, transferred, and managed. By enabling programmable, self-executing transactions, tokenization allows for near-instant settlement, reduces counterparty risk, and ensures immutability and transparency through decentralized ledger systems. This automation eliminates many of the frictions found in traditional financial infrastructure, while also offering regulators better oversight tools through real-time asset traceability and compliance visibility. These features not only enhance transaction efficiency but also help prevent systemic fraud and streamline complex operations like trade settlement or bankruptcy resolution.

Another major advantage of tokenization is its ability to improve liquidity, interoperability, and accessibility. Tokenized assets — from real estate to gold, intellectual property to stablecoins — can coexist on the same blockchain and be traded without the need for traditional intermediaries. This reduces processing time and costs while opening up investment opportunities to a broader population through fractional ownership. In turn, this democratizes access to previously illiquid or high-barrier markets. Moreover, because blockchain protocols are often open source and built to international standards (e.g., ISO 27001), they enable seamless cross-platform interoperability and foster innovation on a level playing field.

Finally, tokenized systems can operate 24/7, outside the constraints of traditional market hours, and are structurally more cost-efficient. By replacing legacy architectures, reducing intermediaries, and automating through smart contracts, these systems drastically cut administrative burdens and minimize human error. However, realizing their full potential still requires regulatory modernization, particularly to accommodate decentralized protocols, novel asset classes, and embedded compliance mechanisms.

2. Distributed Ledger Technology, the Backbone of Tokenization

DLT is a digital infrastructure that innovatively merges distributed computer networks with cryptography to establish a novel approach for recording status updates and asset transactions among participants within a network. This technology empowers all involved parties with a simultaneous, certain, and reconciled understanding of the transaction history, eliminating the need for intermediaries to provide assurance or for subsequent data reconciliation.

In a distributed architecture, numerous participants, known as nodes, maintain an identical copy of a shared ledger. To ensure the integrity of this shared record, new transactions undergo a consensus-based verification process, requiring agreement among the participating nodes before adding to the ledger. Once verified, these transactions are secured through cryptographic immutability, meaning they form an unalterable historical record, guaranteeing data integrity.

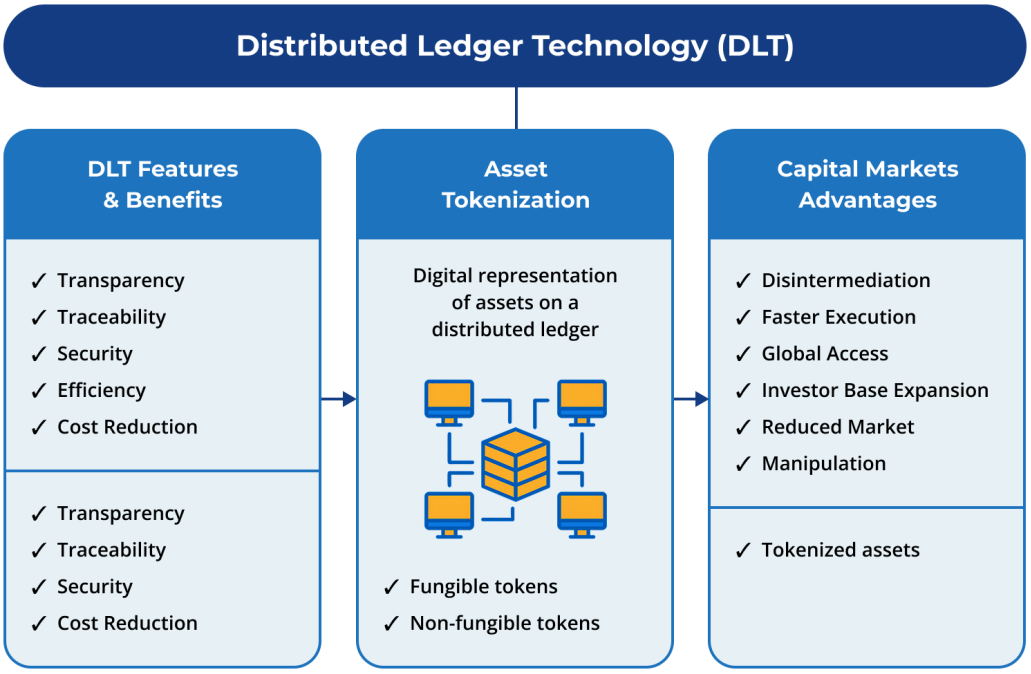

Figure 3: DLT, its features, asset tokenization, and advantages in capital markets.

While the DLT presents a list of advantages, it also comes with a set of new risks. Distribution creates governance issues, code safety issues, wallet-related issues, and oracle issues, to name the most common ones. All of these issues can be properly addressed, but all of them raise question marks when compared to the current regulatory set up.

2.1 Different Types of Tokens

Tokens can be segregated by their fungibility and by the nature of the underlying elements.

2.1.1 Fungible and Non-Fungible Tokens

Fungible tokens are interchangeable and divisible units of equal value, like currency, while non-fungible tokens (NFTs) represent unique, indivisible assets that cannot be substituted. When NFTs are fractioned into f-NFTs, these fractions are fungible only among themselves, preserving the uniqueness of the original asset. NFTs serve as proof of ownership and authenticity for unique digital or physical items and can also be used for certification purposes due to their distinct and verifiable nature on a blockchain.

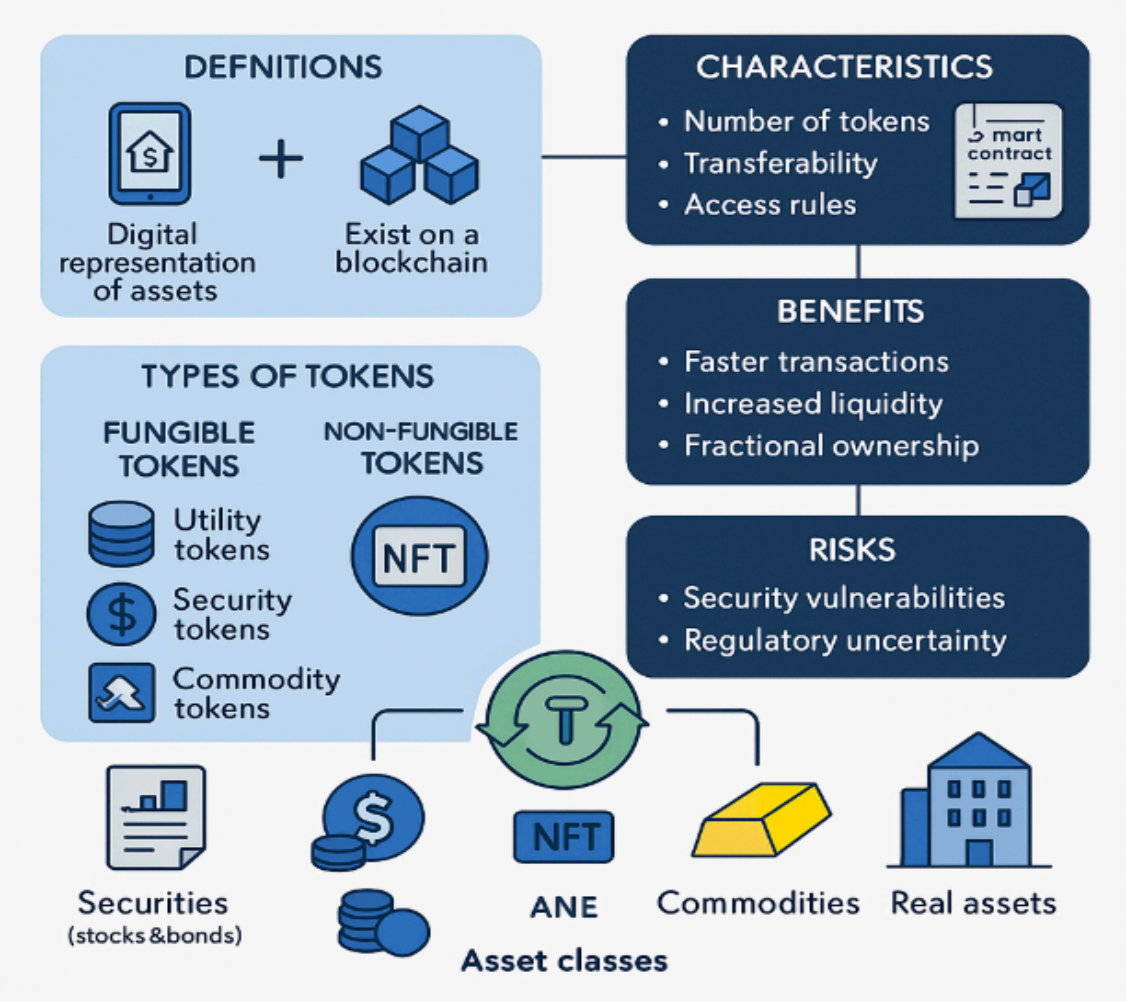

Figure 4: Tokenization.

2.2 Asset Tokenization – Benefits and Risks

The ability to tokenize assets, products, or services and thus to generate a token in the virtual world and link it to a real asset via a smart contract could significantly affect the speed and security of transactions. It can also lower the cost of transactions. The increasingly central role that tokenization will play in data protection and payment security should be emphasized. By relying on a distributed and decentralized ledger, tokenization makes it possible to protect sensitive data (digital assets of all kinds) from users who do not have permission to access or manage them.

When we talk about tokens, we are not referring just to cryptocurrencies. At the moment, token applications are basically pilot or experimental projects, but the technology is constantly evolving.

Tokenized asset classes can include:

- Securities (such as stocks and bonds);
- Commodities (such as gold); and
- Real assets (such as real estate).

The efficiency of automation and disintermediation is a prominent benefit of asset tokenization. Also, faster clearing and settlement processes promote transparency and, most importantly, increased liquidity. Asset tokenization could be an alternative way to achieve fractional ownership of an asset because it reduces barriers to investment and allows retail investors more inclusive access to traditionally illiquid asset classes.

Beyond clear economic advantages, the traceability and “open-book” nature of many blockchains offer a unique opportunity to restore confidence in currently opaque processes. Tokenization maintains privacy while making it easier to combat money laundering and financing criminal and terrorist activities.

2.3 Hurdles and Limitations

Asset tokenization is not without risk. Using DLT in token markets faces several challenges due to its innovative nature. The possible risks the DLT users face include:

- operational vulnerability;
- uncertainty about the purpose of settlement;
- interoperability between different networks that will allow connectivity of different infrastructures;
- interoperability of DLT-based infrastructure with traditional infrastructure;
- network stability;
- robustness of market infrastructure; and

- threats of cyberattacks.

The OECD adds governance risks associated with fully decentralized ledgers because of the difficulty in identifying a single owner or node responsible for the entire network. The absence of a single actor in charge of the process is a major challenge in regulating DLT networks and assigning responsibility for network problems.

3. Representation of the Token

At present, tokens have been used in three big cases:

- The representation of an intangible asset;
- The representation of a tangible asset;
- The evidence of a characteristic.

The intangible assets are all assets that are not corporeal. This category mostly includes rights to either an intangible asset or a service. Tangible assets usually describe the right on the asset itself. The table below illustrates the nature of these tokenized assets through use cases.

	Fungible	Non-Fungible
Tangible Assets	Commodity Tokens (e.g., Gold-backed token, Oil Futures Token): Each token represents a specific, interchangeable unit of a physical commodity.	Real Estate/Property Tokens (e.g., Fractional ownership of a specific building): Each token represents a unique share or the full ownership of a specific, identifiable physical asset. Specific Art Piece Token – A token representing the unique ownership of a particular physical artwork.
Non-Tangible	Utility Tokens (e.g., ERC-20 token for network access, governance token in a DAO): Provide access to a specific service, network, or set of rights within an ecosystem. They are designed to be interchangeable for use. Security Tokens (e.g., Tokenized shares of a company, Revenue share tokens): Represent ownership in an underlying company or financial instrument, granting rights like dividends or voting. They are designed to be fungible shares of that underlying value. Stablecoins (FIAT-backed) – Stablecoins mostly represent a claim on a currency in a bank account. Some argue their stability is tied to the tangibility of the underlying fiat, and they are designed to be fungible representations of that value.	Domain Name Tokens (e.g., ENS domain name, Unstoppable Domain): Each token represents a unique and non-interchangeable digital identity or address. Gaming NFTs (e.g., unique in-game item, avatar) - While they might have utility within a game, their non-fungibility stems from their unique digital identity and often visual characteristics. Royalties tokens for a very specific song or image that represent the rights on the very specific piece of non-tangible art.

Proof of a Characteristic	This is a highly conceptual/edge case: it is difficult to conceive of a fungible "proof of a characteristic" in the same way. If a proof were fungible, it would imply that any proof of that characteristic is identical and interchangeable, which lessens the uniqueness often associated with credentials. However, one could argue for a "Proof of Basic Competency" token where any token verifies that basic competency, making them interchangeable. This is a highly theoretical intersection.	Identity Tokens/Verifiable Credentials (e.g., Digital ID, Diploma NFTs, Medical Record NFTs, KYC Verifications): These tokens uniquely prove a specific attribute or record about an individual or entity. They are inherently non-fungible because the characteristic or record is specific to that individual/entity. Reputation Badges (e.g., "Top Contributor" badge in a community) - These are unique to the individual who earned them.

Table 1: Nature of tokenized assets.

4. The Business Case for Tokenization

Tokenization is increasingly being embraced by governments and major financial institutions as a transformative solution for modernizing capital markets. Entities such as the Bank of England, Euroclear, DTCC, the European Investment Bank, and the World Bank are actively developing and deploying tokenized asset infrastructures, signaling a shift from theoretical exploration to practical implementation. By leveraging smart contracts and blockchain networks, tokenization enables real-time settlement, reduces reliance on intermediaries, and addresses inefficiencies inherent in legacy financial systems, potentially saving $15–20 billion annually in infrastructure costs. Notably, platforms like HSBC Orion and Goldman Sachs' DAP have already supported the issuance of tokenized bonds, while asset managers like Blackrock and Franklin Templeton have introduced tokenized mutual funds, expanding the reach of digital investments.

One of the most impactful promises of tokenization lies in its ability to unlock collateral mobility on a global scale. Currently, only a small fraction of the $340 trillion in marketable securities is actively used for collateral purposes[2][3], and tokenization could radically expand this pool by simplifying trade finalization and enhancing liquidity. Projects such as Euroclear's tokenization of gold, Gilts, and Eurobonds, along with Hong Kong's Project Evergreen, demonstrate the tangible progress being made. As capital flows become more synchronized across tokenized securities and deposits, institutional crypto markets are also adopting traditional finance safeguards – such as privacy-preserving data permissioning – to ensure secure, compliant, and scalable operations. This convergence points to a future where financial markets operate seamlessly across borders, around the clock.

Key questions remain about who controls distributed ledgers, how security and privacy are ensured, and more importantly how global regulatory frameworks will adapt. Independent governance structures – like the Global Synchronizer Foundation, supported by the Linux Foundation – offer a model for transparent, decentralized oversight by market participants and technology providers. As we move from the exploratory phase into widespread adoption, the momentum behind tokenization is building a digitally native financial ecosystem that promises more efficient, inclusive, and resilient global markets.

It is to be noted that tokens, and the smart-contracts, are at the core of Web3. The development of Web3 cannot take place without a sound development of the tokens.

[2] https://siblisresearch.com/data/world-market-cap-profits/.
[3] https://www.businessresearchinsights.com/market-reports/bond-market-123122.

5. Asset Tokenization and Use Cases

Tokenization is unlocking new possibilities across multiple sectors by enhancing liquidity, reducing entry barriers, and improving transparency and operational efficiency. A prominent example is RealT, which enables fractional ownership of U.S. rental properties through tokenized equity issued as ERC-20 tokens. Investors receive rental income directly in their crypto wallets, and smart contracts automate distribution. This approach democratizes real estate investment, allowing participation from as little as a few hundred dollars, while ensuring verifiable, immutable records of ownership on-chain. Though still less liquid than traditional markets, these tokenized assets are more tradable than direct property ownership and are structured to comply with securities regulations, ensuring long-term viability.

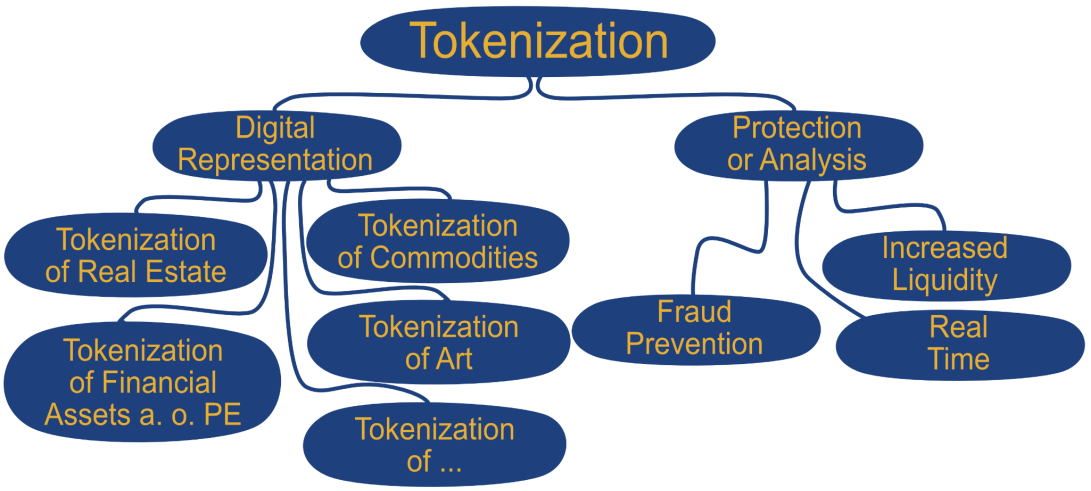

Figure 4: The tokenization process.

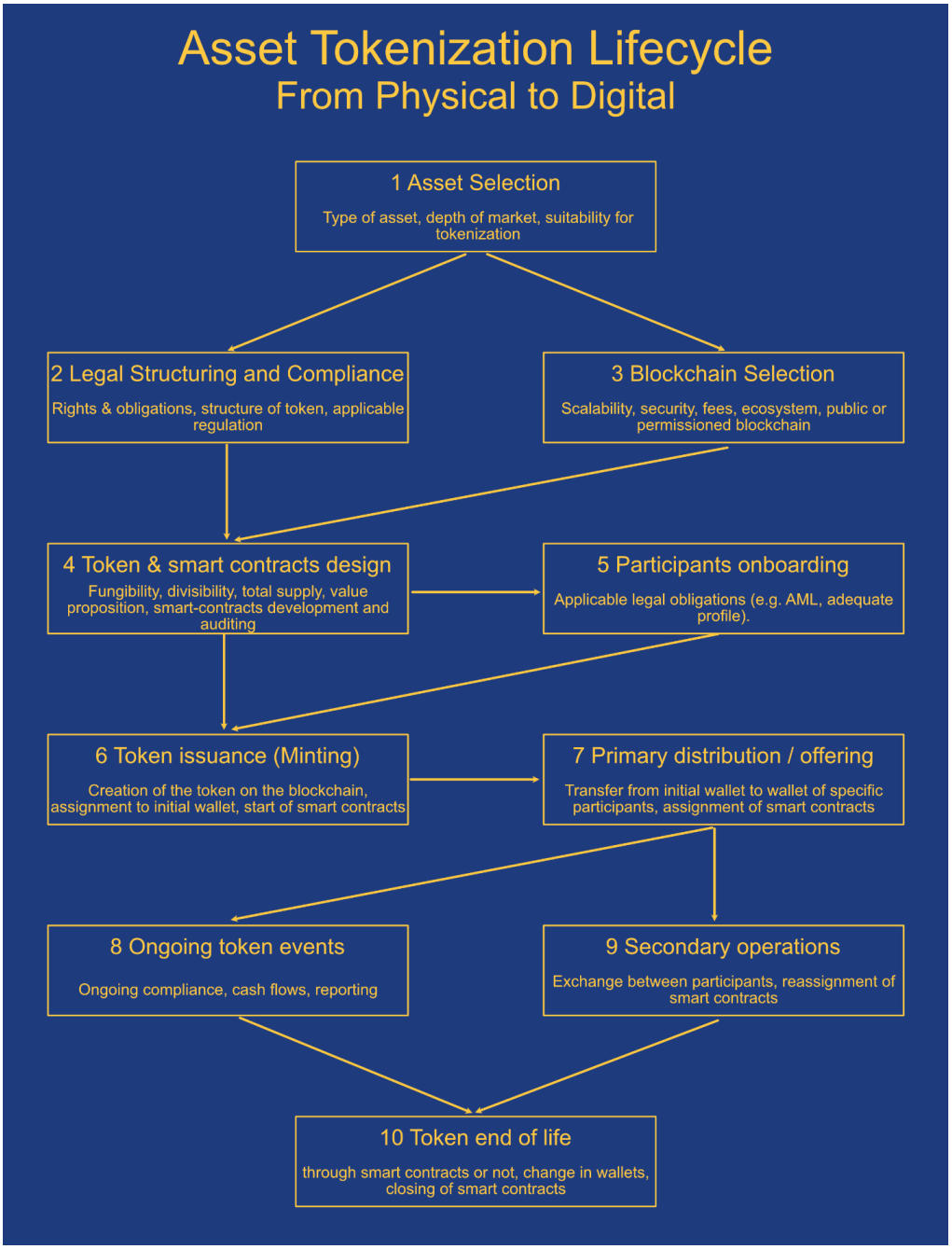

Figure 5: Asset tokenization lifecycle.

In the Middle East, the UAE is spearheading a regulatory-first approach to tokenized payment innovation through Dirham-backed stablecoins. With the Central Bank's Payment Token Services Regulation (effective August 2024), entities like AE Coin and major financial institutions such as FAB, ADQ, and IHC are launching stablecoins fully backed by Dirham reserves. These tokens are audited, regulated, and intended for domestic payments, supporting a stable, sovereign, and digitally integrated economy. Additional approvals, like the DFSA's recognition of USDC and EURC, reflect growing adoption for treasury, remittances, and cross-border transactions. This strategic positioning underscores

how tokenization and regulatory clarity can foster digital currency ecosystems within established financial frameworks.

Beyond real estate and payments, tokenization has the power to reshape public policy and tax administration. The Tokenized Micro Flat Tax (TMFT) introduces a new model of taxation based on programmable logic directly embedded in blockchain transactions. By using smart contracts to automate tax calculation and collection at the point of transaction, the TMFT offers real-time compliance, reduces fraud, and eliminates the need for costly reconciliation processes. This is particularly impactful for taxing digital assets, microtransactions, or cross-border economic activity, where traditional tax systems struggle.

Other use cases include supply chain (e.g., VeChain), healthcare (e.g., Patientory), and agriculture (e.g., BeefChain), each showing how tokenization can expand access, streamline operations, and introduce transparency to previously siloed or opaque industries. These examples collectively highlight the transformative potential of tokenization across finance, governance, and real-world economic activity.

6. The Regulatory Landscape

The regulatory landscape for tokenization in Europe is evolving rapidly, as authorities seek to provide legal clarity and foster innovation while protecting market integrity and investors. Below is a high-level decision-tree as to which regulatory framework applies when approaching specific crypto-assets or crypto assets that are financial products. This is limited to the product-related regulation and does not cover any other aspect.

The European Union's regulatory landscape for crypto-assets is rapidly evolving, driven by a dual approach that seeks to provide clarity for digital innovations while safeguarding market integrity and investor protection. This involves both overarching EU-wide frameworks and specific national initiatives.

6.1 Regulatory Frameworks for Crypto-Assets in the EU and Nationally

At the EU level, the primary regulatory frameworks applicable to crypto-assets are:

- **Markets in Crypto-Assets Regulation (MiCA):** This groundbreaking regulation, fully applicable by December 2024 (with stablecoin provisions effective June 2024), creates a harmonized legal framework across the EU for crypto-assets that do not qualify as financial instruments. It covers rules for crypto-asset issuers (including specific categories like Asset-Referenced Tokens – ARTs, and E-Money Tokens – EMTs), and Crypto-Asset Service Providers (CASPs). MiCA aims to enhance consumer protection, promote market integrity, and provide legal certainty, effectively restricting unregulated offshore entities from targeting EU consumers.

- **DLT Pilot Regime:** Effective since March 2023, this regime acts as a "sandbox" for market infrastructures dealing with tokenized financial instruments. It allows temporary exemptions from existing EU financial rules to foster innovation and gather insights for a future permanent framework. While its uptake has been marginal, it specifically addresses crypto-assets that fall under traditional financial definitions.

- **MiFID II / MiFIR:** For crypto-assets that do qualify as financial instruments (often referred to as "security tokens"), the extensive MiFID II (Markets in Financial Instruments Directive II) and MiFIR (Markets in Financial Instruments Regulation) framework applies. This means such tokens are subject to existing regulations governing market structure, investor protection, best execution, and transaction reporting, treating them akin to traditional securities.

- **Anti-Money Laundering (AML) Framework:** Regardless of whether a token falls under MiCA or MiFID II, all crypto-asset activities are subject to the EU's comprehensive AML/CTF (Counter-Terrorist Financing) regulations. This mandates KYC (Know-Your-Customer) procedures, transaction monitoring, and suspicious activity reporting for relevant service providers.

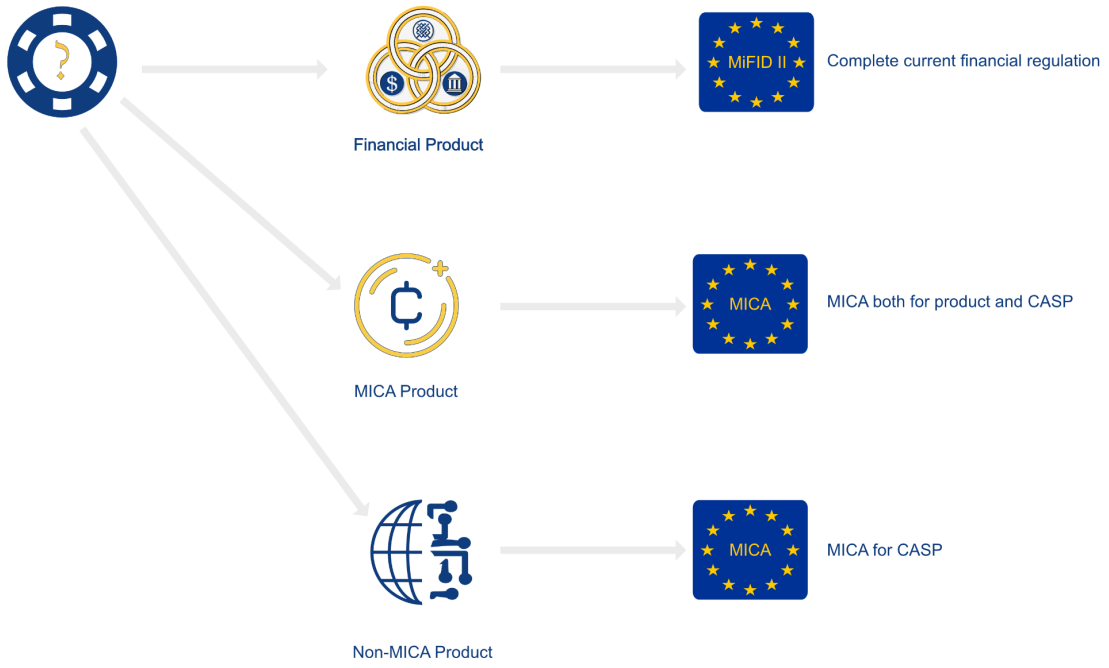

Figure 6: Regulatory framework for different types of financial and crypto-assets under EU regulations.

At the National level, several EU member states and closely associated countries have also developed specific legislation or guidance that often complements or prepares for EU-level regulations:

- **Germany:** Recognizes electronic securities (eWpG), including crypto securities, allowing for the direct issuance of certain securities on a blockchain.
- **France:** Has established a specific crypto-asset registration framework through its financial regulators, the AMF and ACPR.
- **Luxembourg:** With its recent Blockchain Law IV (adopted December 2024), explicitly recognizes and regulates the issuance, registration, and transfer of dematerialized securities using DLT. This positions Luxembourg as a key player for tokenized financial instruments and has already seen the issuance of its first digital treasury notes.

6.2 Common Principles Guiding These Regulations

Despite the diverse frameworks, several common principles underpin the EU and national approaches to tokenization:

- Technological Neutrality: Regulators strive to apply existing financial laws to new technologies where appropriate, rather than creating entirely new rules for every innovation. This aims for consistency and avoids regulatory arbitrage, though its practical application can be complex.
- Investor and Consumer Protection: A paramount goal across all regulations is safeguarding individuals from risks associated with crypto-assets, including fraud, market manipulation, and misleading information. This manifests through disclosure requirements, conduct rules for service providers, and mechanisms for redress.
- Market Integrity and Financial Stability: Regulations aim to prevent market abuse (e.g., insider trading, market manipulation), ensure transparent and orderly markets, and mitigate systemic risks that crypto-assets could pose to the broader financial system. This is particularly evident in the strict rules for stablecoins.
- Anti-Money Laundering (AML) and Counter-Terrorist Financing (CTF): Integrating crypto-asset service providers into the traditional AML/CTF framework is a universal principle, vital for combating illicit financial flows and enhancing global financial security.
- Legal Certainty and Innovation: While imposing regulation, authorities also seek to provide clear legal definitions and requirements, which can foster responsible innovation by giving businesses the confidence to operate and develop new solutions within a defined legal perimeter.

6.3 UK and Liechtenstein: Integrating Financial and Crypto-Asset Regulation

Both the UK and Liechtenstein offer distinct approaches to integrating crypto-asset regulation within their broader financial frameworks:

Liechtenstein: Liechtenstein's Blockchain Act (TVTG) is notable for its innovative approach. It defines a "Token" as a legally recognized container for various rights or assets, effectively creating a legal basis for tokenization. The act also introduces the "Token Container Model," which legally separates the token from the underlying right it represents, allowing for the transfer of legal ownership simply by transferring the token. This comprehensive framework regulates various "Trusted Technology Service Providers" (TTSPs), such as issuers, custodians, and verifiers, requiring them to register with the FMA Liechtenstein and comply with AML/CFT rules. Crucially, the TVTG clarifies that a token is not automatically a financial instrument unless the underlying right it represents falls under existing financial instrument definitions. This pragmatic approach provides broad legal certainty for digital assets while maintaining distinct treatment for financial products.

United Kingdom: The UK's strategy for crypto-asset regulation, outlined in its recent draft rules, proposes to integrate crypto-asset activities directly into its existing Financial Services and Markets Act 2000 regulatory perimeter, rather than creating a separate bespoke framework like the EU's MiCA. This means

activities such as the issuance of UK stablecoins ("qualifying stablecoins") and dealing in, arranging, providing custody for, or operating platforms for "qualifying crypto assets" will be brought under the purview of the Financial Conduct Authority (FCA). This approach subjects crypto firms to stringent FCA regulatory standards, including custody requirements similar to the CASS regime and prudential capital rules under CRYPTOPRU. The UK's framework also has a broad territorial scope, aiming to cover crypto services targeting UK consumers even if offered by overseas firms, often requiring the involvement of a UK-authorized entity. This "due-diligence-ready for institutional money" approach positions the UK as a hub for the institutional end of the digital asset market, offering a rigorous and familiar regulatory environment to traditional financial players.

6.4 Global Regulatory Landscape

Middle East, and Africa: Countries like the UAE in the Middle East are rapidly establishing their own clear regulatory frameworks, notably prioritizing Dirham-backed stablecoins and attracting institutional investment, aiming to become digital asset hubs. Similarly, Singapore (in Asia, but often referenced for its sophisticated regulatory environment) with initiatives like StraitsX (XSGD) demonstrates a proactive, regulated approach to local currency stablecoins. While Africa is diverse, some nations are exploring blockchain for specific use cases (e.g., cross-border payments, land registries), but a unified or extensive regulatory landscape for broader tokenization is still nascent.

United States: The US regulatory landscape is characterized by its fragmented nature, with multiple federal and state agencies asserting jurisdiction over crypto-assets, often leading to uncertainty. The "Howey Test" remains central to determining if a crypto-asset constitutes a "security," placing it under the purview of the SEC (Securities and Exchange Commission). Stablecoins are increasingly a focus, with various legislative proposals and regulatory actions from the SEC, CFTC (Commodity Futures Trading Commission), and Treasury Department. The US generally adopts an "enforcement-first" approach, where regulatory clarity often emerges from legal actions rather than explicit upfront legislation for all crypto-asset categories. This has led to a cautious approach from many traditional financial institutions and a slower pace of broad tokenization outside of specific, heavily vetted projects.

China: China has taken a highly restrictive stance on private crypto-assets and trading, effectively banning them since 2021 due to concerns about financial stability, capital outflow, and illicit activities. This has led to a significant exodus of crypto mining and trading operations. Instead of fostering private crypto, China is a global leader in the development and deployment of a Central Bank Digital Currency (CBDC), the Digital Yuan (e-CNY). The e-CNY is managed and issued by the People's Bank of China and is primarily designed to enhance domestic payments, promote financial inclusion, and facilitate cross-border transactions under strict state control. Tokenization of traditional financial assets or private sector crypto-assets, as understood in other regions, is not a significant focus in China's digital finance strategy, which prioritizes a centralized, state-controlled digital currency.

7. The New Global Financial Landscape

The evolving digital financial landscape presents a fascinating paradox: immense opportunities for innovation, efficiency, and greater inclusion, alongside significant challenges to maintaining stability, security, and fairness. As traditional finance increasingly converges with its digital counterpart, the complexities surrounding regulation, security, and market dynamics multiply. This creates an interconnected financial ecosystem, aspiring to blend the established stability and oversight of traditional banking with the agility and efficiency of digital finance. For this integration to be successful, financial institutions embracing digital assets will require regulators to adapt and devise new frameworks that prioritize enhanced safety.

A smooth transition into this digital financial future hinges on two critical pillars: soundness and innovation. These ensure that emerging technologies are robust, secure, and adaptable. Collaboration between regulators and financial institutions is essential to cultivate trust and ensure compliance, allowing for the safe integration of digital assets into existing systems. When established institutions embrace these changes, they naturally build consumer confidence, thereby accelerating wider adoption.

Beyond the regulatory and institutional shifts, digital assets and blockchain technology hold immense potential for financial inclusion. By dismantling traditional barriers to entry, they empower individuals in remote or economically disadvantaged regions to access crucial financial services like digital wallets, remittances, and lending platforms, significantly advancing global financial inclusion.

Decentralized Finance (DeFi) platforms further democratize access to financial services. Operating without intermediaries, these platforms enable users to participate in financial activities with reduced costs and fewer restrictions, proving particularly beneficial for regions with underdeveloped or absent banking infrastructure.

Tokenization of tax, exemplified by the Tokenized Micro Flat Tax (TMFT) model, represents a groundbreaking shift in how tax systems can be modernized using blockchain technology. The TMFT proposes embedding tax logic directly into digital transactions through programmable smart contracts, allowing micro-level tax assessments and automatic collection at the point of transaction. Instead of traditional filing, reconciliation, or centralized enforcement, taxes are calculated and remitted in real time, based on token movements that reflect economic activity. This model ensures transparency, traceability, and tamper-proof compliance, thereby reducing fraud and simplifying tax administration for both governments and taxpayers.

The TMFT model also enables fiscal policy customization based on transaction types, economic sectors, or cross-border activity. It supports differentiated flat rates for individuals, businesses, and decentralized entities, while maintaining a low administrative burden. Using Proof of Transaction (PoTr) and Proof of Compliance (PoCo) as core mechanisms, TMFT transforms taxation into a

seamless, data-driven process—capable of serving informal economies, digital-native transactions, and decentralized autonomous organizations (DAOs). It addresses longstanding challenges in taxing crypto assets, gig work, and microtransactions by shifting the compliance architecture from reporting to protocol-level enforcement.

The TMFT is designed to align with legal certainty and regulatory oversight, providing a public-private infrastructure for digital fiscal governance. It envisions a future where tax systems are interoperable with tokenized assets, offering real-time revenue visibility to tax authorities and auditability for the public. As a living open-source framework, TMFT is being documented and shared through a dedicated GitHub repository, which includes the complete whitepaper, implementation roadmap, and licensing framework. This initiative is already garnering attention from policymakers, legal scholars, and digital tax reform advocates for its potential to redefine the social contract in the digital era.

Moreover, blockchain technology inherently boosts financial transaction efficiency. It minimizes the need for intermediaries, driving down costs and expediting processes such as cross-border payments and trade finance. The advent of smart contracts further automates complex financial agreements, systematically mitigating human error and the potential for fraud.

Finally, the digital asset space is a fertile ground for innovative financial products. Tokenized assets, stablecoins, and non-fungible tokens are not just opening up novel investment opportunities, but also facilitating fractional ownership and establishing entirely new markets. This expansion significantly broadens both financial markets and the very concept of asset classes, as highlighted by discussions around "Asset Tokenization in Financial Markets: The Next Generation of Value Exchange.

8. Concluding Remarks

Tokenization presents a new model for digital asset ownership, improving transparency, efficiency, and accessibility. Key distinguishing features include a shared ledger, flexible custody options, programmability, fractional ownership, and cross-asset composability. These capabilities have the potential to democratize access to assets, amongst others through financial markets, and drive modernization of infrastructures in both the “financial” and the “non-financial” world.

Despite clear benefits, adoption is hindered by challenges including outdated infrastructure, fragmented regulations, implementation costs and risks and limited interoperability. When considering financial assets, liquidity is nowadays a constraint. For financial and financial-like tokens, successful implementation requires a phased approach and strategic collaboration among financial institutions, regulators, and technology providers. Key design considerations – such as ledger selection, settlement processes, and market operating hours – must also be thoughtfully addressed. This latter point is also applicable to non-financial tokens. However, non-financial tokens should not be imposed by a regulation that does not fit their business model. Neither should they too quickly be assimilated to financial tokens.

Tokenization has the potential to create a more inclusive and efficient system provided that stakeholders align on common standards, robust safeguards, and scalable solutions. To fully realize the benefits of tokenization, economic structures must evolve, especially the financial structures. Traditional financial infrastructure relies on centralized intermediaries and fixed settlement cycles, while tokenized markets offer features like programmability, atomic settlement, and the potential for continuous, "always-on" trading.

Technology alone cannot replace the operational and regulatory foundations essential to economic integrity. A balanced approach is needed between established institutions and emerging players, both in terms of regulation and market influence. Promoting fair access to tokens, open interoperability, and equitable regulatory oversight is essential to avoiding excessive concentration of power and supporting sustainable, inclusive growth.

The absence of global standards and regulatory fragmentation remains a major obstacle to the adoption of tokenization. Policymakers should modernize financial regulations with a focus on technological neutrality – ensuring they accommodate tokenized assets while upholding enforceability, investor protection, and effective risk management. Furthermore, if a set of policies include rules that do not make sense in a tokenized infrastructure, they should be revisited.

As new technologies are integrated into market infrastructure, ensuring interoperability is essential – particularly through the development of common transaction protocols, standardized asset classification frameworks, and consistent reference data models. However, complex financial processes may

necessitate a phased approach to accommodate the evolving industry practices and regulatory catch up.

For tokenized markets to operate efficiently, active participation from liquidity providers and market makers is essential. Without adequate secondary market depth, tokenized assets may remain illiquid, diminishing their practical value despite technological progress. To address this, policymakers and financial institutions should consider strategies to incentivize market-making, such as customized liquidity programs, favorable capital treatment, and the expansion of regulatory sandboxes that encourage institutional involvement.

Advancing the adoption of tokenization will require coordinated efforts from multiple stakeholders, including policymakers, technology providers, and financial institutions. By resolving regulatory uncertainties, evolving market structures, and fostering competitive, liquid markets, tokenization can support the development of a more robust global financial infrastructure. Realizing this potential calls for a balanced and pragmatic approach – one that promotes innovation while safeguarding market integrity, encouraging competition, and ensuring operational resilience.

9. Appendixes

9.1 The Regulatory Landscape

The rapidly evolving regulatory landscape for tokenization in Europe aims to provide legal clarity, foster innovation, and protect market integrity and investors. This decision-tree outlines the applicable regulatory framework for product-related regulation, excluding other aspects.

9.1.1 EU Regulatory and Guideline Timelines

The main texts governing financial activity in the crypto-assets sphere are currently:

- **MiCA** is Regulation (EU) 2023/1114, which entered into force in June 2023 and applies from 30 June 2024.
- **MiFID II** is a directive that entered into force on 12 June 2014 for application as of 3 January 2018.
- The **DLT Pilot Regime**, which is Regulation (EU) 2022/858, which entered into force in May 2022 and applies from 23 March 2023.
- The **ESMA Guidelines** **on Qualification of Crypto-Assets as Financial Instruments** which is ESMA's Final Report (ESMA75-453128700-1323), with the Final Report date being 17 December 2024, and the date of application being 18 May 2025.

9.1.1.1 Markets in Crypto-Assets Regulation (MiCA) – Effective 2024

The EU Market in Crypto-Assets (MiCA) regulation revolutionizes the EU crypto assets sector by establishing a unified legal framework. It enhances consumer protection through transparency and risk warnings, improves market integrity with disclosure requirements, provides legal certainty for businesses with an EU-wide "passport," and specifies rules for stablecoins to ensure stability. MiCA also combats financial crime and promotes responsible innovation. It's a crucial step in balancing crypto-asset market growth, safeguarding consumers, and maintaining financial stability across the EU.

MiCA only covers a specific set of crypto-assets, as shown in the graph. Financial products, or those impacted only by the service provider section of MiCA are excluded.

MiCA's entry into force will prevent unregulated offshore companies from targeting EU consumers, promoting EU-based activity. Crypto asset regulatory clarity amid global uncertainty will attract capital, talent, and companies to tokenize, or motivate other jurisdictions to align, similar to Solvency II. This emerging industry could revive the EU's economy and technology.

MiCA provides:

- Rules for cryptocurrency asset issuers and service providers.

- Rules against market abuse and insider trading, the latter of which will be illegal. Additionally, disseminating false or misleading information about a cryptocurrency asset will also be prohibited.

MiCA supersedes EU national regulatory frameworks for crypto assets. It is a first step to a unique market in this field as some inconsistencies between national laws still need to be worked on.

As a reminder, the primary provisions of MiCA are as follows:

- Establishing definitions for various cryptocurrency assets (e.g., non-asset-referenced tokens, asset-referenced tokens, and e-money tokens) and cryptocurrency asset service providers (CASPs). It applies to natural and legal persons involved in the issuance, offering, or admission to trading of cryptocurrency assets and providing cryptocurrency services within the European Union. Certain cryptocurrency assets, such as NFTs, are generally excluded unless they are fungible.

- Issuers of cryptocurrency assets (except for Asset-Referenced Tokens (ARTs) and Electronic Money Tokens (EMTs)) offering them to the public or seeking trading admission must publish a comprehensive cryptocurrency asset white paper. This white paper must include information about the issuer, project, and risks.

- CASPs must obtain authorization from their national competent authority to operate within the European Union. Once authorized in one member state, they can provide services across the European Union (“EU passport”). The regulation outlines organizational requirements, operational rules, and prudential safeguards for CASPs, including governance, information and communication technology (ICT) security, and complaint handling.

- Issuers of Asset-Referenced Tokens (ARTs) that aim to stabilize their value by referencing other assets must adhere to stricter requirements, including authorization, publishing a white paper, and maintaining adequate funds and a reserve of assets covering their liabilities.

- Electronic Money Tokens (EMTs), which stabilize their value by referencing a single official currency, are subject to specific rules. Issuers must be authorized as either an electronic money institution or a credit institution and must safeguard funds and adhere to rules on issuance and redeemability.

- MiCA includes measures to prevent market abuse related to cryptocurrency assets, such as insider dealing and market manipulation.

- The regulation is designed to safeguard consumers by mandating that CASPs operate with integrity, fairness, and professionalism. It requires them to provide transparent and non-deceptive information and establish robust complaint handling procedures. Additionally, retail holders of cryptocurrency assets have the right to withdraw their assets under specific circumstances.

- CASPs are obligated to implement Know Your Customer (KYC) procedures and monitor transactions as part of Anti-Money Laundering (AML) and Counter-Terrorism Financing (CTF) regulations. The Transfer of Funds Regulation (TFR) “travel rule” mandates that they include information regarding the originators and beneficiaries of cryptocurrency transfers.

- Governance and management bodies responsible for CASPs and issuers of Artificially Intelligent Tokens (ARTs) and Electronic Money Transfer (EMTs) must be reputable, knowledgeable, and experienced.

9.1.1.2 The EU's DLT Pilot Regime

The EU’s DLT Pilot Regime, effective since March 2023 for up to six years, aims to foster financial sector innovation by creating a “sandbox” for testing tokenized securities and DLT-based market infrastructures. It allows temporary exemptions from EU financial rules and intends to facilitate a secondary market for crypto assets that qualify as financial instruments and inform a future permanent regulatory framework. However, its uptake has been limited.

In response, the French AMF and the Italian CONSOB propose making the framework more flexible, broadening its scope, ensuring long-term visibility, developing interoperability, and raising market awareness to encourage greater experimentation and adoption of DLT in European financial markets. A report by ESMA in 2026 will inform the European Commission’s decision on the regime’s future.

9.1.1.3 MiFID II / MiFIR

MiFID II/MiFIR, a cornerstone of EU financial regulation, shapes investment services and financial markets. Tokens are regulated by MiFID II if they’re financial products.

MiFID II (Markets in Financial Instruments Directive II), a comprehensive EU regulation, came into effect in 2018. It aims to create transparent, competitive, and safer financial markets while enhancing investor protection. It covers various financial instruments, including equities, bonds, derivatives, and funds, and applies to investment firms, banks, trading venues, and other financial intermediaries within the EU.

Key areas covered by MiFID II include:

- The Directive introduces new trading venues like Organised Trading Facilities (OTFs), increases transparency requirements across asset classes, and aims to move trading onto regulated platforms.

- MiFID II strengthens business conduct rules, including stricter information provision to clients, investment suitability assessment, and rules on inducements and conflicts of interest. It also enhances product governance to ensure products are designed and distributed in clients’ best interests.

- Firms must take "all sufficient steps" to achieve the best possible result for their clients when executing trades and must disclose their top execution venues.
- Investment firms face more extensive reporting requirements to regulators, enhancing market monitoring and the detection of potential abuses.
- MiFID II introduces position limits and reporting requirements to curb speculation in commodity markets.
- MiFID II places greater scrutiny on specific trading activities, like High-frequency trading, to ensure fair and orderly markets.
- The regulation requires the unbundling of research costs from execution fees to enhance transparency and prevent conflicts of interest.

MiFID II is complemented by other regulations. The most prominent ones are:

- MiFIR (Markets in Financial Instruments Regulation): While MiFID II is a directive requiring transposition into national law, MiFIR is a directly applicable regulation covering areas like market structure, transparency, and transaction reporting. Together, they form the core of the MiFID II/MiFIR framework.
- EMIR (European Market Infrastructure Regulation): MiFID II introduces trading obligations for certain derivatives that are also subject to mandatory clearing under EMIR.
- CSDR (Central Securities Depositories Regulation): CSDR aims to improve the efficiency and safety of securities settlement in the EU. The Settlement Discipline Regime (SDR) introduces measures to prevent and address settlement failures, such as cash penalties and mandatory buy-ins.
- MAR (Market Abuse Regulation): MiFID II's enhanced reporting requirements support the objectives of MAR in preventing and detecting market abuse.
- AIFMD (Alternative Investment Fund Managers Directive) and UCITS (Undertakings for Collective Investment in Transferable Securities 1 Directive): MiFID II impacts how firms providing services related to these funds interact with clients.
- SFDR (Sustainable Finance Disclosure Regulation): Amendments to MiFID II in 2022 require firms to consider clients' sustainability preferences during the investment process, linking it to SFDR.

9.1.1.4 ESMA Guidelines on the Conditions and Criteria for Qualification of Crypto-Assets as Financial Instruments

On December 17, 2024, the European Securities and Markets Authority (ESMA) released its long-awaited Guidelines for crypto-assets to qualify as financial instruments and be subject to the MiFID II discipline. This is crucial for addressing

the complex issues surrounding the new European crypto-asset and EU capital market disciplines.

Regulating new crypto-assets is challenging due to their categorization within existing financial legislation. Determining whether a crypto-activity can be classified under existing financial regulation, adhering to the "technological neutrality" principle, is essential. However, this principle is not always consistently implemented at the legislative level.

The approach to crypto-asset taxonomy varies by legal system, but it's crucial since the phenomenon's emergence. Even the Markets in Crypto-Assets Regulation (MiCAR) or MiCA raises uncertainties, particularly regarding the express exclusion of financial instruments from MiCAR under Article 2(4), which removes what is already regulated by pre-existing financial legislation.

Financial instruments are defined in Article 4(1) of MiFID II, which refers to the list in Section C of Annex I. Summarizing, financial instruments are:

- Transferable securities;
- Money-market instruments;
- Units in collective investment undertakings;
- Options, futures, swaps, forward rate agreements and any other derivative contracts
- Derivative instruments for the transfer of credit risk;
- Financial contracts for differences;
- Emission allowances consisting of any units recognised for compliance with the requirements of Directive 2003/87/EC (Emissions Trading Scheme).

MiFID defines financial instruments with a closed list of notions, relying on Member States for definitions of terms like "share" and "bond".

The European legislator didn't address these issues directly, entrusting them to multiple instruments, including the Guidelines. However, ESMA specifies that the Guidelines don't clarify the entire scope of financial instruments but only those that fall within both MiCAR and MiFID II definitions. The Guidelines' general scope is important because the notion of financial instrument (and securities) is central to European financial regulation, affecting MiFID, the Prospectus Regulation, the Market Abuse Regulation, and the UCITS Directive, among others.

9.1.2 National Approaches

Some EU countries have specific regimes or guidance:

- Germany recognizes electronic securities (eWpG), including crypto securities.
- France has a crypto-asset registration framework via AMF and ACPR.

- Luxembourg and Switzerland (non-EU but often referenced) have advanced frameworks for tokenized securities and DLT.

9.1.2.1 Blockchain Law IV: Luxembourg's New Hub for Digital Securities

On December 19, 2024, Luxembourg adopted Blockchain Law IV, modernizing its financial infrastructure by focusing on DLT. The law regulates the issuance, registration, and transfer of dematerialized securities using DLT, creating a legally secure environment for tokenized financial instruments and positioning Luxembourg as a key player in digital finance.

A key feature of the law is a "control agent" to monitor and verify DLT transactions in real-time, ensuring reconciliation and trust. It allows issuers to issue native DLT platforms, support diverse custody models, and tokenize assets for global investors. This creates a robust legal foundation for startups, funds, and corporations to explore new digital financing mechanisms.

Luxembourg's decision aligns with EU initiatives like EBSI and the DLT Pilot Regime. The legislation supports security tokens, representing traditional financial instruments on a blockchain platform. These tokens offer advantages like efficient fundraising, global investor access, reduced costs, and enhanced transparency. Real estate tokenization is a prominent application, facilitating fractional ownership and increased accessibility for retail investors. Blockchain Law IV aims to position Luxembourg as a leader in tokenized securities by harmonizing innovation with legal certainty.

9.1.2.2 The Blockchain Act (TVTG) in Liechtenstein

Liechtenstein's Blockchain Act (TVTG), effective January 1, 2020, regulates tokenization and blockchain technology. It defines "Tokens" as containers representing rights or assets, both physical and digital. The act introduces "TT Systems" (Trusted Technology Systems) as DLT for token storage and transfer, and the "Token Container Model," which legally separates tokens from represented rights, enabling legal ownership transfer via token transfer.

The law regulates Trusted Technology Service Providers (TTSPs) like issuers, generators, verifiers, custodians, and physical validators, requiring them to register with the FMA Liechtenstein and comply with AML/CFT rules. The Blockchain Act provides legal certainty for digital assets, clarifying that tokens are not automatically financial instruments unless their underlying right qualifies.

The Liechtenstein Blockchain Act provides several main advantages for the Digital Ledger Technology (DLT) sector. It is technology-neutral, meaning it applies to all blockchain and DLT systems, avoiding bias toward any specific platform. A core feature is that a token is recognized as a legal representation, functioning as a legally recognized digital container for rights and assets. The Act establishes regulated roles, which brings clarity regarding the responsibilities of various market participants. It is inherently compliance-ready, with Anti-Money Laundering (AML), Combating the Financing of Terrorism (CFT), and registration requirements built directly into the framework. Finally, it offers significant asset

versatility, as it can be used for a wide range of assets, including securities, real estate, intellectual property (IP), and claims.

9.1.2.3 New U.K. Crypto Rules Are a Big Step Forward

The UK announced new crypto asset draft rules to drive growth and protect consumers. The rules aim to establish the U.K. as a global leader in digital innovation by providing a clear regulatory framework that encourages innovation while protecting consumers.

Under the new rules, crypto exchanges, dealers, and agents will be regulated, and crypto firms with UK customers must meet transparency, consumer protection, and operational resilience standards, similar to traditional finance firms. The UK and US will use the UK-U.S. Financial Regulatory Working Group to support the responsible growth of digital assets. Robust crypto rules will boost investor confidence, support Fintech growth, and protect people in the UK. The government will publish the first-ever Financial Services Growth and Competitiveness Strategy on July 15 to support the financial services sector's long-term growth, with Fintech as a priority sector, and help finance investment and growth across the UK.

The UK's draft regulations propose including several crypto asset-related activities in the Financial Services and Markets Act 2000, such as issuing U.K. stablecoins and dealing in, arranging transactions in, providing custody for, or operating platforms involving qualifying crypto assets. These activities include issuing, dealing in, arranging transactions involving, operating a trading platform for, providing custody of, and staking such assets. The proposed rules have a broader territorial scope, covering most crypto-related services aimed at UK consumers, even when offered by overseas firms. A UK-authorized entity must be involved in such cases. This reflects the UK's strategic move to establish a more rigorous, institution-centric regulatory regime compared to the EU's MiCA framework.

Instead of developing a separate framework like MiCA, the UK is integrating crypto regulation into its established financial services system. This means crypto firms will be subject to the FCA's comprehensive regulatory standards, including custody requirements similar to CASS and stringent capital rules under CRYPTOPRU. While this approach may impose greater compliance burdens and costs, it's designed to be "due-diligence-ready for institutional money." This positions the UK as a hub for the institutional end of the digital asset market, offering a rigorous and familiar regulatory environment to traditional financial players. It also reflects a broader geopolitical strategy in the post-Brexit race to shape global finance.

9.2 The Tokenization of Assets for a Decentralized Future in Europe

As previously said, tokens are digital twins on a blockchain. Even if this is mostly true, another specific case can arise.

In the first case, economic value and rights from preexisting real assets are linked to tokens based on DLT, which serve as a store of value. Issued tokens exist solely within the blockchain, while real assets remain in the real world.

In the second case, asset tokenization involves creating an instrument within the blockchain and issuing native tokens directly on the DLT. Tokens represent digital assets registered in a blockchain infrastructure, ensuring secure and intermediary-free token exchanges. While commonly associated with cryptocurrency, tokens and their transactions are established in smart contracts.

Each Token-based system can be characterized by the following elements:

- number of tokens in circulation;
- users who can transfer them; and
- those who can dispose of the tokens up to the relevant access rules.

In the above list, the term user can also be extended to the term smart-contract. A smart-contract can execute action on tokens automatically, for the owner of either the token, or the smart-contract.

To understand the possible applications in different areas, it is necessary to analyze the different types of tokens, starting with an initial distinction between two broad categories: fungible and non-fungible tokens. Further, among fungible tokens, several other categories can be identified based on their purpose and utility, such as utility tokens, security tokens, and commodity tokens.

9.2.1 European Digital Capital Market Union

The concept of a European Digital Capital Markets Union (CMU) aims to modernize and unify the EU's fragmented financial infrastructure using digital technologies like DLT. The core idea is to create an efficient, integrated, and competitive single market for capital that benefits both businesses and citizens.

DLT, of which blockchain is the best-known example, is central to this vision. Unlike traditional, centralized ledger systems managed by intermediaries (like banks), DLT provides transparent, decentralized, and immutable record-keeping.

Key advantages of adopting DLT in the CMU and public services include:

- Enhanced Efficiency and Accessibility: DLT improves capital markets by enabling faster processing, lower costs, and reducing reliance on manual paperwork. This supports an integrated trading and post-trading landscape and makes services more accessible to all.
- Increased Trust and Transparency: The decentralized nature of DLT, where network participants verify transactions, enhances trust and provides a single, verifiable "golden source" of data.
- Streamlined Governance: Digital platforms improve government efficiency by reducing the need for physical offices and promoting inclusive governance through accessible digital services.

- Improved Taxation: DLT can simplify tax processes, enable real-time and reliable information sharing among agencies, foster fairer taxation, and allow for AI-driven automation of tax calculations and returns.

While DLT offers significant benefits, its implementation faces challenges:

- GDPR Compatibility: The immutability of DLT can conflict with the EU's GDPR requirements for data alteration and deletion. New legal and technical solutions are necessary to ensure compliance with emerging technologies like DLT, AI, and quantum computing.
- Smart Contract Limitations: Automated execution via smart contracts is limited by its code and may not always constitute a legally binding agreement in the traditional sense.

Ultimately, achieving a Digital CMU requires unity and cohesion among Member States to build a common digital financial space that supports long-term economic growth, resilience, and technological independence for Europe.

9.3 Selected Use Cases

9.3.1 Finance

9.3.1.1 Luxembourg's First Digital Treasury Notes

The problem Luxembourg sought to solve was inefficiency and opacity in traditional sovereign debt issuance.

Traditional processes for issuing government debt are often slow, costly, and require multiple intermediaries, which can introduce delays and operational risk. DLT offers faster issuance, greater efficiency, potential cost reduction, and enhanced transparency throughout the bond's lifecycle.

User Journey: The Luxembourg State Treasury acts as the issuer. The Treasury notes are created as digitally native instruments that exist solely on the blockchain. They are then sold at a discount (99.03% of face value) to investors and subsequently listed on the Luxembourg Stock Exchange for trading. manages the instrument and its entire lifecycle, leading to a much more streamlined process than traditional methods. The notes are zero-coupon and will be redeemable at par in six months.

Technology Used: DLT. Specifically, the notes were issued on the HSBC Orion DLT platform, a purpose-built DLT infrastructure. The instrument is a digitally native Treasury note, meaning it was issued directly onto the blockchain, contrasting with a "tokenized" instrument which is a digital representation of a pre-existing traditional asset.Orion manages the instrument and its entire lifecycle, leading to a much more streamlined process than traditional methods.

Status: Successful (Pilot/Milestone). The issuance of €50 million in digital Treasury notes marks a significant success and a major milestone. It is:

- The first digital Treasury note issuance by Luxembourg.

- The second European state to issue sovereign debt using DLT (after Slovenia).
- The Treasury note was successfully issued, sold, and listed on the Luxembourg Stock Exchange, demonstrating the viability of the DLT platform for sovereign financing.
- It is considered the largest Treasury Certificate issuance to date using DLT and positions Luxembourg as a leader in the digital asset space.
- The success has encouraged the Luxembourg State Treasury to explore potential future issuance of a digital sovereign bond.

9.3.1.2 Supply Chain – *VeChain (VET/VTHO)*

The problem VeChain solves is the lack of transparency, efficiency, and trust in global supply chains. VeChain verifies a product's authenticity, quality, and origin from start to finish.

User Journey: Data Capture: IoT/RFID tags on products (e.g., food) record real-world data (temperature, location). Immutability: Data is logged onto the blockchain. Verification: Retailers and consumers scan a QR code on the product to view its entire journey (farm to shelf) and verify its claims.

Technology: VeChainThor Blockchain (Proprietary). Uses Proof of Authority (PoA) for fast, low-energy transactions. Two-Token Model (VET for value, VTHO for transaction gas). Integrates IoT, RFID, and AI.

Status: Successful (Active and Adopted). The platform is successfully deployed in production with major clients like Walmart China for food traceability, demonstrating real-world utility and achieving large-scale corporate adoption.

9.3.1.3 TradeLens (IBM/Maersk)

The problem IBM and Maersk aimed to solve was the highly fragmented, slow, and paper-intensive nature of global container shipping and trade documentation. It aimed to digitize documents and provide a single source of truth for cargo tracking.

User Journey: Input: Ports, customs, shippers input shipping data and documents. Ledger: Data is recorded on the blockchain. Automation: Smart contracts automate customs and compliance. Access: Stakeholders view real-time data via APIs and dashboards.

Technology: Hyperledger Fabric (Permissioned Blockchain). Used a permissioned network, modular consensus (e.g., Raft), and endorsement policies.

Status: Unsuccessful (Discontinued). TradeLens was shut down in early 2023. The failure was primarily due to lack of industry-wide adoption and commercial viability issues. Key competitors were hesitant to join a platform perceived to be controlled by the major player, Maersk, which prevented the network effects needed for financial sustainability.

9.3.2 Healthcare

9.3.2.1 Patientory ($PTOY)

The problem Patientology aimed to solve was the centralized, siloed, and non-interoperable healthcare data. Patientory aims to give patients secure, decentralized control and ownership of their Electronic Health Records (EHRs) and wellness data.

User Journey: Onboarding: The user verifies identity and links health data to a Patientory Wallet. Engagement: User tracks wellness, receives AI health coaching. Monetization (Optional): User grants consent to share anonymized data with researchers for $PTOY token rewards.

Technology: PTOYMATRIX Blockchain (Proprietary, HIPAA/GDPR-compliant). Uses a Web3 platform, AI Health Coach, and the $PTOY utility token to incentivize health behaviors and data sharing.

Status: Active (Ongoing Development/Adoption). While not on the scale of VeChain's corporate adoption, the platform is actively developing and deploying its ecosystem, particularly focusing on the patient-centric data control and monetization model.

9.3.2.2 Medicalchain ($MTN)

The problem Medicalchain aims to solve is the lack of patient control over medical records and difficulty for providers to access accurate, up-to-date EHRs across different systems.

User Journey: Secure Storage: Sensitive data is stored on a private blockchain. Access Control: Patient sets access permissions (logged on a public chain). Service: Patients use their Medicalchain ID to access services like telemedicine consultations, paying with $MTN tokens.

Technology: Dual Blockchain Architecture: Hyperledger Fabric (Private) for storing sensitive data, and Ethereum (Public) for recording access logs, identity, and transactions. Utilizes the $MTN (MedToken) utility token for payments and access fees.

Status: Active (Ongoing Development/Adoption). The project has successfully built its dual-chain architecture and demonstrated its core functionality (patient data control, telemedicine). Its long-term success hinges on achieving broader adoption by healthcare systems and providers.

9.3.3 Commodities

9.3.3.1 Finka Token (Cattle Ranching)

The problem Finka Token aims to solve is the exclusivity and high capital barriers to investing in stable, real-world assets like organic cattle ranching.

User Journey: KYC/AML: Investor completes compliance on a regulated platform. Purchase: Investor buys Finka Security Tokens (ERC-20). Revenue: Investor

automatically receives an annual pro-rata share of the ranch's net operating revenue, as defined and automated by smart contracts.

Technology: Ethereum Blockchain(ERC-20 standard). The token is a Security Token legally backed by real-world assets and revenue streams. Uses Smart Contracts for automated revenue distribution.

Status: Active (Operational/Compliant). Finka Token has successfully implemented a compliant Security Token Offering (STO), demonstrating the legal and technical feasibility of tokenizing real-world agricultural assets under strict financial regulation (Swiss). It has achieved its goal of democratizing investment access to the commodity sector.

9.3.3.2 BeefChain

The problem BeefChain aims to solve is the lack of trust and premium validation for quality claims (e.g., grass-fed, hormone-free) in the beef supply chain, preventing ranchers from capturing higher value.

User Journey: Tagging: Rancher tags calves with RFID at birth. Tracking: All lifecycle events, feed data, and health treatments are logged immutably on the blockchain. Certification: The record supports USDA Process Verified Program claims. Access: Consumers scan a QR code on the packaging to verify the beef's history.

Technology: Cardano (via Atala Trace), previously Hyperledger. Integrates RFID/IoT for real-time tracking and Smart Contracts to automate data logging and certification processes.

Status: Active (Operational and Certified). BeefChain is successful in its core mission, utilizing blockchain to earn a premium for ranchers by providing verifiable, certified traceability. It has achieved regulatory validation with the USDA.

9.4 Tokenization and Regulation

For the time being, there is no form of common legislation specific to tokenization. Each country approaches tokenization differently depending on the stage of development reached by the tokenized asset market and the pace at which it evolves. Some legislators have decided to apply existing financial regulations to tokenized assets; others have created a new tailored regulatory framework or adapted existing rules to regulate the application of DLT in the context of tokenization (see table below).

Technology-Neutral	Guidance / Clarifications	Dedicated, Tailor-Made Frameworks	Adapting Existing Policies
Same risk, same rules – "substance over form"	Clarity over whether and how the assets fall within regulators' remit.	"Blockchain acts". New roles/new actors.	Updating rules to cater to tokens.
European Commission U.K. Financial Conduct Authority (FCA) U.S. regulators Swiss Financial Market Supervisory Authority	German Federal Financial Supervisory Authority (BaFin) clarification on tokens. U.K. FCA's policy statement on cryptoassets. U.S. SEC's digital assets framework. European Regulation on Market for Crypto-Assets (MiCAR).	French blockchain order and digital assets providers. German draft Electronic Securities Act (eWpG-E) and crypto-securities registries. Luxembourg recognition of DLT security transfers. Liechtenstein trusted technology verifying authorities.	European Commission's update for financial rules for cryptoassets. The French Autorité des marchés financiers 2020 analysis of application of financial regulations to security tokens. Swiss DLT proposal.

Source: Iota Kaousar Nassr, "Understanding the Tokenisation of Assets in Financial Markets," Going Digital Toolkit Note No. 19 (2021).

Table 2: Non-mutually exclusive approaches.

The decentralized finance (DeFi) and the token asset markets are experiencing rapid growth. The industrial application of emerging decentralized ledger technology (DLT) has facilitated the identification of gaps, risks, and areas of potential innovation. It is imperative to ensure that users of tokens on blockchains benefit from the same level of protection as those engaged in traditional assets.

It is also crucial, for the scaling-up of the industry, to ensure a tax level-playing field. The same type of asset should be taxed identically, whether tokenized or not. Furthermore, DLT-based transactions are often cross-border in nature. To factor this specific nature in, the OECD has attempted to create a common fiscal standard on crypto assets through international collaboration and dialogue. On October 10, 2022, the OECD published the Crypto-Assets Reporting Framework (CARF).

The CARF capitalizes on existing regulatory and tax frameworks, such as the OECD's common reporting standard and the regulations of the Financial Action Tax Force (FATF), establishing the global standard for know-your-customer

procedures. Similarly to how the common reporting standard was initially conceived to promote tax transparency on financial accounts held abroad, the CARF aims to establish a framework that will facilitate the monitoring of the ownership and utilization of cryptocurrency assets by tax authorities. Furthermore, an initial draft proposal to tax cryptocurrency assets at the European level through the EU's eighth directive on administrative cooperation (DAC8) seeks to standardize the tax treatment of cryptocurrency assets within the European Union. This proposal begins with the position and definition established in MiCAR and aspires to create a unified legal and tax framework that provides certainty and stability. The ultimate objective is to establish optimal conditions for the development of an EU digital market, which is potentially the largest digital market globally, even when considering those in the United States and China.

9.4.1 Outlook and Complexity

Mergers and acquisitions in the decentralized finance (DeFi) space face unique challenges due to the token-based nature of protocols and the complexities of securities laws. While M&A can help DEXs consolidate resources and build sustainable platforms, integrating token-based protocols requires careful consideration of token treatment, regulatory compliance and valuation methods.

Acquiring control in decentralized, permissionless protocols is complex due to decentralized governance and token holders' resistance to consolidation. This challenges traditional M&A structures that involve full ownership and centralized decision-making. Integrating token-based models in traditional equity deals presents a unique challenge in the cryptocurrency space, requiring novel structures and creative approaches to governance and compliance.

As the industry matures, further consolidation could lead to fewer but larger, better-regulated platforms catering to both retail and institutional investors. The ongoing shift toward regulatory clarity and hybrid M&A structures may encourage more equity-based consolidation. However, M&A in cryptocurrency will continue to navigate uncharted waters, balancing innovation in decentralized finance with practical realities of regulation and governance.

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