

FIN-TECH AND DIGITAL ASSETS Beyond the Physical Domain

A Primer on Digital Identity, Assets and Currencies

As Cornerstones of Web3 and Metaverse

By

Brunello Rosa and Iman Pouyamaid



28 May 2025





Page | 2

Brunello Rosa and Iman Pouyamaid

Beyond the Physical Domain:

A Primer on Digital Identity, Assets and Currencies As Cornerstones of Web3 and Metaverse

28 May 2025

Table of Contents

Executive Summary Page	3
1. Introduction: Web 3 and Metaverse	4
2. The Incompatibility of Physical-World in the Metaverse	4
3. Digital Identity as the Foundational of a True Virtual Economy	6
4. AI Agents as Economic Actors in the Metaverse	7
5. Understanding Digital Assets in the Metaverse	8
6. NFTs and Programmable Digital Assets: Unlocking Ownership in the Metaverse	10
7. Policy and Governance: Regulating a Digital-First Economy	11
8. Conclusion: Moving Beyond the Physical to a Digital-First Economy	12
References	12



Rosa & Roubini Associates Ltd is a private limited company registered in England and Wales (Registration number: 10975116) with registered office at 118 Pall Mall, St. James's, London SW1Y 5ED, United Kingdom.

For information about Rosa&Roubini Associates, please send an email to info@rosa-roubini-associates.com or call +44 (0)20 7101 0718.

Analyst Certification: We, Brunello Rosa and Iman Pouyamaid, hereby certify that all the views expressed in this report reflect our personal opinion, which has not been influenced by considerations of Rosa & Roubini Associates' business, nor by personal or client relationships. We also certify that no part of our compensation was, is or will be, directly or indirectly, related to the views expressed in this report.

Disclaimer: All material presented in this report is provided by Rosa & Roubini Associates-Limited for informational purposes only and is not to be used or considered as an offer or a solicitation to sell or to buy, or subscribe for securities, investment products or other financial instruments. Rosa & Roubini Associates Limited does not conduct "investment research" as defined in the FCA Conduct of Business Sourcebook (COBS) section 12 nor does it provide "advice about securities" as defined in the Regulation of Investment Advisors by the U.S. SEC. Rosa & Roubini Associates Limited is not regulated by the FCA, SEC or by any other regulatory body. Nothing in this report shall be deemed to constitute financial or other professional advice in any way, and under no circumstances shall we be liable for any direct or indirect losses, costs or expenses nor for any loss of profit that results from the content of this report or any material in it or website links or references embedded within it. The price and value of financial instruments, securities and investment products referred to in this research and the income from them may fluctuate. Past performance and forecasts should not be treated as a reliable guide of future performance or results; future returns are not guaranteed; and a loss of original capital may occur. This research is based on current public information that Rosa & Roubini Associates considers reliable, but we do not represent it is accurate or complete, and it should not be relied on as such. Rosa & Roubini Associates, its contributors, partners and employees make no representation about the completeness or accuracy of the data, calculations, information or opinions contained in this report. Rosa & Roubini Associates has an internal policy designed to minimize the risk of receiving or misusing confidential or potentially material non-public information. We seek to update our research as appropriate, but the large majority of reports are published at irregular intervals as appropriate in the author's judgment. The information, opinions, estimates and forecasts contained herein are as of the date hereof and may be changed without prior notification. This research is for our clients only and is disseminated and available to all clients simultaneously through electronic publication. Rosa & Roubini Associates is not responsible for the redistribution of our research by third party aggregators. This report is not directed to you if Rosa & Roubini Associates is barred from doing so in your jurisdiction. This report and its content cannot be copied, redistributed or reproduced in part or whole without Rosa & Roubini Associates' written permission.

www.rosa-roubini.com

© Rosa&Roubini Associates 2025 - All Rights Reserved. No duplication, reproduction, transmission or redistribution of this document and its content, either in whole or in part, is by any means permitted without prior written consent of Rosa&Roubini Associates Limited.





Brunello Rosa and Iman Pouyamaid

A Primer on Digital Identity, Assets and Currencies As Cornerstones of Web3 and Metaverse

May 2025

Executive Summary

1. Introduction

- Web3 and Metaverse aim to replicate and surpass the complexity of the physical world; however as economic and social activities transition into these virtual worlds, traditional systems face inefficiencies.
- The infrastructure that supports the physical world is ill-equipped to handle the complexity of digitalfirst cultures. Instead, digital instruments - AI, CBDCs, NFTS, DAOs and SSI - have emerged as key enablers of Web3 and metaverse economies.

2. The Incompatibility of Physical-World Models in Web3 and Metaverse

Key industries such as finance and identity verification highlight the shortcomings of real-world frameworks. These models, designed for physical economies with centralised governance, introduce friction when applied to decentralised, borderless virtual ecosystems.

3. Digital Identity as the Foundation of a True Virtual Economy

- Digital identity systems are more than authentication tools; they serve as digital passports that enable users to access financial services, vote in DAOs, and participate in governance mechanisms.
- In Web3 and the metaverse, where physical-world constraints do not apply, identity becomes the primary trust mechanism that enables users and AI-driven agents to interact confidently.

4. AI Agents as Economic Actors in Web3 and the Metaverse

- In the metaverse, AI entities govern digital spaces, enforce community guidelines, and facilitate peerto-peer transactions. These developments position AI agents as independent economic actors, capable of influencing supply chains, asset prices, and consumer behaviour in the digital realm.
- The growing dominance of AI in digital economies also has profound implications for wealth distribution and labour markets. There is a risk of economic power becoming concentrated among individuals or institutions that own and control AI systems.

5. Understanding Digital Assets in the Metaverse

Digital assets can be divided into two main types: digital currencies and tokenised real-world assets (RWAs). Together, they form the economic infrastructure of Web3 and the metaverse by linking the physical and digital worlds.

6. NFTs and Programmable Digital Assets: Unlocking Ownership in Web3

- The concept of ownership has undergone a fundamental transformation, shifting from tangible, physical assets to digital and programmable property rights enabled by blockchain technology.
- NFTs have redefined ownership in Web3 by establishing scarcity, enabling programmable digital rights, and integrating with AI-driven economies.

7. Policy and Governance: Regulating a Digital-First Economy

- CBDCs are emerging as a pivotal regulatory tool for stabilising financial transactions in Web3. Unlike decentralised cryptocurrencies, CBDCs are government-backed, combining the reliability of traditional fiat money with the programmability of digital assets.
- However, increased state control over digital transactions could raise concerns about privacy and economic freedom.

8. Conclusion: Moving Beyond the Physical to a Digital Economy

As Web3 and the metaverse continue to evolve, its success will depend on our ability to integrate secure, scalable, and transparent frameworks that move beyond the constraints of the physical world.

www.rosa-roubini.com

© Rosa&Roubini Associates 2025 - All Rights Reserved. No duplication, reproduction, transmission or redistribution of this document and its content, either in whole or in part, is by any means permitted without prior written consent of Rosa&Roubini Associates Limited.

Page | 3





1. Introduction: Web3 and the Metaverse

In the last few years, technological developments have allowed the digital world as represented by the internet to evolve from Web 1.0 (read only) to Web 2.0 (read-write) to Web 3.0 (read-write-own), **Figure 1**. In the first iteration of the internet, users could only read what large corporations, able to afford to build their own website, would post on the web. In the second iteration, internet users could also write their own content, for example by producing their own blog posts or – later – participating in social media.

In the latest iteration, the internet has become the place where to share and exchange (and own) value, either native digital, or made digital through a tokenisation process. The process of ownership and digital identification represent two sides of the same coin: assets exchanged needs to be uniquely and unequivocally identified, and the two parties exchanging value needs to be also digitally identified, even if the transaction remain anonymous.



Figure 1: Evolution of the Web, from Web 1 to Web 3

Source: Geocities Institute

The metaverse represents a significant evolution of digital interaction, combining virtual reality (VR), augmented reality (AR), and decentralised networks to create immersive digital economies. Tracing its origins through the development of Web 1.0, Web 2.0, and Web 3.0, this shift marks a departure from centralised internet models towards user-owned digital environments, characterised by blockchain-based transactions and artificial intelligence (AI)-driven interactions (Nath, et al., 2014). The metaverse aims to replicate and even surpass the complexity of the physical world, integrating digital assets, decentralised finance (DeFi), and AI-powered automation to enable frictionless economic transactions (**Figure 2**).

Given this background, since a significant part of human transaction will occur originally, or will be brought, into the cyberspace (Web3 or Metaverse), a significant process of digitalisation of assets, liabilities, and currencies is taking place. As economic and social activities transition into these virtual worlds, traditional systems face significant inefficiencies. The infrastructure supporting the physical world—fiat currency, centralised banking, and conventional authentication protocols—has shown to be ill-equipped to handle the complexity of such digital-first cultures. Instead, digital instruments—including AI, central bank digital currencies (CBDCs), nonfungible tokens (NFTs), decentralised autonomous organisations (DAOs), and self-sovereign identity (SSI)—have emerged as key enablers of metaverse economies (Truong, et al., 2023).

Therefore, this paper will explore why conventional financial and identity models fail in Web3 and the metaverse ("the metaverse" for brevity), how digital identity and AI transform transactions, and the governance frameworks necessary for sustainable digital-first economies.

2. The Incompatibility of Physical-World Models in the Metaverse

To understand the necessity of fully digital models in a virtual-first environment like the metaverse, it is crucial to examine the inefficiencies and structural limitations of existing physical-world systems. While various real-world frameworks struggle to integrate seamlessly into digital environments, analysing key industries such as finance and identity verification highlights the core reasons behind their shortcomings.

www.rosa-roubini.com

Page | 4





Figure 2: Blockchain for Technical Aspects in the Metaverse



These traditional models, designed for physical economies with centralised governance, introduce friction when applied to decentralised, borderless virtual ecosystems (Boukis, et al., 2024). Their reliance on intermediaries, regulatory constraints, and lack of interoperability make them unfit for the demands of metaverse economies, necessitating the adoption of fully digital alternatives (Islam, 2023).

One of the most evident failures of physical-world models in Web3 and the metaverse is the reliance on fiatbased payment systems. The global economy depends on centralised banking networks, credit card transactions, and government-issued currencies to facilitate trade (Brunnermeier, et al., 2019). These systems, while effective within national jurisdictions, struggle to function efficiently in a decentralised virtual space. Fiat transactions incur high processing fees due to intermediary involvement, making microtransactions—an essential component of metaverse commerce—costly and inefficient (Ante and Fiedler, 2024).

Additionally, the reliance on banks and payment processors contradicts the decentralised nature of the metaverse, where users seek financial autonomy and seamless peer-to-peer interactions. Cross-border payments further exacerbate these inefficiencies, as transactions between different fiat currencies require foreign exchange processes, increasing both costs and settlement time (Cong, et al. 2020). Given that the metaverse is inherently global, a financial system constrained by national borders creates unnecessary barriers to trade and economic activity.

These inefficiencies underscore the need for digital financial models that align with the principles of virtual economies. Decentralised currencies such as stablecoins and CBDCs offer viable alternatives by enabling instant, low-cost transactions without reliance on traditional banking intermediaries (Carstens, 2022). Unlike fiat, these digital assets can operate autonomously across metaverse platforms, ensuring seamless integration within virtual economies. Furthermore, smart contracts allow for programmable financial transactions, automating settlements without requiring trust in third-party institutions (Buterin, 2014).

Stablecoins backed by real-world assets introduce economic stability, mitigating the volatility associated with purely speculative digital assets (Radziwill, 2018). By replacing traditional fiat systems with blockchain-based financial mechanisms, the metaverse can facilitate frictionless trade, eliminate unnecessary transaction costs, and promote economic inclusivity on a global scale.

Another fundamental challenge in adapting physical-world models to the metaverse lies in identity verification and authentication. Traditional identity management systems rely on centralised databases, government-issued www.rosa-roubini.com





documents, and KYC (Know Your Customer) procedures to validate user identities (Hori, 2021). While these mechanisms serve the purpose of regulatory compliance in physical economies, they become inefficient and problematic in decentralised virtual environments.

Users in the metaverse often interact across multiple platforms, each requiring separate authentication methods such as passwords, social media logins, or blockchain wallet addresses. This fragmented approach to identity verification creates disharmony, reducing interoperability and making digital interactions cumbersome (Seifert, Page | 6 2020). Additionally, centralised identity systems expose users to significant data privacy risks, as they require the storage of personal information in corporate or governmental databases, which are frequently targeted by cyber threats and data breaches (Schardong & Custódio, 2021).

The limitations of traditional authentication models necessitate the adoption of decentralised identity frameworks, such as Self-Sovereign Identity (SSI). SSI enables users to maintain control over their digital identities, allowing for seamless authentication across platforms without reliance on central authorities (Hanisch, et al., 2023). By leveraging blockchain technology and zero-knowledge proofs, users can verify their credentials without exposing sensitive personal information, enhancing privacy while maintaining trust in virtual interactions (Truong, et al., 2023). This approach eliminates the need for repeated authentication across different platforms, simplifying digital interactions in the metaverse.

Furthermore, decentralised identity models promote inclusivity by removing barriers that exclude individuals who lack access to government-issued documentation or traditional banking infrastructure (Cheng, 2023). The transition from centralised to self-sovereign identity management aligns with the metaverse's principles of autonomy, security, and user empowerment, making it a foundational requirement for a scalable and efficient digital ecosystem.

The shortcomings of physical-world frameworks in the metaverse are evident in both financial transactions and identity verification. Traditional monetary systems, reliant on fiat currency and intermediaries, introduce inefficiencies that hinder seamless economic interactions within virtual spaces. Similarly, centralised authentication mechanisms fail to provide scalable, privacy-preserving, and interoperable identity solutions required for decentralised digital environments.

To fully realise the potential of the metaverse, financial and identity systems must evolve beyond outdated physical-world constraints (MITSloan Management Review, 2024). By embracing decentralised financial instruments such as stablecoins and CBDCs, and implementing self-sovereign identity solutions, the metaverse can overcome the limitations of traditional models (De Felice, et al., 2023). These digital-first frameworks foster efficiency, security, and economic inclusivity, ensuring a sustainable and scalable foundation for the future of virtual economies.

3. Digital Identity as the Foundation of a True Virtual Economy

Digital identity systems are fundamental to enabling seamless interactions across metaverse platforms. Unlike traditional physical-world identity models, SSI frameworks ensure privacy, security, and user ownership while allowing for programmable identity structures that automate economic activity (Hori, 2021). These identities are more than just authentication tools; they serve as digital passports that enable users to access financial services, vote in DAOs, and participate in governance mechanisms (Seifert, 2020). By eliminating the need for centralized intermediaries, SSI fosters a trustless environment where identity verification and transactions occur seamlessly across virtual ecosystems (Schardong & Custódio, 2021). The programmability of digital identities allows for conditional smart contracts, ensuring that users can engage in transactions, earn reputations, and build digital assets in a way that is transparent, efficient, and inherently scalable (Buterin, 2014).

Beyond user authentication, Al-powered agents with digital identities are emerging as key actors in the metaverse economy. These AI-driven entities operate autonomously as financial advisors, virtual assistants, and market analysts, executing complex economic functions in DeFi and NFT trading (Cong, et al., 2020). For instance,

www.rosa-roubini.com

© Rosa&Roubini Associates 2025 - All Rights Reserved. No duplication, reproduction, transmission or redistribution of this document and its content, either in whole or in part, is by any means permitted without prior written consent of Rosa&Roubini Associates Limited.





Al-driven financial advisors can dynamically manage DeFi portfolios, leveraging predictive analytics to optimise investment returns (MITSIoan Management Review, 2024).

Unlike traditional financial institutions that require human oversight, these AI agents streamline decisionmaking, reducing inefficiencies and expanding financial access to global users (Hanisch, et al., 2023). By integrating AI with digital identity systems, metaverse economies can ensure that these autonomous agents interact transparently and are held accountable, reinforcing trust in digital financial ecosystems (Bolt et al., Page | 7 2017).

However, the rise of autonomous AI decision-making introduces ethical and regulatory challenges that could destabilise virtual economies. AI-controlled digital assets and governance structures may lead to economic manipulation, biased decision-making, or systemic vulnerabilities, underscoring the need for accountability frameworks in AI-driven financial transactions (Carstens, 2022).

Without proper safeguards, algorithmic biases could exacerbate financial exclusion, disproportionately affecting marginalised digital citizens (Lamarre, et al., 2023). Ensuring transparency and explainability in AI systems is critical to mitigating these risks. Smart contract auditing, algorithmic oversight, and decentralised dispute resolution mechanisms can help safeguard users against unfair practices while maintaining the integrity of metaverse financial systems (Hadi, et al., 2024).

Ultimately, digital identity is the foundation of a true virtual economy, providing the necessary infrastructure for secure transactions, governance, and economic automation (Brunnermeier, et al., 2019). In the metaverse, where physical-world constraints do not apply, identity becomes the primary trust mechanism that enables users and Al-driven agents to interact confidently (Truong, et al., 2023). A robust digital identity framework ensures financial inclusivity, prevents fraud, and enables programmable economies, driving the evolution of decentralised digital societies (De Felice, et al., 2023).

By embedding identity verification, reputation systems, and smart contract governance into the metaverse's financial architecture, digital identity transforms virtual interactions into a fully-fledged economic system, unlocking the next frontier of digital commerce (Pesce, 2021).

4. Al Agents as Economic Actors in the Metaverse

Al agents are transforming digital economies by autonomously negotiating, transacting, and executing economic tasks on behalf of users. This automation enhances efficiency in DeFi, customer service, and metaverse governance, enabling seamless interactions between human users and digital systems (Ante & Fiedler, 2024).

In DeFi, Al-driven trading bots optimise investment strategies and execute trades with minimal latency, outperforming human decision-making in volatile markets (Cong, et al., 2020). Similarly, AI agents in customer service handle complex queries and personalise consumer interactions, increasing engagement and retention (Hadi, et al., 2024). In the metaverse, AI entities govern digital spaces, enforce community guidelines, and facilitate peer-to-peer transactions, accelerating economic activity within virtual environments (De Felice et al., 2023). These developments position AI agents as independent economic actors, capable of influencing supply chains, asset prices, and consumer behaviour in the digital realm (Islam, 2023).

Beyond automating existing economic processes, AI agents now delegate tasks to other AI systems, creating self-sustaining digital economies. This shift introduces the concept of machine-owned digital assets, where AI entities autonomously manage and trade virtual goods, cryptocurrencies, and even real estate in the metaverse (Truong, et al., 2023). For instance, an Al-driven investment DAO could manage a portfolio of virtual properties, reinvesting profits without direct human oversight (Brunnermeier, et al., 2019).

As these AI economies evolve, fundamental legal and ethical questions emerge regarding accountability and ownership. If AI-driven enterprises autonomously acquire, trade, and distribute assets, who bears legal responsibility for their actions? The absence of a clear regulatory framework raises concerns about liability, governance, and the ethical implications of AI autonomy in economic decision-making (Hanisch et al., 2023).

www.rosa-roubini.com

[©] Rosa&Roubini Associates 2025 - All Rights Reserved. No duplication, reproduction, transmission or redistribution of this document and its content, either in whole or in part, is by any means permitted without prior written consent of Rosa&Roubini Associates Limited.





The growing dominance of AI in digital economies also has profound implications for wealth distribution and labour markets. As AI-controlled assets accumulate wealth, there is a risk of economic power becoming increasingly concentrated among a small group of individuals or institutions that own and control these systems (Carstens, 2022). This could exacerbate existing inequalities, as traditional workers are displaced by AI-driven automation, further widening the wealth gap (Purdy, 2022).

Additionally, legal complexities arise in holding AI accountable for financial transactions, fraud, or breaches of Page | 8 contract (Seifert, 2020). For instance, if an AI-powered trading algorithm manipulates virtual asset prices or executes a faulty trade, determining responsibility remains a challenge (Radziwill, 2018). Addressing these disparities requires proactive regulatory measures, including AI taxation models, decentralised governance frameworks, and digital wealth redistribution strategies, ensuring fair participation in Al-driven metaverse economies (Stackpole, 2022).

Al agents are no longer passive tools but active economic participants shaping the metaverse. Their ability to own, trade, and govern digital assets autonomously redefines traditional economic roles, challenging conventional notions of entrepreneurship and labour (Yilmaz, et al., 2023). As AI-driven markets expand, policymakers and technologists must develop new regulatory and ethical frameworks that balance innovation with accountability (Boukis, et al., 2024). The emergence of self-governing AI economies represents both an opportunity and a challenge—one that requires a nuanced understanding of how AI interacts with digital markets, wealth distribution, and economic agency in the metaverse (Nath, et al., 2014).

5. Understanding Digital Assets in the Metaverse

Before delving into NFTs in the metaverse, it's important to understand digital assets more broadly, which can be divided into two main types: digital currencies and tokenised real-world assets (RWAs), Figure 3. Together, they form the economic infrastructure of the metaverse by linking the physical and digital worlds (De Felice et al., 2023).



Digital Assets: Real-World-Assets and Digital Currencies

Source: Constellation

The process enabling this bridge is tokenisation - the conversion of physical or traditionally non-digital assets (e.g., real estate, equities, bonds) into blockchain-based representations (Figure 4). These tokens can then be traded, owned or programmed within decentralised digital environments (Cong, Li, & Wang, 2020). This process

www.rosa-roubini.com

© Rosa&Roubini Associates 2025 - All Rights Reserved. No duplication, reproduction, transmission or redistribution of this document and its content, either in whole or in part, is by any means permitted without prior written consent of Rosa&Roubini Associates Limited.





introduces new levels of liquidity, accessibility and programmability to assets once limited by geography or regulation (Truong, Le, & Niyato, 2023).

Digital assets fall into two categories:

- Digital currencies including cryptocurrencies, stablecoins and central bank digital currencies (CBDCs). Unlike tokenised physical assets, digital currencies are native to digital ecosystems. They serve as the primary medium of exchange within the metaverse, facilitating transactions for goods, services and other digital assets (Carstens, 2022). Each type plays a unique role: cryptocurrencies provide decentralised financial autonomy, stablecoins offer price stability for daily use, and CBDCs combine digital utility with regulatory oversight (Brunnermeier et al., 2019).
- Tokenised RWAs These are blockchain-based representations of traditional assets such as equities, real estate, commodities or bonds. Tokenisation enables fractional ownership, broadening participation and improving market liquidity (Brunnermeier, James, & Landau, 2019).



Figure 4: The Process of Tokenisation of Assets

Source: Chainlink

This classification can be visualised as a spectrum: on one side, digital currencies enable economic exchange, while on the other, tokenised RWAs bring real-world value into digital ecosystems. Within the latter category sits a more specific type: non-fungible tokens (NFTs).

NFTs are unique, indivisible tokens that can represent both digital-native items and tokenised real-world goods—such as digital art, virtual land, or collectibles. Their non-fungibility makes them ideal for asserting ownership, identity and scarcity in the metaverse (Ante & Fiedler, 2024). While they have captured public attention, NFTs are only a subset of the broader tokenisation framework. Core assets like equities, real estate and bonds still represent the bulk of economic value and are foundational to global financial systems (Islam, 2023).

A common question concerns how users pay for goods and services in the metaverse. This is where digital currencies come into play. Unlike fiat currencies, which face challenges in decentralised environments due to inefficiencies, high transaction costs and geographical barriers, digital currencies enable seamless, global transactions (Brunnermeier et al., 2019). As mentioned already, each type serves a purpose: cryptocurrencies support open finance, Stablecoins facilitate microtransactions, and CBDCs offer secure, state-backed digital payment options (Carstens, 2022). Collectively, these currencies underpin the exchange of all digital assets, including NFTs and RWAs (Buterin, 2014).

Understanding this ecosystem of tokenisation and digital currencies is critical to grasping the significance of NFTs. Just as AI agents in the metaverse can act autonomously to transact, govern or invest, NFTs provide the

www.rosa-roubini.com

© Rosa&Roubini Associates 2025 - All Rights Reserved. No duplication, reproduction, transmission or redistribution of this document and its content, either in whole or in part, is by any means permitted without prior written consent of Rosa&Roubini Associates Limited.

Page | 9





structure for digital ownership, reputation and identity. The next section explores how NFTs build on this infrastructure, enabling programmable ownership and supporting the rise of fully developed digital economies.

6. NFTs and Programmable Digital Assets: Unlocking Ownership in the Metaverse

The concept of ownership has undergone a fundamental transformation, shifting from tangible, physical assets to digital and programmable property rights enabled by blockchain technology. Traditionally, ownership has been defined and enforced through legal frameworks governing the transfer and possession of physical goods (Brunnermeier, at al., 2019). However, the digital era, particularly within decentralised ecosystems such as the metaverse, has redefined ownership through NFTs.

Page | 10

These blockchain-based assets serve as verifiable proof of ownership and authenticity, distinguishing them from traditional digital goods that can be copied and distributed freely (Ante & Fiedler, 2024). By leveraging blockchain's immutable ledger, NFTs introduce scarcity and provenance to digital assets, thereby conferring intrinsic value (Islam, 2023). This technological shift challenges traditional legal constructs of property rights and raises new questions about enforceability, permanence, and governance in virtual environments (Carstens, 2022).

Beyond establishing digital ownership, NFTs introduce programmable ownership, wherein smart contracts automate and enforce rules without reliance on intermediaries (Buterin, 2014). This decentralisation enhances security and trust in transactions, particularly in metaverse economies, where digital real estate, virtual goods, and in-game items are becoming increasingly valuable (Hadi, et al., 2024). Unlike conventional contracts, which require legal intermediaries to uphold agreements, smart contracts self-execute based on predefined conditions embedded in code (Cong, et al., 2020).

This enables functionalities such as automatic royalty payments to creators, fractional ownership of digital assets, and dynamic metadata updates (Seifert, 2020). These programmable attributes allow NFTs to evolve beyond static digital collectibles into functional, revenue-generating assets with long-term utility in decentralised digital ecosystems (Truong, et al., 2023).

NFTs also serve a crucial role in digital identity and reputation systems within the metaverse. Traditionally, digital identities have been fragmented across platforms, requiring users to maintain separate credentials and authentication processes (Hori, 2021). NFTs offer an alternative by acting as digital passports, granting holders exclusive access to virtual spaces, communities, and governance mechanisms (Schardong & Custódio, 2021). Certain decentralised applications (DApps) and virtual worlds already mandate NFT ownership for participation in governance decisions or access to premium content (Hanisch et al., 2023). This approach not only enhances user autonomy but also fosters exclusive and tiered digital economies, where access is dictated by provable ownership rather than centralised authorisation (De Felice et al., 2023).

Additionally, NFT-based reputation mechanisms are emerging as a means to establish trust and credibility in decentralised environments (Pesce, 2021). By tokenising achievements, skills, and contributions, NFTs provide a transparent way to verify user reputation, particularly in DeFi and play-to-earn gaming ecosystems (Sr, et al., 2022). A user's NFT-backed reputation could directly influence their access to financial incentives, community governance, and exclusive economic opportunities (Boukis, et al., 2024). As digital economies continue to evolve, these NFT-based identities may replace traditional authentication models, offering seamless, interoperable, and decentralised identity verification that moves away from reliance on centralised platforms (Cheng, 2023).

The integration of AI with NFTs is further revolutionising digital asset management, giving rise to AI-generated and AI-owned assets (Purdy, 2022). AI agents can now create, trade, and manage NFTs, forming self-sustaining digital enterprises that operate autonomously in the metaverse (MITSIoan Management Review, 2024). AI-generated art, music, and virtual environments can be tokenised as NFTs, allowing creators—both human and machine—to monetise digital creativity without intermediaries (Radziwill, 2018). Moreover, AI-powered trading algorithms are being deployed to optimise NFT portfolios, utilising predictive analytics to identify high-value

www.rosa-roubini.com

© Rosa&Roubini Associates 2025 - All Rights Reserved. No duplication, reproduction, transmission or redistribution of this document and its content, either in whole or in part, is by any means permitted without prior written consent of Rosa&Roubini Associates Limited.





assets and execute trades accordingly (Heath, 2019). This convergence of AI and NFTs introduces new economic models, where digital assets are not only owned but autonomously managed within smart contract ecosystems (Kremenova & Gajdos, 2019).

However, Al-generated NFTs introduce complex legal and ethical dilemmas. If an Al system autonomously creates, sells or trades NFTs, questions arise regarding ownership, accountability and legal personhood (Brunnermeier, et al., 2019). Should AI entities be granted property rights, or does ownership default to the AI's Page | 11 developer, operator or underlying platform? Additionally, regulatory frameworks remain unclear on how AIgenerated content interacts with intellectual property laws, particularly when AI creations are indistinguishable from human-generated work (Visconti, 2022).

Furthermore, smart contracts governing AI-NFT interactions must ensure compliance with legal standards, all while maintaining the decentralised ethos of blockchain-based economies (Lamarre et al., 2023). Addressing these challenges requires a careful balance between technological innovation, regulatory oversight, and ethical considerations, ensuring that AI-driven NFTs contribute to the growth of digital economies without undermining accountability (Hemphill, 2019).

In conclusion, NFTs have redefined ownership in the metaverse by establishing scarcity, enabling programmable digital rights, and integrating with Al-driven economies. As digital assets gain economic and social significance, the ability to automate, secure, and verify ownership through NFTs has profound implications for property rights, identity, and trust in decentralszed environments (Bolt et al., 2017). However, challenges related to legal frameworks, Al-generated ownership, and ethical governance must be addressed to fully realise the potential of programmable digital assets (Nath, et al., 2014). The ongoing evolution of NFTs in the metaverse underscores the broader transformation of ownership in the digital age-where property is no longer just owned but programmed, managed, and autonomously operated within blockchain-powered economies (Yilmaz, et al., 2023).

7. Policy and Governance: Regulating a Digital-First Economy

As digital economies evolve, CBDCs are emerging as a pivotal regulatory tool for stabilising financial transactions in the metaverse. Unlike decentralised cryptocurrencies, CBDCs are government-backed, combining the reliability of traditional fiat money with the programmability of digital assets (Carstens, 2022). This hybrid nature enables CBDCs to address key inefficiencies in digital finance, such as reducing transaction costs, streamlining cross-border payments, and enhancing fraud prevention (Brunnermeier, et al., 2019).

Additionally, CBDCs could promote financial inclusion by providing a stable, widely accepted medium of exchange within virtual economies, mitigating the volatility often associated with cryptocurrencies (Ante & Fiedler, 2024). However, the implementation of CBDCs in the metaverse necessitates a delicate balance between financial oversight and individual autonomy, as increased state control over digital transactions could raise concerns about privacy and economic freedom (Islam, 2023).

A key innovation in metaverse financial governance is programmable money, powered by smart contracts. These self-executing contracts could automate compliance, taxation, and payments, reducing administrative burdens and improving efficiency (Buterin, 2014). For example, virtual businesses could integrate CBDC-based smart contracts to facilitate transparent revenue sharing and automated tax deductions (Cong, et al., 2020). While this automation enhances regulatory compliance, it also introduces challenges related to enforcement and oversight.

Governments may seek to embed compliance mechanisms directly into CBDC transactions, ensuring that digital assets are used in accordance with legal frameworks (Carstens, 2022). However, such measures raise fundamental questions about financial surveillance and the potential for governments to freeze or restrict transactions, effectively exerting direct control over metaverse economies. Policymakers must therefore develop clear guidelines on transaction monitoring, data protection, and user rights to prevent abuses of power while maintaining financial stability (De Felice et al., 2023).

www.rosa-roubini.com

© Rosa&Roubini Associates 2025 - All Rights Reserved. No duplication, reproduction, transmission or redistribution of this document and its content, either in whole or in part, is by any means permitted without prior written consent of Rosa&Roubini Associates Limited.





Beyond financial regulation, the governance of metaverse is shifting toward decentralised models, particularly through DAOs. Unlike traditional corporate governance structures, DAOs leverage blockchain-based voting mechanisms to enable token holders to participate directly in decision-making (Truong, et al., 2023). This model fosters transparency and democratisation, making it particularly suited for metaverse applications such as digital marketplaces, virtual cities, and online social organisations (Hanisch et al., 2023).

A prime example is metaverse real estate management, where token-based governance allows participants to Page | 12 vote on land development policies and resource allocation, ensuring that virtual environments evolve in line with community preferences (Pesce, 2021). However, DAOs are not without challenges. Governance mechanisms must be designed to prevent token-based plutocracy, where wealthier participants exert disproportionate influence over decision-making (Seifert, 2020).

An emerging ethical dilemma in DAO governance is the potential inclusion of AI entities as decision-making participants. AI agents, capable of processing vast amounts of data and making rapid decisions, could contribute to more efficient governance processes (Heath, 2019). However, granting AI the ability to vote or influence DAO decisions raises critical policy questions: Should AI entities have the same governance rights as human participants? If so, how should their influence be regulated? AI-driven decision-making could introduce biases, manipulate governance outcomes, or even prioritize machine-driven logic over human ethical considerations (Hadi, et al., 2024). Regulators must establish clear AI governance frameworks, ensuring that AI involvement in metaverse economies remains transparent, accountable, and aligned with human interests (Hanisch et al., 2023).

Ultimately, the transition to a digital-first economy demands innovative regulatory policies that balance technological advancements with governance safeguards. While CBDCs and smart contracts offer promising solutions for financial oversight, they must be implemented with strong data protection laws and financial autonomy safeguards (Brunnermeier et al., 2019). Likewise, DAOs provide a decentralised governance model, but they require robust frameworks to ensure equitable participation and ethical AI integration (Schardong & Custódio, 2021).

As the metaverse expands, policymakers must proactively shape regulations that foster inclusive, transparent, and accountable digital economies while mitigating the risks of centralised control and algorithmic bias (MITSloan Management Review, 2024).

8. Conclusion: Moving Beyond the Physical to a Digital-First Economy

The rise of the metaverse signals a profound transformation, necessitating a departure from traditional economic, identity, and governance structures that were designed for the physical world. Conventional mechanisms—such as fiat currencies, centralised identity models, and hierarchical governance systems—struggle to scale efficiently in decentralised and highly dynamic virtual ecosystems. The metaverse requires digital-first financial and governance frameworks that can support borderless transactions, secure identity verification, and adaptive rule enforcement. This transition challenges existing paradigms, demanding new solutions that prioritise decentralisation, automation, and interoperability.

Key digital instruments will shape the future of metaverse economies, particularly AI, SSI, CBDCs, and NFTs. AI will enable real-time decision-making, automate transactions, and enhance personalised virtual experiences. However, unchecked AI dominance poses risks of economic manipulation and bias, necessitating governance frameworks that prevent monopolisation and enforce ethical standards. SSI frameworks offer a decentralised alternative to identity verification, reducing reliance on central authorities while ensuring security and privacy. CBDCs, if effectively integrated, can provide a stable and regulated financial foundation in the metaverse, addressing volatility concerns inherent in cryptocurrencies. NFTs, beyond their current role in digital asset ownership, could evolve into reputation and credibility systems, enabling trust and accountability in decentralised virtual spaces.

www.rosa-roubini.com

© Rosa&Roubini Associates 2025 - All Rights Reserved. No duplication, reproduction, transmission or redistribution of this document and its content, either in whole or in part, is by any means permitted without prior written consent of Rosa&Roubini Associates Limited.





However, the integration of these technologies introduces complex challenges that must be addressed, as well as critical areas where future research must be directed to achieve a sustainable digital-first economy. Al-led transactions require regulatory clarity and ethical safeguards to prevent systemic exploitation. Privacy concerns will intensify as digital identities become more sophisticated, necessitating a delicate balance between user anonymity and regulatory oversight to prevent fraud and cybercrime.

Governance in virtual environments must transition from traditional hierarchical models to transparent, Page | 13 algorithmic, and community-driven systems that can dynamically adapt to evolving digital landscapes. Finally, NFT-based reputation and credibility mechanisms could provide a decentralised alternative to traditional trust models, incentivising ethical behaviour and ensuring equitable participation in digital economies.

As the metaverse continues to evolve, its success will depend on our ability to integrate secure, scalable, and transparent frameworks that move beyond the constraints of the physical world. By addressing these challenges proactively, we can create a metaverse that is not only economically viable but also fair, inclusive, and governed by principles of digital trust and autonomy.





References

Ante, L., & Fiedler, I. (2024). The new digital economy: How decentralized finance (DeFi) and non-fungible tokens (NFTs) are transforming value creation, ownership models, and economic systems. *Digital Business*, 100094. https://doi.org/10.1016/j.digbus.2024.100094

Bolt, W., Narayanan, A., Bonneau, J., Felten, E., Miller, A., & Goldfeder, S. (2017). Review of Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction. *Journal of Economic Literature*, *55*(2), 647–649. Page | 14 https://www.jstor.org/stable/26303525

Boukis, A., Siamagka, N. T., & Michaelidou, N. Exploring consumers' journey from physical ownership to digital assets.

Brunnermeier, M., James, H., & Landau, J.-P. (2019). The Digitalization of Money. *Princeton University Press*. https://doi.org/10.3386/w26300

Buterin, V. (2014). A NEXT GENERATION SMART CONTRACT & DECENTRALIZED APPLICATION PLATFORM. https://www.weusecoins.com/assets/pdf/library/Ethereum_white_paper-

 $a_next_generation_smart_contract_and_decentralized_application_platform_vitalik-buterin.pdf$

Carstens, A. (2022). Digital currencies and the soul of money. *Www.bis.org*. https://www.bis.org/speeches/sp220118.htm

Cheng, S. (2023). Metaverse and Digital Asset. 123–144. https://doi.org/10.1007/978-3-031-24359-2_6

Cong, L. W., Li, Y., & Wang, N. (2020). Tokenomics: Dynamic Adoption and Valuation. *The Review of Financial Studies*, *34*(3), 1105–1155. https://doi.org/10.1093/rfs/hhaa089

De Felice, F., De Luca, C., Chiara, S. D., & Petrillo, A. (2023). Physical and digital worlds: implications and opportunities of the metaverse. *Procedia Computer Science*, *217*, 1744–1754. https://doi.org/10.1016/j.procs.2022.12.374

Schardong, F., & Custódio, R.F. (2021). Self-Sovereign Identity: A Systematic Review, Mapping and Taxonomy. *ArXiv (Cornell University)*. https://doi.org/10.48550/arxiv.2108.08338

Hadi, R., Melumad, S., & Park, E. S. (2024). The Metaverse: A new digital frontier for consumer behavior. *Journal of Consumer Psychology*, *34*(1), 142–166. https://doi.org/10.1002/jcpy.1356

Hanisch, M., Goldsby, C. M., Fabian, N. E., & Oehmichen, J. (2023). Digital governance: A conceptual framework and research agenda. *Journal of Business Research*, *162*, 113777. https://doi.org/10.1016/j.jbusres.2023.113777

Heath, D. R. (2019). Prediction machines: the Simple Economics of Artificial Intelligence. *Journal of Information Technology Case and Application Research*, 21(3-4), 1–4. https://doi.org/10.1080/15228053.2019.1673511

Hemphill, T. A. (2019). Book review: Prediction Machines: The Simple Economics of Artificial Intelligence. *Journal of General Management*, *45*(1), 50–51. https://doi.org/10.1177/0306307019854812

Hori, S. (2021, August 12). *Self-sovereign identity: future of personal data ownership?* World Economic Forum. https://www.weforum.org/stories/2021/08/self-sovereign-identity-future-personal-data-ownership/

Islam, S. (2023). Trust in digital asset transactions in a web 3 based metaverse.

Kremenova, I., & Gajdos, M. (2019). Decentralized Networks: The Future Internet. *Mobile Networks and Applications*, *24*(6), 2016–2023. https://doi.org/10.1007/s11036-018-01211-5

Lamarre, E., Chheda, S., Riba, M., Genest, V., & Nizam, A. (2023). *The Value of Digital Transformation*. Harvard Business Review. <u>https://hbr.org/2023/07/the-value-of-digital-transformation</u>

MITSIoan Management Review. (2024). NextTech 2024: Explore the Future Insights of AI Advancements, Nextgen Tech, and Human-centric Approaches.

www.rosa-roubini.com





Nath, K., Dhar, S., & Basishtha, S. (2014). Web 1.0 to Web 3.0 - Evolution of the Web and its various challenges. 2014 International Conference on Reliability Optimization and Information Technology (ICROIT). https://doi.org/10.1109/icroit.2014.6798297

Pesce, M. (2021, October 22). *The Metaverse Could Help Us Better Understand Reality*. IEEE Spectrum. https://spectrum.ieee.org/the-metaverse-could-help-us-better-understand-reality

Purdy, M. (2022, April 5). *How the Metaverse Could Change Work*. Harvard Business Review. Page | 15 https://hbr.org/2022/04/how-the-metaverse-could-change-work

Radziwill, N. (2018). Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World. *Quality Management Journal*, *25*(1), 64–65. https://doi.org/10.1080/10686967.2018.1404373

Seifert, R. (2020). Digital identities – self-sovereignty and blockchain are the keys to success. *Network Security*, 2020(11), 17–19. https://doi.org/10.1016/s1353-4858(20)30131-8

Sr, R. B., Shin, S. I., & Kim, J. B. (2022). WILL NFTS BE THE BEST DIGITAL ASSET FOR THE METAVERSE? AIS Electronic Library (AISeL). https://aisel.aisnet.org/sais2022/16

Stackpole, T. (2022, July 8). Exploring the Metaverse. *Harvard Business Review*. https://hbr.org/2022/07/exploring-the-metaverse

Truong, V. T., Le, L. B., & Niyato, D. (2023). Blockchain Meets Metaverse and Digital Asset Management: A Comprehensive Survey. *IEEE Access*, *11*, 26258–26288. https://doi.org/10.1109/access.2023.3257029

VISCONTI, R. M. (2022). From physical reality to the Metaverse: a Multilayer Network Valuation. *DergiPark* (Istanbul University).

Yilmaz, T., Sofie Sagfossen, & Velasco, C. (2023). What Makes NFTs Valuable to consumers? Perceived Value Drivers Associated with NFTs liking, purchasing, and Holding. *Journal of Business Research*, *165*, 114056–114056. <u>https://doi.org/10.1016/i.jbusres.2023.114056</u>