ORIGINAL PAPER

DOI: 10.26794/2308-944X-2024-12-4-29-41
UDC 338.1.72(045)
JEL O14, O33, P17, P51

Strategic Management of the Metaverse Ecosystem in the Context of Web 3.0: Theory, Framework and Tools

Y. Vertakova[a], E. Shkarupeta[b]
[a] Russian State Humanitarian University, Moscow, Russia;
[b] Voronezh State Technical University, Voronezh, Russia

ABSTRACT

This study explores the strategic management of metaverse ecosystems grounded in Web 3.0, emphasizing the theoretical foundations, conceptual framework, and practical tools required for their advancement. The **subject** of this study is the development of decentralized, user-owned virtual worlds within metaverse ecosystems, bridging digital and physical realities. The **purpose** of this study is to analyze the evolution from Web 1.0 to Web 3.0 and to highlight the transformative impact of these ecosystems within the context of Industry 5.0. The **relevance** lies in the strategic significance of the metaverse as a driving force in future economic and technological development, reshaping industries, work environments, and digital economies. The **scientific novelty** of the research lies in its introduction of a six-domain conceptual framework for managing the digital potential of complex systems in the metaverse, focusing on the blockchain-based democratization of digital assets and user-centric governance. The **findings** reveal significant distinctions between the Web 2.0 and Web 3.0 metaverse ecosystems and demonstrate their transformative potential across various sectors. The study **concludes** that metaverse ecosystems will play a pivotal role in shaping Industry 5.0, necessitating innovative management strategies to fully harness their digital and economic capabilities.

Keywords: metaverse ecosystem; Web 3.0; strategic management; ball metaverse index; top metaverse coins

For citation: **Vertakova Y., Shkarupeta E. Strategic management of the metaverse ecosystem in the context of Web 3.0: Theory, framework and tools. *Review of Business and Economics Studies*. 2024;12(4):29-41. DOI: 10.26794/2308-944X-2024-12-4-29-41**

ОРИГИНАЛЬНАЯ СТАТЬЯ

Стратегическое управление экосистемной метавселенной в контексте Web 3.0: теория, фреймворк и инструменты

Ю. Вертакова[a], Е. Шкарупета[b]
[a] Российский государственный гуманитарный университет, Москва, Россия;
[b] Воронежский государственный технический университет, Воронеж, Россия

АННОТАЦИЯ

В данном исследовании рассматривается стратегическое управление метавселенными экосистемами, основанными на Web 3.0, с акцентом на теоретические основы, концептуальные рамки и практические инструменты, необходимые для их развития. **Предметом** исследования является развитие децентрализованных, принадлежащих пользователям виртуальных миров в рамках метавселенных экосистем, соединяющих цифровую и физическую реальности. **Цель** исследования — проанализировать эволюцию от Web 1.0 к Web 3.0 и подчеркнуть преобразующее воздействие этих экосистем в контексте Инду-

стрии 5.0. **Актуальность** работы заключается в стратегическом значении метавселенной как движущей силы будущего экономического и технологического развития, перестраивающей отрасли, рабочую среду и цифровую экономику. Научная **новизна** исследования заключается во внедрении шестидоменной концептуальной схемы управления цифровым потенциалом сложных систем в метавселенной с акцентом на демократизацию цифровых активов на основе блокчейна и управление, ориентированное на пользователя. **Результаты** исследования выявляют существенные различия между метавселенными экосистемами Web 2.0 и Web 3.0 и демонстрируют их трансформационный потенциал в различных секторах. В исследовании делается вывод о том, что метавселенные экосистемы будут играть ключевую роль в формировании Индустрии 5.0, что потребует инновационных стратегий управления для полного использования их цифровых и экономических возможностей.
Ключевые слова: экосистемная метавселенная; Web 3.0; стратегический менеджмент; ball Metaverse Index; top metaverse coins

Для цитирования: **Vertakova Y., Shkarupeta E. Strategic management of the metaverse ecosystem in the context of Web 3.0: Theory, framework and tools. *Review of Business and Economics Studies*. 2024;12(4):29-41. DOI: 10.26794/2308-944X-2024-12-4-29-41**

Introduction

As shown in the foreword to Grayscale's 2021 study [1] on metaverse ecosystems, the Web 3.0 virtual cloud crypto-economy represents the next investment frontier in the emerging market. At the forefront of this new Internet evolution are the metaverse ecosystems, which are the focus of this study. The convergence of Web 1.0, Web 2.0, and Web 3.0 represents a pivotal inflection point in the digital economy, catalyzing the development of decentralized metaverse ecosystems characterized by interoperable, real-time, immersive 3D environments. These ecosystems leverage blockchain-driven frameworks, enabling disintermediated ownership structures, tokenized asset economies, and decentralized autonomous organizations (DAOs) to facilitate value exchange, governance, and digital property rights. This paradigm shift toward user-sovereign digital environments fuels the proliferation of cryptocurrencies and non-fungible tokens (NFTs), which underpin the metaverse's socio-economic fabric. As technological incumbents capitalize on this emergent frontier, hybridized virtual-physical economic models are redefining market dynamics, fostering a decentralized, participatory, and resilient economic architecture that transcends traditional centralized control [1–3].

Literature review

The metaverse represents a paradigmatic evolution in the cyber-physical continuum, transcending traditional ecosystem constructs by exponentially amplifying immersiveness and actor integration [4]. Within the cybernetic modality of hyperspatial architectures, metaverse ecosystems form an intricate subdomain of the intelligent cyber-social meta-ecosystem, a foundational element of Industry 5.0 [4–17]. As decentralized frameworks underpinned by distributed ledger technologies and cognitive automation, these ecosystems facilitate seamless interoperability, asset tokenization, and real-time socio-economic convergence across virtual and tangible domains. While still nascent, core components such as decentralized governance protocols, interoperable asset economies, and AI-driven experiential design are crystallizing, signaling the metaverse's trajectory toward a resilient, user-owned, and cognitively adaptive meta-economy [4]. The purpose of this study is to make the concept of metaverse ecosystems in the context of Web 3.0 more tangible.

Methodology

The objective was achieved through three steps:

- To describe the evolution of the transition from Web 1.0 to Web 2.0 and Web 3.0.
- To develop a conceptual framework for Web 3.0 metaverse ecosystems.
- To classify the existing and prospective tools for strategic management of the digital potential of complex systems based on the concept of Web 3.0 metaverse ecosystems.

The methods used in this study include system analysis, historical analysis, general scientific methods, and the comparison of data from domestic and foreign studies, as well as materials from the World Economic Forum and technology companies in the Web 2.0 and Web 3.0 domains.

Table 1
Key features of the three stages of Web 1.0 — Web 2.0 — Web 3.0 evolution

	Web 1.0	Web 2.0	Web 3.0
Main idea	Virtual networks	Online communities	Virtual worlds of communities
Interaction	Reading	Reading-Writing	Read-Write-Possess
Core	Static text	Interactive content	Virtual cloud economy
Organisation	Companies	Platforms	Networks
Infrastructure	Personal computers	Cloud and mobile technologies	Cloud blockchain
Control	Decentralised	Centralised	Decentralised
Key company	Netscape	Facebook	Decentraland
Metaverse ecosystems	None	Closed corporate	Open crypto

Source: Developed by the authors based on [1].

Results and discussion

Evolution of the transition from Web 1.0 to Web 2.0 and Web 3.0

Over the past three decades, from 1990 to the present, Internet technology has evolved, transforming the way we interact with the web. This continuous process can be divided into three major eras in the development of online communities [1]:

- Web 1.0: Bringing users together based on virtual networks.
- Web 2.0: Creation of online communities.
- Web 3.0: Formation of a virtual world belonging to communities.

The key features of the three stages of Web 1.0 — Web 2.0 — Web 3.0 evolution are presented in *Table 1*.

The conceptual foundations of Web 3.0, rooted in decentralization, user sovereignty, and blockchain interoperability, have evolved in parallel with advances in virtual reality and immersive digital ecosystems [18]. From early experiments with immersive interfaces such as the Sensorama Simulator of the 1960s to Neal Stephenson's seminal portrayal of a decentralized "metaverse" in "Snow Crash" (1992) [19], the trajectory of digital interaction has continually leaned toward disintermediated, user-empowered paradigms. The advent of Bitcoin in 2009 and the proliferation of NFTs (non-fungible tokens) have facilitated cryptographic asset ownership, enhancing liquidity and enabling programmable digital scarcity within metaverse economies. These innovations promise to underpin a new era of cyber-physical convergence, where tokenized assets fuel decentralized autonomous organizations (DAOs) and peer-to-peer value exchanges. However, to mitigate systemic risks like market manipulation and fraudulent NFTs, robust regulatory frameworks and decentralized verification protocols remain paramount for fostering a resilient and equitable Web 3.0 economy [18].

The evolutionary trajectory of Web 1.0, Web 2.0, and Web 3.0 underscores a paradigm shift in the economic architectures underpinning digital interaction, catalyzing the emergence of metaverse ecosystems predicated on decentralized ownership and blockchain technology [1]. This metamorphosis encompasses a transition from hierarchical, platform-centric networks to peer-to-peer, trustless infrastructures that facilitate disintermediated value exchange and user sovereignty [1]. Enabled by distributed ledger technologies and tokenized digital assets, Web 3.0 fosters an endogenous digital economy where smart contracts automate transactions, non-fungible tokens (NFTs) confer immutable property rights, and decentralized autonomous organizations (DAOs) operationalize governance structures [1]. Consequently, metaverse ecosystems hold the potential to dismantle legacy gatekeeping mechanisms, engendering a heterarchical model of economic activity that harmonizes virtual and physical realms [1].

Metaverse ecosystems 2.0 vs metaverse ecosystems 3.0

The key differences between Web 2.0 metaverse ecosystems and Web 3.0 metaverse ecosystems are as follows [1]:

• Closed corporate Web 2.0 metaverse ecosystems are centrally owned and controlled by big tech companies.

• Open crypto Web 3.0 metaverse ecosystems are democratically owned and controlled by global users.

One of the fundamental limitations of Web 2.0 metaverse ecosystems lies in their monopolistic architecture, where developers impose structural capital constraints and inhibit asset liquidity, thus creating walled-garden economies devoid of interoperability. This results in a rent-seeking environment where participants' digital labor and capital cannot be converted into fungible economic value within external markets. Web 3.0 metaverse frameworks, leveraging decentralized blockchain infrastructures, dismantle these restrictions by facilitating asset ownership through non-fiat tokens (NFTs) and enabling seamless peer-to-peer exchange across digital ecosystems. This paradigm fosters an open, disintermediated market structure where digital capital can achieve full liquidity, thereby introducing an efficient mechanism for transmuting virtual wealth into tangible economic assets within the broader macroeconomy [1].

Web 3.0 conceptual framework of metaverse ecosystems in strategic management

The metaverse, as a transcendent virtual economy, is underpinned by the triadic principles of presence, interoperability, and standardization, which collectively drive its economic scalability and cross-platform viability [3]. Presence leverages immersive VR technologies to engender a hyper-realistic perception of spatial engagement, thus augmenting transaction utility and enhancing socio-economic interactions within virtual marketplaces [3]. Interoperability, facilitated by blockchain infrastructures and tokenized assets, ensures seamless transferability of digital capital — avatars, NFTs, and cryptocurrencies — across heterogeneous platforms, thus creating a unified, frictionless economic space [3]. Standardization, championed by international consortia such as the Open Metaverse Interoperability Group, institutionalizes uniform protocols, ensuring platform-agnostic compatibility and accelerating the metaverse's adoption curve by mitigating technological fragmentation [3].

The conceptual framework of Web 3.0 metaverse ecosystems in strategic management of digital potential is illustrated in *Fig.*

As illustrated in *Fig.*, it is appropriate to consider metaverse ecosystems through seven interrelated cognitive domains [2]:

— The domain of *AI and the Metaverse* investigates the convergence of artificial intelligence and immersive virtual environments, highlighting AI as the cognitive substrate for adaptive systems, autonomous agents, and real-time content generation. This domain further explores the ethical and regulatory dimensions of AI, incorporating blockchain-based financial systems, governance frameworks, and socio-cultural dynamics in digital entertainment and media ecosystems. It is an increasingly prominent subfield within artificial intelligence: generative AI enables not just analysis but also the creation of seemingly new information, based upon the dataset with which the model has been trained. Generative AI can perform content creation of different types (its images and music have drawn particular attention), easily prompted by typing in brief instructions using natural language. Foundation models like GPT (or BERT) are now a recognized paradigm for building AI systems — in which a model trained on a large amount of unlabelled data can be adapted to many different applications. At a time when the virtual worlds soon to populate the metaverse need content, generative AI will be increasingly looked to for scaling up digital creation. In a similar way to what happens in the current version of the internet, AI applications will be used to automate, moderate, and organize content within immersive spaces — or to power hardware capabilities (like capturing physical environments and rendering them in 3D, or adjusting the passthrough in virtual and augmented reality devices).

Ethics will be key; AI should be considered in light of its potential impact on social, economic, and ethical issues as it is increasingly applied in the metaverse. As a field, AI ethics is comprised of many different dimensions stemming from its

Fig. **Web 3.0 conceptual framework of metaverse ecosystems in strategic management**

Source: World Economic Forum. The Metaverse. Global Issue. URL: https://intelligence.weforum.org/topics/a1G680000004EbNEAU (accessed on 10.12.2024).

pervasive nature, from the bias in datasets, to the potential lack of transparency in how models are trained or developed, or the lack of a clear explanation on how it makes decisions. Large language models present significant challenges, not least the inexplicable errors and inconsistencies dubbed "AI hallucinations." Biased models will become biased metaverse content, amplifying existing inequalities and discrimination while reinforcing a lack of diversity and harmful stereotypes (for example, by providing representations of "beauty" tied only to certain, limited parameters including skin colour or age), and erasing cultural context. The "echo-chambers" that already exist in social media could become even more harmful in immersive environments; the potential long-term effects on human cognition are as yet unknown. In addition, new devices to interface with the metaverse may rely on neurotechnology in ways that raise questions about human agency and identity.

— *Industries and the public sector within the Metaverse* focus on the transformative potential of virtual environments for industrial production, entrepreneurship, and public governance. It covers the reconfiguration of supply chains, digital twins, and innovation ecosystems, examining the role of the metaverse in reshaping manufacturing, disinformation management, and capital markets. This domain also addresses the challenges of integrating traditional industries with digital infrastructure to enhance productivity and governance efficiency. In much the same way that the internet and mobile computing have in the past, metaverse technologies are now beginning to affect just about every industry imaginable. The dimensions of this impact have spread beyond gaming and entertainment, and begun to transform enterprise verticals like manufacturing, healthcare, automotive, aerospace, tourism, training and education, architecture, and real estate. The opportunities within each range from creative and design, to collaboration, to maintenance and customer support. Some of the most interesting applications of metaverse technology concern the public sector; governments worldwide are exploring its potential to bolster virtual collaboration, diplomatic engagement, and policy simulations. As the metaverse evolves, its relevance to shaping the future of governance and international relations becomes increasingly apparent. For example, the United Arab Emirates' Ministry of Economy has established what it has called a "third address" located in the metaverse to provide an immersive experience at its virtual headquarters — and, while hailing the metaverse as a great leveller, the island nation of Barbados announced plans to establish a new, virtual embassy there.

Meanwhile, industries such as education, gaming, retail, fashion, and entertainment have all started to refine their approach to the metaverse. The pharmaceutical firm Novartis, for example, has trained employees on labelling using the technology, while US retailer Walmart has used it for

customer service training. For fashion retailers, "virtual dressing rooms" have enabled customers to see themselves in items from different angles and in different environments — revamping the online shopping experience while addressing sizing challenges. The manufacturing, healthcare, financial services, and tourism industries have also developed metaverse applications. The large US bank JPMorgan Chase and Co. opened a lounge in the "Decentraland" virtual world in 2022, while BMW and other carmakers are using augmented reality (AR) to accelerate design and prototyping. In 2020, orthopaedic surgery was performed using AR via the Microsoft HoloLens, enabling the surgeon to view necessary images and records without stepping away from the operating table. The technology also served a tourism purpose during the pandemic; the Dubai World Expo 2020 drew a larger number of virtual attendees than in-person visitors.

— *The Metaverse's social and economic impacts* domain evaluates the intersection of virtual technologies with mental health, social equity, and economic transformation. It considers the psychological and sociological implications of prolonged virtual engagement, global governance structures, and ethical concerns related to inequality, disinformation, and mental well-being. The focus is on ensuring that digital ecosystems foster social inclusion, mental health resilience, and sustainable development. As a virtual ecosystem enabling users to interact with each other and the world in new and innovative ways, the metaverse has the potential to impact social stability and revolutionize economic growth. Its social impact can already be seen in the ways it fosters connections and collaboration across geographical and cultural boundaries, while its economic impact may yet manifest in the creation of new markets and industries. However, the metaverse also raises concerns about privacy, security, and social inequality. Connection and collaboration are key benefits related to social interaction; the technology creates a shared virtual space, where people can communicate and cooperate in ways previously impossible. For example, the metaverse can be used to create virtual classrooms, conferences, and events — enabling people to learn, work, and socialize in a shared space. It also provides opportunities for health and well-being, such as relaxation spaces, virtual therapies, artificial intelligence-assisted counselling, and real-time biometric feedback therapies. New related markets and industries will prove to be key benefits for broader economic growth — opportunities for commerce and entrepreneurship abound, as users spend more time and money in virtual spaces.

Examples of these metaverse-based opportunities include the creation of virtual real estate, and digital goods and services that enable users to buy, sell, and trade virtual assets and experiences. Key social and economic development-related challenges relate to privacy, security, manipulation, and social inequality; the metaverse creates new risks for personal data, not to mention virtual assets and social cohesion, as users share more information and resources in virtual spaces. Criminal activity is a possibility — it could be used for money laundering or cyberattacks, as well as for impersonation or the perpetuation of harmful social discrimination. In addition, potential addiction and other cyber-psychological effects on users need to be addressed. The metaverse is a complex and exciting ecosystem with the potential to change the world. To ensure that it is developed in a way that maximizes benefits and minimizes risks, it is crucial to develop a research agenda that focuses on its social and economic impact. This agenda should include studies on the privacy, security, and psychological implications of the technology, its potential impact on social inequality, and it possible benefits for social interaction, economic growth, and general well-being.

— *Metaverse governance* encompasses frameworks and principles essential for maintaining order, fairness, and accountability within virtual spaces. This domain examines global governance, agile regulatory mechanisms, and ethical standards required to manage justice, law, and illicit activities. It underscores the need for adaptive governance systems capable of responding to the complexities and disruptions inherent in decentralized digital environments. Effective governance structures and mechanisms for the metaverse are needed now, in order to help ensure a more responsible, safe, equitable, inclusive, and interoperable future spread of the technology. The governance being applied should take into full account the specific challenges related to operating virtual economies and creating (and occasionally losing) value there, to adequate rights and protections for its users, and to evenly bal-

anced regulatory frameworks that are satisfactory to all of the relevant stakeholders. Protecting the rights of users will inevitably involve issues related to privacy, data protection, safeguards against manipulative and negatively persuasive content, support for health and wellness, adequate levels of content moderation, proper identity verification to prevent fraud and future harm, and guarantees against fraudulent transactions.

The regulatory frameworks for the metaverse need to balance user freedom with protection from illicit and harmful activity — particularly as it relates to children. True value creation in virtual economies requires mechanisms to enable investment with accountability — where competition creates better experiences and pricing for users while spurring a broad ecosystem where businesses, startups, and creators cannot just participate but flourish. Some potential governance frameworks include decentralized models, cross-sector collaboration, transparency in reporting, ethical guidelines and auditing, sustainable practices and policies, workforce rights for health and safety, and user-centric design and feedback. Technical standards are also crucial, to ensure interoperability and security. It's additionally important to consider the tradeoffs in governing the metaverse, as prioritizing some stakeholders' preferences may come at a cost to others.

— *Infrastructure and the Metaverse* address the foundational technological systems supporting the seamless operation of virtual environments. This domain includes the digital economy, AI integration, cybersecurity, and communication networks essential for maintaining resilient and scalable virtual infrastructure. It explores the symbiotic relationship between physical and virtual infrastructure, emphasizing the importance of energy transition, blockchain, and advanced computing technologies in sustaining the Metaverse's growth. With each major evolution in computing, there has been a corresponding leap in technological infrastructure. The initial adoption of telecommunications, for example, necessitated the creation of a new user interface device — the telephone — and extensive supporting networks. Later, modern computers changed how we interface with information and one another from a distance, and birthed many companies that supported the evolution of computers from behemoths to small personal computers and laptops perched on desktops. Now, the metaverse and spatial computing are in a similarly foundational phase. Some related technologies, such as Web 3, blockchain, and cryptocurrencies, have had ups and downs in terms of public perception; as demonstrated by overinvestment in fibre optic cable infrastructure in the US in the 2000s (much of it went unused for decades), it is challenging to determine which technologies will be worthy of extensive time and resources at an initial stage. However, it is clear that new consumer devices for interfacing with the metaverse will be necessary, alongside related chips and sufficient backend infrastructure.

As time passes, the ways in which users want to transact — be it through blockchain, or fiat currency, Web 3 or Web 2 experiences, or across different levels of bandwidth — will become clearer. Both startups and large companies continue to invest heavily in related infrastructure. Apple's 2024 launch of the Vision Pro headset, enabled by the custom M2 chip, was a key moment for that company's entry into the space. The metaverse is not evolving in isolation; it is increasingly intersecting with other, high-growth sectors like artificial intelligence. The chipmaker NVIDIA's stock has hit all-time highs that underscore this synergy and the demand generated by both the metaverse and AI (Sam Altman, the CEO of OpenAI, said during a 2023 interview that the metaverse will be a major convergence point for users to interface with AI). The continued growth of the metaverse indicates that foundational technologies like consumer hardware, chips, and enabling software are not only important pillars, but also fertile ground for the emergence of entirely new, trillion-dollar companies.

— *Metaverse access and equity* emphasize inclusivity, sustainability, and the mitigation of systemic biases within virtual ecosystems. This domain explores issues of digital communications, virtual and augmented reality, and equitable access to Metaverse resources. The focus lies on addressing systemic racism, inequality, and human rights within digital environments, ensuring that the Metaverse promotes ethical, inclusive, and sustainable development on a global scale. The metaverse presents a significant opportunity for progress and greater prosperity, so it is imperative that access is recognized as a fundamental human right. This calls for a concerted effort to include more diverse voices in shaping its future, to ex-

pand participation generally, and to have global conversations about its governance and standards. This will enhance the metaverse experience, by ensuring that it evolves to satisfy a wider range of perspectives and needs. Core to this inclusive vision is investment in critical infrastructure, to support the metaverse's growth and accessibility, ideally creating a universal access situation where device distribution is not restricted by geography. This will require prioritizing the development of affordable metaverse technology, and making it available regardless of socioeconomic status. Generally expanding internet connectivity is key, particularly in under-served regions, to enable truly global metaverse participation. There is also a need to invest in scalable, distributed computing solutions — which could support the metaverse's expansion in ways that ensure everyone can enjoy real-time, seamless experiences free of technical lags.

The commitment to sustainable development within this digital domain is also important. This will mean channelling resources to data centres powered by sustainable energy sources, aligning the growth of the metaverse with proper environmental stewardship. The potential benefits of metaverse technologies run the gamut of the UN's Sustainable Development Goals; in order to achieve them, we must do away with the status quo and embrace a transformative approach that discards harmful ways of engaging with (and developing) any new technology. This is a multi-stakeholder endeavour, where cooperation will be necessary among governments, private sector professionals, civil society groups, academia, international organizations, industries, and users — in order to forge a way forward. It will require convening at national and global levels, and making an unprecedented commitment to implementation. In that way, we can potentially foster a metaverse that is not only technologically advanced and engaging, but also socially responsible and accessible to everyone. This approach could lay the foundation for a metaverse that both drives global prosperity and ensures equitable participation in an increasingly digital era.

— *The future of work in the Metaverse* investigates how immersive digital technologies are redefining labor markets, education, and organizational dynamics. This domain examines cybersecurity, corporate governance, and advanced manufacturing processes within virtual environments. It highlights the implications for workforce dynamics, remote collaboration, and skill development in a hyper-digitalized economy, underscoring the importance of resilience, adaptability, and human rights in the evolving landscape of work. The metaverse heralds a new direction for the future of work, in ways that promise to interweave advanced digital constructs with profound societal shifts. The technology has triggered a reimagining of learning paradigms, as classrooms are potentially transformed into immersive spaces where students from around the world can participate in shared, enriched experiences enhanced by virtual and augmented reality — potentially democratizing access to valuable STEM (science and technology)-based curricula and other practical tools. Both virtual classrooms and other immersive learning experiences facilitated by augmented and virtual reality have the potential to transform pedagogical approaches, in ways that make education more accessible and engaging. Traditional, related business models are being reimagined, as companies integrate virtual spaces, digital assets, and metaversal strategies into their operational frameworks. As the metaverse gains traction, it has the potential to catalyse the emergence of entirely new industries, professions, and economic models.

The nascent development of everything from virtual real estate to digital asset management has created potential avenues for job creation and new wealth generation that are vast and varied. Some of the novel industry positions and job roles being fashioned in the metaverse include virtual asset managers and digital architects, carving increasingly unique paths to professional development, economic contributions and greater diversification. The metaverse embodies the essence of the Fourth Industrial Revolution, which has been underpinned by the convergence of physical, digital, and biological realms. Augmented and virtual reality technologies, in tandem with artificial intelligence and the Internet of Things, are pivotal. As they move beyond gaming and entertainment, AR and VR have become handy for professional training, design, and general collaboration. On the precipice of what will likely turn out to be a transformative era, a fuller understanding the multifaceted impact of the metaverse on work, education, and manufacturing is crucial for businesses and people everywhere.

Strategic management tools in the concept of Web 3.0 metaverse ecosystems

Table 2 systematizes the toolkit for strategic management within the Web 3.0 metaverse concept across seven areas of the conceptual framework.

The emergence of metaverse ecosystems is intrinsically dependent on the confluence of advanced semiconductor technology and decentralized financial architectures. Companies like Nvidia are pioneering the fabrication of specialized GPUs and silicon architectures capable of rendering hyper-realistic, high-resolution 3D environments essential for immersive virtual economies. Concurrently, sophisticated peripherals, such as motion-tracking controllers and haptic feedback headsets, facilitate seamless user interaction, creating the experiential fidelity necessary for metaverse adoption [21]. At the core of the metaverse's economic infrastructure lies the proliferation of cryptocurrencies and blockchain protocols, which establish a trustless, decentralized mechanism for asset tokenization, cross-platform value exchange, and smart contract-driven governance. These distributed ledgers ensure immutability, scarcity verification, and user sovereignty over digital assets, which are indispensable for maintaining liquidity, market stability, and transactional efficiency in this emerging hybrid economy [21].

Market valuation of Web 3.0 metaverse ecosystems: Ball Metaverse Index

The major players in the Web 3.0 market are [25]:

- Companies developing the infrastructure required for metaverse ecosystems, such as Cloudflare and Nvidia.
- Game engines responsible for creating virtual worlds, including Unity and Roblox.
- Pioneers in content, commerce, and social services for metaverse ecosystems, such as Tencent, Sea, and Snap.

The top 10 companies in the metaverse market as of 20.08.2024 are summarized in *Table 3*.

The metaverse, an emergent socio-digital construct, is predicated upon robust computational infrastructures and decentralized economic paradigms. Nvidia's advancements in high-performance GPUs and proprietary virtual-world design software serve as linchpins for rendering hyper-realistic 3D environments, while auxiliary hardware — such as motion-tracking controllers and immersive headsets — facilitates real-time, kinesthetic interactivity [21]. Concurrently, cryptocurrencies and blockchain technologies constitute the metaverse's financial substrate, enabling frictionless peer-to-peer transactions and immutable asset verification within decentralized autonomous economies [21]. The Ball Metaverse Index operationalizes a taxonomical framework for categorizing firms contributing to the metaverse's techno-economic scaffolding, encompassing computational power provision, high-bandwidth networking, virtual platform development, interoperability protocols, digital payment infrastructures, and identity-linked asset management [25]. This confluence of advanced hardware, cryptographic economic systems, and standardized interchange protocols undergirds the metaverse's scalability, fostering an intricate ecosystem that amalgamates digital and physical economic modalities.

The rapid proliferation of Web 3.0 metaverse ecosystems has catalyzed an exponential increase in user adoption, now exceeding 50,000 lifetime participants, with active wallets serving as key performance indicators for engagement and economic activity [1]. This represents a tenfold increase since the early stages of 2020, underscoring a trajectory of accelerated digital asset penetration and decentralized user participation [1]. Despite its nascency compared to entrenched Web 2.0 platforms, the metaverse's growth trajectory reflects the maturation of decentralized finance (DeFi) frameworks, smart contract interoperability, and tokenized asset ownership models [1]. If the current adoption velocity persists, these metaverse ecosystems may evolve into economically dominant spheres, reshaping digital commerce and network economies through user-centric, decentralized governance [1].

The metaverse, characterized by decentralized virtual economies and the convergence of digital and physical realms, represents an evolving frontier of economic potential. ARK Research projects that revenues derived from virtual worlds, including platform infrastructure and content layers, could surge to $ 400 billion by 2025, reflecting expansive growth in immersive digital experiences [25]. Concurrently, Bloomberg Intelligence forecasts a market opportunity reaching $ 800 billion by 2024, driven by the proliferation of

Table 2

Toolkit for strategic management of digital potential in the concept of Web 3.0 metaverse ecosystems by seven areas of the conceptual framework

Conceptual Framework Area	Tools and Technologies of Web 3.0 Metaverse Ecosystems
AI and the Metaverse [18]	Arts and Culture Media, Entertainment and Sport Blockchain Financial and Monetary Systems Internet Governance The Digital Transformation of Business The Digital Economy Infrastructure
Industries and the Public Sector in the Metaverse [20]	Innovation Entrepreneurship Disinformation Banking and Capital Markets Future of Consumption Retail, Consumer Goods and Lifestyle Data Policy Fourth Industrial Revolution
The Metaverse's Social and Economic Impacts [21]	Mental Health Global Governance Agile Governance Leadership Illicit Economy Values Justice and Law
Metaverse Governance [22]	Health and Healthcare Pandemic Preparedness and Response Advanced Manufacturing and Production Education Human Rights Inequality Systemic Racism
Infrastructure and the Metaverse [23]	Artificial Intelligence Digital Communications Virtual and Augmented Reality Energy Transition Sustainable Development Corporate Governance Cybersecurity Future of Work Future of Computing Behavioural Sciences
Metaverse Access and Equity [24]	Artificial Intelligence Digital Communications Virtual and Augmented Reality Energy Transition Sustainable Development Systemic Racism Inequality Human Rights
Future of Work in the Metaverse	Education Cybersecurity Corporate Governance Future of Work Health and Healthcare Pandemic Preparedness and Response Advanced Manufacturing and Production Justice and Law

Source: Developed by the authors based on [18, 20–24].

Table 3
Top 10 companies in the metaverse market as of 20.08.2024

Name	Ticker	Weight
ROBLOX Corp	RBLX	9.02%
Apple Inc	AAPL	8.51%
Meta Platforms Inc	META	5.69%
CI Galaxy Ethereum ETF	ETHX/U CN	5.01%
NVIDIA Corp	NVDA	4.38%
Unity Software Inc	U	4.07%
Sony Group Corp	6758 JP	3.97%
Microsoft Corp	MSFT	3.35%
Nintendo Co Ltd	7974 JP	3.34%
Alphabet Inc	GOOGL	2.91%

Source: Roundhill Investments. METV: The Metaverse ETF. URL: https://www.roundhillinvestments.com/etf/metv/ (accessed on 21.08.2024).

virtual commerce, social interactions, and decentralized assets, though excluding categories such as hardware, networking, compute, and payment systems [25]. Despite these optimistic projections, recent valuations show the metaverse market cap at a mere $ 7.21 billion as of August 21, 2024, exhibiting a volatile 2.1% fluctuation within a 24-hour period [26]. This disparity underscores the speculative nature of metaverse investments, shaped by evolving adoption rates, regulatory frameworks, and technological scalability.

Web 3.0 metaverse ecosystems represent a paradigmatic shift in digital economies, creating decentralized, crypto-driven virtual worlds where value generation transcends traditional online boundaries. These ecosystems leverage blockchain-based tokenomics, smart contracts, and non-fungible tokens (NFTs) to enable disintermediated transactions and transparent asset ownership, fostering free-market capitalism beyond the constraints of centralized Web 2.0 platforms. The sale of virtual assets — including land, digital commodities, and services — has surpassed $ 200 million, underpinned by dynamic primary and secondary markets that empower developers, third-party creators, and users alike [1]. By dismantling capital controls and introducing immutable, trustless systems, these crypto-virtual environments catalyze rapid innovation, productive efficiency, and new modalities of e-commerce. This convergence of digital assets and decentralized finance (DeFi) augments the metaverse's economic architecture, promoting the seamless integration of commercial activities such as NFT art exhibitions, virtual corporate collaboration, play-to-earn gaming, and programmatic advertising, thus redefining the contours of digital economic sovereignty [1].

The emergence of metaverse ecosystems, driven by the convergence of decentralized Web 3.0 principles and immersive virtual environments, presents a transformative potential for global economic paradigms by reshaping labor markets, vocational training, and industrial manufacturing processes [3, 21]. Virtualized economies facilitate decentralized value creation through blockchain-enabled ownership models, empowering users to monetize digital assets and participate in play-to-earn frameworks, thus broadening income-generation avenues beyond traditional economic constraints [21]. Concurrently, industries such as healthcare and education are poised to benefit from scalable virtual training modules and telepresence solutions, mitigating geographical and socio-economic disparities. In manufacturing, digital twins and AI-driven collaboration tools optimize the lifecycle of product development and smart factory operations, enhancing productivity and reducing costs [3]. Despite these advancements, concerns surrounding the psychosocial impacts of prolonged virtual immersion, includ-

ing potential exacerbation of anomie, cognitive fatigue, and circadian disruption, necessitate a critical evaluation of the metaverse's implications on socio-economic well-being [21].

Conclusions and policy implications

In the course of the study, through the systematization of various interpretations of the concept of the "metaverse ecosystem" and the identification of key characteristics, the authors' vision of metaverse ecosystems as part of the cybermodality of the Industry 5.0 ecosystem was formed. The metaverse, as a version 2.0 of the traditional ecosystem, with a significant increase in the degree of immersiveness and integration of actors, will bring new values and become more human-centered [27]. A conceptual framework for Web 3.0 metaverse ecosystems has been proposed, focusing on six key areas, within which a toolkit for the strategic management of the digital potential of complex systems has been systematized.

REFERENCES

1. Grider D., Maximo M. The Metaverse: Web 3.0 virtual cloud economies. *Grayscale Research.* 2021;1:18. URL: https://digitalcapitalmanagement.com.au/wp-content/uploads/2022/02/Grayscale_Metaverse_Report_Nov2021.pdf (assessed on 10.12.2024)
2. Wang Y., et al. A survey on metaverse: Fundamentals, security, and privacy. *IEEE Communications Surveys and Tutorials*. 2022;25(1);319–352. URL: https://doi.org/10.1109/COMST.2022.3202047
3. Wang H., et al. A survey on the metaverse: The state-of-the-art, technologies, applications, and challenges. *IEEE Internet of Things Journal*. 2023;10(16):14671–14688. URL: http://doi.org/10.1109/JIOT.2023.3278329
4. Shkarupeta E.V., Kolesnikova V.B., Belyantseva O.M. The Metaverse as a Spatial Digital Twin in Industry 5.0. In: Ecosystems in the Digital Economy: Drivers of Sustainable Development. St. Petersburg: *Polytech-Press*; 2021:96–116. URL: http://doi.org/10.18720/IEP/2021.4/5
5. Ma C. Metaverse and machine readable standards: Basic concepts, key technologies, and application scenarios. *Metaverse*. 2024;5(2):2756. URL: https://doi.org/10.54517/m.v5i2.2756
6. Shkarupeta E.V., Dudareva O.V., Mosienko A.V. Metasystems as New Objects of Industry 5.0. *Digital and Sectoral Economy*. 2021;4(25):6–11.
7. Shkarupeta E.V. The Concept of Web 3.0 Metaverses in Strategic Management of Digital Potential: Theory, Tools, and Practical Applications. In: Digital Economy and Industry 5.0: Development in the New Reality. St. Petersburg: *Polytech-Press*; 2022:10–31. URL: https://doi.org/10.18720/iep/2022.3/1
8. Shkarupeta E.V. Web 3.0: Evolution and Practical Applications of Decentralized Management of Industrial Systems' Digital Potential. *Digital and Sectoral Economy*. 2022;3–4(28):106–114
9. Murray A., Kim D., Combs J. The Promise of a Decentralized Internet: What is Web3 and How Can Firms Prepare? *Business Horizons*. 2023;66(2):191–202. URL: https://doi.org/10.1016/j.bushor.2022.06.002
10. Piccarozzi M., et al. Roadmap to Industry 5.0: Enabling Technologies, Challenges, and Opportunities Towards a Holistic Definition in Management Studies. *Technological Forecasting and Social Change*. 2024; 205:123467. URL: https://doi.org/10.1016/j.techfore.2024.123467
11. Dwivedi Y.K., et al. Metaverse Beyond the Hype: Multidisciplinary Perspectives on Emerging Challenges, Opportunities, and Agenda for Research, Practice and Policy. *International Journal of Information Management*. 2022;66:102542. URL: https://doi.org/10.1016/j.ijinfomgt.2022.102542
12. Filipova I.A. Creating the Metaverse: Implications for Economy, Society, and Law. *Journal of Digital Technologies and Law*. 2023;1(1):7–32. URL: https://doi.org/10.21202/jdtl.2023.1
13. Wang F.Y., et al. Metasocieties in Metaverse: Metaeconomics and Metamanagement for Metaenterprises and Metacities. *IEEE Transactions on Computational Social Systems*. 2022;9(1):2–7. URL: http://doi.org/10.1109/TCSS.2022.3145165
14. Huynh-The T., et al. Blockchain for the metaverse: A Review. *Future Generation Computer Systems*. 2023;143:401–419. URL: https://doi.org/10.1016/j.future.2023.02.008
15. Mozumder M.A.I., et al. Overview: Technology Roadmap of the Future Trend of Metaverse based on IoT, Blockchain, AI Technique, and Medical Domain Metaverse Activity. In: *2022 24th International Conference on Advanced Communication Technology (ICACT)*. IEEE, 2022:256–261. URL: http://doi.org/10.23919/ICACT53585.2022.9728808

16. Alabina T. A., Dzangieva K. S., Yushkovskaya A. A. The Metaverse as a Global Economic Trend. *Ekonomika Professiya Biznes*. 2022;1:5–12. URL: http://doi.org/10.14258/epb202201
17. Abramov V. I., Melnik A. D. Metaverses: Prospects and Opportunities for Business. *Management in Social and Economic Systems*. 2022;4(170):19–25. URL: http://doi.org/10.24158/tipor.2022.4.2
18. Ruiu P, et al. Metaverse and Human Digital Twin: Digital Identity, Biometrics, and Privacy in the Future Virtual Worlds. Multimodal Technologies and Interaction. 2024;8(6):48. URL: https://doi.org/10.3390/mti8060048
19. Stephenson N. Snow Crash: A Novel. Spectra, 2003.
20. Martínez-Gutiérrez A., et al. Towards industry 5.0 through metaverse. *Robotics and Computer-Integrated Manufacturing*. 2024;89:102764. URL: https://doi.org/10.1016/j.rcim.2024.102764
21. Mystakidis S. Metaverse. Encyclopedia. 2022;2(1):486–497. URL: https://doi.org/10.3390/encyclopedia2010031
22. Narin N. G. A content analysis of the metaverse articles. *Journal of Metaverse*. 2021;1(1):17–24. URL: https://dergipark.org.tr/en/download/article-file/2167699 (assessed on 10.12.2024)
23. Park S. M., Kim Y. G. A metaverse: Taxonomy, components, applications, and open challenges. *IEEE Access*. 2022;10:4209–4251. URL: http://doi.org/10.1109/ACCESS.2021.3140175
24. Ng D. T.K. What is the metaverse? Definitions, technologies and the community of inquiry. *Australasian Journal of Educational Technology*. 2022;38(4):190–205. URL: https://doi.org/10.14742/ajet.7945
25. Riva G., Wiederhold B. K. What the metaverse is (really) and why we need to know about it. *Cyberpsychology, behavior, and social networking*. 2022;25(6):355–359. URL: https://doi.org/10.1089/cyber.2022.0124
26. Say S., Dogan M. Relationship between metaverse cryptocurrencies (meta coins) and sustainability indices. *Journal of Business Economics and Finance*. 2023;12(4):142–149. URL: http://doi.org/10.17261/Pressacademia.2023.1841
27. Fedorov A. A., et al. Technology for Designing Neuro-Digital Ecosystems for Implementing the Industry 5.0 Concept. *Scientific and Technical Bulletin of St. Petersburg State Polytechnical University. Economic Sciences*. 2021;14(3):19–39. URL: https://doi.org/10.18721/JE.14302

ABOUT THE AUTHORS / ИНФОРМАЦИЯ ОБ АВТОРАХ

Yulia Vertakova — Doctor of Economics, Professor, Department of Marketing, Russian State Humanitarian University, Moscow, Russia
Юлия Вертакова — доктор экономических наук, профессор кафедры маркетинга, Российский государственный гуманитарный университет, Москва, Россия
https://orcid.org/0000-0002-1685-2625
Corresponding author:
vertakova7@yandex.ru

Elena Shkarupeta — Doctor of Economics, Professor, Department of Digital and Sectoral Economics, Voronezh State Technical University, Voronezh, Russia
Елена Шкарупета — доктор экономических наук, профессор кафедры цифровой и отраслевой экономики, Воронежский государственный технический университет, Воронеж, Россия
https://orcid.org/0000-0003-3644-4239
9056591561@mail.ru

Conflicts of Interest Statement: The authors have no conflicts of interest to declare.
The article was submitted on 22.11.2024; revised on 10.12.2024 and accepted for publication on 12.12.2024. The authors read and approved the final version of the manuscript.