



The metaverse as a technology for innovation and social impact: A Contribution from Actor-Network Theory

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Abstract

This research contributes to the understanding and analysis of the technological phenomenon of the metaverse, from the perspective of actor-network theory (ANT), through a mixed methodological approach (qualitative and quantitative information) supported by social network analysis. The results reveal the dynamics of the metaverse in terms of its origin, typologies, spokespersons, enrollments, controversies, obligatory steps, translations, interests, and relationships with the technological phenomenon. The discussion and conclusions of the research reveal the complexity of the metaverse's network dynamics as a technology for innovation and social impact, as it configures and integrates dynamic multi-user environments that define new dynamics of sociability, beyond dual devices and technologies.

Keywords

Metaverse; Actor-network; Socio-technical network; Technology; Social innovation.

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El metaverso como tecnología para la innovación y el impacto social: una contribución de la teoría del actor-red

Resumen

Esta investigación contribuye a la comprensión y el análisis del fenómeno tecnológico del metaverso, desde la perspectiva de la teoría de actor-red (TAR), mediante un enfoque metodológico mixto (información cualitativa y cuantitativa) con el apoyo del análisis de redes sociales. Los resultados revelan la dinámica del metaverso en cuanto a su origen, tipologías, voceros, enrolamientos, controversias, pasos obligatorios, traducciones, intereses y relaciones con el fenómeno tecnológico. La discusión y las conclusiones de la investigación revelan la complejidad de la dinámica de red del metaverso como tecnología para la innovación y el impacto social, ya que configura e integra entornos dinámicos multiusuario que definen nuevas dinámicas de sociabilidad, más allá de los dispositivos y las tecnologías duales.

Palabras clave

Metaverso; actor-red; red socio-técnica; tecnología; innovación social.

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1. Introduction

The metaverse is a technological phenomenon under construction, driven by technological homologation and isomorphism ([Ioannidis and Kontis 2023](#); [Sadin 2024](#); [Lnenicka, Rizun, Alexopoulos, Janssen, 2004](#)). It is complex and disruptive because it integrates and depends on other technological developments such as artificial intelligence, IoT, blockchain, augmented and extended reality, digital twins, haptic sensors, quantum internet, 5G, and Industry 4.0 ([Dionisio, Burns and Gilbert 2013](#), [Sadin 2017](#); [Ambrosio and Fidalgo 2020](#); [León 2023](#); [Dhaya, Adline, Kanthavel, 2025](#); [Papadopoulos 2025](#)).

The metaverse format is the construction and implementation of dynamic multi-user virtual environments, enabling sociability- experience, interaction, updating, and added value- based on the parallel dynamics and interrelation of the present and the virtual ([Hui 2019](#); [Duan et al., 2021](#); [Barrio 2023](#); [Gendler 2023](#); [Sadin 2023](#); [Bonini and Treré 2024](#)); the question regarding the technological phenomenon is that companies should not be the only spokespersons for the metaverse; on the contrary, transversal and universal, open-source innovations should be included, which mark the main lines of the evolution of the metaverse, where utility and applicability are prioritized in real user demands in terms of experience and training.

The research aims to analyze the Metaverse as a disruptive technology, based on the fact that the structure of consumption, sociability and social interaction are affected by the condition of the digital citizen and the design and implementation of digital devices or environments.

[Ioannidis and Kontis \(2023, p. 160\)](#) address the previous discussion, basing their argument on four historical epochs of the metaverse and the proposal of a future epoch:

- “Consolidation of the Concept (1905-2009). Introduction to the concepts of parallel worlds, virtual worlds, and the interconnection of the virtual world with the real world; through novels (The Modern Utopia, 1905; The Machine Stops, 1909; Pygmalion's Spectacles, 1913; Another Earth, 1976; Mirror Worlds, 1991; and the theory of Digital Twins, 2002), video games (Habitat, 1986), and films (Avatar, 2009). And the foundation for the development of artificial intelligence with the article "Computing Machinery and Intelligence" (1950), which proposes a test to distinguish a machine from a human”.
- “Metaverse models (1982-2011). Describing fully integrated metaverses with capabilities and benefits for users, through novels (Neuromancer in 1984 and Snow Crash 1992) and films (Tron 1982, The Matrix 1999 and Ready Player One 2011)”.
- “Experimentation and implementation with technology (1962 to date). First simulator called Sensorama (1962), launch of metaverse-oriented video games in 1993 (CitySpace, CyberTown, Worlds and Active Worlds), game (Habbo Hotel 2000), the first NFT (Quantum 2014), smart contracts (inventor Nick Szabo 1993), cryptocurrencies (Wei Dai 1998 and Bitcoin 2009) and blockchain networks (Satoshi Nakamoto 2008), advances in 5G speed (Industry 4.0 2011), creation of avatars (coined by game designer Richard Garriott 1980) for games and social interactions, launch of generative AI (ChatGPT in November 2022)”.
- “Metaverses as platforms (2003-2023). Cooperative/massive online games (Roblox-2006-); commercial and social (Second Life-2003-); digital spaces/terrains (Decentraland-2020-)”.
- “Metaverse as a prospective scenario (2023 onwards). Interoperability as a reality (fast and fluid navigation between metaverses by users), realistic avatars (capturing facial expressions and linked wallet), users will be able to use their money or NFTs on all platforms of the metaverse in a decentralized way”.

This latter period allows us to support the importance of the actor-network theoretical (ANT)¹ framework in this research, insofar as the heterogeneity, complexity and identity of the metaverse are not simply the

¹ Argued and explained by the authors Bruno Latour ([1992, 1996, 2001, 2005, 2022](#)), [Michel Callon \(1986\)](#) and [John Law \(2004: 2008\)](#)

product of links, but of: i) subnetworks with defined interests in historical sociotechnical processes²; ii) the recognition of the non-human as an actor (technology, machines or inanimate objects); and iii) each point of the network is of the metaverse, it is a contextualized network with consolidated interests³ and actants⁴.

The research question is defined as: How, in what manner, and in what ways do the multiple actants consolidate the metaverse network?

Theoretical reference - The Actor Network Theory -

In ANT, a "network" is a network of nodes with dimensions and connections, where each actor has a role. It is characterized by ([Prá and Antonello 2022](#); [Chinedu and Chinedu-Eze 2018](#); [Hanseth et al. 2004](#); [Rhodes 2009](#); [Latour 1996](#)): (i) interconnectedness independent of distance; (ii) the absence of predefined hierarchies established by actants; (iii) an actor can be immersed in different networks; and (iv) the reliability and stability of the network depends on the alignment of the interests of the actants within it.

ANT ([Krpmotic C. S. and Barone 2024](#)) proposes the creation of a map, identifying everything that leaves a trace or imprint. It analyzes what was not taken into account; it does not only address the crystallized problem; it reviews the process of social construction. The reconstruction of the sociotechnical network involves the analysis of the different messages that had different enrollments and negotiations.

[Castillo et al. \(2019, p. 8-9\)](#) describe the ANT position, citing [Latour \(2005\)](#), [Tirado \(2001, 2009\)](#), [Tirado and Doménech \(2005\)](#), and [Tirado et al. \(2014\)](#) regarding power, mediation, translation, composition, blackboxing, and delegation:

The actor-network perspective shares the consideration of power as a strategic process that is expressed in the relationships between diverse entities, both social and material. This is what [Latour \(2005\)](#) calls mediation. This notion refers to the possibility of mediation that entities acquire when they participate in certain frameworks. And playing the role of mediator is nothing other than being between, allowing the connection of other elements or entities ([Tirado, 2001](#); [Tirado and Doménech, 2005](#)). Such connection "generates a movement of force that transforms a given state of affairs" ([Tirado, 2009, p. 2](#)). Indeed, just like technology, power can be understood as "an act of mediating between other entities that persists in time and space" ([Tirado, Baleriola, Giordani, & Torrejón, 2014, p. 29](#)). The stability or fluctuation of a framework, or the production of its duration and scale, refers to a local production, emerging from one or more mediations, in which some agents formulate their programs of action, or the traces they expect other actants to produce; they establish links that modify or recreate the original interests (translation); they create new sets of actions (composition); they enclose or hide their complexities and links (blackboxing); or they inscribe their agency in another type of agent or materiality (delegation) ([Latour, 2005](#)). In this sense, the technical can be understood as a product of human and non-human articulations, the effect of negotiations and mediations between expert knowledge, contingent social processes, and material configurations that promote the relative stability of certain behaviors.

Research based on ANT ([Krpmotic C. S. and Barone 2024](#)) should not only involve interviews and discourse analysis, but should address: i) grey literature, minutes, and records of meetings or debates; and ii) questions regarding who takes agency?, who sends messages?, who is made invisible?, what were the negotiations?, and what is appropriate for the actants?.

The categories of analysis in actor-network theory are ([Krpmotic C. S. and Barone 2024](#)): i) the artifact (its

² "how, with what instruments, with what machinery, under what material, historical, anthropological conditions is it possible to produce objectivity" ([Latour, 2013, p. 5](#))..... "Under this theory, the social is not a stable matter that must be unraveled, but rather it remains in constant movement and re-assembly through connections between actors, devices and tools that only emerge when the controversies generated by the actors themselves on a given issue are followed, where it is the actors who create their world and generate arrangements so that a certain course of action prevails over others." ([Romero, 2014, p. 4](#))

³ Actors who produce knowledge to convince or establish their paradigm for a previously defined common goal or interest. According to [Latour \(1999\)](#), actors interact and support each other through collaborative learning about the ways in which each plays their role.

⁴ A neutral term for each element that infers in a network; entities not differentiated by being people or artifacts, objects, or any physical or intangible form that interacts within a collective.

description does not start with concepts, it is not labeled under any concept, any tag and it produces effects, examples water, land, border, technology, etc.); ii) the black box (stabilized, but generates controversies, example a law, product, which establishes a discourse or language or message); iii) Controversies (must be observed, endures over time and involves most of the actants); iv) Device (it is said that it works but it does not work, it does not fulfill what it is designed for, it generates more problems or unwanted situations and it continues to be applied or imposed, all actants know it and despite this they continue to implement it); v) clues (messages, concepts, elements that were emitted); vi) Obligatory steps (asking questions from the black box from different approaches); vii) translations (uses of language, patterns); viii) spokesperson (tries to change a concept in the black box, tries to put a concept in the black box).

[Eze et al. \(2014\)](#) and [Patiño \(2024\)](#) establish 4 phases of ANT with emphasis on Technologies or digital objects: i) registration, the actants develop a conception of the technology and its role. ([Faraj et al., 2004](#)); ii) translation, is the process in which the interests of the actants are exposed, who influence others to adopt the technology ([Callon, 1986](#)); iii) framing, consists of the transformation or improvement of the characteristics of the technology to be used ([Faraj et al., 2004](#)); and iv) stabilization, in which the technology is adopted by the actants and it cannot be modified ([Chinedu et al., 2018](#)), and in case of any adjustment, the process must be started from scratch, that is, placed in the translation phase.

Therefore, translation processes in science and technology consist of four stages ([Latour 1995](#); [Callon 1995](#)): i) problematization - questioning roles among actants; ii) interest generation - calling on and linking other actants; iii) enrollment - rethinking roles and interests; and iv) mobilization - influential actants persuade in different contexts.

2. Methodology

The methodological approach of the research is mixed ([Patton 2002](#); [Chaves 2018](#)), explanatory-argumentative, where the following sources of information were appropriated: 1) Primary. *Interviews with experts from the Society, Internet and Culture Team (E-SIC) belonging to the Gino Germani Research Institute (IIGG) of the UBA; *questionnaire sent to metaverse experts on September 7, 2024⁵; *Conversation and debate based on participation with presentations that relate the concept of metaverse in the period of the postdoctoral stay⁶ and 2) Secondary: i) articles in specialized metaverse journals⁷; ii) Interviews and video-conferences on the Web related to the metaverse; and iii) websites, magazines, articles, theses, minutes, minutes, gray literature and projects related to the topic of the metaverse.

The methodological operationalization is defined by the following steps based on the actor-network theory:

- Origin and Correlation of the Metaverse. Establishes historical facts related to the object of study that have an impact on its origin and correlation.
- Spokespersons and Enrollments. Defines the actants involved in consolidating the discourse, adapting and implementing the concept in their activities or organizational or ideological profile.
- Controversies and Obligatory Steps. These involve the majority of actants in the consolidation of programs, projects, and public policies that involve the majority of actants.
- Translations. Establishes the most significant actants that generate discourse, dynamics, products,

⁵ Concept, actors, spokespersons, enrollments, controversies, mandatory steps and consideration/proposition

⁶ * National University of Rosario. Faculty of Political Science and International Relations. August 2 and 3, 2024; 12th Conference on Current Debates in Contemporary Political Theory - Current Situation. Between Realism and Imagination - Axis 7 - Algorithmic Becoming and Capitalist-Patriarchal-Colonial Assemblage -. Presentation: "Ethics and Algorithmic Transparency as an Exercise in Public Policy" *University of Buenos Aires. Faculty of Social Sciences. (August 20-23, 2024); UBA Political Science Conference. Focus: Administration and Public Policy. Presentation: "Public Policy Analysis from a Network Approach" *José C. Paz National University. (September 12-13, 2024). IV Conference on Democracy and Inequalities. GT No. 19: "Technology and Society: New and Old Challenges and Opportunities in the 4.0 Paradigm." Presentation: "Industry 4.0: A Basis for the Development of the Metaverse."

⁷ The scientific journal Journal of Metaverse (<https://dergipark.org.tr/en/pub/jmv>); the Asia-Pacific Academy of Sciences (APACSCI-<https://aber.apacsci.com/>) with Metaverse magazine (<https://aber.apacsci.com/index.php/met/about/editorialPolicies#focusAndScope>) and independent publisher Mary Ann Liebert, Inc. (<https://www.liebertpub.com/action/doSearch?AllField=metaverse>).

agency, and discussion related to the concept, based on the criteria of capacity, resources, governance, leading organizations, innovation-users, alliances, and digital technologies.

- Interests / relationships. It is defined by the levels of consolidation in a network, since in the process of building networks there are different levels that consolidate human and social capital ([Teja et al. 2014, p. 18](#)): i) Recognizing that the other exists, generating a type of relationship based on Acceptance -A-; ii) Knowing what the other is or does, qualifying the relationship of Interest -I-; iii) Providing sporadic help as a principle of collaboration with the intention of Reciprocity -R-; iv) Cooperating in response to agreements to share activities or resources as a step of Solidarity -S-; and v) Partnering to build and validate Trust -C-, based on objectives and projects defined in the short, medium, and long term.
- Relationships between actants and Rhizomes of the metaverse as an actor-network. Based on the information and analysis of the origin, spokespersons, enrollments, mandatory steps, controversies, translations and interests of the metaverse, the actants (companies, governments, organizations, spokespersons, metaverses, metaverse technologies, correlational technologies, enrollments, translations, controversies and mandatory steps) are organized in a mode 2 matrix in an exploratory way, with the relationships between actants, where the existence of a link will be represented by one (1) and the non-existence of a link by Zero (0). The computational tool Ucinet 6.0 will subsequently be used to establish graphs ([Ortiz and Espinosa, 2023](#); [Wasserman and Faust, 2013](#); [Velázquez et al., 2005](#); [Quiroga, 2003](#)), in order to visualize the relational dynamics of the actants according to the juxtaposed subnetworks.

3. Results

3.1. Origin and Correlation of the Metaverse

The metaverse is not a technological innovation of the century XXI; its origins are linked to science fiction and the simulation of real environments with technologies. Both share the principle of appropriating a three-dimensional digital world (a shared virtual reality (VR) experience) that allows us to interact in real time with sensory and co-creation guarantees ([Lnenicka et al., 2024](#); [Vargas, 2024](#); [Papadopoulos, 2025](#)).

The first is very generally referenced from the science fiction novel "Snow Crash" (1992) by the writer Neal Town Stephenson ([Ball, 2021](#); [Acevedo, 2022](#); [Montes, 2023](#); [Ramallal et al., 2022](#); [Villarreal, 2022](#); [Galíndez, 2024](#); [Neves and Bacalhau, 2024](#)), which proposes a context given by an internet called the metaverse, which operates as a persistent virtual world shared by the richest 1% of the world's population; where it is accessed through digital avatars as an escape from the harsh reality of the 21st century: i) hyperinflation; ii) reduction of government; iii) recognition of the sovereignty of private companies and communities; and iv) territories made up of business franchises or private residential neighborhoods that function as micro-states (with their own laws, regulations, and security).

And the second, shows a: i) Pre-metaverse, applied process of a simulation environment for training by the US Army, in 2018 "Synthetic Training Environment" ([León 2023, p. 105](#)); and ii) technology companies aim for interreality (the fusion between the virtual world and the physical world) what we do in the physical world influences the experience in the virtual world and vice versa ([Besnier, 2022](#); [Basdevant et al., 2022](#); [Fuenmayor, 2022](#); [López et al., 2022](#); [Llano, 2022](#); [Mystakidis, 2022](#); [Riva and Wiederhold, 2022](#); [Serec, 2022](#); [Sucari et al., 2022](#); [Crespo et al., 2023](#); [Medina, Almachi and Zumba, 2023](#); [Schöbel and Leimeister, 2023](#); [Ritterbusch and Teichmann, 2023](#)).

The metaverse is a process derived from the technological artifact, therefore, its genealogy and correlation validate the discussion of interoperability⁸ and interconnectivity⁹, which respond to a logic of parameterization and processing of information (data, datafication and algorithm) that depends on the semiconductor agent

⁸ "Standards, protocols, technologies, and mechanisms that enable the flow of data and communication and information in real time between different systems, with minimal human intervention."

⁹ "the ability to connect and transmit information between different systems, devices, and networks in a data center"

or microchips; which are typical of the development of microelectronics, which is linked to optics and photonics, which produces lasers and ultraviolet light sources (Company: Cymer), as an instrument in the production of optical elements (Company: ZEISS) for lithography equipment, which are those that allow rare earth materials to be processed¹⁰ (Companies: Applied Materials, Lam Research Corporation, KLA-Tencor, Tokyo Electron Limited, Advanced Semiconductor Materials Lithography) in the foundry of silicon wafers for semiconductors (Companies: Global foundries, Taiwan Semiconductor Manufacturing Company, Samsung, Semiconductor Manufacturing International Corporation and United Microelectronics Corporation).

The actant, semiconductor industry highlights Taiwan's monopoly in the global semiconductor market (60%), with Taiwan Semiconductor Manufacturing Company Limited (TSMC) supplying chips to companies such as Apple, Qualcomm, and Nvidia; followed by Samsung of Japan (16%) and Global Foundries of the United States (7%). TSMC has a supply alliance with the Dutch company ASML Holding NV regarding extreme ultraviolet radiation machines.

And the rare earths actant, evidences China's monopoly in: i) the production of rare earths in the world (60%); ii) the processing of 90% of the world's rare earths; and iii) the importation of rare earths, 98% of which comes from China, by the European Union between 2021 and 2024 ([Baskaran, 2024](#); [Vargas and Silvestris, 2024](#)).

3.2. Spokespersons, enrollments, mandatory steps, and controversies of the metaverse

The spokespersons, enrollments, mandatory steps, and controversies of the metaverse will respond to the correlation of ecosystems (Rare Earths, Microelectronics (semiconductors), Industry 4.0, Computer Science and Information Technology (Artificial Intelligence, Extended Reality), optics, and photonics (lasers and ultraviolet light sources for optical elements for lithography equipment) ([Table 1](#)).

Table 1.

Spokespeople, enrollments, mandatory steps and controversies of the metaverse

SPOKESMEN	ENROLLMENTS
Digital Platform Companies	Universities
Gaming Software and Venture Capital Companies	Governments
Technology and Social Media Companies	International Organizations
Technology, IT, and Consulting Companies	International Banks
OBLIGATORY STEPS	CONTROVERSIES
Technological Infrastructure	Interoperability
Digital Citizenship	Interconnectivity
Algorithm Design	Ethics and Algorithmic Transparency
Datafication	Algorithmic Bias and Discrimination
Technological Singularity and Convergence	Data Protection and Exploitation
Investment, Profitability, and Sustainability	Access, Equity, Universality
Data Opacity and Quality	State Regulation and Governance
Governance	Inclusion and the Digital Divide
Added Value and Differentiator	Psychological and Physical Changes

Note: Prepared by the authors 2025

¹⁰ "Vanadium: wind or solar generators such as in electric cars; Lithium: rechargeable batteries in the electric car industry; Cobalt: key to the operation of lithium batteries in electric vehicles; Tantalum: capacitors that store and distribute energy (devices such as cell phones or computers); Niobium: highly resistant to heat; used in engines, rockets, and combustion equipment; Indium: a conductive and transparent metal, essential in photovoltaic energy, found in all types of screens; Antimony: hardens lead in storage batteries; used in car and airplane furniture for its fireproof properties; Tungsten: X-ray tubes, television sets, cable filaments, switch contacts, and electric current. Germanium: used for a smaller and more precise wavelength in fiber optic networks, in infrared, in solar panels, CDs or DVDs, and lasers."

An essential step of the metaverse is the ability to generate added value and differentiate it from the black box of the internet in terms of sociability, content production, gamification, storage and distribution of information; and the central controversy of the metaverse is the psychological and physical changes due to the technology-human symbiosis (Mystakidis, 2022), regarding the combination of physical reality with virtual reality emulated by the technologies implemented and tested by Industry 4.0 (artificial intelligence, digital twins).

Footwear and sportswear companies (Nike, Vans, and Adidas) are very prominent in the metaverse, seeking to position their brands digitally; and neurotechnology companies (Neuralink, Neurable) are the key players setting expectations regarding the possibility of a perfect and stable human-technology symbiosis (brain-computer interface). Below, a brief description and purpose of the metaverse's enrollments are outlined (Table 2).

Table 2.

Metaverse enrollments

ENROLLMENTS
Universities
University of Tokyo (Japan) - to promote engineering education and studies among young people through a virtual replica of a virtual space without geographical borders.
University of Oxford (England) - virtual world called Oxford Virtual Learning Environment (OLE), students access learning resources and activities.
University of Buenos Aires (Argentina) - A video game-like metaverse is being established in the Innovation and Artificial Intelligence Laboratory of the UBA Law School - 2022
IE University (Segovia, Spain) - Creation of the Metaverse Center and opening of campuses in the Roblox and Decentraland metaverses - 2023
Hong Kong University of Science and Technology (HKUST) - Digital replicas of its campuses through a metaverse platform -
New York University - virtual world called NYU Island, students access lectures, workshops and other academic events from anywhere in the world-
Stanford University - a virtual world called the Virtual Human Interaction Lab (VHIL), where students experience and deepen human behavior and social interactions.
Manuela Beltran University - Colombia - Virtual classrooms where students connect with different devices (cell phone, computer, VR, and AR)
Taipei University (Taiwan) - National Taipei University of Technology, establishes Taiwan's R&D center to research the metaverse and AR
Government Initiatives (Kshetri et al 2024 (p. 2-3))
Finland - Developing Tampere as a metaverse city through an urban-social digital twin. 2023
South Korea - Project to create a virtual platform "Metaverse Seoul" for public procedures - 2022
Australia - New Wales City Explores Use of Virtual Reality for Healthcare Professional Learning and Training, and Extended Reality to Improve Transportation - 2023
United States - Augmented reality in Philadelphia to improve the public transportation experience for people with disabilities. And Use of the digital twin in cities such as Orlando, Las Vegas, and Boston to map everyday city dynamics. 2001
United Kingdom - Conversational AI and Extended Reality learning and assessment platform for healthcare professionals to integrate their workforce into the medical metaverse. 2022
Japan - Explores a metaverse-based educational support system using virtual reality and avatars to encourage children who don't want to go to school. 2023
Israel - the first Metaverse embassy in South Korea, a meeting room, and a setting for the history of international relations between Israel and South Korea. 2022

Continued on the next page

Government Initiatives (Kshetri et al 2024 (p. 2-3))

Norway - Tax Authority Virtual Offices on Decentraland Metaverse - Decentralized 3D Virtual Reality Platform - 2022

Egypt - The Ministry of Development uses the “3D Virtual Reality” metaverse to improve services and worker training. The General Audit Office of Healthcare promotes medical tourism through the metaverse. 2022

China - Citizens experience urban development and government services in the future 2025, through XiRang (China’s first metaverse platform) located in Shanghai’s Fengxian District.

Netherlands - Fectar platform teaches Ukrainian children to recognize landmines

United States Army since 2018 “Synthetic Training Environment”

Sportswear and Footwear Companies in the Metaverse

Vans - Interactive Sportswear Experience in the Roblox Metaverse -

Nike - Interactive Sportswear Experience in the Zepeto and Roblox Metaverses

Adidas - marketed in the Zepeto metaverse, the Sandbox and Second Life

International Banks

HSBC - The Sandbox, the bank’s virtual room in the metaverse

JP Morgan - Virtual bank room in the Decentraland metaverse -

International Organizations

INTERPOL - virtually enter the building with avatars, using virtual reality devices -

IDB-emerging technology laboratory (TechLab) and created the “Office in the Metaverse” to share information on projects, activities and host external visits to its virtual offices.

WB - The World Bank’s EdTech team, with support from the Digital Development Partnership (DDP), is promoting the use of the metaverse for workforce development through virtual and extended reality (XR) labs.

Note: Prepared by the authors 2025.

3.2.1. Metaverse Translations

Artificial intelligence and the metaverse define actants by their capabilities and resources, rather than by the structural logic of the market; these consolidate translations that develop bets on a geopolitical condition (Table 3), with approximately 18 companies (73% US, 11% China, 5% Japan, and 11% South Korea) consolidating approximately 22 metaverses, 19 artificial intelligences, 2 metaverse processes, and 3 artificial intelligence processes.

All the information detailed in the actor-network analysis process (Tables 1, 2, and 3) is used as a starting point, establishing the most significant metaverses based on the criteria of capacity, resources, governance, leading organizations, innovation-users, alliances, and digital technologies.

The geopolitical status of the US and Chinese actants is evident as drivers of the metaverse. The review of the information reveals 17 metaverses as significant actants, represented by 13 private actants with translations in virtual worlds with real-time interactive games and content creation experiences with sociability processes that apply different technologies or digital objects, based on artificial intelligence, virtual reality, and extended reality (Table 4).

The translations are demarcated by the discussion of a governance system given by standards of interoperability, inclusivity and open processes (Nvidia, Google, Meta, Epic Games and Microsoft)¹¹ and a governance system based on transparency, user control (identity, digital assets) and unrestricted data controlled by users and not by platforms (Animoca Brands, The Sandbox and Decentraland)¹².

¹¹ “Metaverse Standards Forum” (<https://metaverse-standards.org/>)

¹² Open Metaverse Alliance -OMA3- (<https://www.oma3.org/#blog>)

Table 3.
Translations Artificial Intelligence and Metaverse

Country	AI Translation	AI Name / Process	Company	Metaverse Name/Process	Metaverse Translation
EEUU	Solving real business problems	IBM Watson	IBM	UXart (IBM)	Art and urban intervention experiences with technology. Laboratory and museum of art and technology at the forefront of digital art.
	Multimodal system that interprets and generates audio, text, videos, and images. Chatbot assistant	Gemini	Google	Search Labs (Google)	Machine learning products and services; testing ground for new products with experimental technologies.
	Generating videos from Excel, Word, and image files for business purposes	Google Vids		Labs google (Google)	
	Answer questions, write texts and create images.	Copilot	Microsoft	Microsoft Mesh (Microsoft)	Dedicated to business, with the goal of developing personalized 2D and 3D immersive experiences for work offices, meetings, and virtual events for up to 200 people around the world.
	It is attached to WhatsApp, Instagram, Facebook and Messenger applications that answers questions, creates images and organizes content.	Meta AI	Meta Platforms Inc	Horizon Worlds (Meta Platforms Inc)	A shared virtual universe in real time with a social focus where users can create online content
	Text-to-speech tool that learns like ChatGPT	Voicebox			
	Improve key business functions and enhance customer experiences	NVIDIA AI Enterprise	Nvidia	Nvidia Ace (Nvidia)	Creating non-player digital humans that interact with generative AI
	Customize images using canvases containing nine styles that modify the appearance of a painting and twenty different materials	NVIDIA Canvas		Omniverso (Nvidia)	The virtual world as a tool for working and improving industrial processes.
	Business Workflow Automation	Amazon Q	Amazon	AmazonMetaWorld	Digital experiences where you access physical experience centers through a virtual avatar, to compete, accumulate points, win gifts and meet social media influencers.
	Processes data on the mobile device, not in the cloud; to strengthen privacy	Apple Intelligence	Apple	Exploring with the Space Computing Instrument	Vision Pro Spatial Computer - Using Cameras in the Environment and Human-Reality Interaction
	Natural language processing to generate coherent responses in written conversations	ChatGPT	Open AI	Venturing into AR hardware, in order to diversify its products and services	Integration of augmented reality with advanced AI
	Generative Artificial Intelligence to create custom three-dimensional objects	Roblox IA	Roblox Corporation	Roblox	Creation and design of massively multiplayer online games and user-generated virtual worlds; human co-experience for sharing immersive digital experiences.
	AI-powered immersive experiences, to create hyper-realistic and dynamically adaptive gaming environments, employing machine learning algorithms to eliminate repetitive gameplay	Gaming con IA	Epic Games	Fortnite	Cooperative online games for up to 4 people.
	Teach children and young people about the risks and opportunities of (AI)	CyberSafe AI: Dig Deeper (Ciberseguridad en la IA)	Mojang Studios -Microsoft-	Minecraft	Build, explore, and share virtual worlds with cross-platform compatibility. A one-time purchase is required.
	Partnering with Inworld to create NPCs (Non-Playable Characters), Inworld uses advanced artificial intelligence to create generative characters whose personalities, thoughts, memories, and behaviors are designed to mimic the deeply social nature of human interaction.	Alianza con la empresa Inworld IA	Decentraland Foundation	Decentraland	Open-source virtual environment where you can buy virtual land plots, sell virtual properties and assets, host events, and create personal metaverse spaces
	Blockchain	IA Generativa como asistente	Linden Lab	Second life	Communities and everyday activities, real-time information sharing, transactions and making money
Sansar				Attend or create real-time virtual events for relaxing experiences	

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Country	AI Translation	AI Name / Process	Company	Metaverse Name/Process	Metaverse Translation
JAPAN	Designed to compete against drivers in Gran Turismo Sport	GT Sophy	Sony	Sony Metaverse Lab	Under construction of immersive experiences
CHINA	Blockchain	IA Generativa como asistente	Animoca Brands	The Sandbox	Virtual and gaming world where users purchase digital land and monetize experiences within their digital plots.
	an AI chatbot that has a "high emotional quotient" that allows it to understand memes and satirical cartoons.	Ernie Bot	Baidu	Pixelynx	The musical metaverse with games, AI and web 3
	Collaborative optimization through multi-modality joint modeling, exhibiting comprehensive improvements in comprehension, generation, reasoning, and memory, along with notable improvements in hallucination prevention, logical reasoning, and coding skills	ERNIE 4.5		XiRan	Create shared virtual universes in real time. Users can create online experiences.
SOUTH KOREA	The ability to offer searches for users and provide marketing and shopping elements for advertisers, through generative AI	HyperClova	Naver Z -Google Coreano-	Zepeto	Avatar customization, item design and sharing; creation of virtual universes and real-time interaction.
	Translation, photo editing, and summary notes on the device	Galaxy AI	Samsung	Smart City	Virtual online players
				SAM House Tour	Virtual home simulation with Samsung products
				Island in Fortnite	A space in the metaverse in partnership with Epic Games

Note: Prepared by the authors 2025.

Table 4.
Translations in the metaverse

Technological Convergence in All Metaverses: *Virtual Reality and Extended Reality; *Artificial Intelligence for Information Processing			Translation	Specific Technology
Actantes significativos	Metaverso	Pais		
Roblox (Roblox Corporation)	Cooperative/Massively Online Games	EEUU	Creation and design of massively multiplayer online games and user-generated virtual worlds; human co-experience for sharing immersive digital experiences.	Blockchain
Fortnite (Epic Games)			Cooperative online games for up to 4 people	
Minecraft (Mojang Studios)			Build, explore, and share virtual worlds with cross-platform compatibility. A one-time purchase is required.	
Decentraland (Decentraland Foundation)	Acquisition of land and digital spaces for the personalized creation and monetization of experiences	Open-source virtual environment where you can buy virtual land plots, sell virtual properties and assets, host events, and create personal metaverse spaces.		
The Sandbox (Animoca Brands)	CHINA	Virtual and gaming world where users purchase digital land and monetize experiences within their digital plots.		
Pixelynx (Animoca Brands)		Music Industry	The musical metaverse with games, AI and web 3	
UXart (IBM)	Digital Art Laboratory and Museum	EEUU	Art and urban intervention experiences with technology. Laboratory and museum of art and technology at the forefront of digital art.	
Second life (Linden Lab)	Commercial and sociability	EEUU	Communities and everyday activities, real-time information sharing, transactions and making money	
Sansar (Linden Lab)			Attend or create real-time virtual events for relaxing experiences	
Horizon Worlds (Meta Platforms Inc)			A shared virtual universe in real time with a social focus where users can create online content.	
XiRang (Baidu)		CHINA	Create shared virtual universes in real time. Users can create online experiences.	Conversational robots
Zepeto (Naver Z)		SOUTH KOREA	Avatar customization, item design and sharing; creation of virtual universes and real-time interaction.	Social Network of Avatars

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Technological Convergence in All Metaverses: *Virtual Reality and Extended Reality; *Artificial Intelligence for Information Processing				
Actantes significativos	Metaverso	País	Translation	Specific Technology
Microsoft Mesh (Microsoft)	Immersive organizational work-meetings	EEUU	Dedicated to business, with the goal of developing personalized 2D and 3D immersive experiences for work offices, meetings, and virtual events for up to 200 people around the world.	3D via Microsoft Teams, meta-headsets, and real-body imaging scanning
Search Labs (Google)	Production and innovation in companies		Machine learning products and services; testing ground for new products with experimental technologies.	Generative AI
Labs google (Google)			Creating non-player digital humans that interact with generative AI	
Nvidia Ace (Nvidia)			The virtual world as a tool for working and improving industrial processes.	Digital Twins Advanced Robotics Cybersecurity 3D Manufacturing Big Data Cloud Computing Internet of Things (IoT)
Omniverso (Nvidia)				

Note: Own elaboration 2025 from [Basdevant and Ronfard, 2022](#); [Chen and Cheng, 2022](#); [Barrio, 2023](#); [Neves and Bacalhau, 2024](#); [Papadopoulos, 2025](#).

3.2.2 Interests / relationships

The mapping of approximately 17 metaverses¹³ in the world yields a range of approximately 35 actants¹⁴, which could be more if the developments implemented by the world's governments are included ([Table 3](#), regarding government initiatives, [Kshetri et al. 2024](#)). Their nature is as follows: i) banks (2); ii) athletic footwear companies (3); iii) microchip manufacturing and production (4); iv) microchip design and marketing (4); v) gaming software and venture capital companies (5); vi) technology, IT, and consulting companies (15); and vii) technology and social media (2).

A symmetric (nxn) matrix is constructed with the qualitative relationships among the 35 actants (including the 13 organizations that lead the 17 metaverses); the interests are determined by: i) 31% cooperation (they share activities and/or resources and/or projects); and ii) 8% provision (they contract for project design or development) ([Table 5](#)).

Table 5.

Existing Interests / relationships in the dynamics of the network metaverse.

	Total	%
Existing Relationship Type		
Cooperation (C)	368	31%
Provision (P)	92	8%
Total, Existing Relationships in the Network (C+P)	460	38%
Total Non-existent relationships in the network (TNR)	730	62%
Possible Relationships (RP) = Nx (N-1)= 35 x(34)	1190	100%

Note: Prepared by the authors 2025.

Subsequently, the 35 actants are combined with the 17 metaverses in a matrix ([Figure 2](#)), which consolidates 52 actants¹⁵; the actants' interests are determined by: i) 14% cooperation (they share activities and/or resources and/or projects); ii) 4% provision (they contract for project design or development); and iii) 3% contact (they exchange experiences) ([Table 6](#)).

¹³ [Annex - Table 7](#)

¹⁴ [Annex - Table 8](#)

¹⁵ [Annex - Figure 3](#)

Table 6.

Existing network Interests / relationships with metaverse actants

Existing Relationship Type		Total	%
	Cooperation (C)	368	14%
	Provision (P)	92	4%
	Contact (Ct)	76	3%
Total, Existing Relationships in the Network (C+P + Ct)		536	20%
Total Non-existent relationships in the network (TNR)		2116	80%
Possible Relationships (RP) = Nx (N-1)= 52 x(51)		2652	100%

Note: Prepared by the authors 2025.

3.2.3 Relationships between actants and rhizomes of the metaverse as an actor-network

The analysis of the origin, spokespersons, enrollments, mandatory steps, controversies, translations and interests of the metaverse, consolidates 204 actants (human and non-human actants), where the relationships are established by mode 2 matrices (rows: companies, governments, universities, countries, banks, international organizations, metaverse technologies - and columns: metaverses, correlation technologies, controversies, mandatory steps, translations). This matrix ratifies the dynamics of the actants according to the juxtaposed subnetworks:

- In the geopolitical condition, the concentration of the actants is the United States (20 relationships), China (11 relationships), and Taiwan (5 relationships).
- The correlation of the metaverse actant with the actants of artificial intelligence, virtual reality, and extended reality (21 relationships for each).
- The Google actant meets all three conditions within the spokesperson, translator, and enrollment metaverse (15 relationships).
- Spokesperson and translator actants are Meta Platforms Inc. (8 relationships); Nvidia, Microsoft, and IBM (11 relationships).
- Samsung - Spokesperson and Enrollment - (12 relationships).
- Apple as spokesperson (5 relationships) and Amazon as enrollment (11 relationships).
- Relevant artifacts are microelectronics and computer science and information technology (92 relationships).
- Black boxes - Semiconductors (89 relationships) and Industry 4.0 (18 relationships)
- The most representative spokesperson for Artificial Intelligence Development Companies (10 relationships)
- The most representative enrollments: Universities (8 relationships) and Government Initiatives (12 relationships)
- The most dynamic metaverse actants on the network: i) Roblox and Decentraland (11 relationships); ii) The Sandbox (10 relationships); and iii) Nvidia's industrial metaverses - Omniverse and Nvidia Ace (15 relationships)
- The difference between metaverses based on relationships: i) commercial-sociability (9); ii) cooperative/massive online video games (7); and iii) production and innovation metaverses in companies (8).

A metaverse approach is proposed as an actor-network ([Figure 1](#)) where the following is evident: i) the technological artifact; ii) intermediary actants (China, USA, Holland, Japan, Taiwan, Extreme Ultraviolet Lithography Machines, Rare Earths); iii) three black boxes (Metaverse, Industry 4.0 and Semiconductors); iv) Spokespeople with a historical trajectory; v) Translations from the offer; vi) Enrollments that reflect multiscalarity (Government, Company, International Organizations and the financial system); vii) obligatory steps and controversies that imply agreeing on the fundamental (humanity vs. technological development).

Figure 2 shows the relationship between the ecosystem of metaverse actants (Google, Meta Platforms Inc, Microsoft, IBM, Linden Lab, Naver Z, Baidu, Animoca Brands, Epic Games, Decentraland Foundation, Mojang Studios, Roblox Corporation) with the semiconductor ecosystem (Amazon, Apple, Samsung, Tencent, Sony, Arm, TSMC, AMD, Intel, Global foundries, Qualcomm) and the consolidation of the ecosystem of artificial intelligence actants (Open IA and Nvidia) and neurotechnology (neuralink).

The metaverse's actor-network graphs reveal: i) the centrality, intermediation, and proximity of large technology companies (Google, Microsoft, Samsung, Apple, Amazon, IBM, Meta, Sony, and Nvidia); ii) Roblox is the main metaverse; and Nvidia is the most dynamic artificial intelligence company.

The actant (semiconductor and metaverse), is guarded by large technology companies (Google, Amazon, Apple, Microsoft, Samsung, Tencent, Meta Platforms, Cisco Systems, Broadcom Inc, Sony) because its updates and innovations allow the creation and correlation between technologies or digital objects validated by the Iort¹⁶, industry 4.0¹⁷, 5G¹⁸, 6G¹⁹, quantum Internet²⁰, Edge Computing²¹.

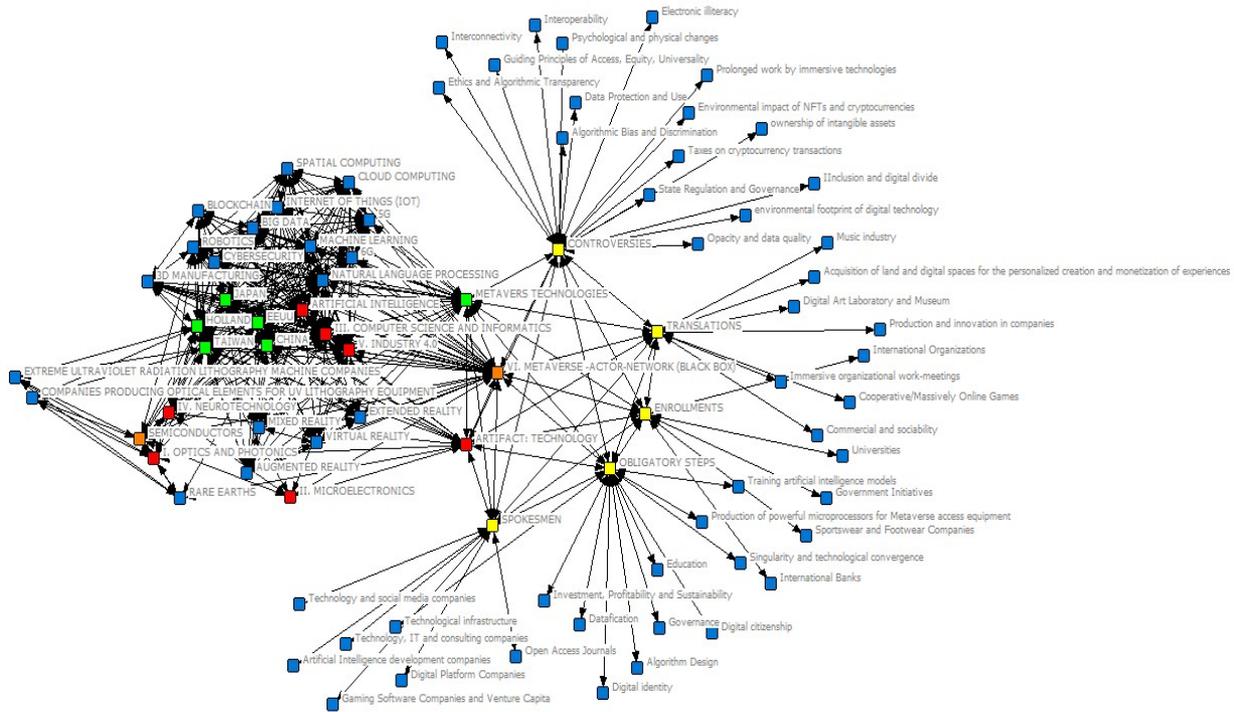


Figure 1. The metaverse as an actor-network
Note: Prepared by the authors 2025, based on Ucinet 6.0

¹⁶ [Ávila 2022 \(p. 3\)](#), expands the scope of the IOT, explaining the relationship with the IORT - Internet of Robotic Things - "a robotic infrastructure that feeds on IOT systems and that, thanks to the data provided by the IOT, builds an artificial intelligence computing network interconnected with or towards a new emerging IORT network that allows automated autonomous tasks to be performed based on parameters or orders received through the IOT network ([Simoens, Dragone and Saffiotti, 2018](#))"

¹⁷ Industry 4.0: "It originated in Germany between 2011 and 2015. Its goal is to introduce smart grids into the supply chain, connecting computers, machines, and systems that record and update information in the cloud in real time and interpret meanings to generate knowledge through algorithms."

¹⁸ 5G: "It enables the virtualization of network functions, simplifying operations and improving flexibility, availability, and efficiency, increasing device and application coverage in remote areas."

¹⁹ 6G: "The first network trials are estimated for 2026 in China; its main objectives are: i) to reduce communication delays within a network and to optimize energy consumption to extend device charging times."

²⁰ Quantum Internet: "A set of systems and devices (quantum teleportation and qubits) that enable connections, secure transmission of information between computers over long distances, and the construction of algorithms that solve problems that cannot be addressed with classical computers. The countries investing in quantum research are the United States and China; the companies with quantum laboratories are Intel, IBM, and Google."

²¹ Edge Computing: "There's no need to upload data directly to the cloud or a centralized data processing system; it integrates intelligence into edge nodes, enabling real-time data processing and analysis close to the data source."

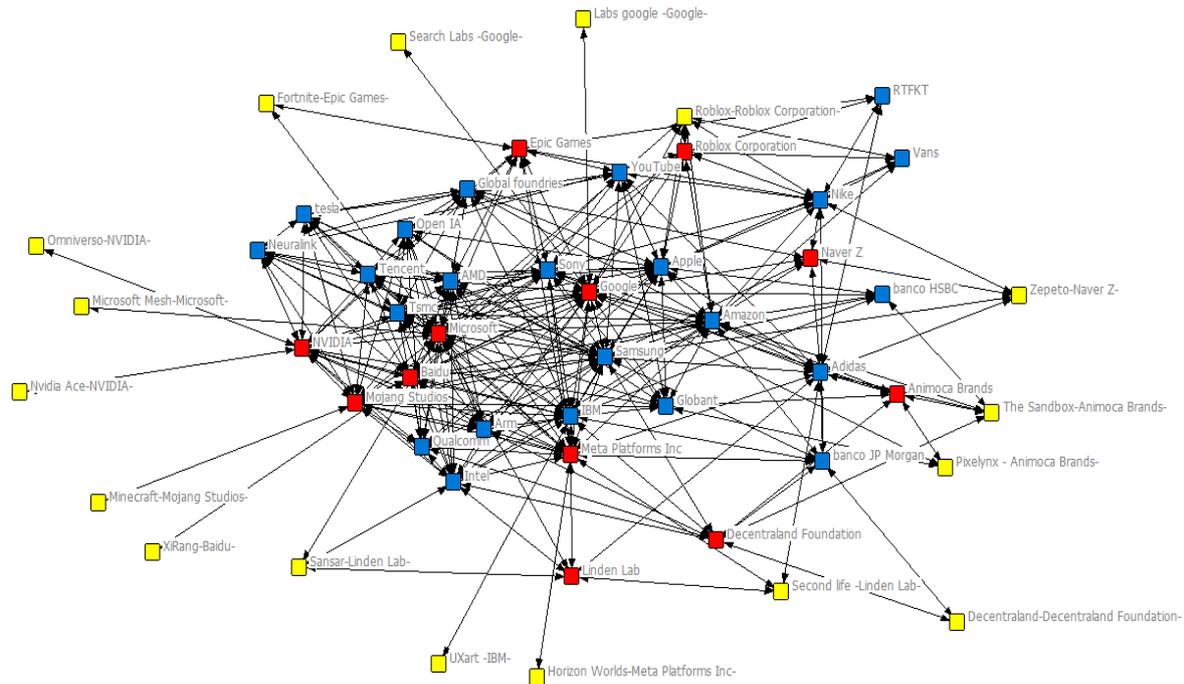


Figure 2. Subnetworks of the metaverse as an actor-network

Note: Prepared by the authors 2025, based on Ucinet 6.0

4. Discussion

The metaverse as a technology for innovation and social impact.

The metaverse as a technology for innovation and social impact currently consolidates organizational processes that are streamlined with digital and technological tools: i) Showrooms, induction processes, training programs, and virtual corporate events - Platforms and Apps -; ii) interaction and the flow of day-to-day information - Intranet -; iii) psychotechnical tests, analysis of behavioral styles (skills and emotional management), team evaluation and feedback, training in hardware and software skills, brand positioning and corporate culture, wellness and recreational activities - Video games / Gamification -; iv) virtual worlds, to socialize, form teams, train, educate, and collaborate with each other from anywhere in the world; immersive, three-dimensional, and multisensory learning to practice soft skills (specific situations, feedback, tutoring, coaching, and connecting with other organizational cultures) - Virtual reality and augmented reality -; v) knowledge management, consultation of processes, decisions and experiences in real time, through data analysis using AI - Knowledge and Information Libraries.

The metaverse, in addition to being as persuasive as television and social media, is a technology that can modify what we think and perceive about reality, based on: i) it emulates cognitive mechanisms of experiences in places and bodies; ii) brain-to-brain attunement and synchronization; and iii) the ability to experience and induce emotions. Virtual reality (VR) and augmented reality (AR) technologies, used in the metaverse, are capable of activating GPS neurons and making humans present in digital places. GPS neurons (order and place cells) are what allow us to construct our autobiography in space, time, and place.

Therefore, the design and implementation of metaverse public policies, by governments, must consolidate technological and digital convergence, under guiding principles of access, equity and network neutrality,

in order to guarantee different actors (public, social and private) / users (digital citizenship / digital native), multisensory interaction with virtual reality (VR), augmented reality (AR) and mixed reality; and technical conditions that allow: i) immersive social collaboration-realism-; ii) integrated communication in real time-ubiquity and access-; iii) digital interaction and knowledge-interoperability and scalability-; iv) coding and languages on platforms- identity-; and v) interconnectivity.

The State, as a regulatory and innovative agent, must assume the risk of articulating and guaranteeing the public value generated by:

- The main technologies that exist for the development of the Metaverse: i) augmented reality and virtual reality (Extended Reality); the former adds digital information to the physical world, and the latter is the experimentation of the digital world; ii) the digital twin, which generates a copy of a real-world object from its own data or information, in order to predict behaviors or actions; and iii) blockchain, which serves the purpose of data storage and commerce where physical goods can be converted into virtual objects.
- The different actors (public, social, and private) who maximize the status of digital citizen and the design and implementation conditions of devices or digital environments that affect the structure of consumption and social interaction.
- The guidelines of platform owners regarding creativity and the quality of goods produced and offered by suppliers.

Since the metaverse's status as a technology for innovation and social impact responds to an interconnected, immersive social network with multi-platform fluid communication and dynamic interactions between human and non-human actors (digital artifacts) in real time, the functionality of the State and the political regime must discuss: i) the approach to governance and incentives to strengthen the co-creation and transfer of knowledge among clients, owners, suppliers, and social actors; ii) the redefinition of big data analysis for autonomy and privacy protection; iii) the consolidation of prospective and simulation exercises regarding problems/situations that affect interoperability between software and hardware; interconnectivity for socioeconomic impact and transformation; and the general social, ethical, and legal norms of the condition of citizenship in the digital world.

For the exponential and social development of the metaverse, the consolidation of Industry 4.0 is key. It develops a technological architecture with network integration capabilities that support manufacturing based on collaboration, flexibility, and reconfigurable processes. This offsets the learning curve for implementing the metaverse as a technology for innovation and social impact, in terms of:

- The production and implementation of cyber-physical systems, which also addresses the same challenges of an incipient adoption of digitalization, due to the widening technological gap, the lag of the Internet of Things (IoT), the vulnerability of cybersecurity protocols, and the lack of specialized human capital training.
- The concept of the smart factory, which encompasses the study and analysis of the supply chain (suppliers, customers, and partners) under principles of logistics optimization and efficiency that respond to the variables of quality, traceability, time, and cost; this advancement in the technological organizational structure allows the metaverse to define measurable scopes of resources and processes in terms of demand (tourism, gaming, art, social media, virtual property, simulation of reality, etc.), supply (energy, big data, AI, and blockchain), and constant feedback from algorithms (supervised and unsupervised learning).
- Cybersecurity, as a research program between public and private actors, identifies potential algorithms that threaten the technological architecture of cyber-physical systems. These results, in the applicability of the metaverse, allow for the consolidation of large databases for analytics on dynamics, patterns, labels, profiles, names, and trends in its decentralized construction (open source).

- Simulation using digital twin technology, which allows for the consolidation of information for the detection and correction of problems in virtual prototypes that may have flaws in reality. This knowledge transfer to the metaverse allows for minimizing costs in real-time adaptations and modifications of virtual environments (ergonomics, interaction with AI, digital identity, etc.).

5. Conclusions

The metaverse does not yet have the potential of artificial intelligence and digital platforms, in that these have a direct relationship with real-time location and movement due to the technological convergence of digital devices (tablets, cell phones, etc.); the metaverse has not yet been established in everyday life and in the acceleration of information validation, not because of structural or technological failures, but because of the different typologies or taxonomies of the metaverse conditioned by classic processes such as games, social networks, and monetary transactions.

The metaverse is a technological undertaking that validates Industry 4.0 (digital twins, advanced robotics, cybersecurity, 3D manufacturing, and the Internet of Things (IoT), the everyday use of artificial intelligence (AI), big data, cloud computing, augmented reality, and virtual reality; and the disruptive processes of 5G, 6G, quantum internet, edge computing, and neurotechnology.

The metaverse is not an expanded social network or a traversable version of the internet; it is the technological capacity and convergence of the real world with the virtual world, with socioeconomic processes (co-creation of goods and wealth), innovation (NFTs)²², and language and identity (avatars). The technological convergence of the metaverse consolidates a decentralized macro-network where interactive, collaborative, interoperable, creative, and dynamic platforms are juxtaposed in real time with multisensory interactions with digital artifacts that energize vested and disseminated interests among human and non-human actants.

The metaverse proposed by technology companies aims for interreality (the fusion of the virtual and physical worlds). Therefore, it is important to include neuropsychological, neuroscience, and anthropological studies in the discussion of metaverse designs, with regard to the construction of reality and the dynamics of social action.

The analysis does not lie in the commodification of the metaverse, on the contrary, it is the logic of technological capitalism in the modification and interaction of machine-machine and machine-human, where strong competition is evident at the peak of technological singularity and in the construction of actants for the development of a sociotechnical society in the increase in the generation of content delimited by digital/virtual environments and parameters.

Mapping the metaverse based on the postulates of actor-network theory allows for the inclusion of non-human actants in social network analysis, where associations are not only keyed to reciprocity, transitivity, homophily, and closeness; but also to heterophily, multiplexity, weak ties, and structural holes.

The metaverse as a rhizome does not respond to lines of hierarchical subordination; it demonstrates its complexity and links as a black box, which is built with the evolution of the technological artifact from an abductive perspective, where the creative and inferential nuance the conjugation of information processing, electronic tools, automatic systems, devices and technological resources, and the adaptability of human/organizational activities to digital objects.

²² Non-fungible tokens (NFTs) are cryptographically based digital assets that meet the following characteristics: (i) They are not cryptocurrencies; they represent the value associated with content creation; (ii) they are used as currency to make transactions in virtual environments using blockchain technology; (iii) they guarantee the transaction and remuneration of the value of the created content by introducing programming codes; (iv) they allow exclusive access to specific locations and properties in the virtual environment; and (vi) owners with like-minded ideas or interests can establish communities of experiences and collaboration to create content.

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Data Availability

The article provides the relevant data sources and links.

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Víctor Hugo Tabarquino Muñoz: Conceptualization, Labeled Data, Formal Analysis, Original Draft Writing, Research, Text Correction, and Data Validation.

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Annex

Annex - Table 7.

Relevant Metaverses and Interests / relationships

Metaverse	Lead Organization	Sector	Interests / relationships
Second life	Linden Lab – EEUU-	Technology and social networks	Adidas advertises on the platform Meta acquires Second Life
Sansar			Microsoft Windows and Intel cooperate in the metaverse
Horizon Worlds	Meta Platforms, Inc (Facebook, Instagram y WhatsApp) -EEUU-		*Meta and Amazon alliance for projects *Partnership with Sony and Microsoft to improve virtual experiences and data transfer between platforms *Meta belongs to the "Metaverse Standards Forum" association, which includes Nvidia, Google, Meta, Epic Games, Sony, and Microsoft.
Labs Google Search Labs	Google -EEUU-	Technology, IT and consulting	*Google uses the Roblox platform *Google is part of the UXL Foundation (Intel, Qualcomm, Samsung, Arm, Microsoft); *Amazon is a partner
Omniverso	NVIDIA -EEUU-	Software, microchip design and marketing, games, creative design, autonomous vehicles, and robotics	*Partners and investors in technology projects (Open AI, Tesla, Microsoft, Neuralink, Intel)
Nvidia Ace			*Partners in microchip manufacturing and production (Global Foundries and TSMC) *Open Robotics project with Qualcomm
Roblox	Roblox Corporation-EEUU-		* Interactive Sportswear Experience on the Roblox platform (Vans World and Nikeland) * Google Office on the Roblox platform * Apple and Amazon (Roblox on device) * Open IA, Sony, and RTFKT are business partners of Roblox Corporation
Fortnite	Epic Games-EEUU-		* Epic Games uses the Microsoft platform * Epic Games contracts with RTFKT Inc. to design game engines, NFTs, and blockchain authentication. * Sony, YouTube, and Tencent are Epic Games' business partners.
Decentraland	Decentraland Foundation	Gaming software and venture capital company	*Samsung Virtual Store on the Decentraland platform *JP Morgan Bank Virtual Lounge on the Decentraland platform *Ethereum blockchain *Decentraland belongs to the Open Metaverse Alliance (OMA3) association, which includes Animoca Brands and The Sandbox. *Artistic collaboration between IBM and UXArt on Decentraland
The Sandbox	Animoca Brands – China-		*Adidas and Amazon buy space on The Sandbox platform *HSBC bank virtual lounge on The Sandbox platform *Ethereum blockchain *Partnership with Decentraland on metaverse-related topics
Pixelynx		Globalant and Google Partner in the Musical Metaverse	
Microsoft Mesh	Microsoft -EEUU-		*Roblox on Device *Partners and Investors: Open AI, Amazon, Meta, Tesla, Neuralink, AMD, Tencent, Sony * Partner of the UXL Foundation
XiRang	Baidu -the Chinese Google-	Technology, IT and consulting	Partners Tesla, Microsoft, Apple, Nvidia, AMD, Meta, Sony, Tencent, Intel, Qualcomm, ARM, Amazon
Zepeto	Naver Z – South Korea		*Partners: Samsung, Apple, Google, and Intel *Adidas, Nike, and Samsung sell in the Zepeto metaverse
UXart	IBM (EEUU)		Partners: Samsung, Apple, Amazon, Google, Microsoft, Intel, Meta, Sony, AMD, JP Morgan Bank, HSBC Bank
Minecraft	Mojang Studios (Sweden)	Video game development company	Microsoft Partner, YouTube

Note: Prepared by the authors 2025.

Annex - Table 8

Relevant actant in the Metaverse

Core business								Organization that has its own metaverse
Name	Chip manufacturing and production	Chip design and marketing	Gaming software and venture capital	Technology, IT and consulting	Technology and social networks	Sportswear and Footwear	Banks	
Linden Lab					1			1
Roblox Corporation			1					1
NVIDIA		1						1
Google				1				1
Epic Games			1					1

Continued on the next page

Meta Platforms Inc					1				1
Animoca Brands		1							1
Microsoft				1					1
Decentraland Foundation		1							1
Baidu				1					1
Naver Z				1					1
IBM				1					1
Mojang Studios			1						1
Intel	1								
Qualcomm		1							
Samsung		1							
Arm	1								
Open IA				1					
tesla				1					
Neuralink				1					
Global foundries	1								
Tsmc	1								
Vans							1		
Nike							1		
Adidas							1		
Apple				1					
Amazon				1					
Sony				1					
RTFKT				1					
YouTube				1					
banco JP Morgan								1	
banco HSBC								1	
Globant				1					
AMD		1							
Tencent				1					
Total	4	4	5	15	2	3	2		13

Note: Prepared by the authors 2025.

Annex

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		Linden Lab	Roblox Corporation	NVIDIA	Google	Epic Games	Meta Platforms Inc	Animoca Brands	Microsoft	Decentraland Foundation	Baidu	Naver Z	IBM	Mojang Studios
2	Linden Lab	0	0	0	0	0	C	0	C	0	0	0	0	0
3	Roblox Corporation	0	0	0	P	0	0	0	C	0	0	0	0	0
4	NVIDIA	0	0	0	C	C	C	0	C	0	C	0	C	C
5	Google	0	P	C	0	C	C	C	C	0	C	C	C	C
6	Epic Games	0	0	C	C	0	C	0	C	0	0	0	0	0
7	Meta Platforms Inc	C	0	C	C	C	0	0	C	0	C	0	C	C
8	Animoca Brands	0	0	0	C	0	0	0	C	C	0	0	0	0
9	Microsoft	C	C	C	C	C	C	C	0	0	C	0	C	C
10	Decentraland Foundation	0	0	0	0	0	0	C	0	0	0	0	C	0
11	Baidu	0	0	C	C	0	C	0	C	0	0	0	C	C
12	Naver Z	0	0	0	C	0	0	0	0	0	0	0	0	0
13	IBM	0	0	C	C	0	C	0	C	C	C	0	0	C
14	Mojang Studios	0	0	C	C	0	C	0	C	0	C	0	C	0
15	Intel	C	0	C	C	0	C	0	C	C	C	C	C	C
16	Qualcomm	0	0	C	C	0	C	0	P	C	C	0	C	C

Figura 3. Most relevant Interests / relationships between Metaverses

Note: Prepared by the authors 2025.