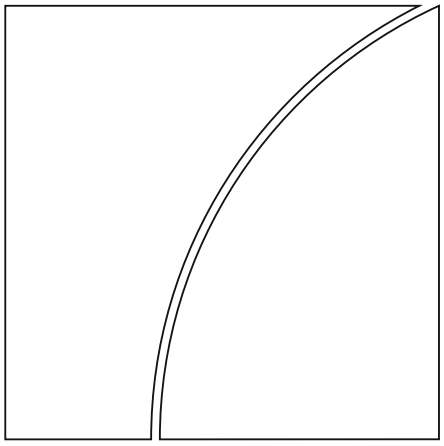

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The economic implications of services in the metaverse

Carlos Cantú,[*] Cecilia Franco[†] and Jon Frost[‡]

Abstract

How could an immersive computer-generated environment ("the metaverse") impact services in the digital economy? Investment in virtual worlds has grown rapidly. Yet the technology still falls short of achieving fully immersive experiences. And despite hyperbolic predictions, various indicators show interest has fallen in the last two years. While some use cases show promise (eg gaming, education, healthcare), others seem distinctly gimmicky (eg virtual bank branches, land speculation). If the metaverse does succeed, it could mean: (i) a blurring of lines between the tradable and non-tradable sectors, (ii) greater cross-border economic integration and (iii) new demands on payment services. In principle, retail fast payment systems, retail central bank digital currencies or tokenised deposits could be designed to support services in the metaverse. To prevent virtual environments and money from becoming fragmented and dominated by powerful private firms, public policy would need to support efficient, interoperable payments and provide clear standards on data privacy, digital ownership and consumer protection.

Keywords: metaverse, digital economy, services, payment services, education, healthcare.

JEL classification: E42, I19, I29, L8, O31, O36.

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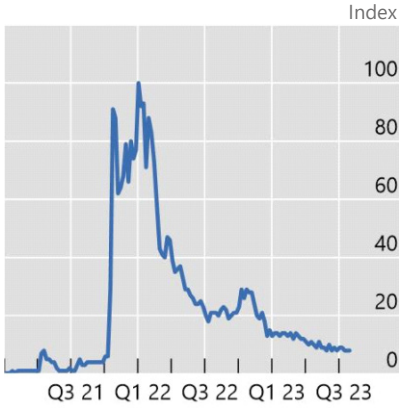
1. Introduction

As virtual reality (VR) and augmented reality (AR) have become more advanced, they have allowed for the creation of new, computer-generated worlds. These immersive virtual environments, usually represented in three dimensions, are accessible via VR and AR headsets, smart glasses, phones, computers and other devices. Users, represented in such environments by three-dimensional representations of themselves ("avatars"), can engage in a broad range of activities that increasingly resemble either the real world or a fictitious, surrealistic world. While the idea of virtual worlds has existed for several decades, the last few years have seen companies, investors and enthusiasts scale up their ambitions. These parties expect that users may spend much more time (and attention and money) in such virtual worlds; that there may be business opportunities from new services; and that digital scarcity of virtual land, buildings and other objects can make them valuable. In short, many see new opportunities in "the metaverse".[1]

Interest in the metaverse spiked after Facebook rebranded itself as Meta in October 2021. The move signalled a shift by the social media company toward building a composite universe, melding online, virtual and augmented worlds (Isaac (2021)). Internet searches for the term "metaverse" exploded after the announcement (Graph 1.A). Venture capital (VC) investors and mainstream companies like Microsoft also announced big investments in the technology. But the hype subsided rapidly as the general public and investors lost interest. This coincided with the bursting of a

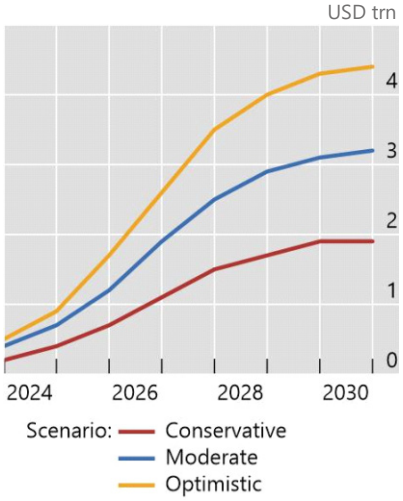
The hype has collapsed, but debate about the metaverse as an industry continues — Graph 1

A. Internet searches for the term "metaverse" peaked in early 2022



B. The price of metaverse tokens has also collapsed[1]

C. Consultants make bold predictions about the total addressable market[2]



[1] The Metaverse Index, launched in April 2021 by Index Coop, is a basket of tokens designed to capture the trend of entertainment, sports and business shifting to a virtual environment. It is represented by a tradable ERC-20 token. [2] The total addressable market refers to the revenue opportunity available for products or services. This projection, by Statista, assumes a digital economy of US$ 12.8 trillion. The conservative scenario assumes a 15% shift of such activity to the metaverse, the moderate scenario assumes at 25% shift, and the optimistic scenario assumes a 35% shift.

Sources: CoinMarketCap; Google Trends; Statista (2023).

[1] The term "metaverse" is a portmanteau of the Greek "meta" (beyond) and "universe", first coined by Stephenson (1992). The annex contains a glossary of terms associated with the metaverse.

speculative bubble in cryptocurrencies, which recent metaverse projects often are associated with. A metaverse index consisting of cryptoasset tokens designed to capture the trend of entertainment, sports and business shifting to a virtual environment collapsed in early 2022 and had not recovered as of late 2023 (Graph 1.B).

Still, consultants and investment banks have continued to make bold claims about the future potential of the metaverse. One consultancy estimates that 400 million users were active in the metaverse in March 2022 (Metaversed (2022)). Looking forward, Statista (2023) forecasts a total addressable market (revenue opportunity) of US$ 4.4 trillion in 2030, assuming an optimistic scenario where the digital economy shifts by 35% to the metaverse (Graph 1.C). Other institutions have published even larger estimates (Citi (2022), McKinsey & Company (2022)). There are serious doubts about the credibility of these estimates because they are strongly influenced by commercial interests, in particular a desire to sell metaverse-related consulting services and financial products to clients. For example, in August 2023 it was reported that Meta's Horizon Worlds platform had less than 200,000 monthly users, down from a peak of close to 300,000 in February 2022. One investigator found only 900 daily users in practice (Protos Staff (2023)). How the investment projects made during the boom will perform and whether the concept of the metaverse will remain relevant going forward are open questions.

This paper explores the potential economic impact of services in the metaverse. It does not take a position on the likelihood that the metaverse (or similar innovations) will succeed. Rather, it considers the potential macroeconomic impact if the underlying technologies – particularly VR, AR, immersive worlds and digital property – become widely used in the services sector of the economy. We argue that such a shift could diminish the role of national boundaries and with it the ability to enforce taxation, labour laws and other regulations. It may also blur the distinction between the tradable and non-tradable sectors. An important foundation for such services is the ability to make instant payments, ideally across borders and currencies, and to create digital representations of assets (tokenisation). These payments do not need to be based on cryptocurrencies or a blockchain. A system or interlinked fast payment systems, tokenised deposits or central bank digital currencies could allow for instant, verifiable payments and could thus form a superior alternative to volatile speculative assets. This could also support programmability and tokenisation in virtual environments.

As we will argue, some use cases for VR, AR and immersive virtual environments, particularly in education, healthcare and gaming, may have value. If societies want these applications to be socially useful and not fragmented or dominated by a few powerful private firms, public policy must take action. A reinforced push toward efficient, interoperable payment systems, accompanied by clear standards on data privacy, digital ownership and consumer protection, could help promote superior market outcomes than a purely laissez-faire approach would.

This paper is organised as follows. Section 2 explores the origins and growth of the metaverse, including its inspiration in fiction. Section 3 discusses selected types of services in the metaverse. Section 4 focuses specifically on payments for metaverse-related activities. Section 5 notes implications for public policy, and Section 6 concludes.

2. The origins and growth of the metaverse

The origin of the term "the metaverse" is Neal Stephenson's irreverent 1992 cyberpunk novel *Snow crash*. In that book, the metaverse is a virtual world, conceived as a 100-metre-wide street ("the Street") running around a perfectly spherical planet, where it is always nighttime. Users access this virtual world either with sophisticated VR headsets (for the well-heeled) or in cheap public terminals that display the Street in grainy black-and-white (for the masses). Users have avatars that are either highly realistic and beautifully rendered (for those with the resources or programming skills) or that are a prototypical standard, ie cheap off-the-shelf models like "Brandy" for women or "Clint" for men. In the book, the "real" world is an anarcho-capitalist dystopia, where nation-states have broken down and people live either in chaotic urban environments or heavily armed "burbclaves". The metaverse is thus a welcome escape. Notably, Stephenson's metaverse is operated by a private global technology firm, called the Global Multimedia Protocol Group, which is a monopoly. This world makes for a strange blueprint for a new virtual world (Doerr and Frost (2024)), but the book is strikingly prescient. Similar ideas for virtual worlds are present in William Gibson's *Neuromancer* (1984), Ernest Cline's *Ready player one* (2011) and other books.

One of the main issues when analysing the metaverse is the absence of a standard definition. The definition of the metaverse, along with its implications, may change depending on the possible enabling technologies and the ecosystem aspects considered. In this paper we consider the metaverse from a more general point of view, ie any virtual world where the user uses a personal avatar.

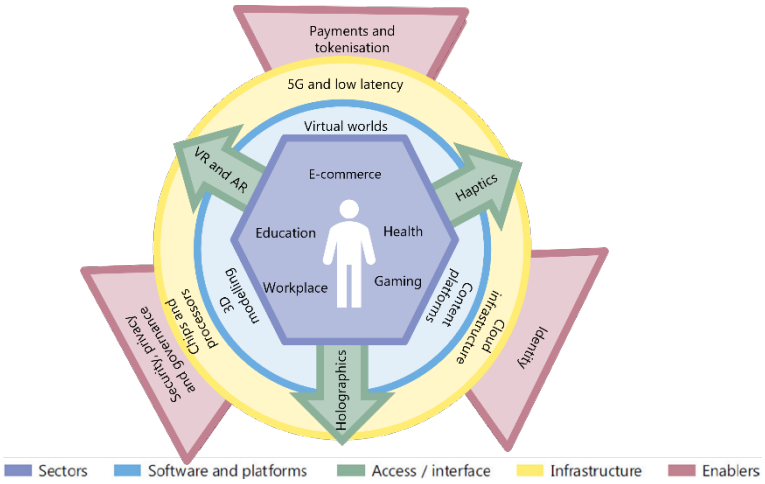
At its most basic level, the metaverse requires three features: a sense of immersion, real-time interactivity and user agency (Park and Kim (2022)). The intertwined layers that build the metaverse are sectors, software, interface, infrastructure and enablers. Graph 2 represents these layers. At the core of the system (purple) are the sectors the user interacts with. These include health, education, gaming, workplace, e-commerce and others. These sectors unfold in virtual environments and locations where people converse, trade and socialise. They are supported by software and platforms (blue). Significant advances in real-time rendering of photorealistic environments, true-to-life virtual physics and real-time three-dimensional modelling tools support the creation of these virtual worlds (Accenture (2022)).

Users access these realms in two and three dimensions, through devices such as VR headsets, smart glasses, mobile phones and computers. VR, AR, haptics and holographic interfaces overlay the physical world, creating new opportunities for interaction and engagement (green arrows in Graph 2). Technological infrastructure powers the hardware and enables the efficient interaction between the virtual and real world. This infrastructure (yellow) includes chips and processors; low-latency, cloud and edge computing; next-generation connectivity and internet access (mobile internet (5G), WiFi 8, satellite). Finally, three important enablers (red) provide the railways that connect the real-world self with a virtual self. Payments and tokenisation allow for the exchange of value and thus a virtual economy in the metaverse; identity solutions serve as authentication and validation mechanisms; and security, governance and privacy protocols provide the legal frameworks and regulatory structure that allow the metaverse to exist (CB Insights (2022)).

For the metaverse to achieve commercial viability, much will depend on retail adoption of the interface technologies. Use of VR and AR has been growing but from a very low base. Statista (2023) estimates a cumulative installed base of 25.8 million

The metaverse is built on multiple layers of technology

Graph 2



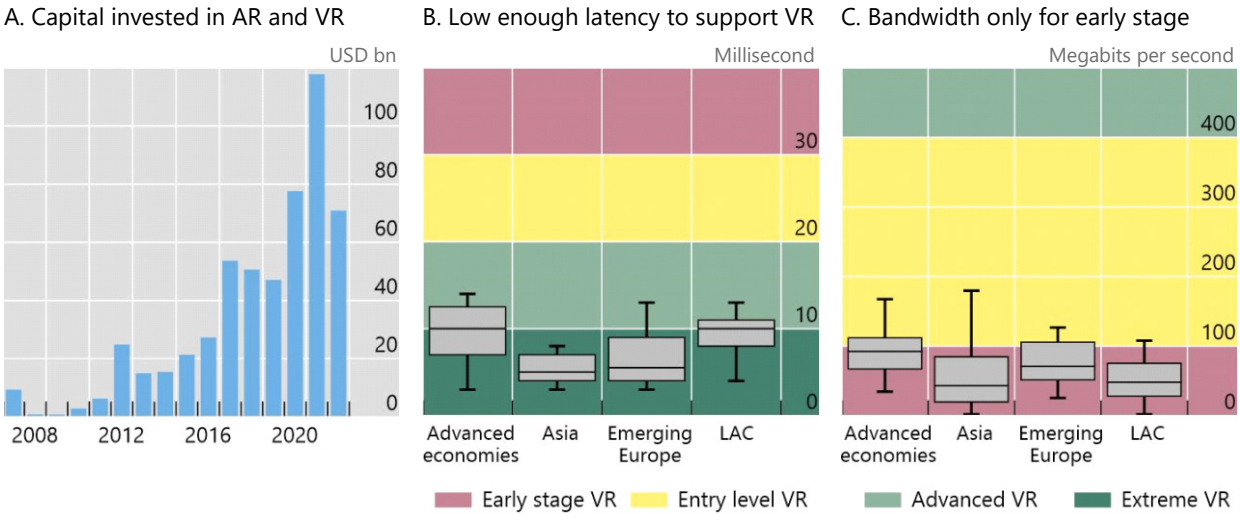
Note: The sectors are applications that the end user will interact with. Software and platforms facilitate distribution and discovery of content, experiences and applications. This includes the core set of tools for building three-dimensional experiences, including design, game engines and artificial intelligence services. Access / interface includes device hardware, components, accessories / peripherals and operating system (OS) layers that are part of the human interface layer. Infrastructure refers to the components such as cloud computing, semiconductors, networks, etc that power the metaverse. Enablers are specific tools to enable the metaverse economy, to manage digital identity and to regulate governance, privacy and content moderation.

Source: Authors' elaboration.

VR headsets as of end-2023 – still a tiny fraction of the market for smartphones, laptops and other devices. Investment in these technologies has picked up, reaching more than US$ 120 billion in 2021 (Graph 3.A). As elsewhere in technology, there are strong network effects, meaning that use can become self-reinforcing. So far, applications have generally underwhelmed expectations. Even among experts in the area, views are split. Indeed, one survey of 624 technology innovators, developers, business and policy leaders, researchers and activists finds that 54% expect the metaverse will be a much more refined, fully immersive aspect of daily life for a half billion or more people globally by 2040, while nearly as many (46%) expect it will not be (Pew Research Center (2022)).

Investment in AR and VR is rising, but infrastructure is not advanced enough

Graph 3



Sources: PitchBook Data, Inc; Speedtest; Mangiante et al (2017); authors' calculations. LAC is Latin America and the Caribbean.

One obstacle is the high price of VR sets. In 2023, the price of a VR set ranged from $250 (Meta Quest 2) to $3,500 (Apple Vision Pro) (Baker (2022)). Consumers might not be willing to pay those prices. Prices will likely come down as the technology matures and competition increases among producers of VR inputs.

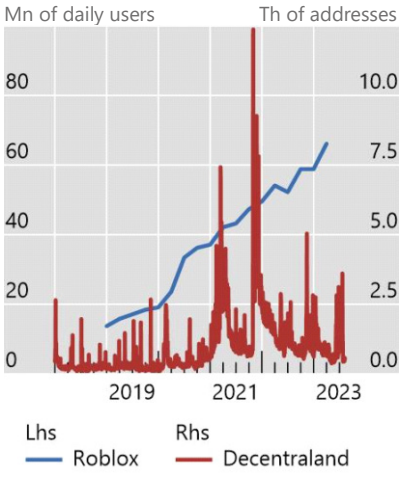
A further limit is technological, and it is particularly binding in emerging market and developing economies. Because VR requires creating a convincing user experience, it has very high demands for latency (ie the time it takes for data to be transmitted) and bandwidth (ie the volume of data that can be transmitted). In many countries, average latency of internet connections has improved and is now able to accommodate VR and AR applications (Graph 3.B). Yet bandwidth remains a problem around the world, and it is particularly lacking in Latin America and the Caribbean and some countries in East Asia (Graph 3.C). One factor that deters wide adoption is that the technology around VR has not evolved far enough to make the headsets comfortable to wear for extended periods. During an experiment that exchanged a desktop-based work environment for a VR environment, some employees noted feeling extreme nausea, anxiety and severe migraines as well as discomfort with the VR headset (Biener et al (2022)).

Still, VR is not a necessary condition for the metaverse. Other technologies provide immersive access to virtual worlds. One alternative is AR, where rather than fully immersing the user in computer-generated visuals, digital imagery is overlaid on the user's view of the actual world (Marr (2022)). In Vernor Vinge's *Rainbows end* (2006), AR is dominant, with humans interacting with virtual overlays of reality all the time. Even lower-tech virtual worlds (Second Life, Axie Infinity, Roblox) have taken off, with users taking part on laptops, smartphones and tablets. Indeed, Roblox had 66 million daily active users and 202 million monthly active users as of the second quarter of 2023, and it was estimated in 2020 that two-thirds of US children between nine and 12 played Roblox (Ruby (2023); Kharif (2020)). Notably, these examples have far more users than decentralised applications like Decentraland, which is the largest blockchain-based virtual world (Graph 4.A; note the different scales of the right and left axes).

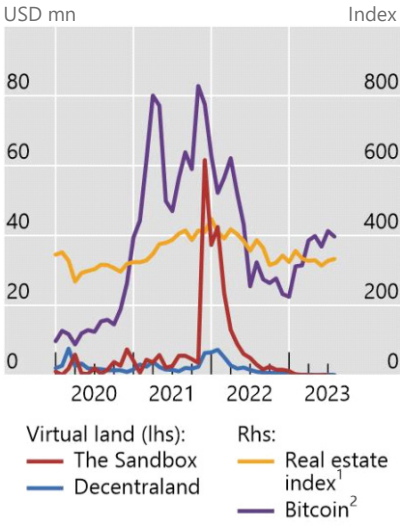
Much activity in metaverse applications to date has focused on speculation. In particular, users can purchase virtual land in several metaverse environments. In Decentraland, a non-fungible token (NFT) termed LAND represent parcels of virtual real estate. The volume of land sales has so far correlated with real estate prices in the real world (Graph 4.B). Yet it also correlates strongly with the price of Bitcoin (Graph 4.C), suggesting that speculation is a key motive. Interestingly, there is evidence that land prices are also strongly influenced by "location" within virtual worlds, such as proximity to virtual places that are frequented by a large number of people (Goldberg et al (2021)). Dowling (2022a) shows that LAND price series had steadily risen in value and failed market efficiency tests.

Decentralised metaverse applications are tiny and largely speculative Graph 4

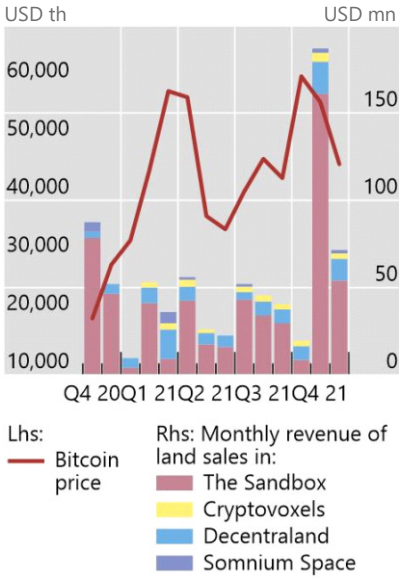
A. Decentraland active addresses are tiny relative to centralised worlds



B. Virtual land sales correlate with the prices of real-world real estate…



C …but also with the price of Bitcoin



[1] FTSE NAREIT real estate 50 index. [2] Rebased price, 2019 = 100.

Sources: Bloomberg; Coin Metrics; Dune; Roblox; Statista.

3. Services in the metaverse

While some use cases of VR technology are very gimmicky (eg virtual land speculation, metaverse bank branches), others show real promise (eg online learning, telemedicine, gaming). Generally, the metaverse is most applicable to supporting services in a domestic and cross-border manner. As such, the metaverse is thought to expand the domain of human activity by overcoming spatial, temporal and resource-related constraints imposed by nature (Momtaz (2022)).

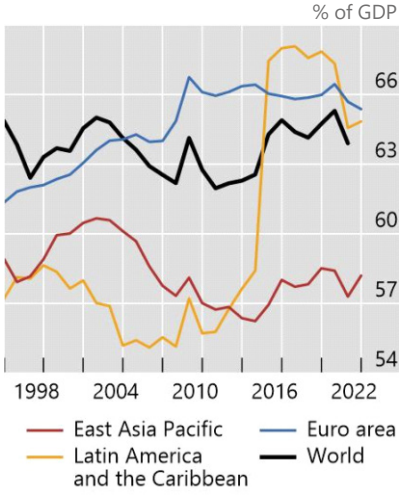
The services sector has grown in countries around the world and now makes up a majority of total output in most economies (Graph 5.A). If part of the sector moves to the metaverse, the potential could be ample. Some consultants expect that revenue from services in the metaverse will reach US$ 490 billion by 2030 (Graph 5.B). The largest gains correspond to revenue from gaming and e-commerce (around US$ 200 billion and US$ 150 billion, respectively). This is followed by health and fitness, workplace and education. Again, there is the caveat that these claims are likely inflated by the desire of these firms to sell consulting and other services to companies interested in the potential of the metaverse. Nonetheless, we can assess the comparative magnitude of expected revenues in each sector by looking at the composition of companies that have invested in the metaverse (Graph 5.C). We can then compare this to revenue estimates by sector.

Consistent with the magnitude of revenue estimates, most companies that have invested in the metaverse belong to the e-commerce sector. Following in size is the workplace sector, where expected revenue is not as large. This might indicate that the revenue-generating capacity of the workplace sector in the metaverse will be comparatively smaller but have higher margins. A similar conclusion can be drawn

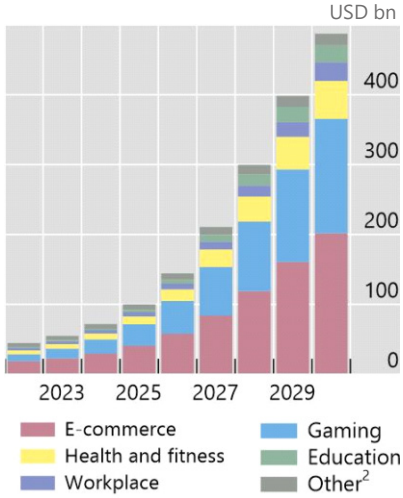
from looking at investment by the education sector. By contrast, the share of gaming and health and fitness companies that have invested in the metaverse is smaller, while their revenue is expected to be quite significant. Several studies already analyse e-commerce and gaming applications of the metaverse in depth (eg Alcedo et al (2022), Boldi et al (2022), Dąbrowski and Suska (2022), Wainwright (2023) and Klimas and Czakon (2022)). Hence, we will discuss these sectors only briefly. Our analysis will delve deeper into education and healthcare, where the potential societal impact may also be large.

The metaverse will be a disruptive force in the services sector — Graph 5

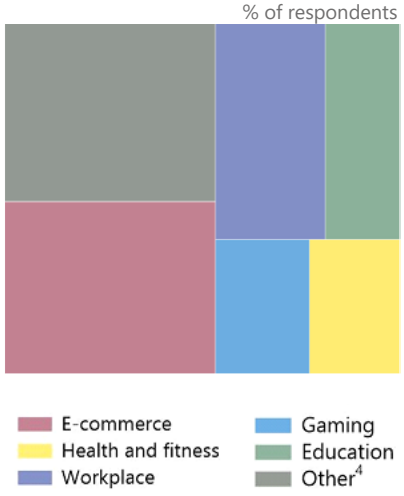
A. Value of services in the economy has risen over time[4]



B. Revenue growth in the metaverse is expected in gaming and e-commerce



C. Sectors of companies that invested in the metaverse[3]



[1] Services include value added in wholesale and retail trade (including hotels and restaurants), transport and government, financial, professional and personal services such as education, healthcare and real estate services. Also included are imputed bank service charges, import duties and any statistical discrepancies noted by national compilers as well as discrepancies arising from rescaling. [2] Virtual assets, advertising, AR and VR hardware, digital media and live entertainment. [3] According to a March 2022 survey of companies from selected countries that have already invested in the metaverse. [4] Marketing and advertising, travel and hospitality, construction, transport, customer service, defence and entertainment.

Sources: Statista (2023); World Bank.

3.1 Gaming and e-commerce

Gaming is the largest category in the entertainment industry, with revenues exceeding those of the film and music industries. The gaming market is sizeable, with an estimated 3.4 billion gamers by the end of 2023 and revenue of $US 188billion (Newzoo (2023)). Even if metaverse-based games are adopted by only a fraction of the total gaming community, this could translate into significant numbers of adoption into the ecosystem (Citi (2023)). Gaming in the metaverse would benefit if it becomes interoperable between different platforms. In the movie adaptation of the book *Ready player one*, different planets host each game inside the main metaverse platform ("The Oasis"). Users can seamlessly change games without changing their avatar and take with them whatever items they won in the previous game. For this to happen there need to be standards that ensure interoperability between the different platforms. One initiative is the Metaverse Standards Forum, which provides a venue for cooperation between standards organisations and companies to foster the development of interoperability standards for an open and inclusive metaverse.

E-commerce is the second-largest area of investment in the metaverse sector. E-commerce received a permanent boost during the Covid-19 pandemic, helping to support economic activity as countries enforced strict quarantine measures to curb the spread of the virus. Online purchases skyrocketed during the pandemic. For example, new orders on the platform Mercado Libre in some Latin American countries grew by more than 100% compared with the previous year (Cantú and Ulloa (2020)). In addition, e-commerce drove a greater use of remote payments. Card-not-present transactions rose during the pandemic and remained higher than their pre-pandemic level, notably in emerging market economies (Alfonso et al (2021)). The metaverse would provide e-commerce with a new set of opportunities. For example, one application is the ability of users to virtually try on clothes or cosmetics. Virtual and augmented reality would make it possible for a user to see how a product would look and choose a suitable size (Citi (2022)). Fashion brands have already started to offer fashion shows in the metaverse, allowing users to buy the real-life version of the virtual clothes. As users spend more time in the metaverse, stores and products could transform to match their preferences. As with gaming, interoperability would be key, allowing users to use the products they buy across different platforms. In 2023, retail sales in the metaverse were still in early stages (Goldberg et al (2023)). Still, a high number of well-known brands were actively engaging users for marketing purposes.

3.2 Education

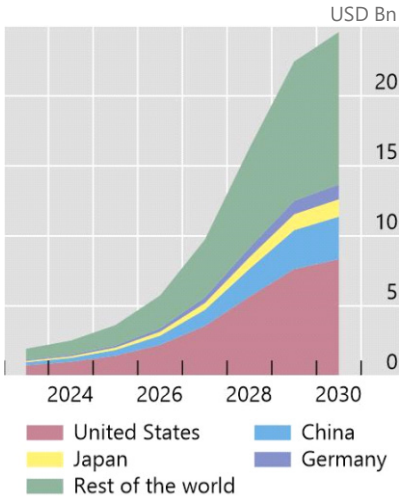
According to some market research estimates, revenue in the metaverse eductation segment could reach US$ 24 billion by 2030. The largest markets are expected to be the United States (US$ 8 billion) followed by China (US$3 billion), Japan (US$ 1.2 billion) and Germany (US$ 1billion) (Graph 6.A). An increasing demand for remote learning and a rising adoption of VR and AR technology in the formal classroom are the two drivers of the education segment of the metaverse.

Regarding the first driver, virtual classes took off during the pandemic. As schools closed, students turned to their computers to attend class and continue with their education. Zoom, one of the most popular videochat platforms for streaming classes, was downloaded more than 300 million times (Graph 6.B). Schools and universities were a major driver, alongside workplace and other applications. In total, from the second quarter of 2020 to the second quarter of 2023, the Zoom app was downloaded more than 1.2 billion times. Duolingo, an app for learning languages (founded by a US-based Guatemalan computer scientist), also saw a sharp increase in active users during the Covid-19 lockdown period. Notably, this shift did not revert. The app continued to attract more users even after lockdowns were lifted. Other data support the rise in demand for remote education. For example, the growth in the number of foreign students enrolled in massive open online courses accelerated during the pandemic, while the number of courses offered expanded steadily (Graph 6.C).

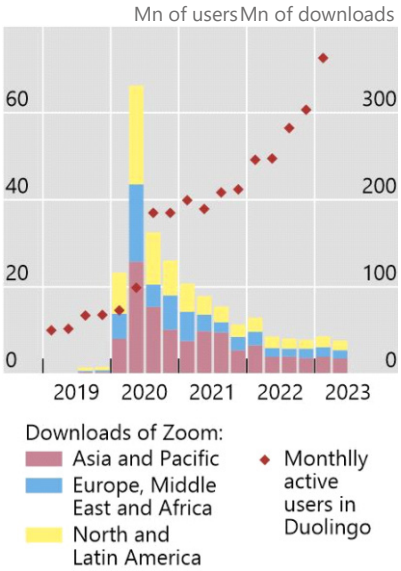
Turning to the second driver, VR and AR can help teachers overcome barriers to learning and offer realistic experiences that otherwise would be impossible. One case is to teach material that is difficult to observe directly. For example, Curiscope's Virtuali-Tee is an AR T-shirt that allows students to examine the inside of the human body as if they were in an anatomy lab (Kye et al (2021)). Another case where VR can be useful is for simulations in conditions that entail high risks to students. For example, in Second Life students can safely carry out hands-on experiments related to radioactivity and learn about nuclear safety (Kanematsu et al (2014)). Simulations are also helpful when the environment is difficult to produce due to high costs. In one

Higher demand for virtual learning could drive education in the metaverse Graph 6

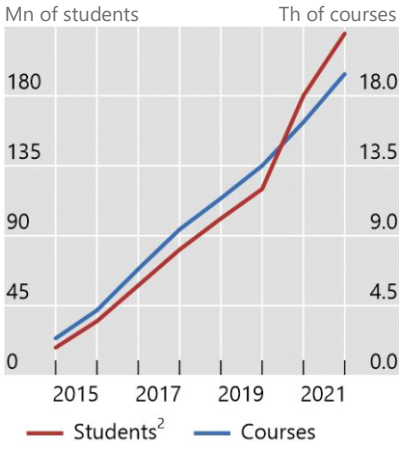
A. Revenue in education is expected to rise over time



B. Downloads of Zoom mobile app worldwide rose in the pandemic[1]



C. Massive open online courses show the demand for remote education



[1] Downloads in Apple Sore and Google Play. [2] Number of international or foreign students enrolled.

Source: Organisation for Economic Co-operation and Development, Class Central, Statista (2023).

case study, professionals and trainees wearing a HoloLens 2 met in Boeing's Aircraft Maintenance Metaverse in a space equipped with aircraft-specific virtual assets of a Boeing-737 to simulate aircraft maintenance (Siyaev and Jo (2021)). Traditional virtual learning can also transform from passive viewing of a recording to a fully interactive experience. For example, the VoluProf project by Fraunhofer HHI has the objective of creating mixed-reality applications that make online lectures (with photo and audio realistic avatars) accessible to students. This enables students to interact more directly with the lecturer, even at a distance (Fraunhofer (2023)).

The metaverse has the potential to make education more effective and inclusive. In the metaverse, classes can take place in virtual classrooms where students interact with teachers and classmates in a more immersive manner and access course materials, assignments and assessments. Online learning in the metaverse may be able to break the frontier of social connection and informal learning, ie physical presence in a classroom could cease to be a privileged educational experience (Mystakidis (2022)). Learning may become more engaging when students take part in virtual field trips to museums and galleries or travel geographically or through time to witness historical events (Hupont Torres et al (2023)). This could be particularly beneficial for learners who have difficulty physically attending places due to health conditions (European Commission (2022)). Using internal social networks, students can interact with people of diverse backgrounds and foster collaborative learning.

A review of studies on education in the metaverse finds an overall positive impact. For a K–12 education setting, 19 of 21 surveyed studies report some positive findings for student learning; for a higher education setting, 21 of 25 studies report a positive impact on students' learning outcomes (Pellas et al (2021)). Some of the positive effects these studies find include improved learning outcomes and achievements; increased motivation, self-efficacy and engagement for knowledge

acquisition; and enhanced interaction and collaboration in several learning tasks (Tili et al (2022)).

Still, there are drawbacks that could be detrimental for learning and could expand educational inequalities. Some studies on the use of VR technology in the classroom find that it overloaded and distracted students. Glitches in the system or low-quality rendering discouraged students, while the equipment caused physical discomfort or dizziness in others (Chang et al (2020)). The high cost of VR and AR and the lack of standardisation in content and distribution could exclude low-income households from these opportunities and widen the educational gap. One study finds that during the pandemic, students from low-income households that lacked internet or a dedicated space for studying learned only 67% as much math and 87% as much reading as their peers – equivalent to a loss of learning of three months in math and one and a half months in reading (Nextrope (2022)).

So far, expectations on benefits to education have not materialised. For instance, Zoom revenues have remained relatively stable after the pandemic, which has resulted in a decline in the value of Zoom's stock price. Indeed, a lower stock price might imply that investors do not expect any kind of future advancement in virtual learning, at least in the near future.[2]

It is important to stress that the educational opportunities of the metaverse can reach full potential only if the virtual and real world meld in ways that preserve real teacher-student and student-student social relationships (UNICEF (2023)). The pandemic increased the demand for virtual learning, but it was also a lesson on what happens when students learn in isolation without physical human interaction. While there are opportunities, it is unlikely all learners would be able to benefit from them in practice.

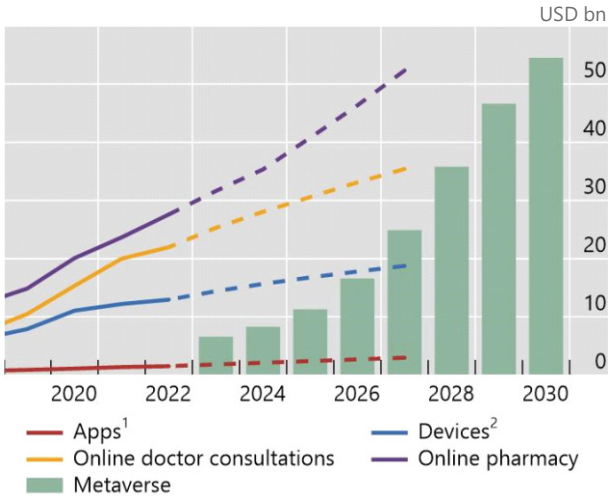
3.3 Healthcare

The global healthcare industry consists of medical care, diagnostics, pharmaceuticals, health insurance and a number of related products and services. The Covid-19 pandemic accelerated the digital transformation of the healthcare industry. There were broadly four areas of digital applications that helped to combat the pandemic: telemedicine, flow modelling, location tracking and contact tracing (Cantú et al (2020)). The momentum of the digital health sector continued after the pandemic as users increased their trust in online medical consultations and the use of online pharmacies. One source (Statista (2023)) expects revenue from these two segments of digital healthcare to rise from US$ 30 billion to US$ 50 billion, and from US$ 25 billion to US$ 35 billion, respectively, from 2022 to 2026 (Graph 7.A). In tandem, revenue from the health sector in the metaverse also rose. Metaverse healthcare revenue is expected to grow from US$ 5 billion in 2022 to more than US$ 50 billion by 2030. The revenue numbers include estimates on the penetration rate of the metaverse in health. By 2030 the penetration rate could reach a maximum of 7% of the population in some countries (Switzerland, Singapore, Sweden, Norway and Denmark), while for other countries the penetration rate could be less than 1% (Mexico, Russia, India and China) (Graph 7.B).

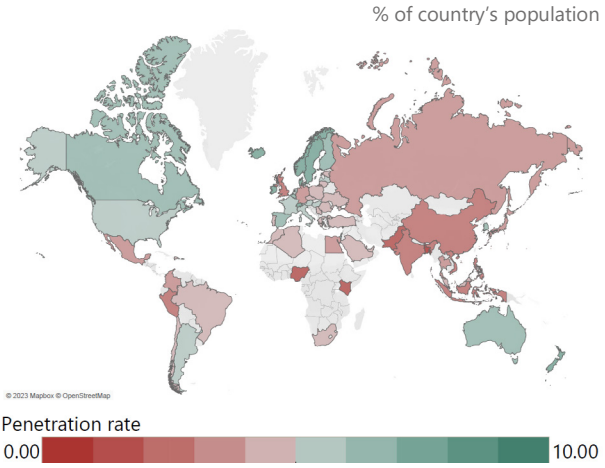
[2] See www.macrotrends.net/stocks/charts/ZM/zoom-videocommunications/revenue.

The metaverse could present opportunities for digital health Graph 7

A. Revenue in digital health is expected to rise



B. The penetration rate of the metaverse in healthcare in 2030 is expected to be highest in high-income countries



[1] Medication checker apps and contraception and fertility apps. [2] Blood pressure meters, fever meters, glucose meters and care phone/social alarms.

Source: Statista (2023).

The main area where the metaverse can have a significant impact is patient care. Here, such applications could in principle improve access, enhance diagnostics and expand methods of treatment (European Commission (2022)). First, the metaverse could break down physical barriers between patients and healthcare providers. Patients could visit doctors in virtual clinics in the metaverse, while temperature, vital signs and other information can be collected and reported through smart wearables. This could be especially helpful for people living in rural areas or those who have difficulties travelling (Petrigna and Musumeci (2022)). Another benefit of virtual clinics in the metaverse is that they eliminate the risk of infectious disease transmission between patients and medical personnel. Second, for diagnostics, doctors could seek virtual advice on the spot from other medical experts and improve their consultations (Bansal et al (2022)). Also, some features of the metaverse could help patients better understand their illness and recommended treatment. Doctors could combine elements of gamification and immersive experiences to explain complex concepts and provide virtual walkthroughs of procedures to patients. Patients would be more engaged in their treatment (Bhugaonkar et al (2022)). Finally, the metaverse could open new ways to provide treatment, rehabilitation and therapy. Through extended reality and remote-controlled devices, patients could receive physical, speech and psychological therapy. Some studies show that virtual reality exposure therapy (VRET) can help treat certain phobias and anxiety disorders (Slater et al (2020)).

Education and training for healthcare professionals is a second area that could benefit from the metaverse. Future doctors could train for surgeries using AR and VR technology in a virtual environment that is as realistic as the real world. For example, the Seoul National University Bundang Hospital trains medical staff in a smart operating room in the metaverse. In one exercise, more than 200 thoracic surgeons received training on lung cancer surgery. High-resolution VR cameras broadcast the surgery in 360 degrees while each doctor accessed the virtual environment through a VR headset (Koo (2021)). The same technologies can also improve surgery planning. In the metaverse doctors could create an optimal surgery design in 3D or visualise a

rendering of a patient's anatomy in real time. For example, one study finds that mixed-reality technology enhanced the spatial understanding of brain tumours compared with magnetic resonance imaging (MRI) and 3D models on a monitor (Fick et al (2023)).

The metaverse could also help in the administrative and operative functions of the healthcare sector. For example, practitioners can optimise clinical operations through digital workflow modelling. This requires building a "digital twin" of the clinical environment (eg radiology, emergency room, etc) that simulates everyday workflow using operational and sensor data. The virtual replica allows testing of different operational scenarios and layouts efficiently and quickly (Siemens Healthineers (2022)).

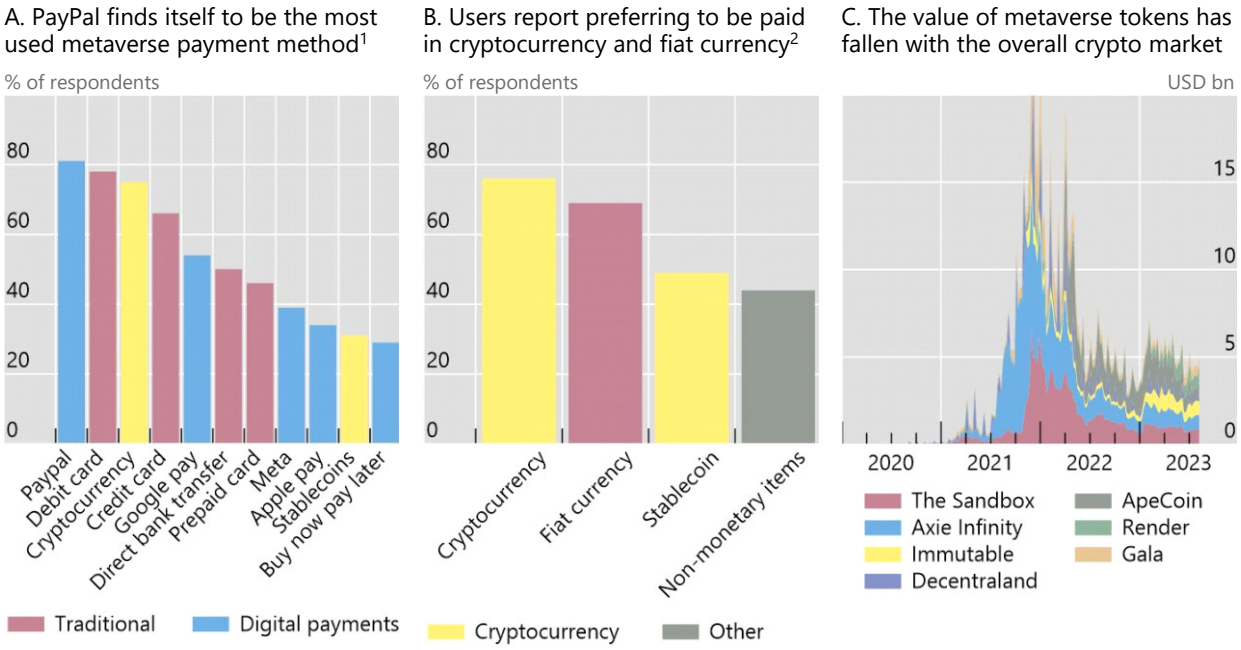
Still, the healthcare sector in the metaverse faces important challenges related to data privacy, information security, the high cost of the technology and adverse effects on health. Hardware used to generate a completely immersive experience in the metaverse collects detailed and intimate physical data on the user. These data could be a bountiful target for hackers. In 2022 there were 25 reported cyber attack incidents in the healthcare system in the United States, affecting 290 hospitals (Wang et al (2022)). This figure is very likely to be vastly underreported. The most significant was the ransomware attack targeting CommonSpirit Health – operating 150 hospitals – that compromised the personal data of 623,774 patients (Emsisoft (2023)). Other threats to data collected by wearables include tampering with the data, injecting false data, obtaining low-quality user-generated content, tracing ownership and breaching of intellectual property. The next challenge relates to the high costs of healthcare in the metaverse. Wearables are not cheap, the equipment used in all the applications of the metaverse in the healthcare sector described above is expensive, and even more expensive is the infrastructure required for the high end-to-end connectivity needed for its efficient operation. As in education, high costs might lead to only wealthy hospitals benefiting from the metaverse, widening the gap in healthcare services (Chengoden et al (2023)). Finally, the use of VR and AR technology could magnify psychological issues currently associated with watching too much television or playing videogames. These include social isolation, preference for virtual interactions, body neglect, persuasion, exposure to violence and lack of ground truth (Slater et al (2020)).

4. Payments in the metaverse

For metaverse applications to be commercially viable and to promote economic activity, payments are a crucial foundation. Existing metaverse applications already handle a wide variety of payment methods to purchase items directly or to transact in native utility or governance tokens (Graph 8.A). According to a survey of 10,000 metaverse users, commissioned by PayPal and fielded by Logica Research (Lau (2023)), users do not uniquely choose one payment method but pay in a wide variety of ways. The most commonly used means of payment in the existing metaverse is – perhaps predictably, given the study's sponsor – PayPal (over 80% of respondents). This is followed closely by debit cards (78%). Other traditional forms of payment are all commonly used according to the survey – credit cards (66%), direct bank transfers (50%) and prepaid cards (46%). These payment services can be used to buy metaverse tokens, or digital representations of value, in Roblox, Minecraft and Second Life. Those tokens, in turn, can be traded for tokenised goods and services (eg virtual

objects and clothes for avatars, services provided by other users). As virtual worlds grow, consumers may want to use their typical payment method out of convenience, which makes it important for these platforms to accept them. The survey's definition of the metaverse is broad and includes some videogames, but if we focus exclusively on blockchain-based metaverse applications, the top method of payment would be stablecoins and other cryptocurrencies. This includes Bitcoin and Ethereum, and utility and governance tokens in these platforms. The Sandbox's native token, SAND, can be traded on exchanges like Gemini, Crypto.com and Binance. Similarly, MANA, the token native to Decentraland, can be purchased on Coinbase, Kraken and others. Responses to the same survey indicate that a very high percentage of users of the metaverse consider it important to be able to use cryptocurrencies (89%) and stablecoins (84%) for purchases in the metaverse (PayPal (2023)). More than half of metaverse users expect their use of cryptocurrencies to increase in the next five years. Cryptocurrency is also the preferred choice to receive payment for work done in the metaverse (76% of respondents), followed closely by fiat currency (69%) (Graph 8.B).

The metaverse already accommodates different forms of payment — Graph 8



[1] Usage of payment methods in the metaverse to purchase items directly or purchase in-game/world currencies. [2] Answers to the question: "In which of the following forms do you get paid/want to get paid for the work you do in the metaverse?"

Sources: Lau (2023); CoinMarketCap.

More generally, the structure of payment systems in the metaverse depends on whether the model for the metaverse is centralised or decentralised.

In a centralised model of the metaverse, a central entity (eg a corporation) owns the rights to the platform and makes all final decisions. As such, this entity would make all decisions on how payments work in the platform. For example, a corporation may choose to open payment rails to payment service providers in the real world. Irrespective of whether the payment methods are centralised or not, the payment system in the platform would always be centralised and under the control of the system operator. In this case, if the virtual world in question has its own native token, then the benefit of a centralised system is that it can implement protocols to stabilise the value of such tokens (eg against a fiat currency), put limits on transactions and

clearly establish pricing rules for the marketplace. The obvious downside is that this can entail barriers to users wishing to transact on other platforms and various forms of rent-seeking behaviour through payment fees and control over transaction data.

Two examples of centralised metaverse tokens are Robux in Roblox and the Linden dollar in Second Life. Users can purchase Robux in the platform or earn Robux by selling clothes for avatars or building experiences. Users buy Robux in packages of fixed quantities at different prices, which means that the per unit price (or exchange rate) depends on the package bought (Graph 9.A). For the case of Linden dollars, residents of Second Life can purchase them directly in the platform. The Linden dollar has a flexible exchange rate that depends on supply and demand but has stayed closely around US$ 0.0031. However, transaction fees create a variable per unit price that depends on the quantity bought. To buy Linden dollars there is a 10% transaction fee (up to US$ 14.99), while to sell them there is a 5% transaction fee. The centralised nature of these immersive worlds gives power to their owners to prevent any kind of arbitrage in their platform.

The decentralised model of the metaverse is based on the idea of Web 3.0, or Web3. Web3 refers to a larger movement that seeks to decentralise the internet based on blockchain and open protocols (Edelman (2021)). The first wave (Web 1.0) spanned from roughly 1989 to 2004. This was characterised by a few large content creators and the majority of users as consumers of content. The current wave (Web 2.0) started in 2004 and is based on user-generated content shared on social media platforms (DiNucci (1999) and O'Reilly (2005)). Supporters of the idea of Web3 often note the potential for it to take back control of the internet from large firms (big techs), to decentralise wealth creation and to promote data privacy. Yet it is also, of course, a popular marketing term for VC investors and others seeking to commercialise new proposals. Notably, the idea of a decentralised internet is foreshadowed in Neal Stephenson's *The diamond age*. In the book, a new "media net" that does not allow transactions to be traced (or taxed) precipitates a breakdown in tax bases and ultimately in nation-states themselves.[3] Payments in a decentralised metaverse could work through blockchain technology. If the native token of these systems has as base protocol a token standard, for example ERC-20 from Ethereum, then the so-called currency is interoperable, standardised and consistent with the functionality of the native blockchain. Users in decentralised systems have some direct control over the rules of the platform. In some cases, this translates into voting rights directly in the system's policies.

Two examples of tokens in decentralised systems are MANA in Decentraland and SAND in the Sandbox. MANA is an ERC-20 fungible token and is available for purchase on many crypto platforms like Coinbase, Kraken, etc. The crypto-exchange platform is the intermediary that facilitates converting fiat currency into the cryptoasset, but it does not have total control over its value. In crypto-exchange platforms, users can connect different payment methods such as a bank account, debit card, PayPal or wire transfer. Users store the metaverse tokens in their crypto wallets and link the wallet to their metaverse account. In Decentraland, users need MANA to buy LAND, which is a non-fungible token representing a parcel of virtual space in that metaverse. There is cap on the amount of land plots (90,000), which contributes to a feeling of scarcity. SAND is also an ERC-20 fungible token available to purchase at different crypto-exchange platforms. However, the difference is that

[3] A colleague with a background in the crypto sector shared the anecdote that one senior executive did not want to fight tax evasion. In his words, "the whole point is to starve governments of tax revenue so that they wither and die".

SAND is also a governance token. The Sandbox has a "play-to-earn" model that allows users to be both creators and players simultaneously. SAND allows holders to participate in governance decisions on the platform using a decentralised autonomous organisation (DAO) structure. Users can exert voting rights on elements such as the platform roadmap, feature prioritisation, content and game creators, etc. The supply cap of SAND is 3 billion, but currently only 1 billion are in circulation. Just like other tokens in the crypto world, the market capitalisation of tokens used in the metaverse also showed a peak and a sharp decline in 2022 (Graph 8.C).

These systems might provide only an illusion of decentralisation. A study that analysed voting decisions in Decentraland finds that very few individuals effectively decided many governance proposals (Goldberg and Shar (2023)). In almost 27% of all polls, the most influential voter essentially decided the outcome, which was not necessarily in line with the consensus among the other voters.

Even more, users might be less interested in the decentralisation aspect of the metaverse and put more weight on simplicity and entertainment. A survey commissioned by blockchain entertainment provider Coda Labs shows that traditional gamers are more interested in playing an exciting game than in the "tokenomics" associated with many Web3 metaverse applications (Coda Labs (2022)). Lack of user interest is rooted in uncertainty about how this type of gaming would work, not having a crypto account or wallet set up, the likelihood of being scammed, the high costs of entry and it being too new or risky.

In general, whether centralised or decentralised, the native tokens in the metaverse do not satisfy the conditions to be considered currencies. An analysis of the price of these tokens shows that they are characterised by a continuous emergence of bubbles, with a volatility that is far higher than traditional fiat currencies or even the tokens used in gaming (Vidal-Tomás (2022)) (Graph 9.A). This implies that they cannot be used as means of payment or medium of exchange as done with traditional fiat currencies. Instead, like other cryptocurrencies, they are more akin to speculative assets. The very nature of the decentralised metaverse gives rise to speculation. First, anyone can buy the native tokens from cryptocurrency exchanges – even those who are not interested in the growth and development of the virtual world. Second, there is no central authority or central bank that can guarantee the stability of the exchange rate or serve as lender of last resort or liquidity provider. Both characteristics benefit speculators' activity (Vidal-Tomás (2023)).

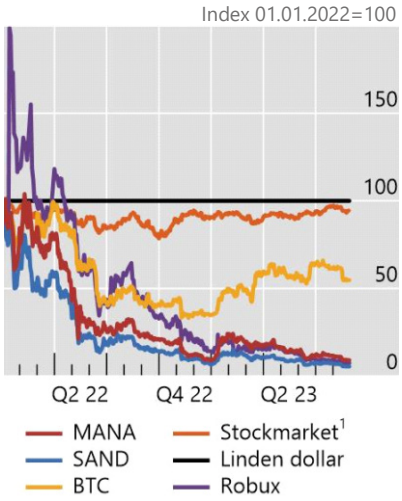
Stablecoins could be a more plausible means of payment in the metaverse, but they too pose risks. While stablecoins have been touted as a solution to the volatile behaviour of cryptoassets, they have often struggled to maintain their peg in practice (Kosse et al (2023)). Many of them are issued by central intermediaries. If one of the major stablecoins, like Tether or USDC, became a medium of exchange in the Web3 metaverse, this could lead to a situation where the stablecoin issuer acts as a kind of dominant (not to say central) bank in the virtual world. This could pose risks to the system, as some stablecoins are prone to bank runs and collapse (CGDFS (2023) and Briola et al (2023)).

NFTs are emerging as a popular asset in the decentralised metaverse because they provide proof of ownership of products and property bought in the platform. NFTs are not exclusive to the metaverse. People buy NFTs of videos, pictures, tweets and real and financial assets in external NFT marketplaces.[4] NFTs for metaverse items

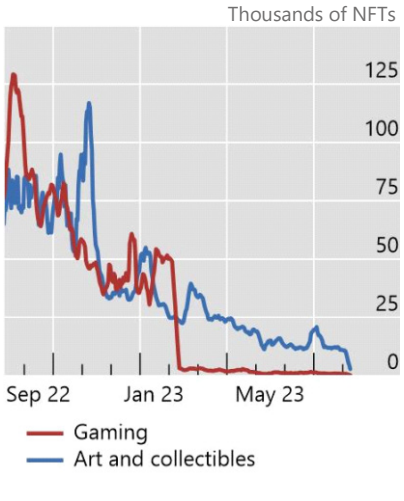
[4] In practice, tokenising such real and financial assets can be very difficult, given informational frictions (eg asymmetries in knowledge about assets), legal challenges (eg enforcing contracts) and technical

As crypto tokens and NFTs fall, other contenders for payments arise Graph 9

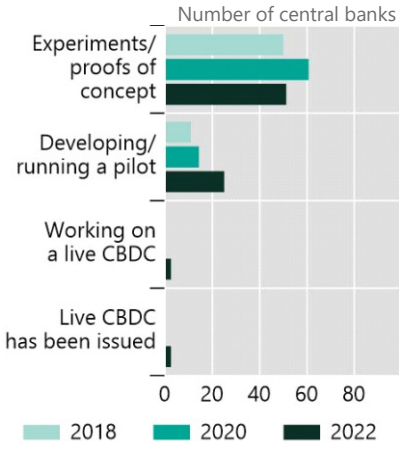
A. Prices of decentralised metaverse tokens are highly volatile



B. Number of NFT sales has dropped off



C. Central banks are making headway on CBDC projects



1 Dow Jones Industrial Average.

Sources: CoinMarketCap; Coin Metrics; NonFungible.com. Kosse and Mattei (2023).

can also be listed on external NFT marketplaces. For example, marketplaces like Open Sea or Rarible already support the sale of virtual real estate and items from Decentraland and the Sandbox. NFTs lived through the same hype cycle as the broader crypto market and the number of sales has gone off a cliff since 2022 (Graph 9.B). Still, more research needs to be carried out to understand what drives their price and how it correlates with other markets. Empirical analysis finds NFT pricing to be quite distinct from the pricing of other cryptoassets in terms of volatility and price transmission (Dowling (2022b)). The analysis finds little spillover between NFT markets. This is unlike cryptoassets and stock markets, which tend to have high spillover effects among their individual markets.

Centralised (commercial) payment platforms and cryptocurrencies are not the only options for payments in the metaverse. If metaverse applications were to take off, payments could also occur through other means. The key requirements from a user perspective are that payments can happen quickly (ideally in real time) and ideally in a secure and seamless manner across borders (given the borderless nature of virtual worlds). Aside from speculative motives, users would generally want the currency used in such transactions to be stable against their income, expenses, and financial assets and liabilities in the real world.

In this light, the future holds a number of further possibilities for payments in the metaverse. One option is tokenised deposits, or digital representations of commercial bank deposits in a programmable platform (BIS (2023a)). By allowing for real-time, automated payments that can be made contingent on certain actions (eg transfer of virtual property in the metaverse, completion of specified tasks), tokenised deposits could play a role in facilitating virtual exchange. Another option are central bank digital currencies (CBDCs), which are a digital payment instrument, denominated in the national unit of account, that is a direct liability of the central bank. CBDCs, too, could be designed to facilitate requests for payment and proof of payment in a

challenges (eg "ramps" toward the real world and links with existing ledgers). For a discussion, see Aldasoro et al (2023).

domestic or cross-border setting, thus supporting metaverse services. CBDCs are increasingly relevant as a financial policy and plumbing question. BIS surveys have found that more central banks are exploring the design of CBDCs and more pilots are going live (Graph 9.C). Retail CBDCs would be directly accessible by households and businesses, potentially with banks and non-bank digital wallet providers providing retail services (Auer et al (forthcoming)). Wholesale CBDCs, whose use is confined to financial institutions, could form a basis to support tokenised deposits and the tokenisation of real and financial assets. They could potentially support cross-border transactions through multi-CBDC arrangements (BIS (2023a)).

Indeed, it is in the cross-border dimension that these applications may be particularly important for the metaverse, as users are likely based in multiple jurisdictions. Multi-CBDC arrangements could allow for much faster and cheaper payments between the fiat currencies of different users, improving on today's correspondent banking system. For example, Project mBridge, a pilot between the central banks of China, Hong Kong, Thailand and the United Arab Emirates with the BIS Innovation Hub, uses a permissioned distributed ledger technology (DLT) platform for various use cases, starting with cross-border payments for international trade (BIS (2022)). The project demonstrates the feasibility and promise of a shared platform for multi-currency cross-border payments and helped central banks to identify policy, legal and regulatory considerations. Another example is Project Icebreaker, a collaboration between the Bank of Israel, Norges Bank, Sveriges Riksbank and the BIS Innovation Hub. This project tests the technical feasibility of conducting cross-border and cross-currency transactions between different DLT-linked CBDC proofs of concept. The aim is to gain a deeper understanding of the technologies used, as well as to identify the key technical and policy choices and trade-offs that central banks would need to consider in designing CBDC implementations that facilitate cross-border payments (BIS (2023c)).

Cross-border payments can also be promoted by linking domestic fast payment systems (FPS). In many countries, FPS have helped to dramatically speed up domestic transactions, lower costs and enhance financial inclusion (CPMI (2021)). One striking example is the Pix instant payment system in Brazil, launched in November 2020. Pix offers free peer-to-peer payments and dramatically cheaper payments for merchants through a simple mobile interface where the user needs only a phone number, quick response (QR) code or other key. Within its first year, Pix was quickly adopted by two-thirds of the country's adult population (Duarte et al (2022)). Similarly successful systems are in place in jurisdictions like Costa Rica, the euro area, India, Malaysia, Singapore and Switzerland – some operated by the central bank and others by private actors, often with an important role for the central bank as overseer or catalyst. As more countries implement FPS, the potential to link the systems together grows. In this light, Project Nexus is a blueprint to connect multiple instant payment systems, most recently involving the Eurosystem, the central banks of Malaysia and Singapore and the BIS Innovation Hub. It aims to enable cross-border payments from sender to recipient across borders in less than 60 seconds (BIS (2023b)).

These infrastructures could meet the needs of payments for applications in the metaverse. They could allow seamless, fast and secure transactions on a 24/7 ("always-on") basis across different jurisdictions. New features like programmability could allow for contingent payments and the tokenisation of real and financial assets, including virtual property in the metaverse. A unification of ledgers could allow for large efficiency gains. Many of these features would not be immediately noticeable to end users, whose goal may simply be to pay and be paid in the applications for goods and services that they use or provide. Still, by promoting interoperability and

eliminating barriers between assets in various, fragmented environments, these payment platforms could act as a gateway to different applications. They would thus serve as an important infrastructure function for a broader virtual economy.

5. Implications for the digital economy and public policy

The aim of many metaverse applications is to achieve a shift in the way economic activities – particularly services – are perceived, executed and monetised in both real and virtual environments. Despite the hyperbolic claims of metaverse promoters, there are open questions around the technology and how widely adopted the applications will be. Without taking a stance on this debate, or making predictions of our own, we identify at least three economic implications of the potential use of the metaverse for economic services in the future. Of course, many implications depend on the sectors in which such applications are adopted, who designs and controls the virtual environments, and which incentives they face in doing so.

A first potential implication of services in the metaverse is a blurring of lines between the tradable and non-tradable sectors of the economy. In the real world, tradables are goods that can be easily bought and sold over geographic distance and are thus subject to the law of one price. Physical commodities like oil and financial assets like stock shares can be transacted in efficient, integrated markets and are thus subject to price arbitrage. Non-tradables, which are generally understood to include real estate and services, cannot be transported and may have very different prices in different locations. Information technology has already increased the degree of tradability of non-tradables, such as education. By allowing for realistic interaction between users in geographically distant locations, the metaverse could accelerate this process. Similarly, it may allow for new types of (virtual) goods and services to become important, such as virtual experiences, entertainment content and digital art.

Second, and relatedly, the borderless nature of the metaverse could in principle facilitate greater international economic integration. This could drive a more efficient allocation of resources across borders. Geographic barriers that prevented exchange in services across countries may fade, allowing for providers in one jurisdiction (eg educational institutions, music and language teachers, healthcare providers, financial and tax advisors) to more easily offer services to clients elsewhere. While many current applications focus on gaming, we have discussed the applications in education and healthcare, which could in principle offer great promise. For example, users could take a class at a prestigious university without physically attending or have a consultation with a top specialist without having to fly to their country. This increased flexibility could lead to better utilisation of resources, boosting overall economic productivity.[5]

As a corollary, labour dynamics could be transformed. If the metaverse grows, so too could the demand for labour, potentially for very different types of jobs (eg virtual object designers, virtual event planners). And as more users are connected in different places around the world, the available supply of labour may also rise. Candidates would be able to apply for roles in the metaverse irrespective of location. One of the

[5] This could have further implications that are currently difficult to foresee. For instance, as boundaries blur, industries that were previously unrelated may start to compete or collaborate in innovative ways. This can reshape market dynamics, as firms from diverse sectors compete for consumers' attention and resources. Traditional market definitions and competitive strategies could undergo a transformation, influencing the overall structure of industries.

benefits of globalisation has been a reduction in cost as industries moved their production lines to countries with cheaper labour. With the metaverse, this could expand to more sectors. Yet as already seen in many applications (eg Roblox, Axie Infinity), the ability of users to market their labour and their creations may also promote more project-based or "gig"-type working relationships. These relationships may resemble informal labour arrangements in emerging market and developing economies, yet they may also become more common in advanced economies.

This hints at one further aspect of this integration: a greater difficulty in enforcing (domestic) laws and regulations in purely virtual environments. For instance, when two users (one from the United States, one from Vietnam) agree on a contract for services in a purely virtual environment, which jurisdiction will this relationship fall under? While legal frameworks currently have provisions for cross-border services, these may not be widely known to the (retail) users who are likely to transact in the metaverse. Moreover, will authorities have the resources and capacity to monitor compliance with existing regulations for different sectors? Can they enforce labour laws and the range of other rules designed for the real world?

Third, services in the metaverse could lead to new demands on payment services, including a surge in demand for real-time and cross-border transactions. As discussed in the previous section, there are competing candidates to fulfil this demand, including traditional payment cards, new digital payment providers, cryptocurrencies, CBDCs and (interlinked) FPS. If the metaverse becomes macroeconomically relevant, the payment instruments that win in this competition may see a substantial boost in their overall adoption. This could influence their use in the real world too. In this light, central banks and financial regulators may have an interest in better understanding and influencing the choice of payment instruments in the metaverse. To prevent virtual environments and money from becoming fragmented and dominated by powerful private firms, authorities may wish to reinforce efforts to promote more efficient, interoperable payments that can fulfil user demands. At a minimum, and regardless of which payment instruments are used, authorities will need to ensure compliance with anti-money laundering and combating the financing of terrorism regulations in order to safeguard market integrity.

Beyond these three implications, there are important questions for public policy around who designs new metaverse applications and to what end.

To date, the largest investors in VR, AR and metaverse applications are large firms (big techs) and VC investors, whose primary motives are commercial.[6] While commercial motives are often a strong and important driver of innovation (Janeway (2018)), there are well-known concerns when new technologies exhibit large network effects. In these cases, private actors may have strong incentives to create proprietary applications and to prevent these applications from being interoperable with those of competitors. They may also work to monetise the personal data of users. And indeed, the immersive nature of VR raises the stakes with respect to online privacy. The combination of transactions, biometric data, readings from wearables and more could result in exceptionally invasive data collection and profiling by private entities. While promoters of a decentralised metaverse generally share concerns about these risks, it is not clear that the blockchain-based alternatives that they are putting

[6] For instance, big techs may hope to have closed loop systems where they can take a large cut of digital property sales or sell software licences. Venture capital investors hope to invest in the next high-value firm that provides core infrastructure or services. Consultants hope to make fees off of companies finding their spot in the metaverse. Investment banks hope to have a means of increasing their core business.

forward (many of which rely on speculation in various tokens) would do a better job at promoting competitive markets or protecting data privacy.

In this context, a number of observers have argued for industry-wide or public policy initiatives to set governance frameworks and standards for the metaverse (see eg Ball (2022), Singh (2023) and Yin et al (2023)). Some commentators make comparisons with the governance frameworks underlying the internet, which include common protocols around visual presentation, file loading, graphics and data exchange. In the metaverse, a key task is to establish open standards and protocols that will gradually foster interoperability among platforms. This entails standardised message and file formats for seamless data exchange and the transfer of goods across various metaverse environments. For other commentators, the burden is clearly on public policymakers and regulators, who are called upon to define rules encompassing data privacy, consumer protection and ownership rights, which are important given the virtual property prevalent in the metaverse. In either case, it is argued that such initiatives have to take place early on to have an influence on the course of innovation in the space.

For public authorities, it is naturally difficult to define clear rules prior to the maturation of the technologies and applications of private users in the metaverse. If such applications grow and become widely adopted, there will doubtless be ample debate about the appropriate policy approach. As in the cryptocurrency and DLT space, this debate may be strongly influenced by the ideological considerations of the commentators, including anarcho-libertarian actors who are highly sceptical of any role for public policy or regulation. Yet in cases where risks clearly materialise and result in consumer harm, it is likely that the general public and governments will push for regulatory interventions to prevent the recurrence of such harm in the future.

In this light, early engagement by authorities may be worthwhile. Because public sector actors are following public policy mandates defined by their respective societies, they face very different incentives than the big techs, VC investors and other actors that dominate the space. By engaging early on, learning about the technologies and applications and espousing principles for open, competitive and compliant applications, public sector actors could promote superior market outcomes than if they took a purely laissez-faire approach in which they are absent from the debates and developments. Applications of existing rules and regulatory principles could set a foundation for responsible innovation, which could pay off even when there is uncertainty over the ultimate direction of technological innovations.

6. Conclusions

Immersive virtual environments are still far removed from the full potential envisaged by many, and it is not a foregone conclusion that the metaverse will achieve widespread adoption. Yet above the din of hyperbolic (and often commercially motivated) claims, it is possible to make out the sounds of some quite useful potential applications of the underlying technology. As we have argued, some use cases (eg gaming, education, healthcare) could show promise in addressing real needs of households and businesses.

If these use cases are widely adopted, this could have some important implications for the digital economy. These include: (i) a blurring of lines between tradables and non-tradables; (ii) greater cross-border economic integration (with

implications for efficiency, labour markets and regulation); and (iii) new demands on payment services, for instance that they be fast, programmable and cross-border. While many promoters of metaverse applications propose a role for cryptocurrencies and other tokens, retail FPS, CBDCs or tokenised deposits could play the same role. As public authorities consider which of these instruments will be most widely used, they must also consider the direction in which metaverse applications develop, the actors driving this progress and their incentives. Principles around competition, interoperability, consumer protection and data privacy may be particularly important if such new virtual worlds are to arise.

There is still ample room for further research in this area. For economists, this includes understanding new forms of exchange and new market and business models that may or may not resemble services currently performed in the real world. For computer scientists, substantial work is to be done to understand technology choices and their impact on user outcomes, (cyber)security, scalability and more. For legal scholars, there is scope to consider how regulatory compliance, civil disputes, property rights and more will be arranged in a virtual world that goes beyond the boundaries of national jurisdictions. For sociologists and communications scholars, there are important questions about the societal processes and narratives that accompany such technology developments. And the fact that the metaverse has its origins in science fiction means that there is likely work for literary critics to compare real-world developments with their origins in creative writing.

As visions of the metaverse have captured the imaginations of many, there is thus considerable work to shape whether and how these visions turn out in (virtual) reality.

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Glossary

Avatar – in the metaverse, a representation of a user from the real world, whom it mimics. Etymologically, the word comes from the Sanskrit word for "descent", referring to deities descending to Earth and taking on human form.

Augmented reality (AR) – a technology that overlays a view of the actual world with digitally generated real-time sound and vision. The user usually views the combined actual and digital content through a handheld device, a VR headset or smart glasses.

Bandwidth – a measure of how much data can be transmitted over a specified period of time.

Blockchain – a permissionless distributed ledger in which details of transactions are held in the ledger in the form of blocks of information.

Central bank digital currency – a digital payment instrument, denominated in the national unit of account, that is a direct liability of the central bank.

Cryptocurrency – a type of private sector digital asset that depends primarily on cryptography and distributed ledger or similar technology.

Digital wallet – an interface that allows users to make transfers or otherwise transact in digital money and assets.

Distributed ledger technology (DLT) – a means of saving information through a distributed ledger, ie a repeated digital copy of data available at multiple locations.

Latency – the time it takes a data signal to travel from one point on the internet to another and back.

Non-fungible tokens (NFTs) – unique cryptographic tokens that exist on a blockchain and cannot be replicated. They are used to represent ownership of eg artwork, real estate or other assets.

The metaverse – an interconnected virtual world or space that is characterised by the enablement of social interaction and value distribution and a certain degree of immersion. The term is a combination of the Greek word "meta" (meaning beyond or transcending) and the stem "verse" from "universe".

Tokenisation – the process of recording claims on real or financial assets that exist on a traditional ledger onto a programmable platform.

Tokenised deposit – a digital representation of a bank deposit in a programmable platform. A tokenised deposit represents a claim on a commercial bank, just like a regular deposit.

Virtual reality (VR) – hardware and software that create an artificial environment that looks and sounds real. VR simulates parallel or fictitious three-dimensional surroundings, often using a VR headset or smart glasses, speakers or headphones and a hand controller for navigation and haptic feedback.

Web3 – a loosely defined set of initiatives around a "third stage" in the development of the world wide web. Backers claim it will create a more secure, transparent and open internet that enables direct interactions between users and their peers without intermediaries.

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