Unreal Estate

Metaverse, extended reality and
the future of our physical world

pi labs

Acknowledgements

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Metaverse, extended reality and the future of our physical world

Mostly confined to cyberpunk and tech forums prior to 2021, the 'metaverse' has since experienced breakout attention and entered the common vernacular. Boasting a growing suite of extended reality hardware, game-like virtual worlds, a whole new asset class and the attention of the world's most influential billionaires, the metaverse looks like more than a passing fad. Will it achieve its promise of a fairer, more efficient and immersive experience of the internet or simply replicate the business-as-usual we have come to learn from big tech? What will all of this mean for the real estate sector which has been defined through the provision of physical space?

Questions or feedback?

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The metaverse..?

Much like the term 'cyberspace', 'metaverse' is said to have originated in science fiction. Neal Stephenson's 1992 cyberpunk novel Snow Crash is regularly cited for originating the phrase, but Google Trends data shows most usage of the term has occurred since the fourth quarter of 2021—nearly two decades since it was introduced.

Much like the term 'cyberspace', 'metaverse' is said to have originated in science fiction. Neal Stephenson's 1992 cyberpunk novel Snow Crash is regularly cited for originating the phrase, but Google Trends data shows most usage of the term has occurred since the fourth quarter of 2021—nearly two decades since it was introduced. By no coincidence, this is when Facebook Founder and CEO Mark Zuckerberg announced a rebranding to 'Meta'—reflecting his vision for the future of online social interactions.[1] As such a recently popularised term, it's little surprise there are different views about what the metaverse is. We've seen this before with motor vehicles, computers, television components and many other innovations.[2]

Many viewpoints characterise the metaverse as the user interface for 'Web3', similar to how smartphone apps and web browsers served as user interfaces for 'Web2'. However, definitions start to diverge on how all-encompassing the term 'metaverse' really is. Some, for example, draw parallels between the metaverse and virtual worlds such as Sim City, Second Life, Roblox, Fortnite and Minecraft. Others emphasise the role of blockchain, cryptocurrencies, non-fungible tokens (NFTs), virtual land, platform interoperability and ownership of your online assets. The contents of this White Paper will no doubt displease a number of vested interests. Nevertheless, we have focused less on attempts to define the metaverse and more on the innovations in extended reality and virtual space that symbolise a disruption to the way we use and interact with our physical spaces.

TERMINOLOGY

Meta = Beyond
Verse = (Uni)verse

Figure 1: 'What is metaverse' online search interest
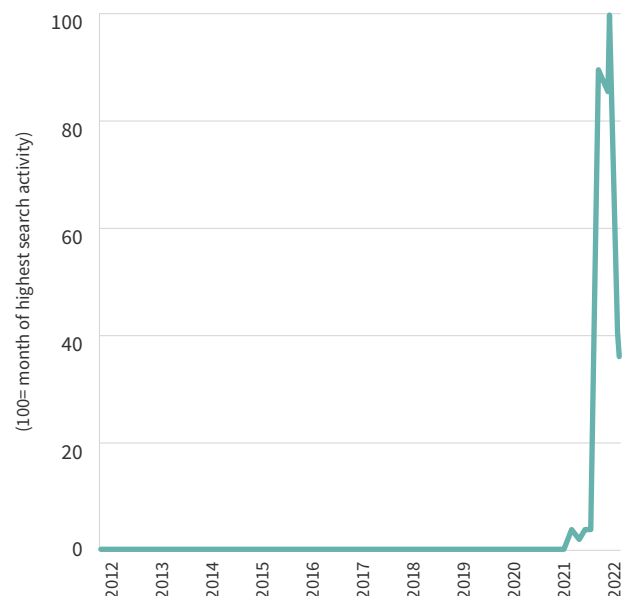
Figure 1: Google Trends

THE METAVERSE

Is it anything more than hype..?

According to Bloomberg, 'metaverse' was mentioned once in their sampling of company earnings reports in Q2 2020, four times in Q3 2020, nine times in Q4 2020, 37 times in Q1 2021, 100 times in Q2 2021 and 449 times in Q3 2021.[3,4] Crunchbase data also shows a surge in the use of the word among start-ups, with 221 companies founded in 2021 containing 'metaverse' in their descriptions—a nearly-threefold increase from 2020 (see Figure 2).[5] There appears to be at least one notable incentive for companies to mention the metaverse as much as possible—with commentators highlighting the 30% share price hike of a beleaguered gaming developer after announcing an 'NFT game'.[6] Experts in extended reality also gesture to the low user counts on some of the most hyped metaverse platforms (see Table 3 on page 33).

Although this paper will share insights which suggest the metaverse is in the throes of a speculative hype cycle, there also seems to be a sizeable amount of smart money going into long-term metaverse projects. In early 2022, Microsoft announced their $68.7 billion acquisition of Activision Blizzard—but not solely to expand their gaming enterprise,

as the metaverse also featured heavily as a motivator of this deal.[7] Apple is rumoured to have approximately 2,000 staff dedicated to their XR hardware project—with wide speculation that a device will be launched in 2022 or 2023.[8] Alongside their name change, Meta is also going big on the metaverse financially, expecting to invest upwards of $10 billion on development each year as they work toward their goal of '[helping] the metaverse reach a billion people and hundreds of billions of dollars of digital commerce this decade'.[9] Examples of developments in their pipeline include haptic gloves for improved sensory immersion, avatars which reflect a user's real-life expressions, as well as VR headsets for immersive work.[10]

In August 2021, Nasdaq and Yewno launched the NYMETA index to track metaverse-themed companies which meet certain patent criteria and have a market capitalisation of $500 million or more.[11] The index comprises listed companies such as Nvidia, Shopify, Apple, Roblox, Electronic Arts and others.[12] In addition, a recent forecast expects the sector to grow from a $61.8 billion industry in 2022 to $426.9 billion by 2027.[13]

Figure 2: Companies with 'metaverse' in Crunchbase descriptions

(by year founded)
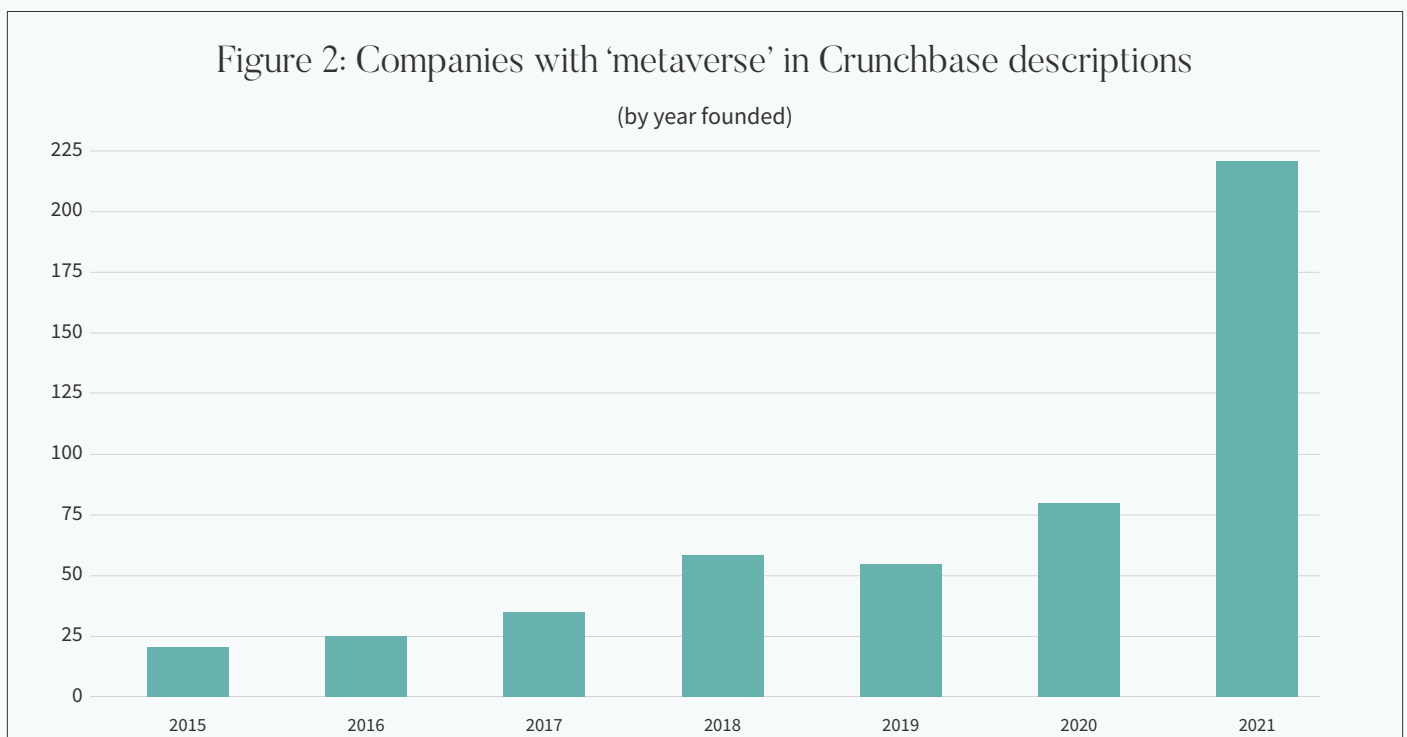
Figure 2: Crunchbase, 2022

THE METAVERSE

Will it stick?

With such a short runway since the metaverse has reached mainstream discourse, and with ongoing debates as to what the metaverse actually is, it also appears that much of the consumer demand for the metaverse is inchoate.[14] In other words, consumers have a number of pain points which can be addressed by the metaverse, but they aren't necessarily asking for specific products to solve those pain points just yet. With virtual work, for example, CEOs are struggling to call staff back to their workplaces following COVID-19 lockdowns due to concerns around collaboration, innovation and productivity, but immersive virtual workplaces are yet to be explored as potential middle ground.[15,16]

In the meantime, it appears that gaming is the driving force of the metaverse—with gaming-focused virtual worlds such as Roblox, Minecraft, Sandbox, Otherside and a list of others making significant in-roads with commercial partnerships, user stickiness, and/or virtual land sales. Approximately 60% of Roblox's user base belongs to Generation Z (those born between 1997 and 2012).[17,18] Another 25% were born after 2012. It is often argued that these cohorts will drive metaverse adoption, due in large part to their growing up with its Web2 predecessors. This is an interesting argument. Can we really say that the habits or interests of a 10-year-old can be extrapolated to adulthood? In such a scenario, shouldn't Millennials still be collecting Tazos and Pokémon cards? This may turn out to be a false equivalency.

According to a recent survey, nearly half of Generation Z respondents reported feeling more like themselves online than offline. What's more, the sampling of early-to-mid adulthood Millennials reported a similar result, suggesting that Generation Z may not simply 'grow out of it' (see Figure 3).[19] Mark Zuckerberg's view that a large portion of our lives is already spent online raises the question: does the metaverse really represent that much of a behavioural shift from what we're already doing?[20]

Figure 3: Responses to: 'Where do you feel most like yourself?' (by generation)
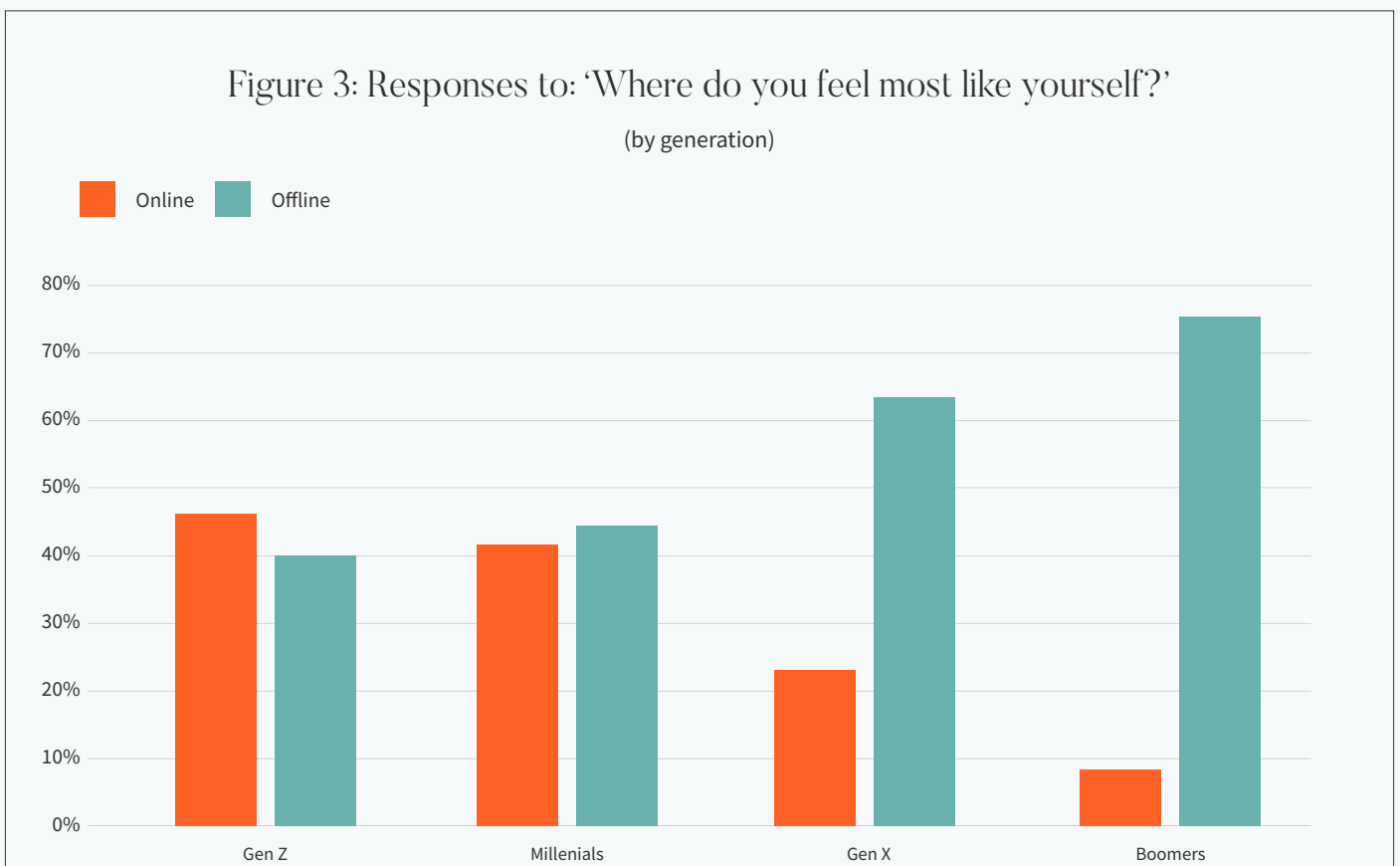
Figure 3: The New Consumer, Toluna 2022

THE METAVERSE

Motivations for metaverse adoption

Concerns about the impact of technology adoption and social movements on younger generations span the ages. Quotes have been attributed to Greek philosophers such as Hesiod and Plato on their concern for the recklessness of youth, and history is littered with revolutionary innovations feared to have negative effects on memory and social order (the printing press); the retention of limbs (trains); intimate conversations (radio); patterns of family interaction (television); violence (video games); and mental health (social media).[21,22,23] Although these fears turned out to have varying levels of justification in hindsight, the addictive nature of some of these more recent innovations has been a topic of growing intrigue. This sheds some light on what we might expect to see from metaverse developers as they vie for our attention and return patronage, particularly since key focuses of metaverse developers are (i) gamified experiences, and (ii) social experiences—which appear to drive the next iteration in the evolution of online gaming and social media.

Aside from addiction, motivations for metaverse adoption can also be framed through the lens of 'toward' and 'away-from' motivators. This framework speaks to the inclination for humans to take action toward a desired outcome or away from an undesired outcome. If you ponder it for a moment, you will recall some instances of toward and away-from motivation in advertising. Take air freshener for example. A homeowner might be motivated toward a fresh smelling home, or away from the potential embarrassment of guests exposed to a less fragrant experience. In the context of the metaverse and associated innovations, a would-be adopter of virtual workspaces might be motivated toward a more productive remote working arrangement or away from their arduous daily commute (or both). A would-be adopter of virtual healthcare might be motivated toward a wider variety of healthcare professionals available online or away from queues at the GP's office (or both). This framing will not only vary from one application to the next, but also from one person to the next. With proponents of the metaverse expecting the percentage of the internet enabled by real-time 3D software to increase from 2% to 50% in a decade,[24] we should expect to see toward and away-from motivators playing a central role in identifying and addressing the low hanging fruit of metaverse use cases—eventually leading to mass adoption.

THE METAVERSE

The real estate perspective

Metaverse expertise among real estate professionals

Although the metaverse is a term that only entered popular vernacular in 2021, the real estate sector has been engaged in related undertakings (virtual reality and blockchain, for example) for years. Examples include various attempts at asset tokenisation through blockchain technology; virtual tours of built and yet-to-be-built spaces; interior design applications such as IKEA Place; and many others. Nevertheless, when Bright Spaces CEO and Co-Founder Bogdan Nicoară polled his LinkedIn network to gather perspectives on the question 'Is real estate ready for the metaverse?' 52% of 58 respondents suggested 'no' and 22% were 'not sure'.[25] Soon after, in May 2022, CBRE polled their LinkedIn audience on whether their companies were developing a metaverse strategy. Of the 290 respondents, 18% responded 'yes', 49% responded 'no', 26% responded 'I don't know' and 8% responded 'we don't need to'.[26] When we canvassed the perspectives of 151 real estate executives and technologists in the course of this research, attitudes toward the metaverse ranged from 'oh my god, somebody's just found a new boy band' scepticism to existential concerns for the viability of commercial real estate in a virtually immersed future. When it comes to the self-assessed expertise of mid-to-late-career real estate professionals, however, just 15.9% report any expertise beyond 'I follow the headlines' (see Figure 4).

Figure 4: Responses to: 'What is your level of expertise in the metaverse?'

(mid-to-late-career real estate professionals, n=151)
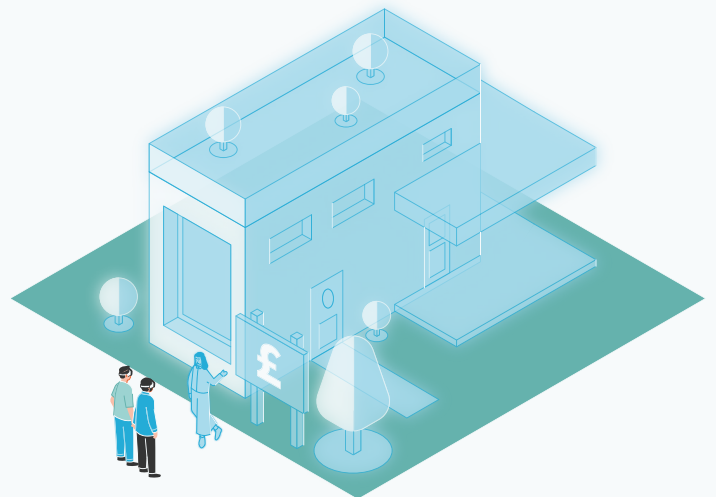
Figure 4: Pi Labs, 2022

THE METAVERSE

Impact of metaverse and other issues

Respondents to our survey were asked what impact they expected certain issues to have on the real estate sector in the coming zero-to-four years. The issues presented included inflation, interest rates, the availability of labour, online communication mediums (such as Zoom and Microsoft Teams), as well as the metaverse. The majority of responses to questions concerning the economy (inflation, interest rates and availability of labour) were as expected, with 81.4%, 74.2% and 78.8% of respondents giving a negative or extremely negative response respectively. When the same question was asked about online communication mediums and the metaverse, however, responses skewed in the opposite direction. 76.2% of respondents expected a positive or extremely positive impact of online communication mediums on the real estate sector in the coming zero-to-four years, but, the majority of respondents (53.6%) expect the metaverse to have no impact (see Figure 5). Interestingly, more of the remaining minority expected a positive impact.

"

...the majority of respondents (53.6%) expect the metaverse to have no impact on the real estate sector in the coming zero-to-four years.

"

Figure 5: Responses to: 'What impact do you expect [issue] to have on the real estate sector in the coming 0-4 years?'

(mid-to-late-career real estate professionals, n=151)
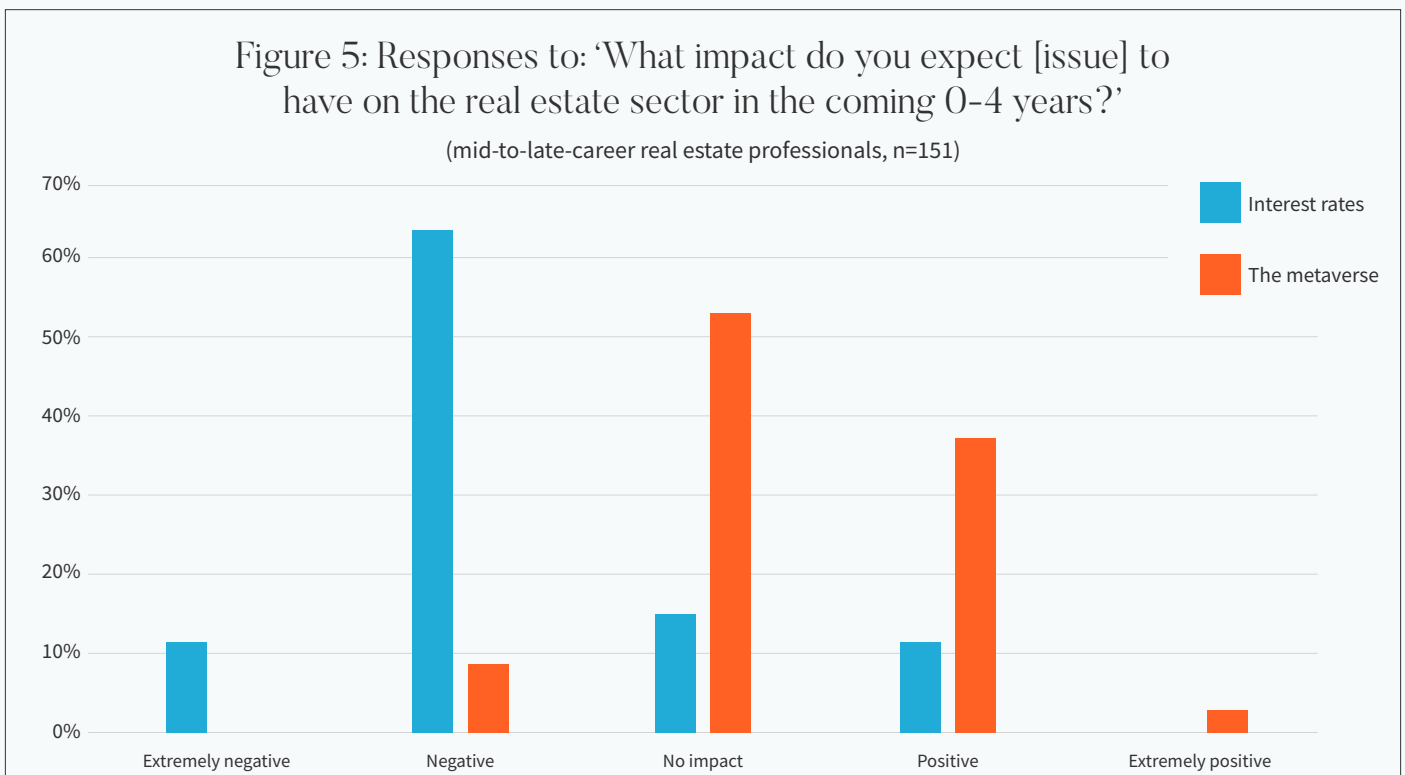
Figure 5: Pi Labs, 2022

THE METAVERSE

Gap between expectations and actions

Although 37.9% of respondents reported a positive expectation of the metaverse's impact on the real estate sector in the coming zero-to-four years and 6.6% expected a negative impact, just 21.9% reported their organisation taking any action on the metaverse (either forming a strategy, yet to execute a strategy or actively participating in the metaverse—see Figure 6). This suggests a gap between expectations and actions—46.3% of respondents expect an impact (whether positive or negative), but only 21.9% have taken action. Respondents were not asked about this, but we hypothesise that possible reasons include a lack of internal capabilities and/or difficulty in seeking credible and unbiased advice on the metaverse, or the prioritisation of more urgent concerns such as those addressed in the survey. The latter option is lent weight by the economic principle of loss aversion—the tendency to mentally prioritise avoiding losses over achieving equivalent gains. In other words, the threat of losing £1 due to inflationary issues weighs heavier in the mind of a real estate professional than the opportunity to gain £1 by executing a strategy on the metaverse.

" 46.3% of respondents expect an impact (whether positive or negative), but only 21.9% have taken action. "

Figure 6: Responses to: 'What is your org's approach to the metaverse?'
(mid-to-late-career real estate professionals, n=151)
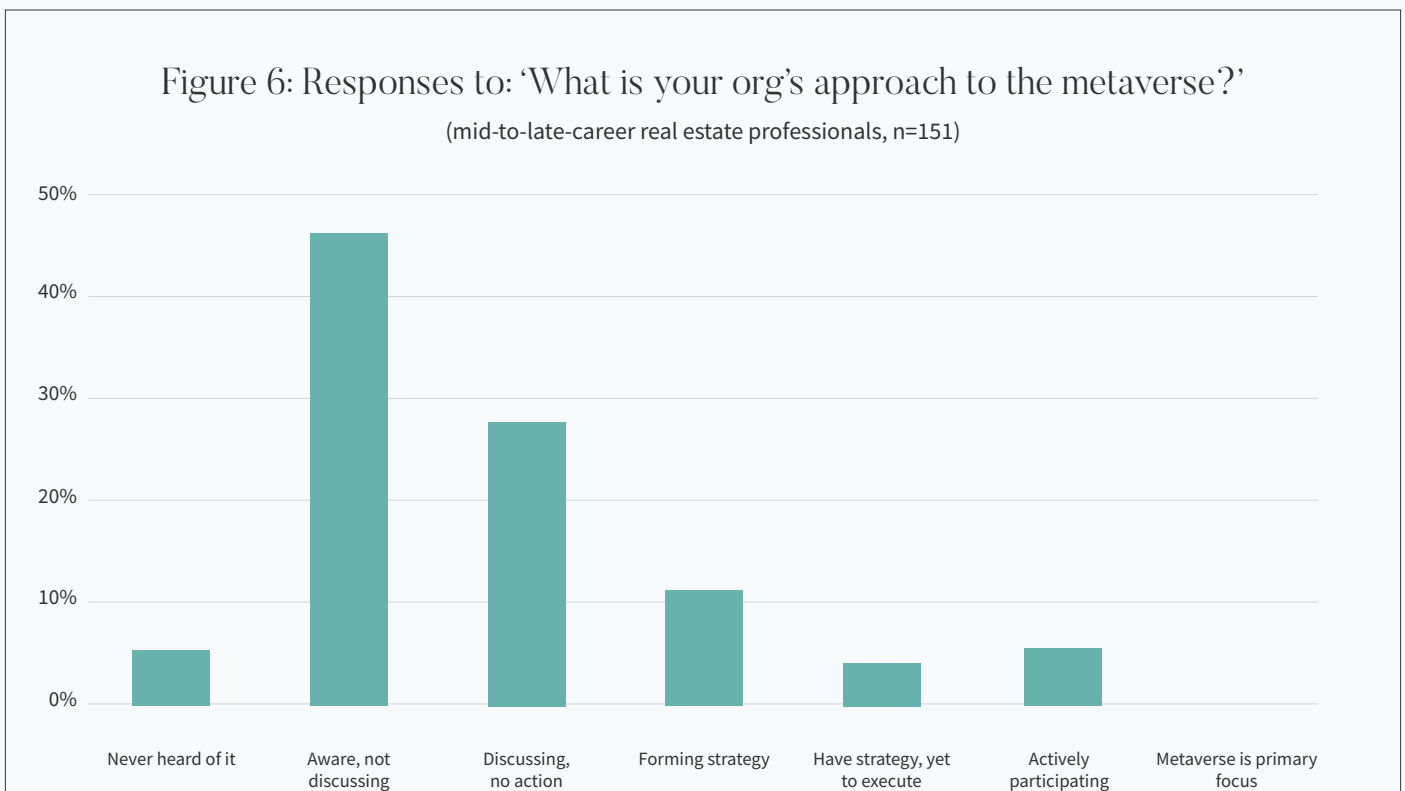
Figure 6: Pi Labs, 2022

Extended reality

Extended reality (XR) is an umbrella term for 'reality-plus' technologies using any kind of display. Augmented reality (AR), mixed reality (MR) and virtual reality (VR) are all forms of XR.

Extended reality (XR) is an umbrella term for 'reality-plus' technologies using any kind of display. Augmented reality (AR), mixed reality (MR) and virtual reality (VR) are all forms of XR. Throughout this paper, XR is used to refer to these collective technologies. Comparable in their 'reality-plus' nature, XR technologies can be plotted along a reality-virtuality continuum proposed by Paul Milgram and coauthors in 1994 (see Table 1). AR, for example, is closer to physical reality than VR, which is a more fully immersive (or virtual) experience. MR, plotted between the two, can be viewed as either the real world with added computer-generated enhancements, or a virtual world integrating the user's physical surrounds. To illustrate the first idea, consider a boardroom meeting, where one colleague is attending as a hologram. For the second, consider the same colleague being physically seated at their dining table and interacting with colleagues as if they were in the room.

Extended reality can also be considered in terms of invasiveness to the user. For example, an AR app on somebody's phone (such as Pokémon Go or Dent Reality) is much less invasive than a brain-computer interface or, to borrow a concept from Matt Groening's Futurama animation series, advertisements in your dreams.

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Comparable in their reality-plus nature, XR technologies can be plotted along a reality-virtuality continuum...

"

EXTENDED REALITY (XR)

An umbrella term that covers VR, AR and MR. XR is 'reality-plus' technology using any kind of display.[27]

Augmented reality (AR)	Mixed reality (MR)	Virtual reality (VR)
AR overlays digital information on real-world elements. AR keeps the real world central but enhances it with other digital details, layering new strata of perception, and supplementing your reality or environment.[28]	MR brings together real world and digital elements. You interact with and manipulate both physical and virtual items. MR allows you to see and immerse yourself in the world around you even as you interact with a virtual environment.[29]	VR is fully immersive. Using a head-mounted display (HMD) or headset, you'll experience a computer-generated world of imagery and sounds in which you can manipulate objects and move around using haptic controllers.[30]
-	**Reality-Virtuality continuum[31,32]**	+

Table 1
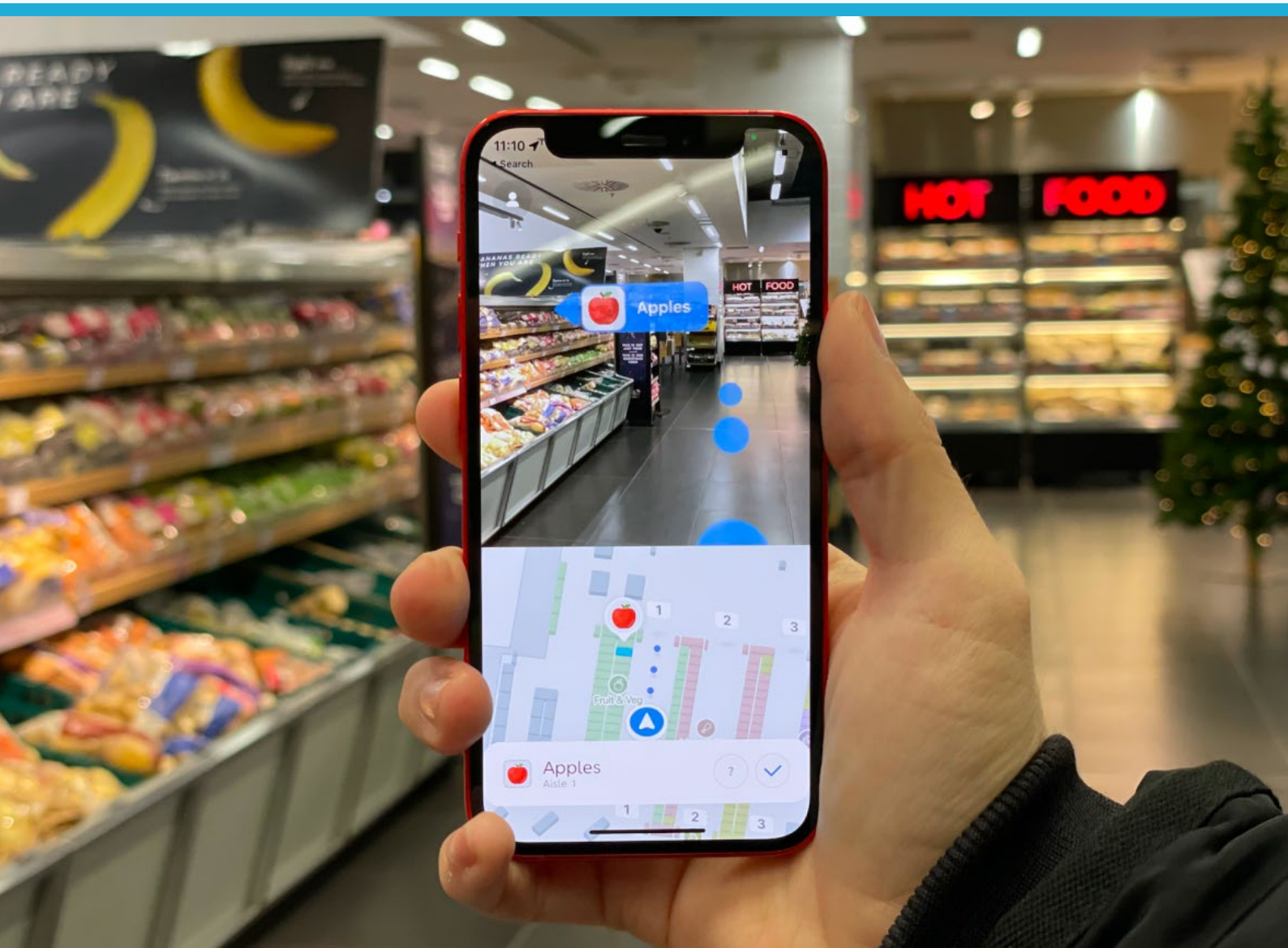
EXTENDED REALITY

The checkered past, present and future of XR

The Sensorama

Although worldwide interest in XR reached an all-time high in 2022, it is by no means a new phenomenon.[33] In 1955, cinematographer Morton Heilig wrote a paper titled 'The Cinema of the Future' and followed it up seven years later with an immersive cinematic invention named the Sensorama. Heilig produced five films compatible with the Sensorama— this offered the viewer wind, smell and vibration consistent with the 3D display. Heilig believed that his invention had a particularly useful application in training for hazardous professions, stating 'If a student can experience a situation or an idea in about the same way that he experiences everyday life, it has been shown that he understands better and quicker…' Nevertheless, the Sensorama was relegated under a tarpaulin by Heilig's swimming pool for generations. His wife was still repaying the debts accrued during Heilig's entrepreneurial pursuits decades after his death.

The first VR hype cycle

The next popularly-cited artefact of XR lore was the Sword of Damocles—a late-1960s VR headset so named due to the need for it to be hung from the ceiling, not exactly an irresistible proposition. XR largely remained the preserve of government, researchers and enthusiasts until the 1980s, when evidence begins to emerge of the early stages of a hype cycle. At this time, media interest was piqued and the appearance of the term 'virtual reality' in English language books experienced a sharp upswing, peaking in 1995 (see Figure 7). The good vibes were to be short lived, however, with the 1996 discontinuation of Nintendo's virtual boy just a year after it was launched, and the 1997 bankruptcy of VR game and training platform developer Virtuality.[34,35] Mentions of 'virtual reality' in English language books waned until a renewed upswing in the mid-2010s, which happens to be the period that saw the rise (and subsequent fall) of Google Glass and its 'Glasshole' wearers, as well as the $2 billion Facebook acquisition of Oculus.[36,37]

Today's challenges

One of the challenges XR, in particular VR, has faced, has been the queasy feeling induced in users. Oculus founder Palmer Luckey cited two forms of sickness: motion sickness and cybersickness. This has served as a significant hurdle to venture capital investment (see comments by Mitch Lansky at Benchmark Capital after Oculus' successful Kickstarter campaign).[38] The challenge of queasy users persists to this day. Research indicates that symptoms are influenced by visual stimulation, locomotion and exposure times.[39] Managing these factors offers a roadmap for VR developers seeking to achieve maximum adoption.

Another key challenge facing XR is trust and perception. Apple's XR woes have been partly blamed on concerns that VR alienates people from the outside world.[40] The 'Glasshole' experience is analogous to the discomfort of drinking in a bar or having a private conversation in the proximity of someone wearing a recording device.[41] Novelists have also captured the imagination of consumers with unalluring dystopian tales of virtual immersion such as Ready Player One, Snow Crash, The Matrix and Neuromancer.

"

When you live in a shithole, there's always the Metaverse, and in the Metaverse, Hiro Protagonist is a warrior prince
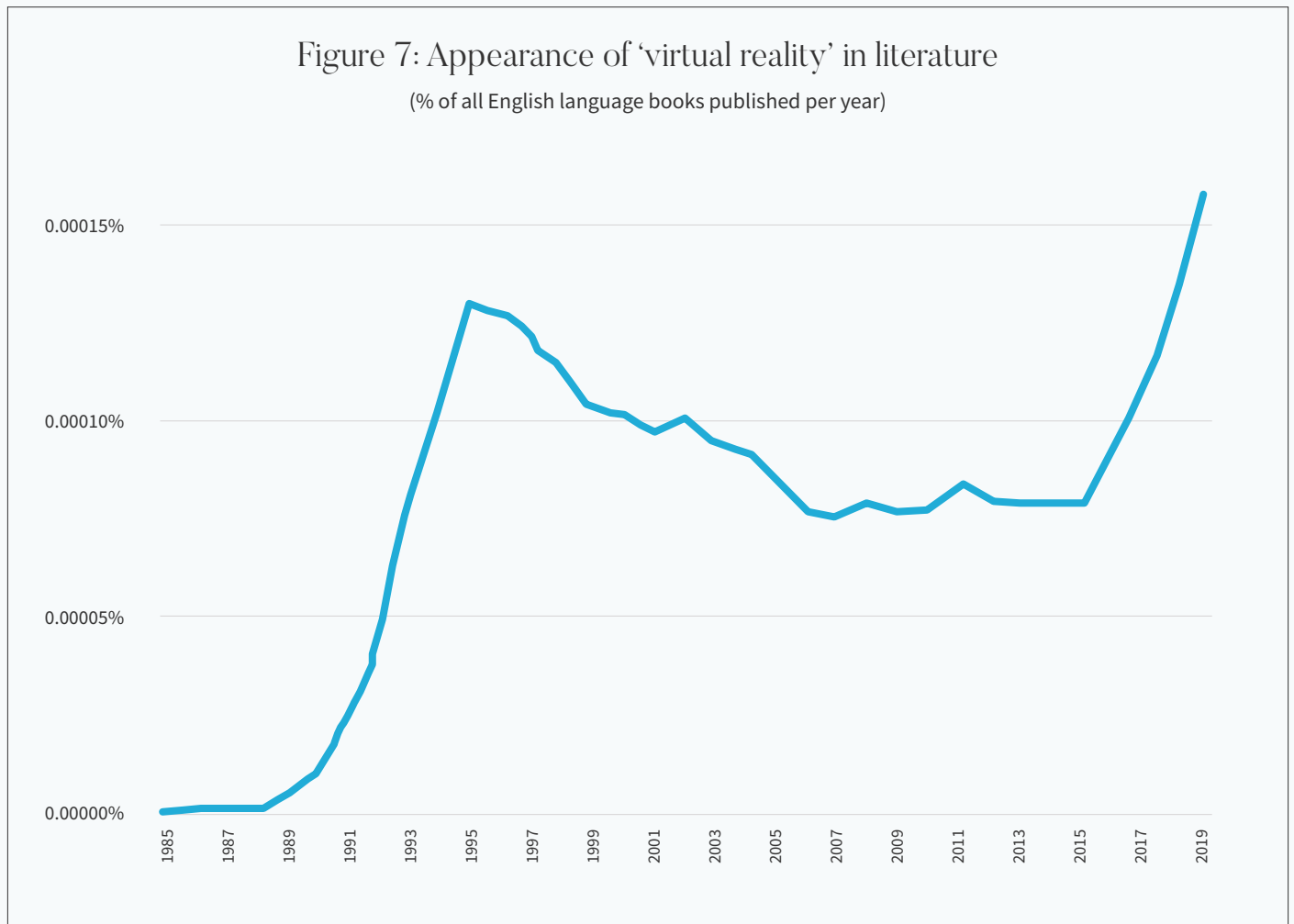
SNOW CRASH (NEAL STEVENSON)

"

Figure 7: Appearance of 'virtual reality' in literature

(% of all English language books published per year)

Figure 7: Google Books Ngram Viewer, 2022

USE CASE

VR in training and education

By Henry Martin, Business Development Associate and Luke Graham, Head of Research

It's busy tonight. There are people flooding into the stalls and into the grand tier at a blistering pace. People wearing various styles and colours but all with the same formal chic for an evening of this calibre. Sandra's eyes are peeled, scanning the crowd for anything out of place: abandoned luggage, odd or suspicious behaviour, sudden movements, a change in the environment or a strange smell. On the inside, her senses are on red alert, poised and ready to spring into action, but on the outside, she gives off a focused, calm demeanour so as not to unnerve the ticket holders for this evening's performance.

This isn't her first rodeo, but since the new protocols have been introduced, she's had to test her skills under new conditions, in different environments… with ever-evolving threats.

Suddenly, Sandra's eyes are drawn to the hollow sound of a glass hitting the red carpet of the theatre floor. She takes in the man who dropped it. He carries a look that mixes both fury and bewilderment, fury for having spilt his drink, and bewilderment at the fact that the glass somehow didn't smash. She eyes the situation up to see whether there is need for any intervention, but before she can ponder for a moment longer, her VR headset is removed, and sitting in front of her is her superior at Corps Security, Kate.

"You missed it, I'm afraid." Kate says softly.

Sandra sits there in silence racking her brain for a what seems like an eternity to understand what she could have 'missed' before finally, the penny drops. It was a distraction. The man holding the drink wasn't the threat, he was merely a distraction…

For security firms servicing the real estate industry, immersive virtual reality training such as the above scenario mightn't be far away. Corps Security is one such organisation. Formerly known as the Corps of Commissionaires, Corps Security's roots extend as far back as the mid-19th century. This heritage comes with its downsides, however, with some would-be clients mistaking their military heritage with rigidity and an inability to move with the times. In 2020, they sought to change this through several initiatives. One was for their Regional Director

for London, Seetan Varsani, to focus more directly on major accounts and strategic development. As luck would have it, Corps Security were contracted to manage the security for a media and technology hub in East London at the time. One of the tenants was MOONHUB.

Inspired by the technological level-up required for the Apollo 11 moon landing, MOONHUB is a virtual reality training platform providing bespoke and off-the-shelf training using live immersive scenarios delivered via virtual reality headsets. While working in retail as a business and economics undergraduate at the University of Leicester, CEO and Co-Founder Dami Hastrup found that very little information was retained by his colleagues while undertaking iPad-based training. Contemplating how to solve this pain point, Hastrup turned to VR. In early-2017, he recruited his university classmate Hannah Sutcliffe as Co-Founder and COO, as well as colleague Vinh Ly as Co-Founder and CTO. Sutcliffe brought with her a background in languages, human resources and international sales and marketing. Ly, on the other hand, a self-trained software developer. The founding team of MOONHUB spent their first couple of years speaking to their target users and refining their value proposition before closing a $2.6 million seed round in April 2022.[42] In May 2022, the founding team of MOONHUB was featured in Forbes' 30 Under 30 list under European technology.[43]

Training for security professionals comes in many different shapes and sizes—which means it also varies substantially in cost. eLearning modules are an example of a cost-effective and scalable solution, but this approach is limited by the lack of tactile and situational exposure. It can also be very boring. Face-to-face scenario training solves these problems, but is very costly. For example, the cost of sending every Corps Security officer to a three-day annual face-to-face training programme would be approximately £800,000 in trainee salaries alone. On top of this cost are venue fees, equipment, transport and instructors.

A happy medium between eLearning and face-to-face training is virtual reality. This approach allows trainees to observe simulations and respond to prompts set by the software. Varsani echoes MOONHUB's claim that the ability to retain information with immersive learning such as this increases the effectiveness of training (via knowledge retention) by 72%, while also saving 62% of training costs on the face-to-face alternative. Admittedly, not all of Corps Security's training programme has transitioned to virtual reality. Varsani believes about 60% of the required training could be conducted in virtual reality with the current state of the technology, but that this could increase as the technology develops.

Security is just one of many professions ripe for virtual reality-based training. Another profession, perhaps one of the best known, is military aviation. The US Air Force deploys virtual reality in order to maximise the training of their junior pilots while controlling costs. Since the highest volume of training is at the beginning of a pilot's career, the economic impact of virtual reality is greatest at this stage. According to experienced pilots, the original intention was to replace about 15% of training with virtual reality, but this hasn't come without

challenges. At this stage of a pilot's career, they have 'low airmanship'. In other words, they haven't had enough real-life experience operating a $100 million piece of hardware hurtling through the air at mach three. In addition, despite the impressive resistance to motion sickness attained by military pilots, few are able to withstand half an hour of virtual reality without falling sick. This has served as a persistent bugbear of virtual reality companies—causing obstructions to investment and consumer retention.[44,45]

MOONHUB is aware of these perceptions of VR, and has developed a solution to mitigate these effects. Since the majority of training can be conducted by a stationary character (such as a security guard standing at their post or a surgeon at an operating table), MOONHUB scenarios require little change in position of the user. When this is needed, MOONHUB create 'hopping points' which effectively teleport the user to the next location. As a result, MOONHUB users have never reported symptoms of motion or cyber sickness. MR is also a potential solution for XR-based training, and an area of interest to MOONHUB.

Q&A with Zara Riahi, CEO & Founder of Contilio

We recently caught up with Zara Riahi and her team at Contilio. We discussed everything from the origins of Contilio and its relevance to the metaverse conversation, as well as her expectations for the future of XR and the metaverse in the built world.

What is Contilio?

Contilio helps to track progress, installation quality and predictive risks automatically for all tasks on the construction site. We're the missing link in smart project controls, keeping the Building Information Modeling (BIM) up to date throughout construction by augmenting it with insights and connecting it to the intelligent site data and updated schedule. This creates intelligent construction digital twins that may be used for digital handover, smart asset management, dispute management and CO2 tracking. This allows us to help global asset owners, real estate developers and general contractors make timely, data-based decisions and perform agile risk management and oversight. The benefit is significantly enhanced productivity and delivery speed, as well as reduced rework costs and waste.

How did Contilio come about?

After many years working in the construction industry and repeatedly running into the same problems with delays, cost overruns and rework costs, we realised this was caused by a lack of timely, actionable and objective insights that everyone could access. Site data was collected manually. It was slow, relied heavily on spot checks, and analyses were conducted in silos by multiple people (including site managers, project controllers, quality managers and surveyors). Risks were identified based on lagging and insufficient information.

This prevented decision makers from having a preventative approach to project risks. Our founding team started working on these problems together in 2018—having previously worked together in the past and sharing personal networks within London Business School, Stanford University, the University of Edinburgh and others. We have since grown to a team of around 20 diverse and highly talented people, and are always on the lookout for others who would like to drive change in the world's largest industry, help save the environment, as well as preventing over $5 trillion in construction waste annually.

Do you consider Contilio to be a metaverse/XR company?

Absolutely! A core part of our technology is to intelligently understand the construction world in 3D, and to automatically identify and assign meaning to every element of a site or building (whether structural, architectural, service, etc). Our ability to reduce the volume of lidar (light detection and ranging) data 20-fold and visualise the insights efficiently means we can help create smart digital twins to help robots navigate sites and assets, use them for training purposes, or for digital handover and smart operations. These digital twins are structured and machine readable, which means owners and operators can connect them with other sources of data during operations as well. Our 3D artificial intelligence (AI) platform has been trained on over 50 terabytes of data and deployed across a number of flagship building and infrastructure projects around the world.

How did you go about developing your product?

Prior to starting Contilio, we conducted more than 40 interviews with industry executives and other relevant stakeholders to better understand our target consumer pain points and strategic priorities. Combined with an in-depth technical assessment and growing trends in 3D data capture, we were able to confirm our thesis. Soon after we started to build the product, the COVID-19 pandemic struck. This caused mass confusion and created difficulties in terms of access to construction sites globally. This prompted an immediate need for remote site walkthroughs, automated analysis and digital monitoring. In response, we introduced key functionalities that allowed our customers to bring different types of data together in an efficient, secure manner. This empowered their teams and supply chain to collaborate remotely from a unified source of truth. Given that rework costs are responsible for 5-12% of total construction costs, many customers began looking for solutions that enabled them to verify the quality of installed work, as well as the downstream effects of installation errors after the initial shock of the pandemic. An increased focus on environmental sustainability and net zero targets has since offered an additional layer of necessity for our product.

What are your thoughts on the future of XR in the built world?

So far, XR's applications in the built environment have mostly focused on streamlining real-scale BIM data with the help of XR headsets—enabling all stakeholders to navigate design plans and operating assets remotely from the comfort of their office. With increased adoption of 3D reality data and the impressive technological advancements of the likes of Apple, Microsoft and Leica, this will expand to include point cloud data and the intelligence (progress, quality, risks, safety, etc) enabling the site and office to come together. This will allow them to work on issues close to real-time, irrespective of their locations. For those onsite, one of our goals is for our users to be able to walk through a site with an AR or MR headset and identify problem areas in real time. Such intelligent twins can also be used for training purposes and to create maps for onsite robots—enabling predictive project controls and maintenance. In 10 years from now, you could transport into your construction sites using XR, AI and a Zoom or Teams call. This creates the opportunity to build and maintain your assets intelligently, increasing access to new and green financing and insurance products. However, to get there you need to invest in technology and work collaboratively with technology providers.
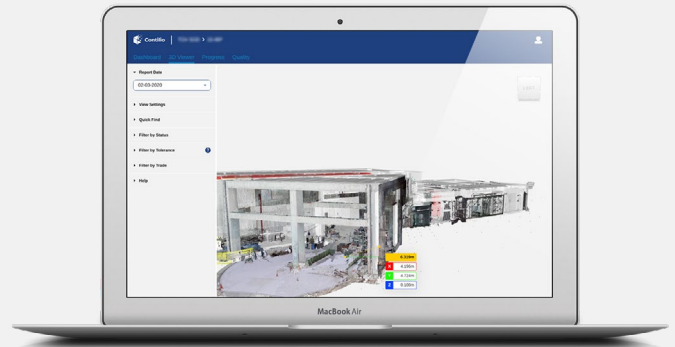
What does the future have in store for Contilio?

COVID-19 made a lasting impact on the construction and property landscape in terms of technology adoption, with many companies increasing the use of technology to access, track, predict and audit the performance of their sites and assets. Many owners, developers and investors have started to demand the use of such technologies across their global portfolios to ensure consistency. In our view, there has never been a better time to grow and expand our reach. We have ambitions to continue our expansion, including raising our next financing round. This will fuel our US expansion and allow us to continue developing and refining our product. We are currently working with several partners to develop a world-first automated carbon tracking during construction, as well as a number of other exciting projects.
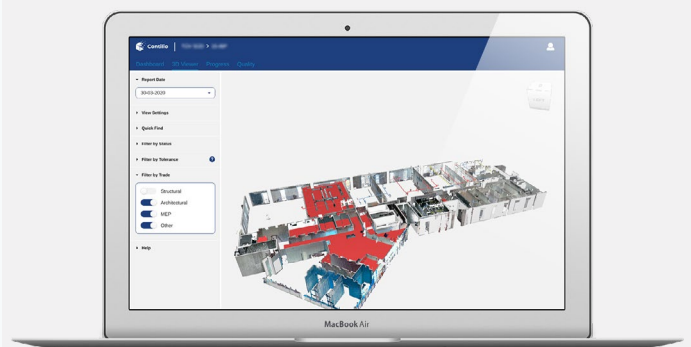
EXTENDED REALITY

Enhancing or disrupting our physical world?

The rise of virtual work

The concept of virtual work was established long before the COVID-19 pandemic made it front-and-centre for the masses. Between 2010 and 2019, approximately three in four employed persons in Great Britain didn't do any work from home (see Figure 8), leaving approximately a quarter who did.[46] In 2020, this changed substantially as lockdowns prompted widespread work-from-home orders. As communities re-emerged, a heated debate surrounding the post-pandemic return to office ensued.[47] Consulting firm Accenture is one of the organisations that had a head-start on remote work—launching its Nth Floor virtual workplace in 2019.[48] Accenture have since doubled down on this project, expecting upwards of 150,000 new hires to spend their first day in the metaverse in 2022.[49] Real estate giant CBRE has also taken the plunge—announcing high-tech offices with XR studios, as well as an employee developing an exploratory-stage virtual office in Decentraland (with some confusion around whether this was sanctioned by CBRE leadership or not).[50, 51] But which way will virtual work go? On one hand, AR and MR offer a more immersive physical experience in the physical workplace. On the other, VR offers a substitute to the physical workplace. The advent of Meta's Horizon Workrooms offers a glimpse into the organisation's intentions, as does Zuckerberg's statements on the efficiency of VR-enabled workstations.[52] If his claim is accurate that lifelike avatars could be a few short years away, these complementary forces

within the virtual workspace appear to represent a downward force on office space demand. On the other hand, some argue that this downward force is overstated. Nikki Greenberg of Real Estate of the Future, for example, points to the advent of the internet and listing websites as an earlier example: "…it's unlikely one will replace the other. Real estate agents didn't get rid of their offices when they created a website".

"

[The] trendline to offsite work lends currency to the future of collaboration and coworking in these virtual worlds. Eventually, rather than ask employees to collaborate over Zoom and voice calls, employees will be expected to attend meetings and other work activities using an avatar in a virtual office in the metaverse. Not only will this help to drive adoption of the metaverse by coercing people to spend more time there, but it will also increase the growth of the metaverse economy through spending on virtual office leasing; construction and architecture; digital avatars and fashion; and other virtual items and services.

TERRY WINTERS[53]

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Figure 8: Employed population who never work from home
(% of Great British population)

Figure 8: UK ONS, 2022

EXTENDED REALITY

Helping or hindering in-store retail?

In the mid-2000s, mail-order catalogue retail represented a significant portion of non-store retail in the UK. At this time, proponents were arguing 'catalogues are more relaxing and offer a value-filled experience, getting the consumer to feel the product, allowing them to dream... The web's ability to do this is limited'.[54] However, between 2008 and 2022, eCommerce grew to dominate non-store retail by climbing from 36.5% in January 2008 to a high of 96.5% in October 2021. Over this period, online retail has also steadily conquered in-store retail. Nearly all growth in UK retail can be attributed to eCommerce (see Figure 9). In early-2022, 'textile, clothing

and footwear' purchased online represented a quarter of all sales in the category. However, there are a number of forces limiting the internet's conquest of fashion retail. First is the uninspiring two-dimensional experience of online retail in Web2. Second is the inefficiency of ordering products the purchaser hasn't tried on, and the inconvenience of the returns process. Third is the time gap between checkout and order fulfilment—although this has improved in recent times with micro fulfilment innovations.[55] Fourth is a dependence on the development and proliferation of enabling technologies to make the experience more immersive (such as XR hardware).

Figure 9: UK average weekly retail sales (monthly intervals)
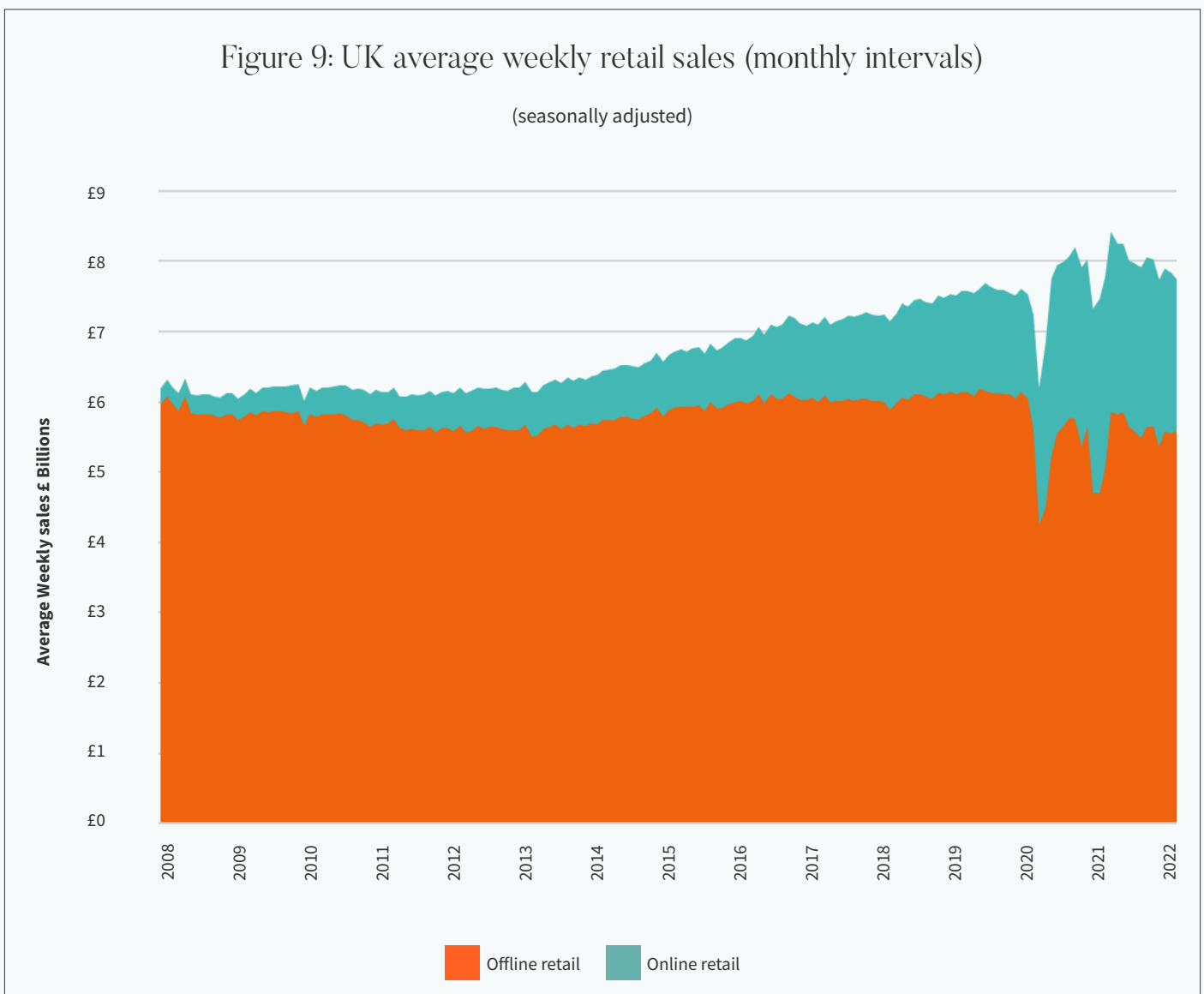
(seasonally adjusted)

Figure 9: UK ONS, 2022

Aside from demand-side concerns, retailers themselves have less control over the buyer experience online and some therefore restrict many products to their in-store sales channels (in particular premium fashion brands). This raises an interesting question as to which retail categories will be most affected by the metaverse. Will the existence of a virtual mirror enable consumers to 'try on' an outfit from home prior to purchasing it? Will premium retailers deploy AR and MR to attract more consumers to their brick-and-mortar stores? Will this result in a bifurcation of retail, where some needs are satisfied from home through VR and others continuing to be served in-person with augmented experiences? Will VR experiences mimic physical retail or will adoption prompt innovations in visual merchandising? Will the increased adoption of the metaverse (VR in particular) lead to virtual fashion becoming more important to a consumer than their at-home wear? One can catch glimpses of what might be coming through examples such as Marks & Spencer's deployment of Dent Reality; Balenciaga's 2020 VR-enabled runway show; and avatar customisation on virtual platforms—including a Roblox user's $4,000 purchase of a virtual Gucci handbag for their avatar. [56,57,58,59]

"

Virtual experiences for retail continue to have limitations despite synergies from innovative technology. The ability for a virtual client to experience the same service as they would in-store is inhibited by virtual shopping failing to meet certain key psychological needs that shopping can fulfil. While touching a fabric could be replicated through haptic gloves, for many [apparel] clients their final purchase decision is made based on how a garment fits. AR or a virtual mirror could show a client how a garment would look when worn but it simply can't fully replicate how a garment fits, or more specifically how a garment feels. How a garment both looks and feels are linked to the self-confidence, an implicit psychological need, a client might be trying to improve by wearing their purchase. These and other limitations provide a clear roadmap for future attempts to apply any new technology for retail.

TEDDY FEHER

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EXTENDED REALITY

Entertainment, leisure and wellness

In-home entertainment, leisure and wellness technologies have been developing for generations, with transformative innovations such as radio, television, console gaming, telecommunications, VHS, DVD, personal computers, cloud streaming, digital health, eSports and quantified self to name a few. Some of the more recent innovations experienced a surge of adoption during the COVID-19 pandemic lockdowns—perhaps most famously Peloton, an interactive fitness platform. Although a number of these so-called stay-at-home stocks endured price corrections as communities re-emerged from statutory lockdowns, confidence in the longer-term viability of related innovations appears to be buoyant. The gaming and eSports verticals, for example, have experienced more than double the venture investment in the first half of 2022 than the first half of 2021, suggesting that 2022 investment will comfortably overtake the 2021 record (see Figure 10).[60] Meanwhile, European cinema attendance had been stagnant prior to the COVID-19 pandemic lockdowns and has struggled to return to pre-pandemic levels since.[61]

On the fitness front, a recent survey of 1,001 Americans by FitRated found that 40% of gymgoers were 'willing to drop their current real-world gym memberships for ones in the metaverse'.[62] Proponents of the metaverse and extended reality envisage a world where somebody can attend a live event alongside a friend or relative; experience immersive tours of real or fictional destinations from the comfort of their living room; work out with friends in a Martian desert; or interact with a hotel concierge in Decentraland.[63,64,65,66] In a scenario where adoption of metaverse and extended reality technology goes mainstream, Alicia Navarro, CEO and Founder of deep work platform Flown, highlights a number of factors to take into account. First is mobility: how can users be encouraged to move their body at healthy intervals while immersed in stationary extended reality experiences? Second is a related consideration of path dependency and ergonomics: how can we better design our devices and applications around us? Third is accessibility: how can we ensure extended reality and the metaverse doesn't become a distinction between the 'haves and the have-nots'?
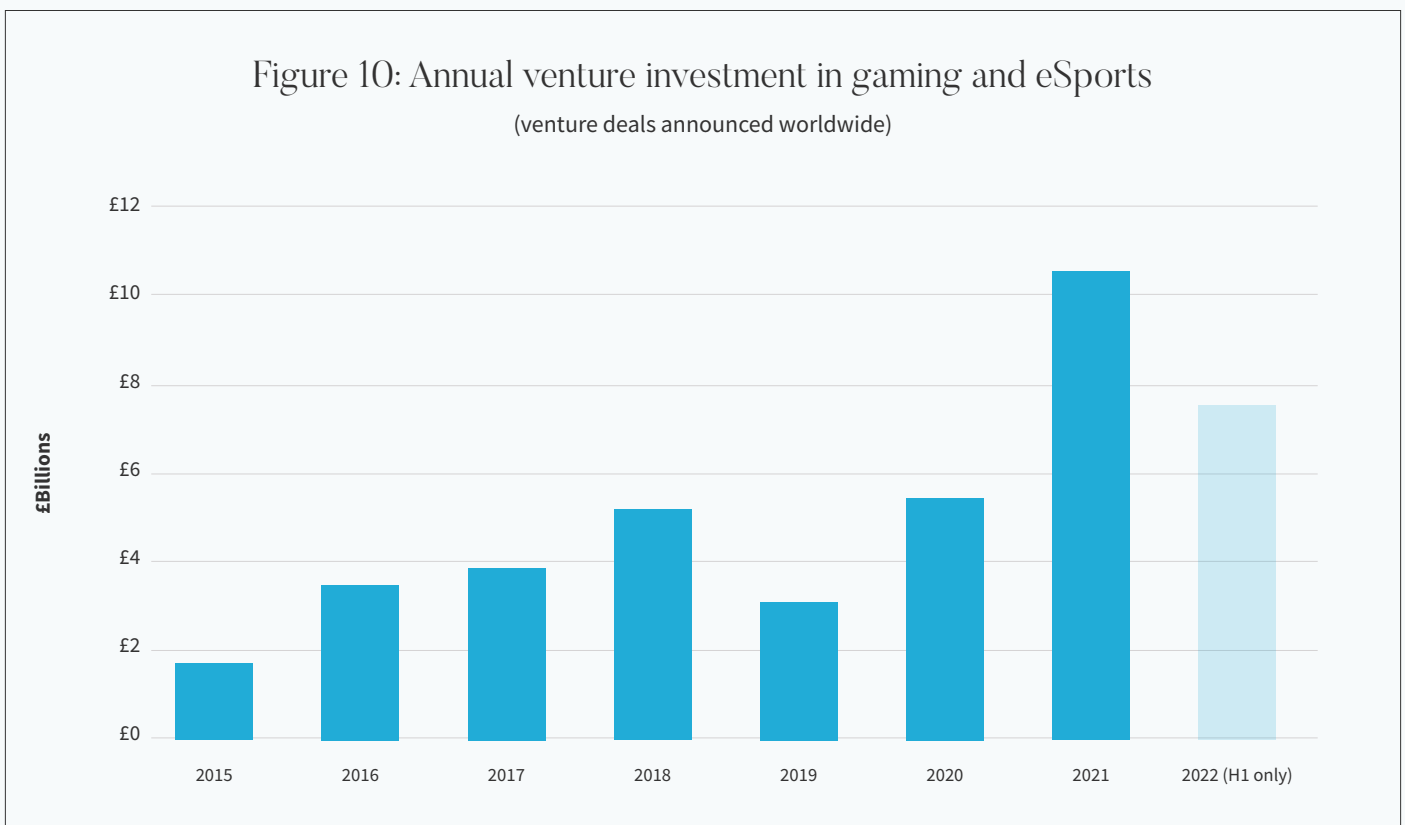

Figure 10: Annual venture investment in gaming and eSports
(venture deals announced worldwide)

Figure 10: Pitchbook

EXTENDED REALITY

A quick detour down the rabbit hole…

One might easily conceive of a world where the metaverse progressively renders the likes of retail, entertainment and office space obsolete—but from here it's easy for some to fall into a Yoda-like line of reasoning that reaches a 'dark side'-like conclusion. It goes something like this: if an increasing proportion of our life is spent on the virtual side of the reality-virtuality continuum, one could be led to believe that logistics and residential real estate become the only viable property types remaining (*well, they're both certainly trending in that direction—see Figure 11*). In this scenario, logistics serve to supply any physical goods (food, clothing, electronics, etc) required within our homes—the place we spend the near-entirety of our time. But what kind of homes? If you have a virtual home environment, what's the purpose of a living room? Could you not simply stay in a bed with integrated bathroom facilities? Is it necessary to have space any larger than a coffin-like pod? If so, how would the value of one pod be differentiated from another and what role would location

have? Then again, if brain-computer interfaces advance to the level that one's consciousness could be digitalised, are our physical bodies now also redundant? In such a scenario, residential real estate is also no longer required (other than in the virtual world). This may seem ridiculous, and overly reminiscent of the plot of The Matrix, but 17th century philosopher Rene Descartes contemplated such an existence in the context of an evil demon placing an illusory world before his senses. Centuries later, while working as a British Academy Postdoctoral Fellow at the University of Oxford, Nick Bostrom postulated that we could be living in a computer simulation. Simulation Theory, as it came to be known, closely resembles The Sims computer game in which our descendants have given us life through a computer simulation.[67] Simulation Theory has since been lent credence by the likes of Elon Musk and Neil deGrasse Tyson, with researchers and thought leaders claiming that it is anywhere from 50% likely to near certain.[68]

Figure 11: Residential & Industrial RE weightings in MSCI UK index

Figure 11: MSCI
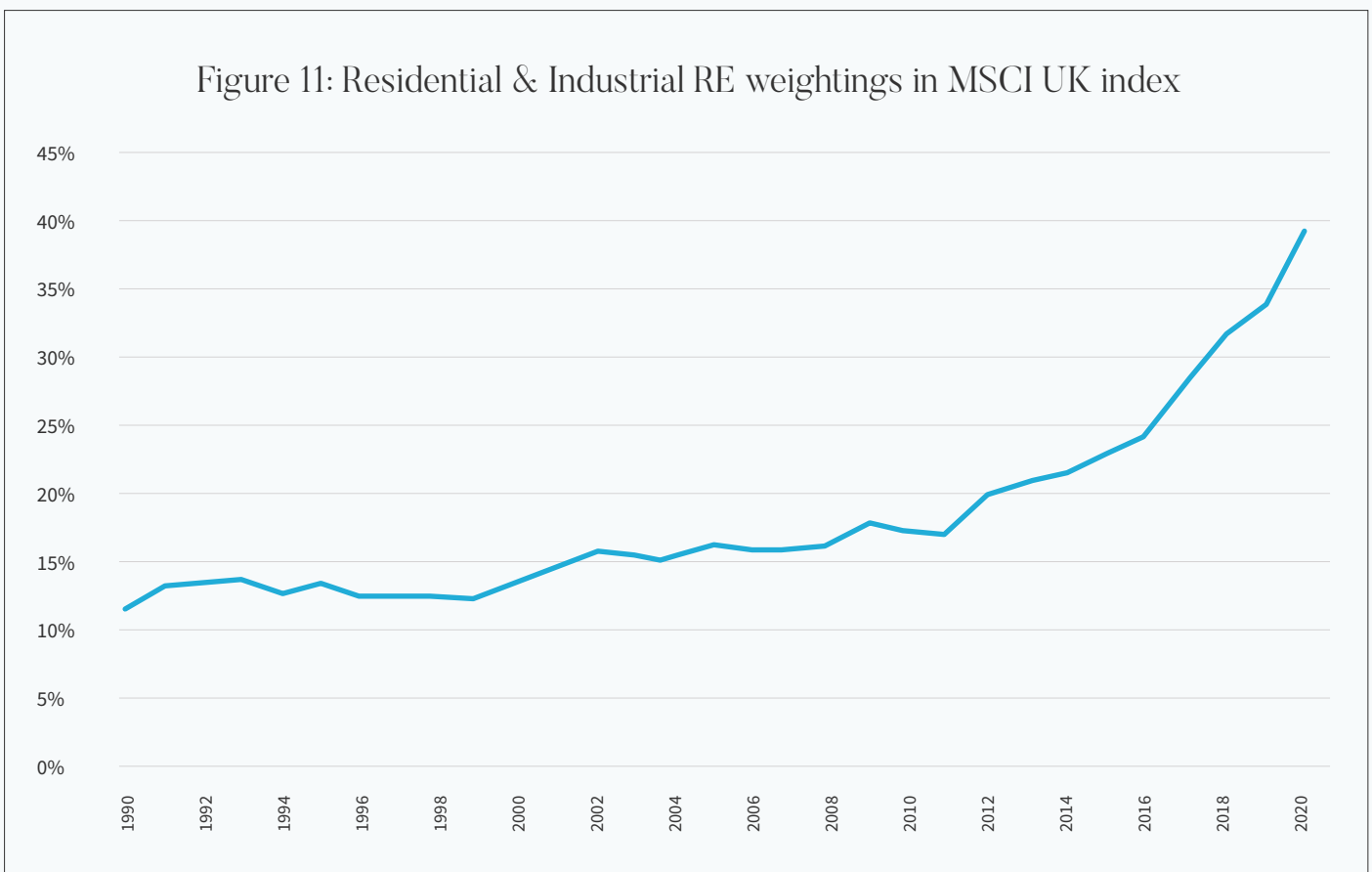
The virtual land rush

Since 2021, the cumulative investment in land in the metaverse has grown from tens-of-millions to billions of US dollars (see Figure 12).[69] Recently, major contributors to this investment activity have been Sandbox (who launched Sandbox Alpha in November 2021) and Otherside (whose NFT mint in April 2022 crashed the Etherium blockchain network).[70,71] Of course, buying virtual land does not imply ownership of land in the real world. Instead, much like the 'recycling bin', 'Bitcoin mining' and 'shopping cart'; virtual land serves as an interface metaphor (or skeuomorph) designed and named to enable users to more easily adopt the technology. Many virtual worlds go a step further than nomenclature by retaining additional attributes of physical land such as gravity; town planning (roads and districts, for example); and digital representations of vegetation. More than a decade before the recent boom in virtual land associated with Web3 and the metaverse, the Web2 predecessor 'Second Life' had already produced millionaire virtual real estate moguls.[72] However, the platform ran into bouts of legal trouble when changing the terms of service and freezing the accounts of users—both of which affected users' property prices and/or ability to transact.[73,74]

Figure 12: Cumulative investment in metaverse virtual land
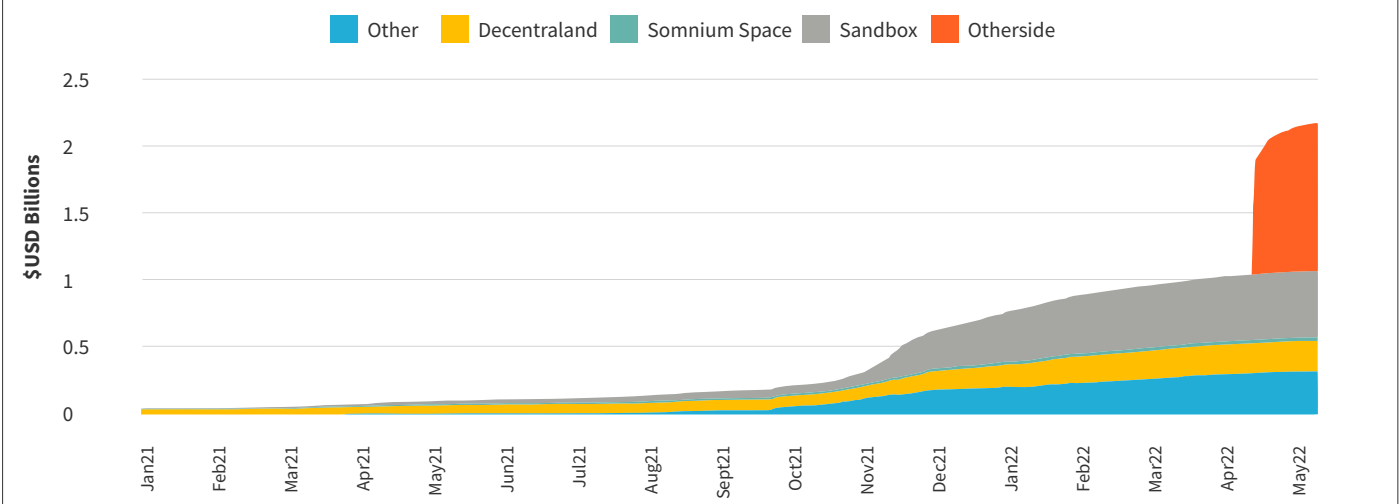Primary and secondary markets, $USD

Figure12: NonFungible.com

THE VIRTUAL LAND RUSH

Virtual real estate value

Location, location, teleportation

In the Decentraland metaverse, an individual 'parcel', which represents 16 square metres of virtual land, ranges in listing price from a low of 3,874 MANA (the digital currency of Decentraland) to a high of 600 million MANA (with a median listing price of 15,000 MANA) at the time of writing (see bottom of page for more information on MANA).[75] In a world where users can seamlessly teleport from one location to the next, what causes the difference between the lowest and highest-priced land? After all, location (aspect and proximity to desired amenities) is widely espoused by real estate professionals as a key tenet of value. This kind of debate about value regularly emerges among metaverse enthusiasts—and shifts depending on each metaverse's unique user experience (UX) attributes. In the case of Decentraland, users are able to navigate their avatars around the metaverse in first or third person, exploring the map at their leisure. This gives rise to the opportunity for 'peripheral traffic' between neighbouring parcels and estates (estates being combinations of multiple parcels held by the same owner). A consequence of peripheral traffic, as in real life, is that luxury brands are highly sensitive about who their neighbours are. Arguably, this also applies beyond luxury brands. As is the case in the physical world, it pays to position yourself where your target market can easily find you.

> " Location has value in the metaverse. During our 2021 fashion show in Decentraland, the high-end brands were very specific as to who they did and didn't want to have next door to them in the district. Just like a brick-and-mortar retail strip like Rodeo Drive or Fifth Avenue, a premium fashion brand doesn't want something akin to a fast food restaurant next door. Samsung is another useful example. When they set up their store in Decentraland, without a doubt the land around them increased in value because it would benefit from peripheral traffic.
>
> **ANDREW KIGUEL** "

At the time of writing, 1 MANA exchanged for $1.0065. Over the 2021 calendar year, however, the exchange rate for 1 MANA ranged from $0.0762 to $5.9023 (see Figure 13).[76] An interesting period to observe within this time frame is from 27 October 2021 to 30 October 2021. On 27 October, 1 MANA was exchanged for $0.7534. On 28 October 2021, Facebook Founder and CEO Mark Zuckerberg announced the new vision for his company, including a rebrand to Meta.[77] By 30 October 2021, 1 MANA was exchanged for $3.5647 (a nearly five-fold increase). Since its peak of $5.4792 the following month, MANA has trended downward, approaching a figure closer to what it was prior to the Meta announcement. Currency risk is evidently a layer of complexity to take into account with respect to virtual land.
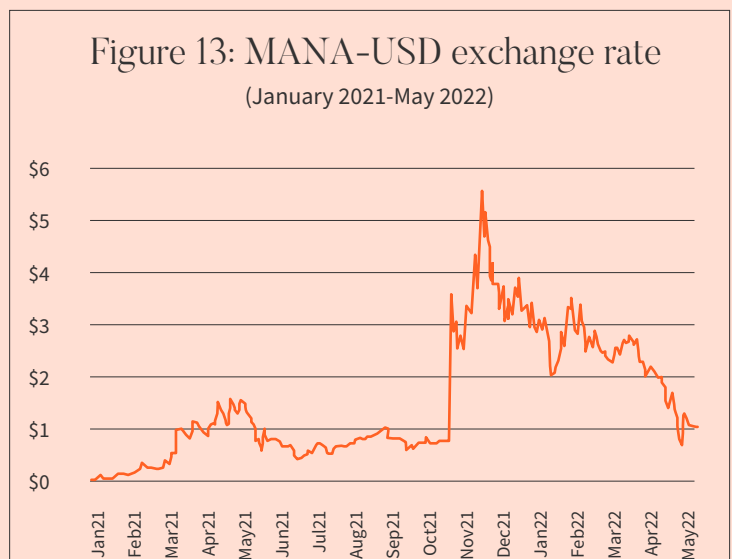

Figure 13: MANA-USD exchange rate
(January 2021-May 2022)

Figure 13: Yahoo! Finance

THE VIRTUAL LAND RUSH

Contemplating valuations of virtual land

At the time of writing, the median listing price per square foot of an individual parcel in Decentraland was £4.39. Framing virtual land in such a way allows us to compare it to real estate prices in the real world. Agricultural land in the UK, for example, was worth around £7,000 per acre in late-2021, which translates to approximately £1.72 per square metre or £0.16 per square foot. Decentraland parcels look relatively expensive. On the other hand, prime residential real estate in London was worth £1,470 per square foot in 2019 (see Table 2). Now Decentraland parcels look relatively cheap.[78,79]

There are three ways of valuing land in the physical world: the cost approach, direct capital comparison, and the income approach. The cost approach is founded on the idea that the value of something is based on what it cost to build (or create). It doesn't work for real land, let alone a greenfield site in the metaverse. Direct capital comparison is also a tough pill to swallow for a real estate economist. If a metaverse estate agent says a plot of virtual land is worth $1 million because a celebrity next door paid this price, does it make it so? Arguably not.

The income approach is where things get more interesting.[80] What is the revenue generating potential of a plot of land in the metaverse? Can it be leased out to a tenant on a fixed or revenue sharing basis? Can it generate revenue for the owner's company by offering experiences or promoting real-life products? One challenge facing the income approach at this stage of the metaverse's development are the disparate rules governing each metaverse platform, how those rules are changed, and how this impacts what a virtual landlord is able to have developed on their plot—just like the impact of planning and zoning laws on value in the physical world. Another challenge applies to the capitalisation rate. What is the appropriate risk premium? How much does this vary from one platform to the next? As we know from the physical world, capitalisation rates can vary widely from one jurisdiction (and property type) to the next. Until investment decisions are made with these sorts of considerations taken into account, virtual land investments appear to be purely speculative, even ignoring the currency issue.

Simplified DCF valuation based on customer acquisition cost

Jane is a fashion designer contemplating a purchase of virtual land. Based on her previous online marketing strategies, she is accustomed to spending £4 to acquire each customer. She inspects a virtual plot, which a metaverse estate agent tells her experiences around 1,000 passers-by each day, and it has been doubling every year. They expect it to continue to do so for another five years as the platform grows. Jane's research of the neighbourhood suggests she can expect about 1% of the foot traffic each day to purchase something from her. That's 10 purchases on day one. Jane will build the virtual store with a no-code software development kit, meaning she won't have to pay a software developer. Jane isn't overly optimistic about the long-term future of virtual land platforms and expects to sell the land for £0 after the five years of projected growth. Over the five years, Jane will save a total of £651,604 in customer acquisition costs from the projected sales on her plot. Considering the above, and an annual discount rate of 10% (compounded daily), the plot of virtual land is worth £424,185 to her today. Any price below this would serve as an arbitrage opportunity on her customer acquisition cost, meaning she should buy.

£/sqft of Decentraland and UK real estate	
Property type	**£/sqft**
Decentraland parcel	4.39
UK agricultural land	0.16
UK industrial land[81]	41.32
London prime residential	1,470.00
The Scalpel (London office)[82]	1,832.00

Table 2

> How to think about metaverse land. There are hundreds of thousands, maybe millions of websites. So websites are not scarce. BUT. Some websites are extraordinarily valuable.

KOSTAS KETIKIDIS[83]

THE VIRTUAL LAND RUSH

Transaction costs

As we'll discuss in more detail later, the decentralised finance movement arose in response to the deterioration of trust in institutions and intermediaries during and after the Global Financial Crisis.[84] En masse, populations across the world began to question why bankers and other middlemen were able to make a fortune at the perceived expense of their retail customers. Middlemen 'clipping the ticket' have since found themselves on notice—with initiatives to unseat them such as Purple Bricks (bypassing traditional estate agents in selling homes); decentralised finance initiatives (bypassing bankers and other financial intermediaries); and smart contracts (bypassing legal intermediation, enforcement and arbitration). In real estate, typical transaction costs arising from middlemen can include legal fees, valuation fees, and government taxes such as transfer duty. In the metaverse, transaction costs have also begun to emerge.

Centralised Web2 powerhouses such as Apple and Google have come under fire in recent years for the sizeable cut they take on in-app purchases made on their devices.[85] Meta has joined this criticism, but seem likely to introduce creator fees on their own platforms in 2023.[86] Currently at 30% (with some discounts available to smaller developers), these fees represent revenue in the tens of billions for the tech giants each year.[87] Empowering creators appears to be a central tenet of decentralised metaverses, but this hasn't prevented the emergence of other transaction fees. When the minting of the Otherside metaverse project took place in May 2022, it prompted so much activity on the Etherium blockchain that it crashed. By the end of the auction, those involved had purportedly accumulated over $120 million in 'gas fees' on the network.[88] Simply put, gas fees are paid to blockchain miners in order to offset the cost of the computational power required to register the transaction. Demand based, gas fees are highly volatile (see Figure 14). A number of solutions have been floated to mitigate gas fees. One is to transact during quieter periods (a bit like scheduling your washing machine for an overnight cycle). The second is Dutch auctions. The third, which appears to have a subversive agenda, is for metaverse platforms to create their own blockchain networks.[89]
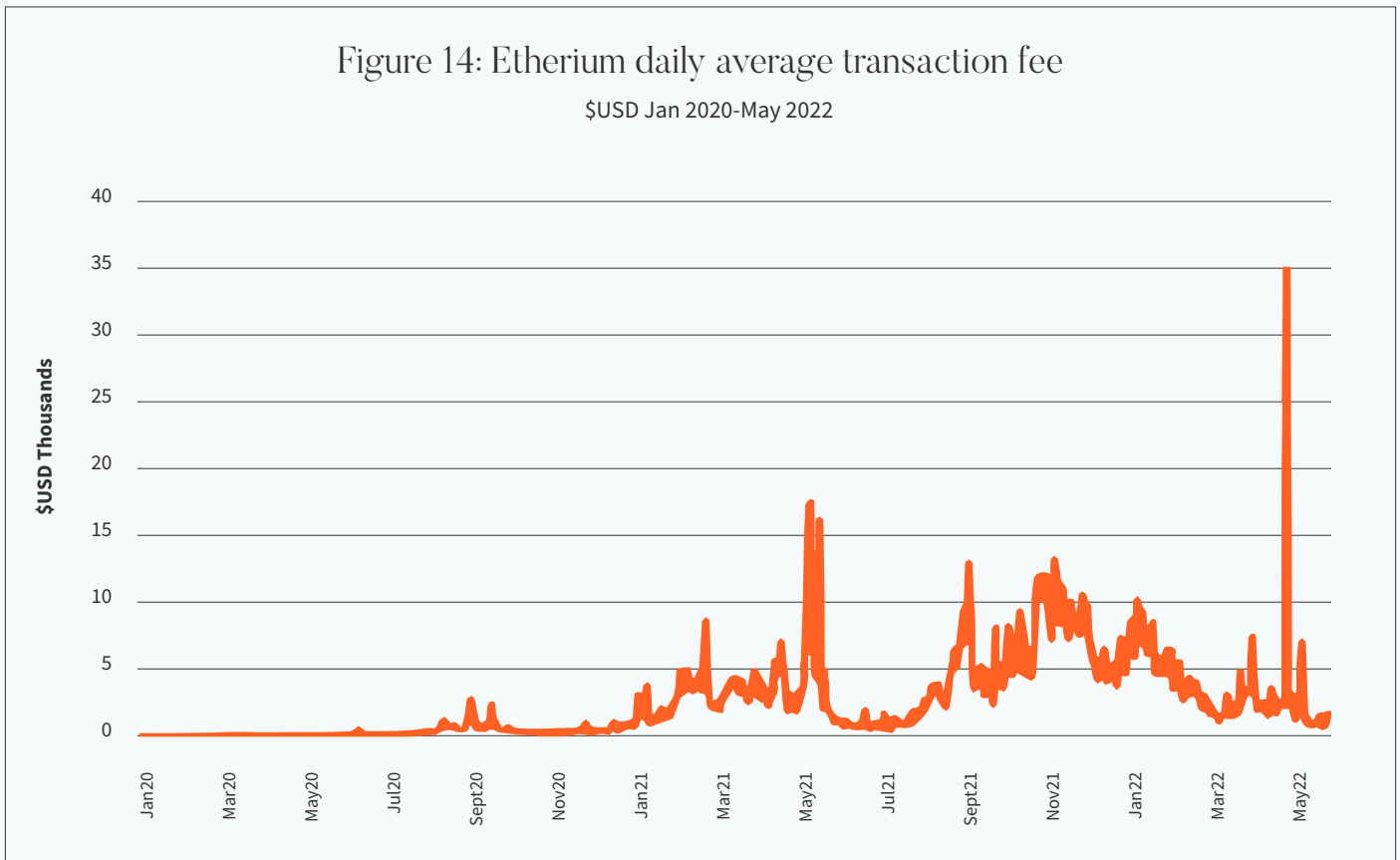

Figure 14: Etherium daily average transaction fee

$USD Jan 2020-May 2022

Figure 14: Blockchain.com

THE VIRTUAL LAND RUSH

Between-metaverse scarcity: entry barriers

An observation made by first-time metaverse visitors is the low fidelity (pixelated or cartoonish) nature of the platform. A common question which emerged from our research was 'if film, video games and collaboration software are able to apply high-fidelity visual effects to their products, why is this metaverse platform more reminiscent of a 1990s video game?' There are a number of answers to this question. First is the processing power required to deliver a high-fidelity experience to users without affecting latency. One remedy to this has been to create 'shards'—a common practice in massive multiplayer online role-playing games (MMORPG).

Shards used in a game (or virtual world) means that users are hosted on different servers in order to manage processor demand. If attending a concert in the metaverse, this means you'd be surrounded by a crowd, but it'd be capped at around 100, not the entire 11 million who attended (consider Fortnite's 2019 Marshmello concert). Solving this problem is no easy feat, particularly if concurrently working toward more lifelike avatars and virtual environments.

MMORPGs in their current state can take years to develop. One example is Elder Scrolls Online, which was in development from 2007 to 2014 and rumoured to cost $200 million.[90] Game development engines promise to lower barriers to entry as they develop over time, but incumbents will benefit from early mover advantages. New entrants would then be faced with the uphill battle of building their own networks and incentivising users to switch. This is likely to serve as a limiting force on the proliferation of metaverse platforms.

Within-metaverse scarcity: land supply

Mark Twain is often cited as the originator of one of real estate's favourite locutions—*buy land, they're not making it anymore.* But around the time Twain was purported to have said this, the Dutch were hard at work transforming thousands of acres of the North Sea into habitable land. The space race ensued mere decades after his death, precipitating speculation about our potential existence as a multiplanetary species. Another half-century later, one could holiday on a man-made island in Dubai or enlist in a navy exercising freedom of navigation around China's manmade islands in the South Pacific. If the very notion of land scarcity doesn't hold in the physical world, what makes us think it will hold in the virtual world? The answer relies on the Friedman-notion of rational investors acting in their own self interests. In Decentraland, for example, voting power is allocated by the amount of MANA (currency), NAME and LAND (parcels) held by a participant. If you own one parcel, your voting power is 2,000. If you have one MANA, your voting power is 1.[91] A similar arrangement exists for Sandbox, where voting rights are granted to holders of SAND (the 'main utility token of the platform').[92] Landholders in Decentraland and other metaverses therefore have an uncanny resemblance to the British .landed gentry of the 19th century--voting on decisions such as the supply of new land; the size of new land (Decentraland plots increased from 100sqm to 256sqm in 2019); whether to add vehicles; and a long list of other decisions which affect all users.[93] This governance structure suggests that a purportedly decentralised world could very well become a centralised one in the event that land ownership is concentrated in few wallets—as is often the case with company shares and other assets, including supposedly-democratised cryptocurrencies.

THE VIRTUAL LAND RUSH

Decentralisation, democratisation or none of the above?

Apportioning voting rights on the basis of share ownership might seem like a reasonable or even natural governance structure for a corporation, but doing the same with tokens and/or virtual land doesn't appear to align well with the notion of decentralisation. This is particularly the case if the vision of the metaverse is for the public to spend a considerable portion of their waking hours immersed in it. One might argue that anybody can become a token holder on a platform by simply exchanging fiat currency for a unit of the virtual world's currency, but this voter may have a fraction of the voting power of others who are more active on the platform, which better resembles a plutocracy than a democracy.

Metaverse evangelists claim that the true leaders of the movement are the communities who have been involved for years, and corporates are simply followers.[94] In these communities, 'decentralisation' and 'open' are common phrases. Among others, their objectives include interoperability between platforms, the ownership of one's own digital assets, user control over a platform's governance, and greater revenue opportunities for creators. According to Matthew Ball, interoperability faces the challenge of contradicting the interests of the multibillion-dollar technology incumbents investing in developing the metaverse. Past behaviour could

be the best predictor of future behaviour here, with the likes of Microsoft, Sony and Apple all choosing not to support 'third-party rendering', and to obstruct cross play.[95] Aside from Apple and Google's creator fees, another cited example of the coercive power of centralised platforms is Spotify—where a small percentage of artists make a liveable income.[96] The Chinese government has also purportedly intimated that their metaverse will preserve the authoritarian characteristics of the country's existing systems.[97]

The science fiction origins of the term 'metaverse' offer a less-than-flattering prediction of how the centralised-versus-decentralised debate could play out. In Neal Stephenson's Snow Crash, metaverse users of low socio-economic status are easily identified by their generic and/or poor-quality avatars. Although government power has been largely ceded, it was to corporations, not the public. One example is the for-profit Central Intelligence Corporation (a merger of the Library of Congress and Central Intelligence Agency).[98] With billions of dollars of corporate investment, exclusive NFT clubs with five-figure entry costs, 'reputation scores' for users and four-figure virtual handbags on offer, it seems Stephenson might have been onto something.

"

This Metaverse is going to be far more pervasive and powerful than anything else... if one central company gains control of this, they will become more powerful than any government and be a god on Earth. What we want is not a company but a protocol, that anyone can implement.

TIM SWEENEY[99]

"

THE VIRTUAL LAND RUSH

The decentralised autonomous organisation

Vitalik Buterin started Etherium after experiencing an emotional misfortune on MMORPG World of Warcraft. The centralised platform is owned and developed by Blizzard Entertainment, an entity which weakened his 'beloved warlock's Siphon Life spell'. After purportedly crying himself to sleep, Buterin put himself to work researching blockchain and cryptocurrency, seeing everything to do with government regulation and corporate control as 'being plain evil'.[100] Etherium was launched in 2015, and by 2022 plays host to 4,833 decentralised autonomous organisations (DAOs) with a combined $10 billion in assets under management.[101] A DAO is an 'internet-native business that is collectively owned and managed by its members… decisions are governed by proposals and voting to ensure everyone in the organization has a voice'. The rules of a DAO are set inside a smart contract, and once the contract is live on Etherium, it cannot be changed except by a vote.[102] DAOs are often cited as the governance entity of metaverse platforms, but many are yet to be established. Somnium Space, for example, is currently a centralised metaverse owned and operated by a UK company.[103] Axie Infinity is owned and operated by Asia-based Sky Mavis, who claim in their white paper to 'gradually evolve [Axie Infinity] into a community-owned Decentralised Organization' (see Table 3 for more examples).[104]

Decentralised finance

If there's a theme that rivals the sudden and recent surge of mass interest that characterised the metaverse, it's decentralised finance (DeFi). This surge of interest has not gone unnoticed by the US Securities and Exchange Commission (SEC), which has warned operators that if offering investment products in the US, they are still required to register their offerings.[105] This likely comes as unwelcome news to DeFi proponents, many of whom align with Vitalik Buterin's assessment of the evils of government regulation and corporate control. The 2008 Bitcoin white paper by an author under the pseudonym of Satoshi Nakamoto is often cited as the foundation of DeFi. By 2022, another 18,464 cryptocurrencies had been created with upwards of 300 million users worldwide.[106] Metaverse platforms are often accompanied by a cryptocurrency—such as ApeCoin (Bored Ape Yacht Club and Otherside); MANA (Decentraland); and SAND (Sandbox). As highlighted earlier, these currencies are volatile against fiat currency, which has led to the establishment of 'stablecoins'. A stablecoin is pegged to a currency like the US dollar or a commodity like gold in order to serve as a medium of exchange rather than just a speculative asset.[107] A 2021 paper by the Bank of International Settlements claims that 'full decentralisation in DeFi is an illusion. And indeed, platforms have groups of stakeholders that take and implement decisions, exercising managerial or ownership benefits'.[108]

THE VIRTUAL LAND RUSH

The Pareto principle

As legend has it, in the early-1900s, Italian economist Vilfredo Pareto was harvesting peas from his garden when he observed that around 20% of the pea pods produced around 80% of the peas. Nearly 2,000 years earlier, Matthew (of the Gospel of Matthew fame) made a similar observation: 'For to every one who has will more be given, and he will have abundance; but from him who has not, even what he has will be taken away'—giving rise to the *Matthew principle*. Both principles gesture to unequal distributions, and the inclination for more productivity and/or resources to accumulate toward the top. You've likely heard of claims such as 'the richest 1% own half the world's wealth'.[109] However, you may not have heard that the concentration of Bitcoin wealth is significantly higher than the wealth distribution of the US population—with the top 0.014% of Bitcoin investors holding approximately 26% of all Bitcoin.[110] In a scenario where this trend applies more broadly to cryptocurrencies, the metaverse promises a less equitable society than the one we have today. Can metaverse powerbrokers anticipate application of the Pareto principle and mitigate it?

" For to everyone who has will more be given, and he will have abundance; but from him who has not, even what he has will be taken away "

DECENTRALISATION, DEMOCRATISATION OR NONE OF THE ABOVE?

Name	Governance (Entity)	Currency	Estimated monthly users[111]	Description
Otherside	Decentralised (DAO)[112]	ApeCoin	Under development	Resembling a Gorillaz music video. Serves as the metaverse of Bored Ape Yacht Club. Its vision is an interoperable MMORPG platform where 'high-class NFTs can live, play and frolic'.[113]
Sandbox	Decentralised (DAO)	SAND	30,000	Often promoted as the decentralised crypto-enabled response to Minecraft and Roblox. A voxel-based platform for games and other assets.
Decentraland	Decentralised (DAO)	MANA	300,000	Founded in 2017. Often referred to as the eminent early-stage Web3 non-gamer metaverse.
Voxels (formerly Cryptovoxels)	Centralised [114] (Nolan Consulting)	Ether	<25,000	Another metaverse platform compared to Minecraft. NFT artwork and social interaction opportunities are prevalent.
Somnium Space	Centralised (Somnium Space LTD)[115]	CUBE[116]	<300	An open-source platform. Users can purchase digital land, build homes and buildings, play games, start businesses, offer concerts and live events.[117]
SuperWorld	Centralised (SuperWorld Inc)	Ether[118]	<5,000	Inspired by Pokémon Go. An AR metaverse where users can buy 100m x 100m plots of land reflecting land in the real world, and construct AR experiences on them.
Upland	Centralised (Uplandme Inc)	UPX	253,000	Inspired by Monopoly and Cryptokitties. A virtual property trading game based on real-world addresses. It allows people to buy, sell and develop virtual land.[119]
Axie Infinity[120]	Centralised (Sky Mavis)	Shards	1.8 million	Started in 2018, a play-to-earn system. Universe filled with 'Axies'—creatures players can collect as pets. Claim to be transitioning to decentralised.
Horizon Worlds	Centralised (Meta)	TBD[121]	300,000[122]	Meta's platform for social experiences in virtual reality. Allows users to explore virtual worlds, engaging in both content consumption and creation.
Rec Room	Centralised (Rec Room Inc)	Tokens[123]	>1 million[124]	A 'social app you play like a game'. Cross plays on devices such as phones and VR headsets.
Spatial	Centralised (Spatial Systems Inc)	Fiat	<57,000	Enables users to experience virtual NFT art exhibitions, meetups, and live events together with lifelike avatars.
The Nth Floor	Centralised (Accenture)	N/A	Accenture staff	For Accenture employees to host a virtual coffee break, conduct training, or host important all hands meetings.
Roblox	Centralised (Roblox Corp)	Robux	205 million	An online game platform and game creation system that allows users to program games and play games created by other users.
Minecraft	Centralised (Mojang Studios)	Minecoins[125]	172 million	Players explore a blocky world with virtually infinite terrain, and may discover and extract raw materials, build structures and fight.
Pokémon Go	Centralised (Niantic)	PokéCoins[126]	79 million	Uses mobile devices with GPS to locate, capture, train, and battle Pokémon, which appear as if they are in the player's real-world location.
Fortnite	Centralised (Epic Games)	V-Bucks	270 million	Fortnite is primarily a 'battle royale game'. It is purportedly the most popular game in the world. They have hosted events with high profile celebrities.[127,128]
Second Life	Centralised (Linden Lab)	Linden Dollar	<920,000	An online multimedia platform that allows people to create an avatar for themselves and have a second life in an online virtual world.

Table 3

THE VIRTUAL LAND RUSH

Digital twins, virtual land and the physical world

In early-2022, a Texas-based PropTech start-up made headlines for their pivot from developing digital twins of offices to building and deploying commercial real estate in the metaverse.[129] Now known as SwivelMeta, the entity made a number of layoffs and new hires in order to facilitate this transition—highlighting the contrast between digital twins and virtual buildings. As with the metaverse, there is still disagreement about what a digital twin actually is. Some gesture to a virtual representation of the inside and outside of a building (or other object). Others highlight additional layers akin to computer-aided design (CAD) and building information modelling (BIM). Others go beyond static virtual representations and simulations of a building to include live operational data. Some wonder if in the future a virtual building can reflect the entire state of a building and its contents in real time—something that might be facilitated by the 'internet of everything' (IoE).

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> A digital twin should be more than just a graphical representation of a building. With the internet of things (and eventually the internet of everything), digital twins can and should offer live operational data. We could also learn from Formula 1 racing by using digital twins to digitally simulate scenarios such as weather events, building usage or emergencies.
>
> **ANONYMOUS**
>
> "

THE VIRTUAL LAND RUSH

Digital twins and the internet of everything

The IoE describes a world where 'billions of objects have sensors to detect measure and assess their status; all connected over public or private networks using standard and proprietary protocols'.[130] According to Bright Spaces founder Bogdan Nicoară, IoE could be facilitated not only by sensors, computer vision and LIDAR, but also nanobots embedded in materials, effectively digitalising inanimate objects. In practice, this could bridge the gap between digital twins being used solely as representations of buildings to digital twins being used to facilitate extended reality experiences between in-person and virtual attendees in real time. If a desk is moved in real life, that desk will also move in the digital twin. In retail, this could mean managing in-store inventory in real time for both virtual and in-person shoppers. In office space, it could enable a virtual attendee to navigate the workplace as it is that day—enabling team huddles, brainstorming on a SMART board, or even a game of ping pong between an in-person employee and their remote colleague's hologram (the ball would have to be virtual). For the time being, however, technology serves as

an obstruction to this vision. Such detailed digital twins with millions of data inputs would require storage space and internet bandwidth, particularly if integrating lifelike avatars. It is unclear if the benefits are significant enough for such a large investment to be made. It is also unclear whether it is even desirable for digital twins to facilitate the convergence of AR, MR and VR. Several of our interviewees highlighted the contrasting use cases of these technologies. Others emphasised the value of creating virtual experiences which did not resemble a real-world environment such as an office. Perhaps they will continue to work better separately.

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> The IoE describes a world where billions of objects have sensors to detect, measure and assess their status; all connected over public or private networks...
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Interoperability and the ownership problem

As one of the explicit objectives of metaverse proponents, interoperability is the ability to transit from one metaverse platform to another seamlessly while retaining your digital assets and identity. Although there are a number of benefits of interoperability, it is unclear what this means for digital assets which replicate the real world. Consider an AR metaverse which allows you to buy a parcel of land representing land in the real world. Although you can buy the Eiffel Tower or White House on the platform, this doesn't mean you own them in the physical world (or other metaverses). The challenge doesn't stop there. If the owner of the Eiffel Tower on the platform wanted to overlay an AR advertisement across the Eiffel Tower for other users to see, does that raise any issues?

According to interviews during our research, the ownership issue also emerges in virtual worlds without references to physical land. Consider the example of minting a digital twin as an NFT. Does the architect, developer, owner, operator or tenant have first right of refusal over the NFT? Can ownership of the NFT change hands independently of ownership of the physical building? Given that buildings are stationary structures, can a digital twin NFT exist on multiple platforms, or solely in a virtual representation of its physical location? If a property investor owns both a physical building and its digital twin NFT, does that increase the saleable price of the building?

The virtual property developer

With real estate design and development professionals already familiar with software that compliments their work, it's little surprise that virtual representations of real estate is an area of growing adoption in the industry. Romania-based start-up Bright Spaces have made inroads with commercial real estate projects for clients such as Skanska, ONE United, Impact Hub, Avison Young and several others yet to be announced. In London, Canary Wharf Group offer an interactive and descriptive 3D map of the Canary Wharf estate.[131] The highly ambitious wearable immersive real estate dataroom (WIRED) collaboration between BNP Paribas Real Estate and Unity 3D is an example of where the integration of extended reality and digital twins is headed. In 2021, the WIRED project began by offering an interactive map of Greater Paris, with plans to first extend the area covered to the rest of France, then to the rest of Europe.[132]

Two gaming engines are often cited as the benchmark for developing virtual experiences. One is Unity—the firm collaborating with BNP Paribas Real Estate on WIRED. The other is Unreal Engine. The ability for developers to use these tools with little-to-no coding experience makes virtual property development more widely available, meaning real estate groups are increasingly likely to offer their own virtual experiences in the future.

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Luke joined Pi Labs from the University of Oxford's Future of Real Estate Initiative. He has conducted research on a wide range of issues impacting real estate and PropTech. His background also includes the advisory of PropTech and real estate start-ups in Europe, Africa, and Australia. Prior to this, Luke co-founded an Australian research and investment brokerage. He has a Bachelor of Commerce (Property) from Western Sydney University, as well as postgraduate qualifications in economics and change management from the University of New South Wales. He is currently completing an Executive MBA at the University of Oxford.

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About Pi Labs

Global proptech venture capital (VC) firm Pi Labs backs the innovators revolutionising the future of physical spaces.

Connecting next generation technologists with the real estate world and mentoring forward-thinking founders as they grow and scale their startups, Pi Labs' purpose is to solve the greatest challenges facing the real estate world through technology and create a positive impact on our physical environment for people, businesses and communities.

Founded in 2014, London-based Pi Labs invests in early-stage proptech startups which are transforming how we design, build and experience physical spaces across Europe – where it is the most active proptech VC. Its portfolio companies operate in global markets, including Asia and the US. From pre-seed to Series A and follow-on investments in later funding rounds, Pi Labs has grown its portfolio to more than 60 companies which are shaping the future of our physical spaces, with more than 50% of startups focused on addressing environmental and social issues.

For more information, visit pilabs.vc

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Please cite the work as follows: Graham, L., Baum, A. 2022. Unreal estate: Metaverse, extended reality and the future of our physical world. Pi Labs. London, United Kingdom.

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