European Planning Studies

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ceps20

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To cite this article: Pier Luigi Parcu, Maria Alessandra Rossi, Niccolò Innocenti & Chiara Carrozza (2023): How real will the metaverse be? Exploring the spatial impact of virtual worlds, European Planning Studies, DOI: 10.1080/09654313.2023.2221323

To link to this article: https://doi.org/10.1080/09654313.2023.2221323

Published online: 07 Jun 2023.

EUROPEAN PLANNING STUDIES
https://doi.org/10.1080/09654313.2023.2221323

How real will the metaverse be? Exploring the spatial impact of virtual worlds

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ABSTRACT

In this paper, we perform a preliminary analysis of the technologies, firms and industries that may be affected by the possible futures of the metaverse, attempting to derive some hypotheses on the spatial effects of this process. We distinguish between two possible evolutive scenarios – the 'metaverse shaped by reality view' and the 'metaverse shaping reality view' – and factors affecting them, deriving implications for public policy planning. The first scenario presents relatively traditional core policy challenges: ensuring homogeneous availability of network infrastructures as well as the skills indispensable to catch the new technological opportunities at the local level, accompanying the reallocation of factors of production associated to disruption and addressing inequalities. In the second, the main challenge is more radical: to ensure that desirable features are incorporated in the emerging virtual worlds from the start.

ARTICLE HISTORY
Received 5 April 2023
Revised 23 May 2023
Accepted 28 May 2023

KEYWORDS
Metaverse; market evolution; hype; planning

1. Introduction

The metaverse has been defined in many ways: as a product or a service, as a place, and even as a moment in time.[1] For instance, the author and investor Matthew Ball, in a seminal book on the topic (Ball 2022), described the metaverse as

> a massively scaled and interoperable network of real-time rendered 3D virtual worlds that can be experienced synchronously and persistently by an effectively unlimited number of users with an individual sense of presence, and with continuity of data, such as identity, history, entitlements, objects, communications, and payments.

This definition, along with many others, puts emphasis on the virtual nature of this (set of) technological developments. However, the virtual nature of the metaverse does not exclude the possibility of very concrete spatial economic effects. The technology may potentially have a relevant impact at the local level, influencing both the national dimension as well as the regional and city dimension, modifying the way businesses are conducted and the interactions among people.

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The scale of this impact and its concrete nature will depend on whether the metaverse will deliver on its promises. At one extreme, entirely new forms of social interaction may develop, as well as new connections between virtual and physical experiences. This is the optimistic vision for the future of the metaverse, one where the various technologies will converge in supporting the emergence of a new virtual environment where economic concepts and institutions such as *scarcity*, *property* and *markets* take on new meanings. At the other extreme, the metaverse may end up being a 'catch-all' fashionable label to indicate a disparate set of technologies related to virtual experiences, each of which may have a relatively independent evolutionary path, but all substantially replicating existing human activities in an immersive reality. Even in this case, although the vision of a network of virtual worlds populated by avatars would not become central to human experience, the innovations associated with the metaverse may significantly modify our lives, our culture and the way we interact. Almost all sectors that can benefit from a direct, even if virtual, engagement of users may potentially be affected and transformed. What scenario will emerge cannot currently be accurately predicted. The perception of real technical achievements is still uncertain (Dwivedi et al. 2022), investment values in the financial markets are extremely volatile and skepticism on the reliability of the cryptocurrencies associated with the different virtual worlds is also rising (Vidal-Tomás 2022 and 2023). Finally, and importantly, uncertainties on the nature of the use cases beyond gaming and the current relatively low number of users, even at a time when the concept has received significant attention from the public, raise doubts on the viability of the metaverse on a large scale. Nonetheless, in this paper, we adopt a qualitative methodology to conduct a preliminary analysis of the technologies, firms and industries that may be affected by the possible futures of the metaverse, attempting to derive some hypotheses on the spatial effects of this process. Despite its inevitable limitations, we believe such an analysis is opportune in the attempt to separate hype from reality and to plan appropriate policy responses.

Planning will need to evolve in different directions according to whether it will be current reality to shape the metaverse – i.e. the metaverse will remain a label for a variety of technologies that complement existing human activities and sectors through virtualization – or the metaverse will enable new realities through new forms of social interaction. In the first case, the main challenge will be a traditional one: to enact policies that support territories in gauging the innovation and development opportunities opened by frontier innovations and to ensure territorial cohesion by preventing excessively skewed outcomes in terms of the distribution of the benefits. In the second case, there is an additional, more extreme, challenge for planning. The metaverse as a well-identified network of virtual worlds may become an environment where technology will shape human interactions more deeply than it has ever been the case because man-made governance rules are consciously embedded in technology. This takes the idea that the direction of technological evolution is influenced by conscious human choices that some economists have set at the centre of their analysis of inequality (Atkinson 2015) to the next level. In this possible (though perhaps unlikely) future, planning would need to address the fundamental question of how to design the framework within which social interactions will take place in the new virtual space so that desirable features are embedded in the system from the start (Lazzeretti 2023).

The paper is structured as follows. Section 2 examines the hype that currently surrounds the metaverse concept, both among the public and in the academic community. Section 3 starts addressing the issue of the local (country-level) impact of the metaverse by considering the technological readiness of various countries in terms of the outcome of past investments in key technologies related to the production side of the metaverse, as presently captured by patents and scientific publications. Section 4 focuses on the industry-level and adoption-related impact of the metaverse on the local economies by developing three hypotheses, with the associated implications for planning. The focus of this section is on the above-described 'minimalist' view of the metaverse as a set of technologies and related business models, rather than on the fully-fledged network of virtual worlds (the 'metaverse shaped by reality' view). Section 5 speculates on the 'metaverse shaping reality' view of the emergence of a new space of social interaction. It attempts to single out key dimensions of its evolution, again highlighting (even more speculative) implications for planning. Section 6 concludes.

2. The hype around the metaverse and the reality

The year 2022 can be defined, in many ways, the year of the metaverse: interest among the general population has spiked in the months between the end of 2021 and the beginning of 2022, starting at the end of October 2021, when Mark Zuckerberg announced the rebranding from Facebook to Meta. The latter, meant to be an explicit signal of the company's commitment to the metaverse, accelerated the development, the investments in, and the awareness of, the concept. Facebook also bet more than $10 billion on the development of the metaverse in 2021 alone (Kraus et al. 2022). This section provides some quantitative information on the evolution of public, academic and financial attention towards the metaverse (Section 2.1) and summarizes key demand and technological challenges to its development (Section 2.2).

2.1. The fluctuating attention towards the metaverse

Figure 1 presents the search trend on Google for the word metaverse in the last two years, showing that between January/October 2021, searches for the concept were relatively low in number, and have dramatically increased immediately after the rebranding of Facebook, in November 2021/mid-February 2022. The searches subsequently showed a decline, but still settled at a significantly higher value than in October 2021, suggesting

Figure 1. Metaverse search trend (Jan 2021–Nov 2022). Source: Google Trends; extracted on 11-11-2022

that the idea of the metaverse has finally reached wider recognition, beyond technologists and specialized investors.

Attention by investors and the financial community is also increasing considerably. Many influential companies around the globe are investing to build their own visions of the virtual worlds, by also acquiring smaller companies that are considered to be at the frontier of the technology (e.g., Meta has acquired Oculus VR, Microsoft is buying Activision Blizzard). The latter transaction is under severe review by the EU, UK and U.S.A.[2], and by other jurisdictions, showing the attention also of the regulatory authorities. Direct investment by many different companies brings the overall amount of funds well beyond the large investments of Facebook/META.

While academic interest in the metaverse precedes the latest moment of hype just described, even the academic community has shown a remarkable increase of interest in the concept along with the public. Figure 2 shows the rising trend in the yearly number of scientific publications (ISI publications on scientific journals[3]), particularly from 2008, but also the tremendous spike during the last year, with more than 380 papers published in 2022 alone[4] (more than the overall number of publications from 1995 to 2020). Citations for articles with the topic metaverse, another important indicator of scientific attention, also show a value greater than 900 for the year 2022, which is more than nine times the value recorded in the previous year. The bulk of these publications is in the computer science, engineering and telecommunications domains, and therefore concerns mostly technical aspects of the development of the metaverse. More limited, but rapidly growing, is the interest shown by the social sciences, which account for approximately 10%–15% of the publications.

Over the course of the past year, the hype around the metaverse has also patently met reality, raising doubts on the effective likelihood that this potential technological revolution will deliver on its promises. Nowhere have faltering expectations been more visible than in the financial markets. The best-known company that has decided to bet strongly on the metaverse, Meta, has clearly not been rewarded by investors. Meta has recently demonstrated severely negative performances, with a loss in shares value that was

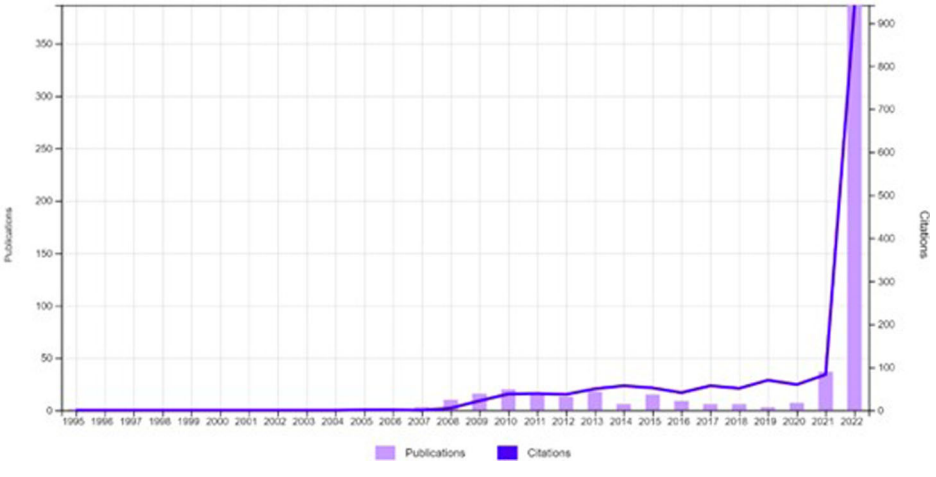

Figure 2. Yearly evolution of scientific publications and citations. Source: ISI Web of Science.

close to 63% during the year 2022, albeit in a context of general retreat of technological titles (Figure 3). Between 2022 and 2023, the company announced that, for the first time in its history, it would be making a staff reduction of approximately 21.000 employees (Financial Times 2023). Also, in March 2023, Meta has informed investors that it will redirect some of its efforts away from the metaverse and towards improving more traditional content recommendation systems through AI applications.

ETF instruments related to the metaverse have also displayed a recent negative performance (Vidal-Tomás 2022). All these financial investments showed a loss greater than 50% in 2022. The largest ETF investing in the metaverse – Roundhill Ball Metaverse ETF[5] – counting on an initial value of Assets Under Management (AUM) of over $850 million, lost approximately 53%. Even if compared to the general decrease in the value of the financial market over the same period, the comparative loss remains about 20% higher. In the last year, other metaverse-focused ETFs, or portfolios, have shown similarly negative performances (e.g. eToro Metaverse Life Smart Portfolio lost 65%; Evolve Metaverse ETF 55% etc).

Financial performance is not necessarily a reliable indicator of the future success of any given technological development, although it does provide some indications on the state of expectations of financial markets and on the ease with which technological bets can be pursued. The next subsection focuses on two other indicators that may provide an explanation of the uncertainties emerging from financial markets, and pertinent information to assess whether there is substance beyond the hype: demand and technological constraints.

2.2. Demand and technological constraints to the evolution of the metaverse

Digital technology has, in the last two decades, made great steps forward and can today enable a more immersive experience: the possibility to easily access the virtual worlds at anytime and from anywhere, thanks to mobile devices, and a deeper bond with real life, for example, by allowing the trading of virtual objects and the use of virtual currencies.

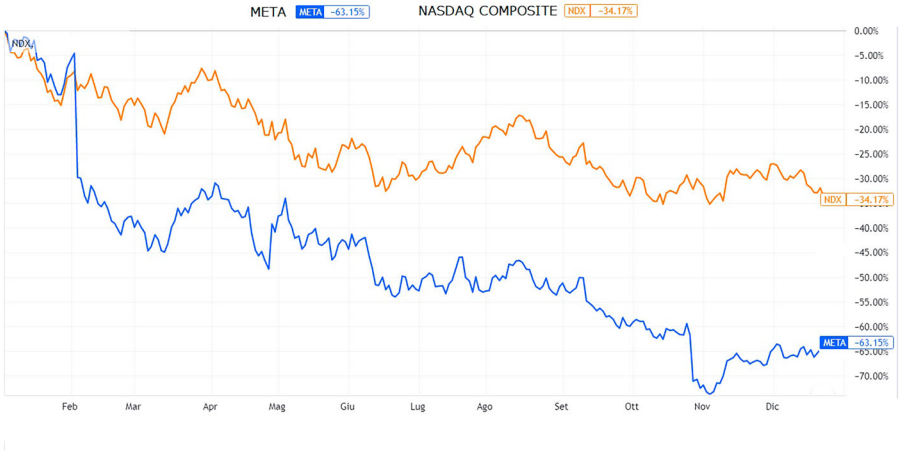

Figure 3. Nasdaq and Meta shares comparison, year 2022. Source: Our elaboration

Thanks to these evolutions, the metaverse, even in its infancy, offers an experience that is quite advanced in comparison to the previous elementary examples of virtual reality (such as Second Life). However, enormous challenges and potential side effects for users today, still partially unknown, remain. To better understand these constraints, it is useful to consider the state of development of the three main components of the metaverse: infrastructure/hardware, software and content (Radoff 2022; Park and Kim 2022).

The infrastructure/hardware layer (fibre networks, WiFi, 5G and beyond, cloud systems, semiconductors) includes the technologies that will make all the other layers of the metaverse possible. Differently from Internet 2.0, this layer needs to include also the new instruments that are necessary to build the human interface with the metaverse.[6] With Internet 2.0, the screen of a pc or of a smartphone was a sufficient interface, while a full metaverse immersive experience requires ad hoc tools that are capable of being intermediaries between humans and the infrastructure. These devices include all the wearable electronics that are in development, such as smart glasses, headsets, gloves and prospectively also deeper forms of man-machine connections. While developing high-performing, convenient, affordable devices presents its challenges, it is in the infrastructure layer that, at the moment, reside the greatest technological hurdles. Fast symmetric bandwidth (allowing users to send as much information as they can receive), low network latency (reducing the time it takes for data to travel from one point to another of the network and back) and overall network speed, all represent crucial features for the metaverse's developments and today's networks cannot meet these needs without significant, possibly radical, changes.

Furthermore, the input collected by the hardware needs to be processed by software to create the models that represent the virtual environment. Although much progress has been made in the past few years in all the software areas related to the development of the metaverse, improvements are still needed to enable a fully-fledged satisfactory virtual user experience (Mozumder et al. 2022). It is possible to single out two main areas of software innovation that may have a decisive impact on the future evolutionary trajectory of the metaverse and therefore on the real impact that it may have at the local level: Decentralization and Spatial Computing. They both do not have clear correspondence to anything in Internet 2.0. Decentralization relates to a vast area of both technological (e.g. distributed ledger technologies, crypto assets and NFTs) and governance innovation that should support achievement of the full potential of the metaverse by assuring a transparent, secure and traceable way to perform transactions and interactions. Spatial computing, in turn, groups a large category of technologies that are related to the access to, and manipulation of, 3D spaces, and to augment the real world with more information and experience.

Finally, the third key component of the metaverse is content. In the 'hype' version, users are expected to create large amounts of multimedia and text content through their avatars, and these entities and their relationships are used to organize events that are combined to form a scenario – something that is at present far from occurring. Nonetheless, content generation probably is the least stringent of the technological constraints because it can be rapidly overcome once a critical mass of users is achieved and indirect network effects start to exert their multiplicative magic. Following a well acknowledged perspective this may be considered as an 'era of ferment' (Anderson and Tushman 1990) that is thus expected to be followed by a period of incremental technical progress that will

enable a wider adoption of the metaverse, leading to a subsequent technological discontinuity.

This points to the feedback effects between technological and demand constraints. Indeed, lack of demand for usages (other than gaming) currently appears the other strong constraint to the development of the metaverse. As for any other network/multi-sided platform, the success of the metaverse hinges on its ability to attract a critical mass of users of different types (e.g. end-users and providers of experiences or services). This, however, seems to be very far from occurring. Following the most recent statistics, there are at present more than 400 million monthly unique users, but they are divided among many different metaverses, with a great predominance of the gaming ones (Roblox, with more than 200 million, Minecraft, with 160 million and Fortnite, with 80 million). This also has consequences for the average age of those users, who are largely younger than 18 years old (Metaversed 2022), and who are thus often unable to make transactions, buy assets, and/or spend easily.[7] The prevalence of gaming platforms leaves a few users sparsely scattered among the many different non-gaming platforms. While estimates may vary according to different sources, available data range between the 200.000 monthly users of Horizon World and the 40–50.000 of Sandbox and Decentraland. These, for the moment, appear to be numbers that may allow for limited interaction, and may thus justify the impression that metaverses are mostly empty worlds.

In this connection, one possible demand-side limitation to wider participation to the metaverse may come from the price level of the most advanced instruments needed to allow for a complete and immersive experience (i.e. the 'professional' VR or AR devices). The best devices have priced higher than $1.000 (HTC Vive Focus 3 and Meta Quest Pro), while VR devices that are expected to come from Apple in 2023 will probably be priced in a price range between $2-3.000. These prices appear to be far too high for mass consumption.[8]

3. A look at countries' technological readiness for the production of metaverse-related technologies through patents and scientific publications

To help ground the analysis of the local impact of the metaverse it may be useful to consider two standard indicators of local knowledge/innovation production: patents and scientific publications. Both have well-known limits in terms of their ability to capture innovativeness (Acs, Anselin, and Varga 2002; Burhan, Singh, and Jain 2017; Dernis, Squicciarini, and de Pinho 2015). Despite the limitations, however, a look at patents and publications may provide a first indication of, on one side, the interest shown in different countries towards metaverse-related technologies and, on the other side, of the countries that may be expected to play an active role in the development of these technologies and therefore to have a first mover advantage in the production of metaverse components. This, of course, does not mean that countries that are currently or prospectively not active on the production side will be excluded from participating to the usage side of the metaverse.

In this section, based on the Espacenet database, we will explore the evolution of the patents that are related to the most important of the technologies that are the foundation of the metaverse. Two of them relate to the above-described area of spatial computing –

Augmented Reality (AR) and Virtual Reality (VR) – and the last one is a frontier technology that aims to replace physical hardware (Brain-Computer Interfaces, BCI). A limitation of this method is that a large amount of the metaverse's development is achieved through computer programming improvements and these kinds of innovations normally are not found in the public domain. However, advancements in AR, VR and BCI, considered among the most important of the technologies that may favour the future massive adoption of the metaverse, are normally patented innovations.

The less known and established of the relevant technologies, BCI, shows an overall number of patents that is slightly over 5.300, while AR has just over 136.000, and VR approximately 183.000. By simply using the keyword 'metaverse' we can identify 'only' another 1.540 patents. Running the search again, considering all the technologies together (to avoid double counting) we reach an overall result of 241.567 patents.

Figure 4 shows that this patenting activity displays a significant growth year on year and an acceleration in the past 5 years, confirming the overall growing investors' interest in the metaverse discussed in the previous section: from 1.888 patents in 2009, to 3.096 in 2010, to 9.832 patents in 2015, 19.419 in 2016, until it reached a peak of 38.395 in 2020.

Of course, it is a well-known fact that, in the last twenty years, many kinds of patents have shown important growth. Figure 5 shows that growth of the patents here considered has been higher than average. In the period from 2015 to 2020, the number of patents that are in some way related to the metaverse showed a threefold increase with respect to other technologies, bringing these technologies to grow in percentage from 1,5% to more than 4,5% of the total (Figure 5).

The simple count of patents is, for many reasons, not a refined measure of the development of a technology (Parcu, Innocenti, and Carrozza 2022), however, they undoubtedly provide an acceptable proxy of the extent of the interest different countries show towards the metaverse. Moreover, they may be considered to provide a very rough indication of the availability within a country of knowledge resources that may influence countries' future ability to participate in the development of the relevant technological trajectories. In industries unrelated to the metaverse, patent endowments have been shown to influence the patterns of technological specialization (Belloc and Pagano 2012). Whether this will be the case also in the key metaverse-related technological domains cannot be foreseen at this stage, but it is nonetheless interesting to explore country-level patent endowments.

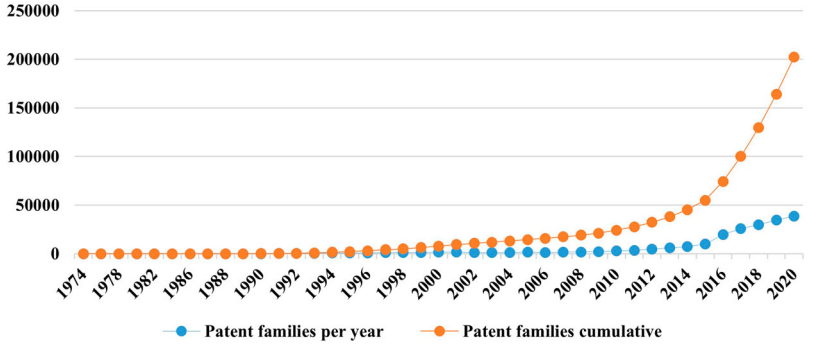

Figure 4. Patent Families AR, VR, BCI, Metaverse. Source: Our elaboration on Espacenet data.

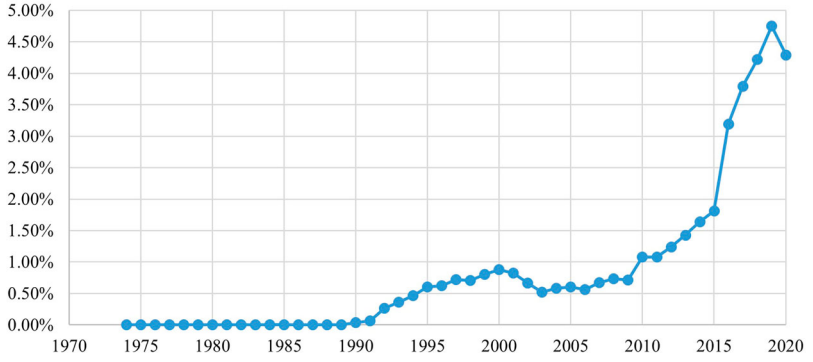

Figure 5. Percentage of metaverse (AR, VR, BCI) patents on all patents. Source: Our elaboration of Espacenet data.

Figure 6 provides information on the distribution of the considered patents by country of the applicant. It indicates a stark predominance of patent applicants from the United States. The U.S. accounts for around 170.000 patents, while the second country – South Korea – accounts for about 52.000 patents, followed by China (33.000) and Japan (23.000).

It is interesting to examine the data suggesting the predominance of U.S. applicants considering a different decomposition of the number of patents, this time by company. Figure 7 presents the 15 companies that hold the largest number of patent portfolios in relation to these technologies. The first place, with more than 8.600 patents, is held by Huawei, followed by LG, with more than 6.000 patents, Microsoft, Tencent, Sony and Samsung follow, all in a range from 4.500 to 4.800 patents, and then Meta, Intel, Oppo and Qualcomm, which each record between 2.950 and 3.300 patents, Google has slightly more than 2.000, and the last group comprises IBM, Apple, Nokia and BOE, who are all in the range between 1.400 and 1.600 patents. The figure, therefore, shows that eight of the fifteen largest patent-holding companies are

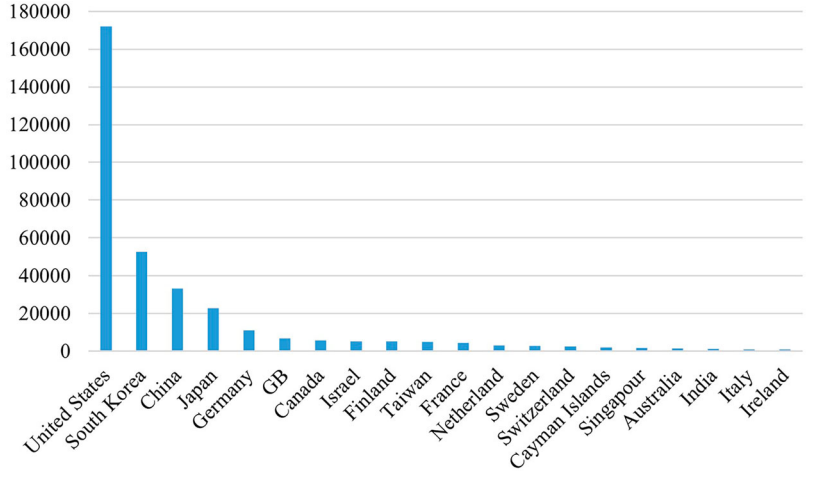

Figure 6. Country of the applicant (20 most frequent). Source: Our elaboration of the Espacenet data.

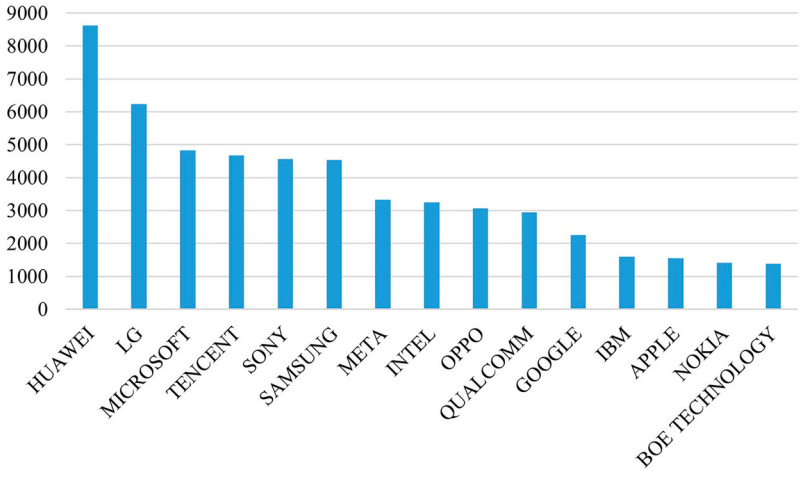

Figure 7. Number of patents per company (top 15). Source: Our elaboration of the Espacenet data.

not American, suggesting that patent endowments of key metaverse-related technologies may be less concentrated in the U.S. than patent applications would imply.

The list of patent holders that emerges from Figure 7, unsurprisingly, includes several innovative technology companies and four of the five GAFAM (Google, Apple, Facebook, Amazon, Microsoft). Whether the standards-based and licensing-based development model typical of the former or the siloed development model of the latter will prevail is currently hard to tell but likely to influence the metaverse's future technological configuration and the extent to which it will be subject to strict control by platforms (on which more below, Section 5).

Additional interesting information may be derived by looking at the countries where metaverse-related scientific publications are produced (Lazzeretti et al. 2022).

Figure 8 shows that the major producers of these publications are China, the U.S. and South Korea. However, a deeper analysis of these results, based on one of the most

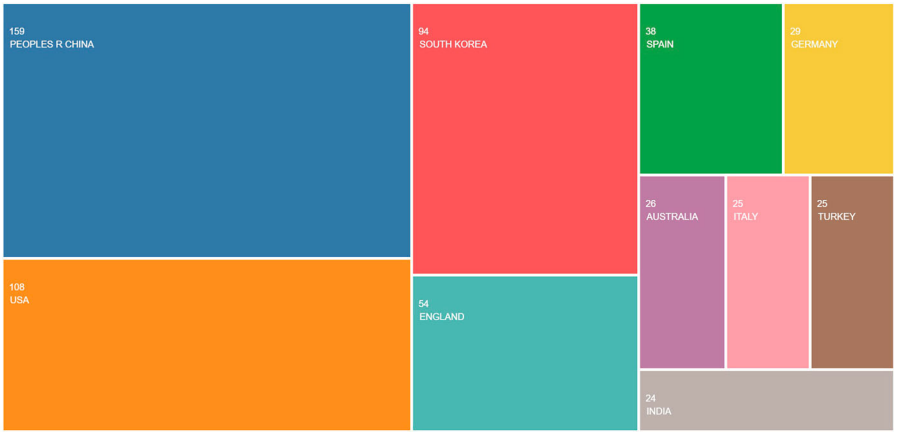

Figure 8. Scientific publications by author's affiliation. Source: ISI Web of Science.

common information to infer the relevance of publications – the citations received – it is possible to notice that the U.S. (682) has more than double the citations with respect to China (297) and that England, with one-third of the scientific publications, received more citations (350) than China. This is in line with more general trends observed in comparing Science&Engineering publications across countries (NSB 2022), which have been interpreted to indicate that the scientific knowledge base available in China is relatively less valuable than that available in the other mentioned countries. However, it may also be the case that the lack of citations reflects more limited international integration of Chinese scientists or simply language obstacles.

4. The metaverse as a virtual replica of existing human activities: prospective industry-level and local impact

In the previous section, to provide some objective elements on the potential local impact of the metaverse, we have considered the production side by looking at the country-level distribution of patents on technologies that may influence the future development of the metaverse and the country distribution of related scientific publications. In this section we broaden the perspective beyond objective measures and enrich our qualitative understanding of the phenomenon, considering the application and use of metaverse technologies at the local level. As mentioned in the introduction, the analysis of this section applies to the 'minimalist' view of the virtual worlds as a collection of technologies that may complement existing human activities. We begin by briefly describing the main sectors affected by the range of technologies that underlie the development of the metaverse. We then highlight three dimensions of these technological developments that we believe will be decisive in influencing their spatial effects, putting forward three hypotheses on their impact and corresponding implications for policy planning.

The most pessimistic view sees the sectoral effects of the metaverse as essentially confined to the gaming sector. In the latter, the virtual worlds-based business model is rather consolidated but what may prospectively make the difference is the potential pervasive use of a group of related instruments (cryptocurrencies, distributed ledger technologies, smart contracts, etc.) that may help developing new business models pushing gamers to increase the time they spend on the game, and their immersion in it, thus raising their willingness to spend. Even in this pessimistic view, it cannot be ignored that innovations developed in gaming may easily spill over to a range of other sectors, and primarily to the traditional content-creation sectors such as the film industry and entertainment more generally.

Early evidence suggests, however, that it is more likely that virtual worlds-related technologies will reach beyond gaming, impacting both the manufacturing and the services sector. Manufacturing is perhaps the sector where the concrete local impact of the metaverse could be most visible. Production lines may be improved by the extended use of 'digital twinning', which allows for the virtual representations of existing business functions, and to realize important savings with extended reality technologies applied to the design and prototyping of products. Also, new forms of marketing and product customization may innovate inventory management. Another sector with a visible local impact that could be widely affected is tourism. This includes the replication of current business, but with the addition of new content through the metaverse platforms, leading to

innovative business models like virtual worlds tourism and sustainable virtual worlds tourism (Go and Kang 2022; Koo et al. 2022; Gursoy, Malodia, and Dhir 2022).

Pinning down the local impact of metaverse-related technologies in other services is harder. A common thread appears to be the fact that the potential disruption induced by these technologies may result in a significant wave of innovation and entrepreneurial opportunities. For instance, the virtual worlds can be considered the new frontier for online shopping, which is especially relevant for e-commerce platforms. The sellers may seek the possibility of presenting their physical products in a new, more interactive way to consumers, thus increasing both customers' loyalty and the demand for the products (Jeong, Yi, and Kim 2022).

Real estate, in the virtual worlds, is already a reality, with the possibility of selling finished properties and virtual plots of lands, allowing the user to monetize their investments by either renting or through other forms of management (Nakavachara and Saengchote 2022).

Advertising could also be profoundly impacted. Entering the metaverse gives visibility to small companies (press, blog, social media, etc.) and even more visibility to big brands (Kim 2021; Taylor 2022; Rauschnabel et al. 2022), who have approached the virtual worlds to refresh their image (e.g. Coca-Cola, Gucci, Nike, Luis Vuitton and Balenciaga) and may possibly exploit the NFT market to develop a new profitable line of business for the future (recently Nike acquired on Roblox the digital shoe market RTFKT).

Beyond industry, metaverse-related technologies may transform other domains that may have a significant local impact. Three main areas stand out. The first is risk management, which has a range of different applications that may benefit from virtualization and experimental forms of social interaction. Improvements in risk management may benefit policy planning in many ways, from the city level, where mobility patterns may be better controlled and oriented, to the global scale of climate change problems, which improved predictive abilities may help to address significantly more effectively. Some cities like Shangai, Brisbane and Singapore have already started experimenting with hazard management tools.

Distance education could also be significantly improved by a more immersive experience for students at all stages of study, from elementary school to university specializations (Jeon 2021; Tlili et al. 2022; Hirsh-Pasek et al. 2022).

Another key domain of application of virtual worlds technologies of social relevance is the health sector. VR can create new channels for the delivery of care, potentially lowering costs and improving services to patients, leading to multimodal medical information standards, medical and social data fusion, telemedicine and online health management (Chen and Zhang 2022). Among the tools, telepresence, allowing people to be together virtually even while they are far apart, digital twinning, and blockchain (related to patients' data management and exchange), are expected to become relevant applications.

More generally, public service provision could find interesting new ways of being organized: tapping into metaverse's technology, Seoul Metropolitan Government, for example, is investing significant amounts of money to set an immersive public service platform, which is expected to benefit elder citizens.

In what follows we put forward three hypotheses on the impact of metaverse-related technologies at the local level. First, we argue that the availability of network infrastructures will be a constraint more significant than in the past to the ability of territories to

exploit the new technological and entrepreneurship opportunities. Second, the nature of technological opportunities opened up by the evolution of the metaverse will tend to limit the role of agglomeration economies and local knowledge spillovers, provided network infrastructures are locally available. Third, convergence among different sectors will increase, leading to much stronger competitive dynamics that may significantly disrupt existing businesses, leading to significant reallocation of economic activities.

Regarding the first hypothesis, it has been noted in Section 2.2 that the infrastructure layer is the one that currently poses the more significant hurdles to the further development of the metaverse. These hurdles relate to the need for infrastructure to ensure sufficient speed to enable a fully immersive experience, whit response times of around 10 milliseconds. Here it is worth adding that, for this to occur, given the constraints imposed by the basic laws of physics, at least some infrastructure elements should be placed near the end user. Therefore, territories can be active users of metaverse-related technologies only insofar as sufficiently well distributed local infrastructures are available. The speed of rollout of advanced connectivity solutions, such as fibre and 5G networks, has so far been determined by factors that are mostly independent of the development of the metaverse concept. Most countries have adopted policies to accelerate network rollout, but penetration remains strongly uneven at the global level, with the U.S., South Korea, Japan and China standing out in 5G deployment (ETNO 2023). In the European context the DESI Scoreboard (2022), while tracing some overall progress, consistently highlights remarkable differences across Member States (for example in terms of spectrum assignment, fixed broadband subscription, 5G mobile coverage), not to mention those among rural and urban areas. Thus, if these differences remain, it is possible to speculate that the ability of different countries and territories to immediately seize the innovation and entrepreneurial opportunities potentially opened up by the metaverse will be uneven, possibly even to a greater extent than it has previously been the case for the opportunities opened up by Internet 2.0.

Our second hypothesis traces a connection between the nature of the technological opportunities associated with the evolution of the metaverse and the extent of local agglomeration economies. To understand this connection, it is worth starting from the observation that the technologies related to the metaverse are expected to unleash a wave of technological and therefore entrepreneurship opportunities both in manufacturing and in the services sector.[9] In manufacturing, as mentioned, this may prospectively take the shape of the further transformation towards automation of industrial processes, opening the way to the emergence of new firms specializing in the provision of innovative solutions. In the services sector, within the simplified metaverse value chain described in Section 2.2, it is content that promises to have the greatest local impact in terms of creation of entrepreneurial opportunities, change in consumers/users' behaviours, and market disruption. Both the nature of the economic activities that (may/will) potentially belong to the *Content layer* and its prospective economic impact may go much beyond what is currently referred to as 'content' in Internet 2.0. This can be immediately perceived by observing, referring to the technological illustration elaborated by a prominent industry expert (Radoff 2022), that the *Content layer* can be said to encompass three sublayers: *Creator Economy*, *Discovery* and *Experience*. The expression *Creator Economy* refers to all the technologies that content creators use to craft the experiences that people may enjoy in the virtual worlds, i.e. the combination of software and marketplaces

that make it possible for creative people and teams to fill the virtual spaces. Companies like Roblox, Decentraland, Epic Games, ones that are either completely new or that come from the game industry, compete with the more well-known digital players, like Microsoft, Adobe, Shopify.

The domain named *Discovery* constitutes a vast ecosystem, presently one of the most lucrative for companies, that includes all the technologies through which, directly or indirectly, information and experiences that can be carried out within the virtual worlds are presented and offered to users. In addition to search engines, curation, and advertisement, in the virtual worlds it is expected that, given the core value of social interaction, community-driven discovery will gain relevance. In this area, Big Techs, with a consolidated and powerful advertising business model, from Google to Facebook, will directly compete with the new inventors of content, from gamers to space creators, like Unity and Unreal. Nonetheless, in the future, community-driven discovery that exploits real-time presence may lead the way if, as expected, the virtual worlds foster the transition from asynchronous social networking to real-time and collective virtual social activities.

Finally, the domain named *Experience* is the content layer in a more properly traditional sense. Here, the competition is open to all content producers that aim at a market that is constituted by the attention and the time of the metaversers. This is the realm for entertainment companies, from Netflix to YouTube, from connection companies like Zoom to social media like Facebook, and today is primarily the domain of the gamer companies as Fortnite, Activision Blizzard, Minecraft, etc.

Increased entrepreneurship opportunities arise in all three layers, although the Discovery domain is certainly characterized by higher barriers to entry. Innovation and entrepreneurship in these domains aim at participating in global markets and require creative ideas and mostly top-down codified technical knowledge that is accessible through global epistemic communities rather than bottom-up cumulative knowledge. This entails that the stock of existing localized knowledge assets is not crucial to seize the technological opportunities offered by the virtual worlds, so that new patterns of local development may emerge with the potential to escape to traditional path dependence constraints. Thus, technological opportunities in the creation of virtual products and experiences may possibly limit the role of agglomeration economies and local knowledge spillovers, which the advent of the intangible economy has, somewhat surprisingly, even reinforced (Haskel and Westlake 2018).

The strength of this hypothesis may also be buttressed by the observation that a technological trend exists in the content layer of the metaverse towards the decoupling of good business ideas from coding capabilities and technical competence based on the increasing availability of ready-to-use software tools accessible to any would-be entrepreneur. Indeed, since the success of the emerging virtual worlds is linked to the ability to spur direct and indirect network effects so as reach a critical mass of users, existing companies active in the Creator Economy domain have an interest in lowering the barriers to participation for any user-developer that may help to build the content needed to engage other users in an immersive experience. If the trend continues, the diffusion of metaverse-related technologies may also improve social inclusion, by alleviating some of the constraints to entrepreneurship. This would be particularly likely if the most idealistic views of Decentralized Finance (DeFi) linked to the evolution of Web 3.0 did effectively

contribute to alleviate also financial constraints to entrepreneurial activities (OECD 2022).[10]

It is important to stress, however, that the second hypothesis, as well as the third, to be put forward next, may hold provided that infrastructures are homogeneously available across territories. The previous (and the following) discussion indicate that local conditions may constitute particularly strong constraints to entrepreneurship. Forms of digital divide, with more extreme implications than in the traditional internet, and unequal distribution of innovation opportunities across territories may indeed be the outcome of persisting inequalities in the distribution of infrastructures.

The third hypothesis on the local effect of the metaverse relates to the degree of convergence among sectors that the metaverse may determine, which is substantially magnified with respect to the traditional Internet. Convergence has been a disruptive force in Internet 2.0, but limited mostly to digital(ized) economic activities or to vertical relationships among sectors. With voice, data and broadcasting simply becoming a stream of packages, competition has intensified across the layers of the traditional value chains, for instance in broadcasting, where firms from traditionally distinct rings of the chain have started competing. In the most sanguine views of the metaverse, by contrast, horizontal convergence across sectors appears likely. For instance, innovations from the gaming industry may be used across a range of different sectors, giving rise to new competitive dynamics. Moreover, convergence will not only be confined to the digital world, but it may prospectively become a matter of physical-digital integrations, giving rise to unexpected innovation opportunities.

Two main implications of the increased degree of convergence can be traced for local economies. The first is that, as it has been the case for previous generations of the Internet, increased convergence entails greater competition and therefore a significant disruption of existing economic activities and business models. A significant wave of reallocation of activities and factors of production may be expected to follow, which may create social tensions and inefficiencies due to reallocation frictions. The second implication of convergence is that it may favour evolutionary scenarios whereby Big Tech platforms, by exploiting their simultaneous presence on multiple convergent domains, play an ever-increasing role in mediating access to global markets by local entrepreneurs and therefore exert an increasing influence on local development. This possible evolution is further explored in the following section.

In the instantiation of the metaverse considered in this section, the main challenge for planning concerns understanding the changes the 'metaverse' may potentially trigger in traditional industries and economic activities, which in turn feed back into changes in the local economies and adjust spatial development policies accordingly. The analysis proposed suggests that the main concerns for planning are not substantially different from previous instances of disruptive technological change, albeit possibly on a grander scale. More specifically, the significant wave of innovation opportunities that the metaverse may bring about calls for appropriate policies to avoid missing opportunities. Our first and second hypothesis together indicate that a precondition of this would be policies aimed at ensuring the homogeneous availability of appropriate network infrastructures across territories. This provides a rationale for public support to the rollout of advanced network solutions that allows to overcome resistance due to acknowledgement of the present lack of user demand for such infrastructures. The

second hypothesis suggests the need for digital industrial policies targeting both technology adoption and local innovation capabilities (Gruber 2019). Since we believe the ability of local territories to escape path dependent patterns of development will be partly linked to the ability to seize the entrepreneurial opportunities associated with metaverse-related technologies, we advocate policies focused on the provision of the required basic and advanced digital skills.

Finally, our third hypothesis suggests that policies mitigating the effects of the reallocation of economic activities that may follow from increased convergence are certainly needed. More generally, a major role for planning would be linked to the need to address the likely employment consequences of this variant of disruptive technological change. It is too early to tell whether job-creation or job-destruction effects from innovation in these technological areas will prevail, but there is no doubt that policies capable of promoting the efficient reallocation of labour across different sectors and industries, as well as to mitigate the social effects of the transition, will be key to prevent undesirable local impacts.

5. The metaverse as an entirely new virtual space: key dimensions of technological and market evolution

A more extreme realization of the metaverse sees it as an entirely new environment for social interaction that, although virtual, may change more profoundly the economy by altering certain basic institutions: *scarcity*, which may become the artificial product of software designers' choices rather than the outcome of objective resource constraints; *property*, whose scope may be entirely redefined by distributed ledger technologies; and *markets*, which may expand and become much more granular. Many more intermediate versions of the metaverse may become reality. In what follows, we explore three key dimensions of development that we believe will play a role in influencing the evolution of the metaverse and sketch some possible associated policy implications. Differently from the previous section, due to the higher degree of uncertainty that surrounds this speculative scenario, we do not formulate specific hypotheses and we limit ourselves to indicating possible evolutionary paths. In any event, at stake is an entirely new role for policy planning, one that involves directing the evolution of the new virtual worlds in desired directions and considers the feedbacks on the real world. The three dimensions have been selected because they reflect the main topics of current debate. They are: the degree of interoperability, of platformization/centralization, and of financialization of the virtual world(s), as better explained below.

Let us start from the degree of interoperability: will there be only one, or will there be a plurality of metaverses, which are only partially able to communicate? The World Economic Forum has recently clarified that, in the metaverse, 'interoperability depends on data interchange across infrastructures to enable participants' ability to access, move, transact and create within and across digital (and physical) worlds' (WEF 2023, 6). This entails making choices at the technical level, related to the ability to connect different networks and technologies pertinent to users' virtual experiences, but also choices in terms of rights and forms of use of metaverse-related technologies, as well as choices related to the ability to guarantee the same type and level of metaverse

experience across different geographies and jurisdictions. Standards of interoperability would define these choices.

A first issue for policy planning in this connection thus concerns identifying the desirable degree of interoperability and the consequent need for standardization. Clearly, greater interoperability is associated to greater user value in terms of direct and indirect network effects: users' benefits from the metaverse experience increase with the ability to enjoy multiple immersive experiences seamlessly and with the increased availability of tools and solutions brought about by the standardization of development tools. However, users' wellbeing may potentially be negatively affected if more interoperability implies less privacy, security or safety. Ascertaining the extent of these trade-offs, which are difficult to describe, let alone quantify today, appears difficult for traditional public policy making due primarily to lack of the relevant information.

This raises a second important issue: who should develop interoperability standards? There is clearly a role for public policy to ensure that design choices reflect basic human rights and are not excessively conditioned by different stakeholders' private interests. Indeed, one key feature of the metaverse as a new immersive reality is that it will be the outcome of designers' choices: the entire ecosystem would be imagined and programmed by designers and humans would interact with machines that are programmed by other humans. This suggests that desirable features reflecting public policy objectives, such as for instance inclusion and non-discrimination, should be embedded from the start *through standards* in metaverse design. However, there is clearly the need to leverage on private stakeholders' information to address the knowledge gap of public decision-makers and thus a need for effective public-private collaborations.

There is also a geographic dimension of the policy issue, as different jurisdictions will want to embed their own vision for public policy values in standardization efforts, as it is already occurring in the realm of artificial intelligence. This presents a further trade-off for local planning. The emergence of this vision of the metaverse is likely to determine a further weakening of the link between local effects and local decision-making (possibly much beyond what has happened through globalization). The nature of users' experience in the metaverse will be determined by choices made far from the local level. Thus, national and local planners may have to decide whether to participate to the full metaverse experience, as it will emerge from public- and private-led design choices taken at the supra-national level, or enforce local rules meant to protect local cultural norms and values, at the cost of a reduced ability to partake to the metaverse experience.

The second dimension to which we draw attention is platformization, i.e. the extent to which digital interactions in the metaverse will be intermediated by platforms, and particularly by the old GAFAM.

Two possible scenarios that pose different policy challenges may emerge, together, of course, with a multitude of intermediate solutions. In the first, current Big Tech platforms, starting from Meta, succeed in orienting the evolution of the metaverse in a way that preserves their central role in digital interactions and expands it to virtual interactions. The alternative is the vision of the Internet that goes under the name of Web 3.0, i.e. Internet as a collection of decentralized applications built on distributed blockchain ledgers (Marchetti 2022). The Web 3.0 concept synthesizes a potential paradigm shift aimed primarily at reducing the weight of centralized servers and platforms in the Internet architecture and restituting control, particularly over their personal data, to users.

Distributed ledger technologies could provide an alternative to platforms to solve the problem of trust at the heart of digital interactions. Such evolution would reduce the power of intermediaries and gatekeepers facilitating the emergence of new decentralized organizational forms.

As for the first scenario, the five major Big Techs, the old GAFAM, are active in every layer of the metaverse value chain, and particularly in what we have described as the Discovery sub-layer. However, they are apparently following different strategies to face the challenge that Internet 3.0 and the metaverse pose to their specific areas of dominance in Internet 2.0. In the previous classification of layers, Meta is mainly located in the Human Interface (Oculus), in the Discovery and in the Creator Economy (Horizon World). Apple has recently declared it is betting on AR (in which virtual elements and images are superimposed onto the real world), thus attempting to confirm its primary role as a producer of sophisticated devices, but is also active in Discovery. Microsoft is probably one of the few companies that seems to be investing in internal R&D transversally in all the possible layers and that, at the same time, is attempting to escalate its presence with acquisitions (e.g. Activision Blizzard in gaming and AltspaceVR in social networking). Somehow in between are Amazon and Google, whose plans for the metaverse have not yet been openly explained. They both seem to be investing mainly internally and especially in the infrastructure layer (mostly through their cloud business), but it is known that they have many other ongoing technological projects (for example Google AI in spatial computing).

A scenario whereby current Big Tech platforms succeed in transferring their leverage over social interactions to the virtual world(s) is one that would justify policy responses aimed at limiting platforms' concentration of power to an even more radical extent than is presently the case. This is an evolution that has already been highlighted in the context of the debate over the concept of 'smart cities' (Cooke 2021). In such a scenario, Big Techs would be able to embed in their technological choices their preferred elements of the design of social interaction, thus shaping the nature of the experiences possible in the new virtual spaces largely outside of any public oversight, going even beyond Lawrence Lessig's perspective that 'code is law' (Lessig 2000). How likely is it that the most salient issue for policy planning will be addressing platforms' concentration of power in shaping the metaverse? This is clearly hard to tell today. Platforms will certainly play a role in making the metaverse as much 'user-friendly' as possible and therefore in facilitating adoption. This has been their key role in Internet 2.0, where they have acted as intermediaries sustaining trust and making accessible direct and indirect network effects from users' interaction. However, there may be limits to the trust that users may put in Big Techs when the latter have the last word on every aspect of the metaverse experience. In a platform-dominated scenario, the value of any piece of virtual land, the value of any transaction, and even the very existence of any avatar in the metaverse would be subject to the *fiat* power of the relevant platform. In economic terms, users' investments in any activity on the metaverse would thus become extremely specific and exposed to risks of hold-up by the platform. As with any other kind of specific investment, this suggests that there would be a problem of users' underinvestment in activities performed on a platform-dominated metaverse. In other words, while it is highly probable that platforms will play some intermediary role in the metaverse, there may also be endogenous forces pushing in the opposite direction.

Another force pushing in the opposite direction, partly technological and partly ideological, is Web 3.0 decentralization. Key components of this evolution would be new 'institutions' like Decentralized Applications (DApps) and Decentralized Autonomous Organizations (DAOs). Both rely on collaboration among Internet users, sustained through a system of well-defined embedded incentives based on the possibility to monetize actions and data. The first (DApps) refers to the new type of services that can be provided based on smart contracts and tokens. The second (DAOs) refers to the main business model that is currently a candidate to be a substitute for Big Techs in Web 3.0: collaborative organizations set up in the pursuit of a common (business, ethical or social) goal and managed through an open, transparent and participatory governance system (Goldberg and Schär 2023).

Essential to the emergence of this vision for the future would be a much greater *degree of financialization* of digital interactions. The alignment of individual and collective incentives would rely on the possibility for users to monetize their actions and data by obtaining tokens and on crypto-based payments. Tokenization, in turn, may provide incentives for users' participation in the metaverse(s), thus alleviating the demand-side constraints that are currently hampering its emergence. This also means that each digital object would become clearly identifiable, with an expansion of the realm of property rights that goes much beyond what legal coding has done in the intangible economy by turning any object, promise or idea into a capital asset (Pistor 2018).

In this scenario, the challenge for public policy would be more extreme. Indeed, at the core of the vision behind decentralized technologies is the idea that systems of incentives based on game-theoretical principles aimed at aligning private interest and the public good and mechanism design can avoid not only centralized control by current intermediaries but also centralized control by governments. According to Gavin Wood, who has coined the term, Web 3.0 is about building systems that do not rely on trust in people, corporations or governments (Wood 2018). In other words, technology design should be considered a substitute for public policy design. As per this view, for instance, distributed ledger-based decentralization would be a substitute for public regulation in the form of data portability and interoperability measures.

In the (unlikely) event that it fully materializes, this view may potentially alter the balance between public and private power even more deeply than it has been the case with the emergence of platforms in Internet 2.0. Governance rules and incentive systems defined within specific DAOs would define rules of behaviour in a multitude of new virtual environments, on which it would in any case be harder to exercise any public oversight. This is, of course, an extreme and possibly unlikely evolution of the virtual space. However, it underscores the case for technology-aware advanced planning of policy responses, to ensure coherence between technological solutions and public policy objectives. One evident example and an area that is of immediate relevance in this connection is the regulation of cryptocurrencies, which are currently governed by companies that are hard to make accountable (Marchetti 2022). The present cryptocurrency crisis and the associated risk of contagion suggests that we are already grappling with these issues. This very example suggests that design's failures in the virtual world may exercise relevant negative feedbacks also on the real world and it is the responsibility of foresighted public policies to anticipate and avoid these consequences.

5. Conclusions

How real will the metaverse be? It is now clear that the initial ambitions with which the concept has entered the public discourse and has attracted attention in the scientific and entrepreneurial communities have rapidly scaled back. In this paper we have attempted to go beyond the recent hype and trace two possible evolutive scenarios. In the first, the metaverse will remain nothing more than a fashionable label that technology companies in a range of frontier domains (AR, VR, BCI and others) may invoke to make their products more appealing. In this scenario, applications will be limited to replicating existing human activities in an immersive virtual environment and it will be physical reality to drive and shape the metaverse. In the second, more imaginative, scenario the metaverse will evolve in a (set of) virtual worlds that will enable new forms of social interactions, substantially affecting key economic concepts and institutions.

In both cases, there will be concrete economic effects spilling over from the virtual to the real environment and there is a need to adapt planning, although the nature of the policy challenges raised will be different. In the more 'minimalist' and disenchanted view of the metaverse, the core policy challenge will be traditional, albeit possibly on a larger scale. Attention should be primarily directed towards policies capable of enhancing local abilities to exploit the innovation opportunities that frontier technologies open up in a wide range of sectors, to prevent the emergence of excessive territorial inequalities and eventually to accompany the reallocation of labour necessitated by disruptive technological change and to mitigate its social effects. If, by contrast, the concept of virtual worlds gains viability and attracts a critical mass of users, the innovative challenge of planning policies for the new virtual space will emerge. In this connection, we have highlighted three key dimensions of evolution of the metaverse(s) – degree of interoperability, platformization, and financialization – identifying some of the policy challenges they may prospectively entail. Planning will be needed to ensure that desirable features are incorporated from the start in the framework within which new forms of social interaction will take place. The article has only sketched a few elements of the reasoning required to start making sense of the spatial impact of the metaverse, with many limitations due also to the inevitably speculative nature of the qualitative analysis proposed. Nonetheless, we hope to have pointed to relevant areas for further research. First, a more refined quantitative mapping of the technologies underlying the production of metaverse components as well as their adoption from a regional perspective is in order, also exploring, for example, the distance of Europe from the technological frontier of the development of key technologies. Second, there is a need for a more precise analysis of the correspondence between metaverse-related technologies and the digital skills and resources indispensable at the local level to capture the opportunities they open up, so as to inform policy planning. Relatedly, it is important to explore the potential employment impact of AR and VR, as it cannot be taken for granted that the conclusions presently reached for AI can directly apply also to these technologies. Moreover, additional research will need to refine our understanding of the relationship between the degree of interoperability, platformization and financialization of the virtual words and local economic outcomes. Finally, it will be important to explore whether and how the emergence of viable virtual worlds may open an important opportunity for planning by providing useful sandboxes for policy experimentation that may improve the way planning is defined and implemented.

Aknowledgements

The authors would like to thank the editors of this journal, two anonymous referees as well as the participants and speakers at the research seminar 'Strolling in the Metaverse', held at the European University Institute on 14 December 2022. The usual disclaimer applies.

Notes

1. Park and Kim (2022) report 54 different definitions of the metaverse.
2. See the following article on the state of the art of the ongoing reviews of the merger https://www.polygon.com/23546288/microsoft-activision-blizzard-acquisition-deal-merger-ftc-latest-news
3. ISI Web of Science search based on the word 'metaverse' using topic as search criteria in all scientific fields (6 December 2022).
4. The hype in the scientific community precedes that of the public. Figure 2 shows ISI publications on scientific journals. Therefore, papers published in 2022 have likely undergone peer-review processes and were prepared in the previous years.
5. https://www.roundhillinvestments.com/etf/metv/.
6. While agreed-upon definitions are hard to provide, it is widely accepted that Internet 2.0 refers to the era of the dynamic Internet (as opposed to the static Internet 1.0), focused on reading and writing content, while Internet 3.0 will focus more on content creation and as explained in Section 5, may possibly be more distributed.
7. However, this skewed age profile can also be interpreted as being good news for the future of the metaverse concept.
8. There are devices at lower prices, some with a price lower than $100 (e.g. the Sony PlayStation VR), these are commonly used only for gaming, leaving few possibilities for those who are interested in the non-gaming metaverse(s).
9. We use this distinction for ease of exposition, but we acknowledge that the distinctions between services and manufacturing are ever more blurred by digitalization.
10. The expression DeFi refers to financial applications built and run on a blockchain, enabling smart contracts-based virtual transactions with no central authorities or intermediaries.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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