



Analysis of Metaverse Development in the Context of Digital Economy

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Abstract. As a new type of economy, digital economy deeply combines digital technology and the real economy, taking digital technology as the core driving force. It can accelerate the upgrading of traditional industries and the birth of new industries. Under the catalyst of digital economy, metaverse will usher in a major development opportunity and the development of metaverse will also promote the development and maturity of digital economy. Impacted by technology and market, the development of metaverse is roughly divided into four stages, the budding period, the growth period, the acceleration period and the maturity period. At present, metaverse can be regarded as the evolutionary upgrade of mobile Internet to the direction of more immersive interaction and deeper transactions, noticeably, empowering the real with the virtual becomes the focus of current metaverse development.

Keywords: Metaverse · Digital economy · Stages of Development

1 Introduction

With the rapid advancement of digital technologies such as 5G, artificial intelligence, blockchain and XR, Metaverse, a new track of digital economy, has gradually become a reality from a concept. Driven by the cross of multiple technologies, it has formed a new world on the basis of the real world and integrated with the virtual world, which has become a trend and a directional existence. The rapid development of digital economy has consolidated the foundation of technology, industrial ecology, application scenarios and users for Metaverse. At the same time, Metaverse will further promote the enhancement of digital economy and the upgrade of information industry. This paper elaborates the relationship between digital economy and Metaverse, the logic of Metaverse evolution as well as the opportunities and challenges faced by Metaverse, and finally focuses on the resolving of the current problems during the development of Metaverse.

2 The Digital Economy Has Given Rise to the Metaverse

2.1 The Digital Economy Has Speeded the Advancement of the Metaverse

With the development of digital technology, the world is gradually moving into a new era of digital economy. The digital economy is the main economic form after the agricultural economy and industrial economy. It is a new form of economy that unifies fairness and efficiency [1], with data resources as the key element, modern information network as the main carrier, and the integration and application of information and communication technology, and the digital transformation of all factors as an important driving force. The digital economy is driving profound changes in production, lifestyle and governance, so that it has become a key force in reorganizing global factor resources, reshaping the global economic structure and changing the global competitive landscape. Changes in the core elements of the digital economy are driving the birth of new industries, business models and scenarios. According to China Academy of Information and Communications Technology (CAICT), the scale of China's digital economy is expected to exceed 60 trillion yuan by 2025 [2].

The rapid development of the digital economy has speeded the evolution of the Metaverse and solidified the foundation for its development. Owing to the rapid development of information technology and the iterative update of media forms, the Metaverse gradually becomes a reality. Breakthroughs have emerged in multiple fields of technologies, providing the initial ability to support in-depth scenarios in Metaverse. In particular, advances in network, computing power, AI and other fundamental technologies provide the foundation and prerequisites for the evolution and exploration of a new generation of crossover scenarios and complex ecologies. In terms of the network and arithmetic technology, 5G is the foundation for new technologies such as AI and cloud computing to fully display their capabilities in the future, which will provide data transmission channels with high-speed and low-level latency for Metaverse and enrich the network foundation of the Metaverse. Metaverse will bring an explosive growth of data, the number of interactive users will reach billions, and the demand for continuous huge amount of computing will significantly increase the demand for arithmetic scale and capacity, etc. The rapid development of and universal access to computing power and cloud computing technology provide the underlying infrastructure guarantee for Metaverse, and the progress of computing power supports the innovation of applications in turn, driving the upgrade of technology and innovation speed of algorithms. In terms of hardware, VR/AR hardware is gradually maturing, and the sector rotation cycle of the new generation of computing platform represented by VR/AR has already started. According to CAICT, the shipment of global virtual devices is expected to reach 75 million units in 2024, of which VR devices account for 33 million units and AR devices, overtaking from behind, account for 42 million units. The growth rate of VR/AR terminal shipments during the five-year period of 2020–2024 is about 86% [3]. Apple MR devices are expected to be released in September 2023, which will further stimulate the development of VR/AR industry and Metaverse; during the period from 2020 to 2021, small-scale popular VR content (primary form of Metaverse content) has emerged, and more popular content and applications are in the exploration period, which is expected to lag 1 to 1.5 years—namely, they will emerge successively in 2023–2024. The emergence of popular VR

content and applications will, in turn, accelerate the iteration of related technologies [4]. In terms of applications, breakthroughs and advances in interaction technology, blockchain, AI and other technologies have created rich application scenarios, ecosystems and content resources for Metaverse. Metaverse is expected to revolutionize the form of interaction between viewers and content, such as the Film-Game Integration, or even the addition of other functions like interaction; the emergence of AIGC expands the extensibility needed for Metaverse; businesses such as NFT and DEFI make initial attempts to explore the Metaverse economic system.

In this context, Metaverse has ushered in a major development opportunity. As of August 2022, the global investment in Metaverse-related fields has reached RMB 16.12 billion, far exceeding the RMB 5.78 billion in 2021 [5]. The huge amount of resources invested has driven the explosive growth of the Metaverse-related field. Major tech giants have joined the game, such as Meta, Unity, Microsoft, and Apple in the US, and Tencent, ByteDance, and Alibaba in China.

2.2 The Metaverse is an Important Scenario for the Digital Economy

The Metaverse is the culmination of digital technology, formed by the cross-driving of multiple technologies. Based on the real world and integrated with the virtual world, it is a digital world where users can create and share value autonomously. The Metaverse may be the next new Internet era that succeeds the mobile Internet in the digital economy era, and will become an important platform of the digital economy.

At present, digital technologies such as 5G, blockchain, big data and artificial intelligence have gained certain technology accumulation, lacking systematic application. As a new digital cyberspace that combines the virtual and the real, and integrates humans and things, Metaverse relies closely on key digital technologies such as computing power network, blockchain and artificial intelligence, which will realize the aggregation of core technological innovation, achieve full-scenario coverage and industry chain synergy, and further advance digital technology.

The various scenarios described in the Metaverse also provide a new outlook for the integration of the digital economy and the real economy, forming a new type of virtual-real integration social form in the context of digital economy, which has far-reaching impact on human life. Firstly, it breaks through the boundary of physical space, serves as the extension and complementation of real life, makes up for the deficiencies and solves many problems in reality. Secondly, it improves production efficiency and social efficiency, since people are provided with greater freedom in the creation and dissemination of information. Thirdly, it changes the economic organization mode, because NFT will greatly accelerate the process of assetization of physical assets on blockchain and digitalization, further realizing the deep integration of digital assets and physical assets. Fourthly, it expands people's entertainment activities, enriches people's spiritual world and provides a place to express personal emotions.

3 An Analysis of Metaverse Evolution

3.1 The Metaverse is the Result of a Joint Promotion of Technology and Market

Metaverse is not an independent, brand new industry or concept, but a natural evolution on the path of established technological progress, industrial development, and capital promotion. It is the result of a joint promotion of both subjective and objective factors.

From the perspective of objective factors, basic general technologies including artificial intelligence, cloud computing, 5G communication is continually upgrading, core devices like sensors, optics, displays and chips have seen rapid progress, and block chain, simulation algorithms continue to iterate. Rare in the previous several rounds of information technology revolution, this simultaneous development and crossover of multiple disciplines points to a virtual space form with high immersion, high real-time and strong connection. The value of information technology is to continuously stimulate and satisfy human senses and consciousness, and continuously enhance the operational efficiency of material elements, thus forming a boost to life and production. Therefore, the concept of Metaverse with three-dimensional experience and more complex interaction fusion between the virtual and the real becomes logically inevitable.

From the perspective of subjective factors, the demand of user side in the current mobile Internet applications has been saturated. It is difficult for core applications like e-commerce, social apps, video apps, games to generate new service experience and business models based on the existing technical level. With the innovation stagnation in global head enterprises, the market needs more advanced and revolutionary service forms to stimulate demand. Besides, the revenue and profit growth of the original Mobile Internet have reached a bottleneck, so industrial capital and venture capital urgently need to find new breakthroughs and profit growth points. Data from China Internet Network Information Center shows that as of December 2021, the size of China's Internet users reached 1.032 billion and the Internet penetration rate reached 73.0%, approaching saturation in the core population with Internet access [6]. According to data from CAICT, from January to November 2022, overall cell phone shipments in the domestic market accumulated 244 million units, down 23.2% year-on-year, with 381 new models listed, down 10.8% year-on-year [7]. In the global market, smartphone shipments fell 10% year-on-year in 2022. According to the fact, Strategy Analytics estimates that it is expected to continue to fall 5% in 2023, with global smartphone shipments reaching their lowest level since 2014 [8]. Meanwhile global Internet companies are generally experiencing significant declines in performance, layoffs and contractions, and declining share prices.

Looking back the history, any major industry in recent times has developed and grown from budding to maturity according to the path of "technology discovery - capital investment - policy guidance - market follow-up". For instance, technology and capital play a central role in the initial stage of Desktop Internet, Mobile Internet or Cloud Computing. The development of Metaverse is the same: in 2021, venture capital and industrial capital have flocked to the concept of Metaverse. Roblox has become the first stock of Metaverse, and the concept stocks' price of Metaverse in China such as ZQGame has soared. Head industrial capitals including Meta, Microsoft, Nvidia, Qualcomm have vigorously promoted and deployed Metaverse in terminals, applications, chips and other

aspects. The strategic layout of capital, especially the head companies for future growth space, became the core pulling force in the early stage of Metaverse industry.

3.2 Analysis of the Evolutionary Stages of the Metaverse

According to the different forms of Metaverse, its development can be roughly divided into four stages, the budding period, the growth period, the acceleration period and the maturity period. Limited by technology and scenarios, Metaverse in the early stage, can be seen as the evolutionary upgrade of Mobile Internet to more immersive interaction and deeper transactions. In the middle and late stages, it will have an increasingly profound impact on the real world, or become the basic way of working, living and the operation of a new civilization in human society.

Phase I: Budding Period (2003–2021)

Second Life, an online game launched in 2003, could be seen as the initial practice of the Metaverse concept. Since then, Roblox was introduced in 2006, and Minecraft was introduced in 2012. Later on, a series of virtual games, social and creative platforms were launched one after another, like Avakin Life (2013), Rec Room (2016), VRChat (2017), and Fortnite Creativew (2018), gradually concretizing the concept of Metaverse. As for hardware, the Oculus Rift launched in 2016 started human's initial experience of the virtual world, the significance of which can be analogous to the introduction of the Apple phone in the Mobile Internet era.

In 2021, the Metaverse made significant breakthroughs. In March 2021, Roblox, the first stock in the Metaverse, was officially listed on the New York Stock Exchange. In October, the social media giant Facebook announced that the company was renamed as Meta. In the same year, global VR device shipments exceeded 10 million units for the first time, reaching the threshold of the industry driven by both content and hardware. Stimulated by capitals and head companies, the Metaverse has gained rapid development in both consumer and enterprise markets, landing in fields including entertainment, education, medicine, tourism and military affairs, gradually transforming into an industry from a concept.

Phase II: Growth period (2022–2029)

Entering 2022, the Metaverse starts to cool down in the capital market, when the industrial circles' understanding of the Metaverse gradually becomes conservative, and the direction of technology iteration grows clearer, so the development of Metaverse enters the growth phase of the hype cycle. The characteristics of this period can be summarized as generating the viryul with the real and parallel the real with the virtual.

In terms of the infrastructure, underlying technologies such as 5G, edge computing, blockchain, artificial intelligence, and chip manufacturing provide basic support for the embryonic form of the Metaverse. Although these technologies are not yet able to achieve the Meta-experience in a mature state in terms of performance, they already have the ability to build the primary stage form as well as business validation iterations.

In terms of the hardware, the new generation of optical and display technologies such as Pancake and Microled have been mass-produced in 2022. The weight, size and other parameters of XR hardware have been significantly optimized and show the trend of integrating VR and AR. It is expected that in 2023–2024, the launch of Apple and Meta's new generation XR terminals will further stimulate the development of hardware

market and drive the rapid progress of the new generation of mobile computing terminals. According to a recent report released by the Next G Alliance, one billion XR glasses and sensing devices are expected to be put into use by 2030, upgrading and replacing mobile terminals preliminarily [9].

In terms of application scenarios, entertainment scenarios like games and social content will take the lead in this phase, and 2B2C fields such as tourism, education, medicine and office are rapidly landing. Digital people with high-quality and low-cost achieve popularity at the C-terminus, becoming the second identity in human's work and life. Artificial intelligence and large-scale parametric models are plying an increasingly profound role in the virtual and the real, and AIGC's ability gradually catches up with human beings. On this basis, the Metaverse platforms launched by the major Internet giants one after another have gradually approached the expected threshold of the Metaverse by completing several iterations of games and social content. However, in the short term, they still exist separately, since the cross-platform connection and interaction protocols have not been fully integrated.

Phase III: Acceleration Period (2030–2035)

Around 2030, there will be landmark advances in the several supporting technologies of the Metaverse. The Metaverse will facilitate comprehensive acceleration of progress when virtual experiences will be closer to reality, economic systems will be more deeply integrated with the real economy, and construction in policies and ethics will be gradually improved. 2030 is a particularly noteworthy point in time. This phase can be characterized as digital twins, complementing the real with the virtual.

In terms of fundamental technology, the interval between 3G and 4G was 15 years, while that between 4G and 5G was 12 years, indicating that the time gap is gradually narrowing. Since 2020, the commercialization of 5G has been lasted for three years, and by the end of 2022, there were more than 2.31 million 5G base stations in China. It is expected that the 6G network will start commercialization around 2030 [10]. 6G technology will build an intelligent endogenous, green and low-carbon network integrating space, air and ground, with the ultimate performance with sub-millisecond air interface latency, as well as integrated services of connectivity, computing, AI (artificial intelligence) and other capabilities. In addition to the communication technology, in terms of the carbon-based chips with differential advantages in both computing speed and power consumption, industry insiders expect that IoT carbon nanotube chips with relatively low difficulty will start commercial use in the next 3 to 5 years [11]. The carbon-based chips applied to smart phones and servers are expected to achieve initial commercialization around 2030. The replacement and upgrade of infrastructure lays the foundation for the accelerated development of the Metaverse. With reference to the development pattern of industries such as 5G and the inherited use of established industries, this process will continue for about 5 years to reach maturity.

In terms of hardware terminals, holographic display and brain-computer interface are also expected to make a breakthrough at this stage, thus revolutionizing the form of mobile computing terminals. Currently, 2D holography has matured and has been applied in many scenarios, while 3D holography has also been partially applied, but it is still far from large-scale commercialization. Moreover, the landing of 3D holography depends on the improvement of 6G network capacity, and its development is driven

by 6G and chip technology, so its development may relatively lag behind 2 to 3 years. China's progress of brain-computer interface is at the same level as that of Europe and the United States, but China has chosen a more difficult and safer non-invasive approach, with a more relaxing policy atmosphere in human experimentation, richer experimental scenarios, and clearer future commercial prospects. At present, brain-computer interface has landed test projects in medical and military fields. According to the tracking of the progress of projects in relevant universities and head companies in China, it still takes 8 to 10 years for brain-computer interface to achieve large-scale commercialization in C-terminals.

In terms of application scenarios, all non-material production links in industrial production are integrated into the Metaverse and combined with high-end manufacturing, which again pushes industrialization to leap forward. To B and to C are integrated into Metaverse scenarios, data are gradually connected, and many new industries, markets and spaces are generated. AIGC becomes the main source of content, while the Metaverse economic system is gradually improved and sound. Such being the case, the integration of the virtual and the real, decentralization and other characteristics of the Metaverse has a thorough influence on people's work and life, leading to an era of Metaverse in all respects. At the same time, native Metaverse platforms adapted to Metaverse information technology are constantly developed to enable better platform integration, in such case, Metaverse platforms gradually form a monopoly pattern.

Phase IV: Maturity Period (2035-?)

This phase is characterized by virtual nativity and a fight between the real and the virtual. The Metaverse will have the potential to merge with more revolutionary technologies in the future to form a more controllable and imaginative form. However, the process will be longer and more uncertain.

Driven by technologies like quantum computing, strong artificial intelligence, brain-computer interface, robotics, the Metaverse at this stage gradually forms autonomous operation rules, will and ecology, and its influence on the operation of real society changes from passive to active, and constantly presents challenges at the ethical and legal levels, with the germ of forming a new civilization ecology. However, this form may lead to the loss of control of human ontological civilization, therefore, this period may be terminated or retreated prematurely.

4 Opportunities and Challenges of the Current Metaverse Evolution

Among the four core aspects of the metaverse: infrastructure, tool platforms, hardware terminals, and content applications, China currently has advantages in communication and computing infrastructure. It is also among the top players in the field of hardware terminal component manufacturing, brand terminal design and integration.

The metaverse will bring significant opportunities in terms of leading the upgrade of information industry. The continuous evolution of Metaverse will generate huge demand for communication, IT, artificial intelligence and related fields, which will further promote investment, construction and research and development in these fields with stronger directionality and higher output efficiency, making it easier to form a positive cycle in

business. Meanwhile, leveraging the existing technology accumulation and industrial strength, and combining with large-scale user data and scenarios, Metaverse will form a continuous impetus to the information industry and realize industrial upgrading.

The challenges of the Metaverse are mainly reflected in two aspects: security of industrial ecological and social governance.

Firstly, for the industrial ecological security, there exist large technical bottlenecks in the domestic Metaverse industrial ecology. As the inheritance and development of the Mobile Internet, the Metaverse continues and strengthens the industrial ecological pattern of the Mobile Internet. With strong capital and technical advantages and global deployment of head companies such as Meta, Microsoft, Nvidia and Google, the U.S. has played a leading and fundamental role in the Metaverse industrial ecology. The U.S. has absolute monopoly advantages in key underlying aspects such as application-specific integrated circuit, operating systems and platform tools, while it is in absolute leadership in upper layers such as hardware terminals, social content and game development, and B-end application development. Relatively speaking, China is still following the advanced in the Metaverse field, and there is an obvious lack of capability in the above core aspects. Besides, the Metaverse industry ecology faces data hegemony. In the current construction of ecology, China is facing the problem of path dependence in the Mobile Internet era and data security, and is moving towards an industrial structure with the United States as the core and dominant position, which is being constantly reinforced. If this trend is allowed to continue, it will have a significant adverse impact on China's industrial security in the long term and at the bottom.

Secondly, for social governance security, the current Metaverse is in the primary stage, with application scenarios concentrated in social content and games. The initial prototype of immersive experience is still established with the real world as a template, following the rules and order of the real world. The emergence of new technologies and new scenarios brings challenges to the social order. For individuals, along with the development of both the virtual and the real, virtual identity will be widely used, and the accompanied high-frequency and comprehensive collection of personal information will have a significant impact on personal privacy and security. The ethical crisis latent in virtual identity may aggravate human's identity crisis, social fear and many other psychological problems, which will seriously affect people's well-being. For market players, the Metaverse relies on basic data sharing with different platforms to achieve decentralized self-management, so data interaction and circulation will become more frequent with more massive data volume, which will lead to more acute data-related problems. At the same time, the generation of a large number of AIGC intensifies the complexity and confusion of intellectual property protection and puts forward higher intellectual property protection requirements for platform organizations. For governments, Metaverse will intensify the competition among digital platforms towards monopolization, which may even threaten national political power and lead to political risks. NFT makes it possible to establish Metaverse economic system, but it also brings many financial risks such as speculation. With multiple attributes such as data, economy and culture, NFT will certainly bring multiple hegemonic threats in the global competition pattern.

5 Promoting the Real with the Virtual is the Current Focus of the Progress of Metaverse

Empowering the real economy will be the key to demonstrate the value of the Metaverse currently. The deep integration of digital technology with the real economy will continuously improve the digitalization, networking and intelligence of the economy and the society.

Firstly, promote the collaborative innovation of the Metaverse industry chain, especially the digital transformation of the manufacturing industry. We should fully leverage capital and technology to upgrade the digitization and intelligence of traditional industries, enhance the soft power centered on technological innovation capabilities. Besides, we should actively participate in the development of new industries in the Metaverse, fully utilize the integration of the virtual and the real in the Metaverse, to create new models of work and life, and achieve overall industry upgrading.

Secondly, further strengthen technological innovation and enhance the construction of Metaverse industry's ecological security system. Firstly, efforts should be made to fill the gaps in key technologies, build a complete, independent and controllable technology system for the Metaverse, focusing on the resolution of bottleneck issues in key technologies such as chips, operating systems and modeling engines, to ensure that key links are manageable and controllable. Moreover, we should promote the localization of key software and hardware, promote the independent construction of the industry's ecological foundation, and firmly grasp the key technologies in the Metaverse.

Finally, improve the construction of metaverse social governance system and promote the healthy and orderly development of Metaverse industry. All parties should actively explore and carry out cautious and inclusive supervision of the Metaverse, timely identify risk points so as to prevent and resolve social risks in the Metaverse. Furthermore, leverage the autonomous governance capabilities of the Metaverse, explore decentralized governance structures and transparent governance rules, with an aim to establish a system of public autonomy and improve the existing governance system.

6 Conclusions

Jointly promoted by digital technology, industrial ecology and capital, the Metaverse is a new industry and form in line with the development of digital economy, and is expected to become the basic way of human's work and life and the operation of a new civilization. Currently, promoting the real with the virtual is the key to the development of Metaverse, which represents the deep integration of digital economy and real economy and its value. We should further strengthen the collaborative innovation of industry chain, strengthen the technological innovation and improve the governance system to ensure the healthy development of Metaverse industry.

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