Chapter 2
Innovation and Technology Ecosystem: Historical Perspectives

Jinling Hua and Rajib Shaw

Abstract Although this book is mainly covering on post COVID-19 technology development, we need to understand the historical perspective of Chinese investment in science and technology over last couple of decades. The Chinese government has placed emphasis through funding, reform and societal status on science and technology as a fundamental part of the socioeconomic development of the country as well as for national prestige. The twenty-first century has thus seen a series of central government initiatives designed to promote "indigenous innovation" and technological development more generally in China. These include the National Medium- and Long-Term Program for Science and Technology Development (2006–2020), the Strategic Emerging Industries initiative, the Internet Plus initiative and the Made in China 2025 Program, among others. Today, China's science investment is largest in the world. Thus, China has developed an innovation and technology ecosystem, which has been nurtured by COVID-19, and further growth is expected in different existing as well as new technologies and its application in different ways. This chapter will throw light on the historical perspectives, while keeping in mind the future growth strategy.

Keywords Strategic guidelines · Indigenous innovation · Technology ecosystem · Growth strategy

2.1 Introduction

The development of science and technology in China today is no coincidence. China's scientific and technological innovation achievements has a historical accumulation for the past 100 years. Tracing back history to 1895, that year, Tianjin Beiyang

J. Hua
Faculty of Policy Management, Keio University, Tokyo, Japan

R. Shaw (✉)
Graduate School of Media and Governance, Keio University, Tokyo, Japan
e-mail: shaw@sfc.keio.ac.jp

J. Hua et al. (eds.), *Considerations for a Post-COVID-19 Technology and Innovation Ecosystem in China*, Disaster Risk Reduction,
https://doi.org/10.1007/978-981-16-6959-0_2

Western learning school, the first modern university in China (Tianjin Beiyang Western learning school), was approved to be established, which is today's Tianjin University. During the half century from 1895 to 1949, domestic wars were incessant, and the working environment of colleges and universities at that time was very difficult. Before the founding of the people's Republic of China in 1948, there were 210 universities in the modern sense in China, which enrolled more than 150,000 students at that time. 150,000 is a rough equivalent to the number of students enrolled in the top two universities in China, which was the number of students enrolled in higher education at that time. By 1949, only more than 30 universities had survived. There are about 50,000 researchers in these research institutions (Xue 2018; MOST 2016).

After the founding of new China, China's scientific and technological development entered a stage of layout and catch-up. One month after the founding of new China, the Chinese Academy of Sciences was officially established. At that time, the central government sent a special working group to the Soviet Union to learn how to build a National Academy of Sciences. The Chinese Academy of Sciences, which focuses on basic research, soon entered normal operation. At the same time, many corresponding applied research institutes were set up in various industrial departments and provinces and autonomous regions (Xue 2018). In the past 70 years since the founding of the people's Republic of China, China's science, technology innovation and technology policy have gone through numerous practices and studies, to provide suitable strategic policy for China's development. China's science and technology has developed more rapidly in recent years and with the catalysis of the pandemic of COVID-19, it has invested and applied many of the new technologies that can be used in the epidemic prevention measures. From the first onset until its current stage, this paper examines this historical perspectives of the development of science and technology in China by dividing it into five periods according to its policy direction. They include technology import, integration of science technology and market, independent innovation, independent innovation-driven development, and catalysis of China's technological innovation ecosystem. This is an extremely long process of exploration and learning, and each stage of the five periods has its decisive role, so as to realize such a sound science and technology innovation ecosystem in China today.

2.2 The Development of Science and Technology Policy in China

This is an extremely long process of exploration and learning. Each stage of the five periods has its decisive role and represents today's technological innovation ecosystem in China (see Fig. 2.1).

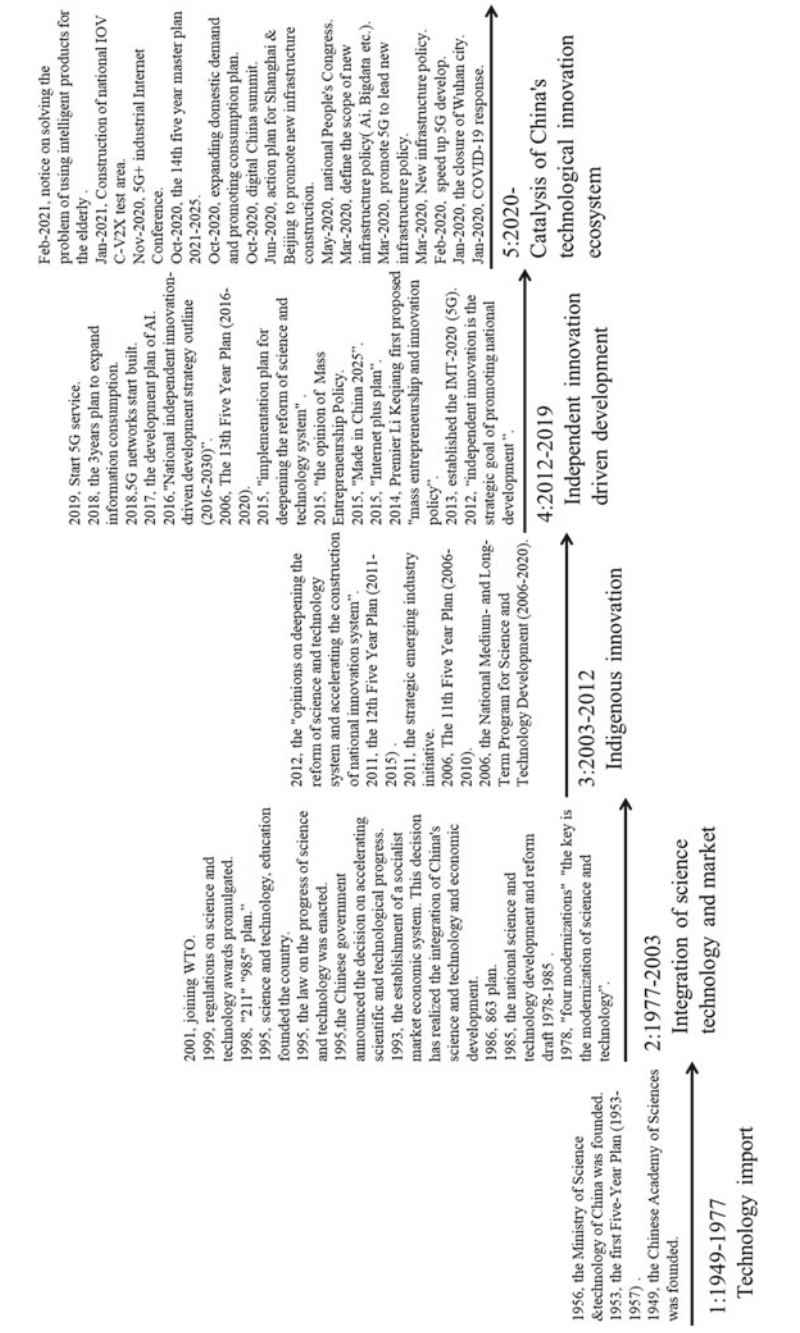

Fig. 2.1 Five stages of science and technology policy in China (*Source* This figure is compiled by the authors references and public materials)

2.2.1 First Period: Technology Import (1949–1977)

This is the early days of the founding of the people's Republic of China (September 1949). There are two points worth evaluating in this stage of science and technology policy. First, the scientific and technological development plan and the national management system were formulated rapidly. The first Five-Year Plan for Science and Technology development (1953–1957) was formulated. Secondly, they began to actively learn from the Soviet Union in the fields of science, technology and education. In the 1950s, China received 6.6 billion rubles of aid loans and 6.28 billion rubles of military aid from the Soviet Union and therefore, in 1951, China began to send students to the Soviet Union. In 1952, it set up a preparatory school for Soviet students in Beijing. By 1953, 63 Chinese universities had reached cooperation agreements with the Soviet Union so in 1956, they began to send university teachers to the Soviet Union. In the ten years from 1950 to 1960, about 90% of China's 9294 people went abroad to study and teach in the Soviet Union, although in 1956, the highest number was 2085 (Gu 2004). The Soviet Union's technical assistance covered all fields of China's national economy under the planned economy mode at that time, which included mining and industrial technology, agricultural technology, education, medical treatment, etc. The Soviet Union sent about 3000 engineers to China, and more than 20,000 Chinese went to the Soviet Union and Eastern Europe to study (Marukawa 2021a).

2.2.2 Second Period: Integration of Science Technology and Market (1977–2003)

The second stage is mainly to link the development of science and technology with the market economy through various regulations and policies, which has also laid a solid economic foundation for the development of the next nearly 30 years (MOST 2016). In March 1978, Deng Xiaoping put forward the "four modernizations" at the "National Science and Technology Conference" held by the CPC Central Committee to realize the comprehensive modernization of agriculture, industry, national defense and science. He reiterated: "the key is the modernization of science and technology" and "science and technology are the primary productive forces". He said: "we must break the rules, discover, create and develop talents, and train world-class scientific and technological experts as soon as possible." The national science and technology development and reform draft 1978–1985 was adopted at the meeting. The moment also witnessed the setting up of regulations of the people's Republic of China on encouraging invention, the regulations of the people's Republic of China on encouraging natural science, the regulations of the people's Republic of China on technological progress, and the patent law of the people's Republic of China were promulgated successively.

The National Conference on Science and Technology brought China's era of "the spring of science." After the "spring of science," the reforms on science and technology human resources, science and technology investment, scientific research institutions, industrial technology and many other aspects have been carried out. In November 1993, the Third Plenary Session of the Fourteenth Central Committee of the Communist Party of China announced the decision of the Central Committee of the Communist Party of China on several issues concerning the establishment of a socialist market economic system, which clearly put forward that, the reform of the scientific and technological system should be carried out simultaneously with the reform of the market economic system. This decision has realized the integration of China's science and technology and economic development. At the same time, various supporting policies have been issued one after another, which provide a strong institutional guarantee for the rapid development of science and technology in China in the next 30 years (MOST 2016; JST 2019a, b).

In May 1995, the Chinese government announced the decision on accelerating scientific and technological progress. China would then implement a strategy of invigorating the country through science and education, mainly to promote economic development and social progress through science, technology and education. In 1998, China launched the "211" higher education development plan and the "985" world-class university construction plan. In order to implement the scientific and technological achievements, the "opinions on venture capital" and "Regulations on national science and technology awards" were published in February 2009 to further encourage scientific research institutions and researchers to carry out innovative incentive measures. At the national scientific and technological work conference held in the same year, the decision on technological innovation, high-tech development and industrialization was also published (Liang 2019; MOST 2016).

In addition, the "100 Talents Program" aimed at cultivating the country's top talents began to be implemented in 1994 and then continued the "1000 Talents Program" (2009) and "10,000 Talents Program" (2012). This talent training policy has lasted for more than 20 years (JST 2019a).

2.2.3 Third Period: Independent Innovation (2003–2012)

Through the practice of reform and opening up and the introduction of foreign investment, more and more Chinese researchers realized that it is not enough for China to blindly catch up with the advanced countries. Hence, they started to explore and propose the necessary and specific development direction of independent innovation with Chinese characteristics. Therefore, the following directional guidance, plans and initiatives are put forward. In 2006, China published the National Medium- and Long-Term Program for Science and Technology Development (2006–2020), in which indigenous innovation was regarded as an important theme (Chen and Naughton 2016; Marukawa 2020). A series of policy documents clarified the goal of building a technologically innovative country, through relevant measures to support

investment in scientific and technological resources, tax incentives, finance, government procurement, intellectual property protection, scientific and technological innovation bases and platforms, human resources, education and other 11 fields. A total of 78 supporting policies were issued (MOST 2016; JST 2019a, b).

At the Science and Technology Innovation Conference (2012), the "opinions on deepening the reform of science and technology system and accelerating the construction of national innovation system" was issued to ensure further improvement of science and technology system. According to this opinion, various departments of the State Council have issued more than 200 policy documents and implemented various reforms such as the formulation of scientific and technological innovation policies, the implementation and supervision of scientific and technological innovation policies in the new era. The policy focus during this period was "indigenous innovation" (Chen and Naughton 2016). According to Marukawa and Kajitani (2015), China has experienced technology transfer from the Soviet Union since its establishment and has been developing through the introduction of technology from developed countries and direct investment from foreign companies since the 1980s. China dreams of pushing the technology of Chinese domestic enterprises to the world stage through indigenous innovation in the future and "cultivating well-known enterprises competitive with international famous brands through independent intellectual property rights."

2.2.4 Fourth Period: Independent Innovation-Driven Development (2012–2019)

When entering the fourth stage, China has firmly established the strategic goal of promoting national development through independent innovation, so a large number of policy oriented plans and outlines are issued during this period. At the 18th National People's Congress in 2012, scientific and technological innovation was positioned as the core strategy to improve productivity and national strength. The central government formulated the development strategy by technological innovation and formulated important policies (MOST 2016). In February 2013, the Ministry of Science and Technology, together with the Ministry of Industry and Information Technology and the National Development and Reform Commission, established the IMT-2020 (International Mobile Telecommunications-2020, 5G) promotion group to gather the industry research force in the field of mobile communication, and started the basic work platform for the research and development of the fifth-generation mobile communication technology and international exchanges and cooperation.

In September 2014, Premier Li Keqiang first proposed "mass entrepreneurship and innovation policy" at the opening ceremony of the "Summer Davos conference" with the theme of "creating value through innovation" held in Tianjin (Li 2018). In March 2015, the "Internet Plus plan" was formulated in the "report on government activities" of the third session of the 12th National People's Congress. The plan

proposes to make full use of mobile Internet, cloud and big data and IoT to promote the modernization of manufacturing industry, the healthy development of e-commerce, the sound development of Internet finance and promote the development and growth of Internet enterprises in the international market. In May 2015, the State Council announced the "Made in China 2025" (State Council of China 2015a). In June 2015, the State Council issued guidance on promoting "the opinion of mass entrepreneurship and mass innovation" (Mass Entrepreneurship Policy) (State Council of China 2015b). The opinions stipulate the development of fixed broadband network, new-generation mobile communication network and Internet, the acceleration of new infrastructure such as IoT and cloud computing, and the implementation of national new-generation information infrastructure construction projects. It is proposed that "Internet Plus plan" should be integrated with "Made in China 2025" (Liang 2019).

In September 2015, the "implementation plan for deepening the reform of science and technology system" was issued. In order to build technological innovation with Chinese characteristics and improve the innovation vitality of technological innovation subjects, 32 reforms and 143 policy measures were issued in 10 fields (Xue 2018). In May 2016, "National independent innovation-driven development strategy outline (2016–2030)" was issued. In the national science and technology innovation competition held in the month, general secretary Xi Jinping proposed a "three step strategy" for China's science and technology development, and declared to build a world scientific and technological power. Three months later, the 13th Five-Year Plan of national science and Technology (2016–2020) was announced (people's daily, November 28, 2017). In March 2017, Premier Li Keqiang instructed in the government work report to accelerate the development of artificial intelligence and related industries. In July of the same year, the State Council announced the development plan of AI (JST 2019a; MOST 2016).

2.2.5 Fifth Period: Catalysis of China's Technological Innovation Ecosystem (2020~)

China has experienced the previous four stages of development and gradually formed a good all-round technology and innovation ecosystem. It is mainly due to the policy support, strong national fund support, and the entrepreneurship and innovation trend of various industries over the years. These promote the vigorous development of new technologies in all walks of life in China, especially its use of new technologies in the response of COVID-19 in Wuhan and all over the country. That is, after the closure of Wuhan city on January 23, the city was the focus of attention of China and the whole world so two hospitals were quickly built in just 10 days. Through a rapid development, Chinese mobile operators laid 5G communication facilities to the hospital construction site, so that all stakeholders could share the construction progress of Wuhan hospital through a 24-h high-definition online live broadcast. In the subsequent COVID-19 response, the latest technologies such as AI, big data and

robotics are widely used in hospitals, government agencies, transportation systems and various amenitized and services at public places.

For example, AI plays an important role in medical CT image automatic diagnosis system and online medical treatment. The AI scanning system developed by Fudan University and Shanghai government is used for the treatment of more than 93% of patients with COVID-19 in Shanghai. Baidu's big data effectively grasped the personnel flow in the early stage of COVID-19, around the Spring Festival and after the resumption of production and work. At the "World Internet Conference" on November 23, 2020, Zhong Nanshan, a Chinese epidemiologist said, "today, technologies such as big data, cloud computing and AI are accelerating the deep integration with transportation, medicine, education and scientific research, promoting the transformation and improvement of the whole society's informatization. Especially for the pandemic of COVID-19, information and communication technology strongly supports the work of COVID-19 response, especially in the aspect of disease epidemic discovery and management. It plays an important role in infectious investigation and judgment, information sharing and disease analysis." This statement leads to the following questions:

- At the critical moment of the outbreak of COVID-19, how did China respond in a timely manner?
- Why did China have so many new technologies that worked for the governance of cowid-19, and
- How did they develop to today's high level?

The answers reply on past China's science and technology innovation strategy, countless practical experience and continuous learning, which has led to the formation of today's sound and developing technology ecosystem in China. The following sections will shed light of some of these issues.

2.3 China's Unique Indigenous Innovation Policy

2.3.1 Characteristics of Indigenous Innovation-Related Policies

Looking back on the prosperity of China's scientific and technological innovation so far, the following scientific and technological policies are of great significance. The National Medium- and Long-Term Program for Science and Technology, the Strategic Emerging Industries Initiative, the Internet Plus initiative, the mass entrepreneurship and innovation and Made in China 2025.

- The National Medium- and Long-Term Program for Science and Technology Development (2006–2020) (2006): This outline puts forward the goal of building

China into an innovative country with world-class scientific and technological strength in the 15 years to 2020. Not only that, it also puts forward the specific implementation method to achieve the goal. The goal can be achieved by increasing the investment in research and development and strengthening the construction of key fields. The specific implementation method is also of great significance. On this basis, three plans have been formulated, the 11th Five-Year Plan of national science and Technology (2006–2010), the 12th Five-Year Plan of National Science and Technology (2011–2015) and the 13th Five-Year Plan of National Science and Technology (2016–2020).

- The Strategic Emerging Industries Initiative (2011): In July 2011, the strategic emerging industries initiative was formulated as part of the 12th Five-Year Plan (2011–2015). The 7 key industries proposed by the strategic emerging industries initiative are basically the same as the 6th content of the 9 strategic themes of "made in China 2025" (Marugawa 2020).
- However, in the "14th Five-Year Plan" (2021–2025) and 2035 long-term goal plan in October 2020, the term "strategic emerging industries" has been reviewed. Moreover, in 2011, all listed industries reappeared in their original form, adding aerospace equipment and marine equipment. In other words, the "strategic emerging industries" of the fourteenth Five-Year Plan is designated as an extension of the twelfth Five-Year Plan (Marugawa 2021b).
- The Internet Plus initiative (March 2015): The Internet Plus initiative defines the goal and specific policy of integration with the Internet. In this paper, the specific objectives of the four aspects of economy, people's livelihood, infrastructure construction and development environment are elaborated and presented as the following;

  i. It aims to improve the industrial structure of manufacturing and agriculture, improve productivity and the acceleration of e-commerce development.
  ii. Promote the development of Internet applications in the fields of health care, education and transportation.
  iii. Further realize the popularization of network, develop the next generation infrastructure such as cloud computing and Internet of things, and realize the industrialization of artificial intelligence.
  iv. Remove institutional obstacles that impede "Internet Plus," achieve substantive progress in data disclosure and credit information system and related legal construction in the public domain.

In the Internet Plus guidance, the ten-year development goal of 2025 was put forward, the industrial ecosystem of networking, intelligence, service and co-integration was basically built. According to this goal, 11 key projects have are put forward. Mass entrepreneurship and innovation later became the first of these 11 priority areas.

- Made in China 2025 (May 2015): In May 2015, the State Council issued "Made in China 2025." It is in accordance with the requirements of "improving the international competitiveness of industrial technology" in the 13th Five-Year

> Plan of national science and Technology, striving to build and enhance the advanced manufacturing industry. According to the information released by the State Council of China, "Made in China 2025" proposes to strive to achieve the strategic goal of manufacturing power through "three steps." The first step: strive to become a manufacturing power in 2025 within ten years. Step 2: by 2035, China's manufacturing industry as a whole will reach the medium level of the world's manufacturing power camp. Step 3: by 2049, we will be among the top manufacturing powers in the world. The main fields of manufacturing industry have innovation leading ability and obvious competitive advantage and build a global leading technology system and industrial system (State Council of China 2015a).

Made in China 2025 takes large manufacturing enterprises as the main target, formulates 5 major projects and 9 major strategies. Industrial technology research base construction, intelligent manufacturing, industrial base, green manufacturing and high-end equipment innovation projects. The nine strategies are as follows: 1. to improve the innovation ability of national manufacturing industry; 2. to promote the deep integration of informatization and industrialization; 3. to strengthen the basic ability of industry; 4. to strengthen the construction of quality brand; 5. to implement green manufacturing in an all-round way; 6. to vigorously promote the breakthrough development in key areas; 7. to further promote the structural adjustment of manufacturing industry; 8. to actively develop service-oriented manufacturing and production-oriented service industry; 9. to improve the international competitiveness The development level of urbanization (China's State Council 2015b).

Marukawa (2020) said that "made in China 2025" is an important part of China's effective industrial policy. Similar to the industrial policies of the 1990s, made in China 2025 adopts a tree structure, with policies and visions of each industry and theme suspended under a series of policy documents. The difference is that "made in China 2025" is more in-depth and comprehensive. From the perspective of policy objectives, he also pointed out that "made in China 2025" pays more attention to the improvement of policies for small- and medium-sized enterprises and is full of expectations for the development of high-tech industrial enterprises.

Another main purpose of "made in China 2025" is to improve the localization rate of China's manufacturing industry. "Made in China 2025" is full of strategic atmosphere of import substitution of high-tech industries. Many high-tech industries listed in the document already exist in developed countries. China hopes to catch up with and surpass advanced countries in this aspect through "Made in China 2025" (Wübbeke et al. 2016). However, after COVID-19200, China's localization direction began to rapidly turn to the strengthening of supply chain. In the fourteenth Five-Year Plan, domestic production will no longer appear. Instead, it is proposed to "improve the level of industry and supply chain." In other words, "in order to achieve autonomy, controllability, safety and efficiency, we will strategically design and select the supply chain of each industry to promote the improvement and upgrading of all industrial chains." It can be said that the policy of improving domestic productivity has turned

to the policy of improving the security and flexibility of supply chain (Marukawa 2021b).

- The mass entrepreneurship and innovation (June 2015): commonly known as "entrepreneurship and innovation," this was proposed by Li Keqiang at the Davos Forum in the summer of 2014, and then included in the government work report in 2015. In June 2015, the State Council issued the opinions on several policies and measures to vigorously promote mass entrepreneurship and innovation, aiming to improve the ability of individuals and small and medium-sized enterprises with shortage of funds. These measures include tax breaks, supporting the venture capital, subsidies for start-ups, innovation demonstration zones and assistance mechanisms for SMEs (China's State Council 2015a).

This is a highlight of China's science and technology, especially innovation policy. From the perspective of policy orientation, mass entrepreneurship and innovation are mainly aimed at individuals or small- and medium-sized enterprises. Mass entrepreneurship and innovation aims to create a new enterprise by promoting the improvement of the environment and using ICT technology, so as to commercialize good business ideas in time and change and influence the industrial structure. It aims to promote the innovation of individual emerging enterprises or start-up, trying to cultivate a new generation of BAT (Baidu, Alibaba and Tencent). Mass entrepreneurship and innovation is positioned as a new engine of China's economic development.

In order for the public to support entrepreneurship, Chinese government departments cooperate to provide the public with coworking space. By subsidizing entrepreneurs' online expenses, providing relevant software for free, and simplifying enterprise registration procedures, the threshold of entrepreneurship can be reduced. In addition, the system of part-time researcher and the system of students' entrepreneurial leave have been implemented. When the patent is granted, more than half of the income is owned by the researcher, and the entrepreneurship support education plan for researchers and college students has been set up. In addition, it also attempts to build a national entrepreneurial ecosystem by introducing new investment systems such as Internet crowdfunding, technology loan mortgage system and stock mortgage system.

This series of entrepreneurial support has a strong sense of establishing a competitive advantage in science and technology entrepreneurship, which is different from the general entrepreneurship. Many ministries and agencies are involved in supporting entrepreneurship. In August 2015, the State Council held a coordination meeting between ministries and agencies to prevent vertical management. The meeting is held twice a year to coordinate various ministries and agencies to support start-ups. For important issues, the adjustment must be reported to the State Council (JST 2019a). Li Keqiang also proposed that this should be integrated with related innovation work, such as "Made in China 2025" and "Internet Plus" (Li 2018). In this policy, 96 measures have been launched in nine major areas. On this basis, more than 1000 entrepreneurship support measures have been implemented (62 policies of the State Council, 258 policies of various ministries and commissions, and 713 policies

of local governments). This led to the development of a number of new companies. The government even requires large Internet enterprises and telecom enterprises to open platform connectivity, data, computing power and other resources to small- and medium-sized enterprises and emerging enterprises, and provide tools, enterprise management, marketing and other support and services. Among them, Tencent has been actively involved in providing various kinds of assistance to emerging enterprises, opening up free commercial instant media WeChat apps, WeChat payment and WeChat official account to many new companies. As a result, many emerging companies have developed rapidly with this platform, including the Chinese version of Uber and Didi Kuaiche (Li 2018).

2.3.2 Positioning of China's Indigenous Innovation—Related Policies

The (a–e) policies in 3.1 above are sorted out according to their level and time (see Fig. 2.2).

(a) The National Medium- and Long-Term Program for Science and Technology Development (2006–2020) (2006)
(b) The Strategic Emerging Industries Initiative (2011)
(c) The Internet Plus initiative (March 2015)
(d) Made in China 2025 (May 2015)
(e) The Mass entrepreneurship and innovation (June 2015).

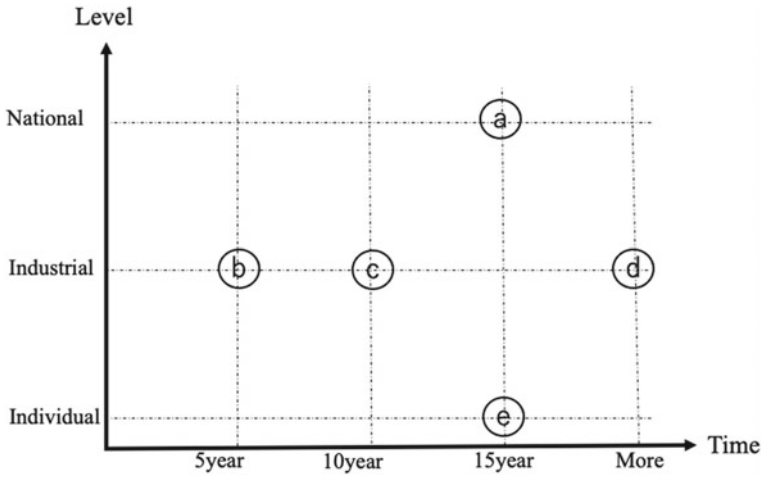

Fig. 2.2 Level and time of (a–e) policies (*Source* Sorted out by the Authors)

These policies are divided into three levels: national, industrial and individual. The implementation time is divided into 5, 10, 15 and more years. According to the direction of the policy, (a) clearly put forward the national medium and long-term goals, the 15-year goal is divided into 3 stages, and the specific implementation guidelines are formulated. (b) Finally, the content of the mentioned industrial fields is summarized in (d). (c) The development strategy of Internet-related industries in all aspects has been formulated. (d) Detailed "action plans" and "implementation guidelines" for various industries have been implemented, and policies for small and medium-sized enterprises have been adjusted. (e) Put forward policies to promote mass entrepreneurship and innovation. Premier Li Keqiang pointed out that the significance of promoting mass entrepreneurship is not only to increase employment and income, but also to improve the mobility among social strata, which helps to realize fairness and realize the dream of equality and freedom for all. The mass entrepreneurship and innovation policies has greatly promoted the establishment of start-up company.

From the national medium- and long-term planning objectives to the industrial field, and then to the formulation of science and technology innovation matrix policy based on mass entrepreneurship is a major feature of China's science and technology policy, is also a process of continuous exploration and correction learning.

2.3.3 Framework of China's Science and Technology Innovation Policy System

Since China's reform and opening up in the 1980s, the reform of China's science and technology system has continued to advance, constantly strengthening the support of science and technology for social development, people's livelihood, ecological environment and national security. Especially after the 18th people's Congress of the Communist Party of China, science and technology innovation was placed at the core of the overall national development, innovation-driven development strategy has been vigorously implemented. Furthermore, science and technology system reform has been continuously promoted. The main structure of science and technology system has been established, and the pattern of reform-driven innovation and innovation-driven development has been basically formed.

At present, China has gradually formed a set of scientific and technological innovation policy development path and policy measures continue to improve. It has basically formed a science and technology innovation policy system with wide coverage, complete categories and diversified tools (He 2011, 2019; Sun et al. 2016; Chen et al. 2013; Fan et al. 2012; Yang et al. 2020). MOST (2016) and some researchers have classified China's science and technology innovation policy system (He 2020; Zhou et al. 2012; Fan et al. 2012). This chapter makes a further summary as follows.

In China's science and technology innovation policies, 8 types of policies can be formed for the elements, subjects, linkages, industries, regions, environment,

openness and feedback of the innovation system. The first is the innovation factor policy, which mainly includes talent, investment and technology facilities policy. The second is the main body of innovation policy, including enterprise innovation policy, colleges and universities. Third is about innovation related policies, including the transformation of scientific and technological achievements, the combination of science and technology and finance, and the policy of civil military integration. Fourth includes industrial innovation policies and innovation policies for specific industries, such as new energy vehicles, IC and mobile phone localization policies. Next is regional innovation policies, such as science and technology parks, high-tech areas and so on. The sixth is to innovate environmental policies, including innovation governance and ecological policies. The seventh is the policy of opening up and innovation, including the policy of international science and technology cooperation and opening up and the eighth is systematic feedback policy, including science and technology evaluation and supervision.

Need to pay attention to here is that different industries have different innovation modes, and we need to take different innovation forms in different regions according to the characteristics of regional economy. For example, the establishment of independent innovation demonstration zones, high-tech zones and so on. After the initial development, there is the need a set of reasonable innovation governance system to promote the formation of innovation ecology, and innovation needs good environmental protection. It needs the cooperation of governments at all levels or international cooperation. Finally, information feedback such as science and technology supervision and evaluation is needed to further promote the sound development of innovation system (see Fig. 2.3).

2.3.4 Chinese Investment in Science and Technology

According to OECD (2018) data and Progressive research service (2020), global R&D expenditure in 2018 was US $2.107 trillion. The USA is the world has the largest R&D investment. The is followed by China, whose R & D expenditure exceeds the sum of the following four countries, namely Japan, Germany, South Korea and France. The ten largest R&D-funding countries of 2018 accounted for $1.789 trillion in R&D expenditures, about 84.7% of the global total. In 2000, China accounted for nearly 5% of global R&D, joining the USA, Japan, South Korea and the countries of Western Europe as the largest funders of R&D. In 2009, China surpassed Japan to become the second largest funder of R&D. From 2000 to 2018, while China's share of global R&D rose from 4.9 to 26.3%, the US share fell from 39.8 to 27.6% and Japan's share fell from 14.6 to 8.1% (Progressive research service 2020).

On the other hand, according to the data of China's Ministry of science and technology (He et al. 2020), China's R&D investment expenditure has maintained rapid growth, ranking second in the world for the first time in 2013 and reaching 2.21 trillion yuan in 2019. Since 1995, the highest growth rate of R&D investment

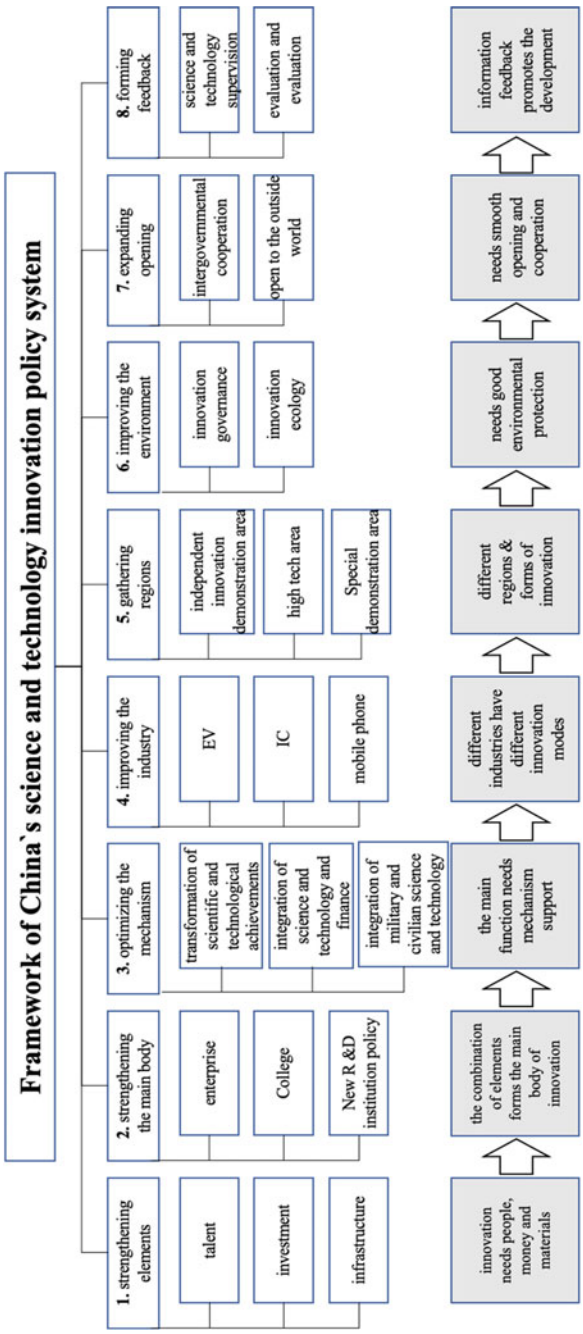

Fig. 2.3 Framework of China's science and technology innovation policy system. 2020 (*Source* Authors based on He et al. () and MOST (2016) Classifications)

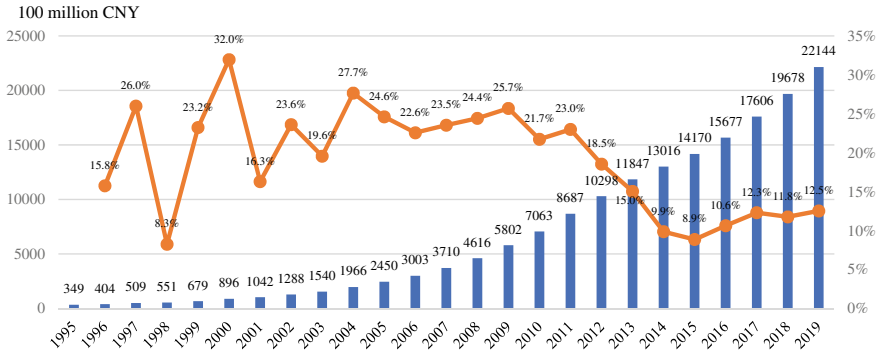

Fig. 2.4 Amount of investment in research and development and year-on-year growth rate in China (*Source* This figure is compiled by the authors using the original data from the Ministry of Science and Technology of China)

expenditure in China has reached 32%, showing a rapid increasing trend (see Fig. 2.4), which provides a strong financial guarantee for innovation-driven development.

According to the trend of R&D expenditure of Japan's Ministry of Education, Culture, Science and Technology on major countries and government-financed R&D expenditures (see Fig. 2.5a, b; MEXT 2019), China's R&D expenditure began to increase sharply after 2000. It can be seen from the government's independent R&D expenditure that the USA and China still rank first and second, while Germany ranks third.

2.3.5 *The Guiding Role of Independent R&D Expenditure of Chinese Government*

The investment of China's government financial R&D ventures has propelled the rapid growth of China's venture capital. Its impact on the rapid growth of China's new technology and start-up is multifaceted. This chapter makes a detailed arrangement on the investment fields and investment process of government-guided funds in China (see Fig. 2.6). According to a survey conducted by China Investment Research Institute in 2018, 73.3% of China's government-guided funds were invested in venture capital, and 83.3% of these funds eventually obtained more than three times of the raised funds, with the maximum amount of 10 times of the guiding funds. 93.3% of the guidance funds in the past three years have been invested in TMC (technology, media, communication) and health care. Among the media and communication industry, the majority of start-up enterprises have capital relations with BAT (Baidu, Alibaba, Tencent). BAT has also invested a huge amount of capital through the listing of shares. BAT funds are invested in two ways. One is the investment fund under BAT, and another is the direct investment of BAT entrepreneur group.

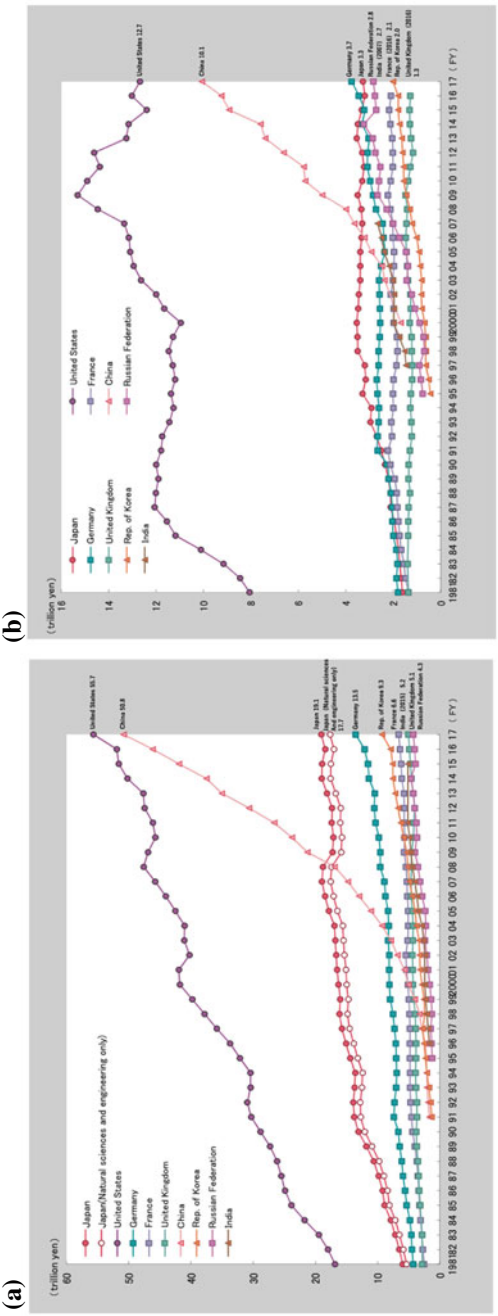

Fig. 2.5 **a** Trends in R&D expenditures in selected countries (OECD purchasing power parity conversion). **b** Trends in government-financed R&D expenditures in selected countries (OECD purchasing power parity conversion) (*Source* This figure was quoted from: MEXT(2019))

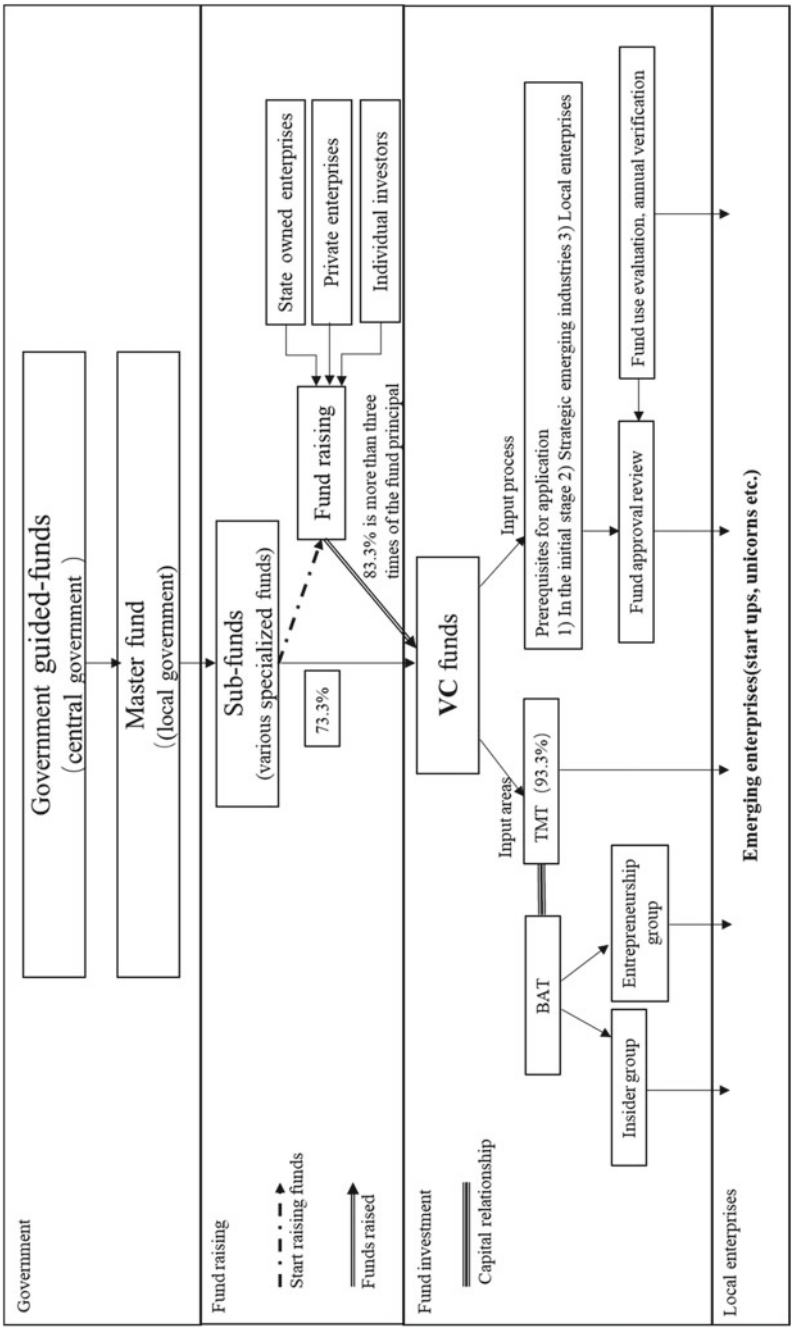

Fig. 2.6 Process of Investment and Use Of China's Government-Guided Funds (*Source* This figure was prepared by the authors using original data from: Ke (2019), MOST (2016), Kimura (2019) and Chinaventure (2019, 2020))

On the other hand, when enterprises apply for funds, there are a series of regulations, which can be roughly divided into three aspects according to different places: (1) in the initial stage, (2) strategic emerging industries and (3) local enterprises. For example, in Shenzhen, more than 70% of the special funds raised by government-guided funds should be invested in the early start-up enterprises, and the amount of the special funds equivalent to twice the principal of government-guided funds should be invested in the local enterprises in Shenzhen (Koichiro 2019).

Why can the government-guided funds cause such a large social capital effect? Ding (2019) made a detailed analysis and drew three conclusions. First, after 2020, Chinese investor groups will return to China and invest in China. The second is the Chinese version of NASDAQ, which was established in Shenzhen in 2009. The establishment of the Chinese version of NASDAQ makes it more convenient for local investors to recover their investment. The third is the rapid growth of China's Monetary Fund in 2016. This is directly related to the mass entrepreneurship and innovation policy proposed by the Chinese government in 2015. Premier Li Keqiang stressed in the "government work report" that mass entrepreneurship and innovation policy are the "double engines" that drive China's sustainable economic development. After that, the State Council issued "the opinion of mass entrepreneurship and mass innovation." In the opinion, it was mentioned that "supporting the venture capital." Reward the venture capital fund enterprises that participate in the establishment of state-owned enterprises and foreign enterprises. More importantly, the opinions put forward the creation of "government guidance fund" for governments at all levels. Due to the mass entrepreneurship and innovation policy, local governments at all levels to guide the creation of funds work rapidly.

According to the Research Report of China Investment Research Institute (2020), the government-guided funds began to grow rapidly in 2015, peaked in 2016 and then gradually decreased (see Fig. 2.7). The investment of the fund has promoted a rapid development of emerging enterprises in China's technology, media and communication fields, and has played a decisive role in promoting today's technology ecosystem in China. However, there are also some problems. These include giving priority to local enterprises in the use of funds and the geographical accumulation of technological innovation in China. By the first half of 2020, the establishment of the government-guided funds concentrated in six hot areas of Zhejiang, Beijing, Shanghai, Shenzhen, Jiangsu and Guangdong. The total size of the government-guided funds in the six hot areas is about 952.736 billion yuan, accounting for 44.41% of the total size. In terms of the number of government-guided funds, Jiangsu Province, Zhejiang Province and Guangdong Province (excluding Shenzhen) ranked first to third, respectively. From the perspective of the size of guidance funds, although the number of government guidance funds in Shenzhen is small, the average size of each guidance fund is about 3.9 billion, ranking first. The second is Beijing. The size of guidance fund is about 274.324 billion yuan, and the average size of each guidance fund is about 3.5 billion yuan. The direction of investment is also concentrated in the field of import substitution, lack of investment in the field of basic research (see Fig. 2.8).

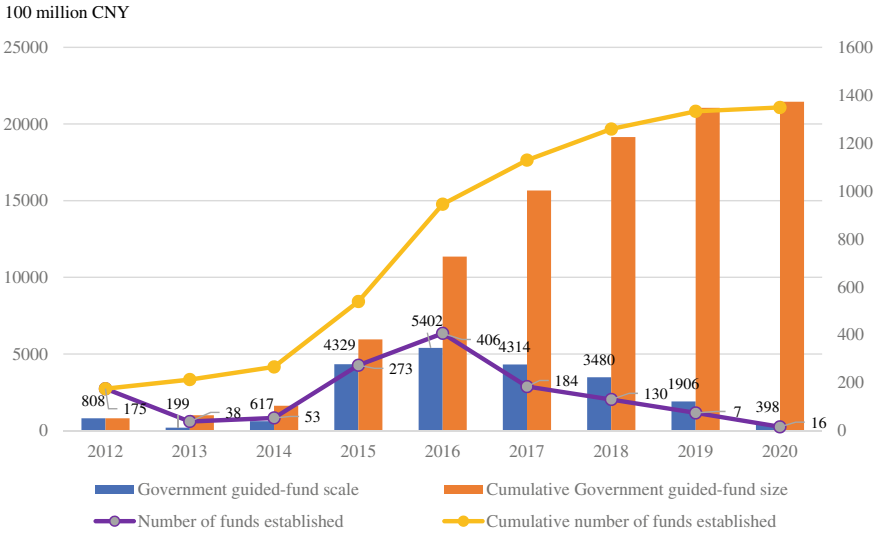

Fig. 2.7 Number and scale of government-guided funds established in China (*Source* This figure is compiled by the authors using the original data from the Special research report on government-guided fund in 2020 (Chinaventure (2020))

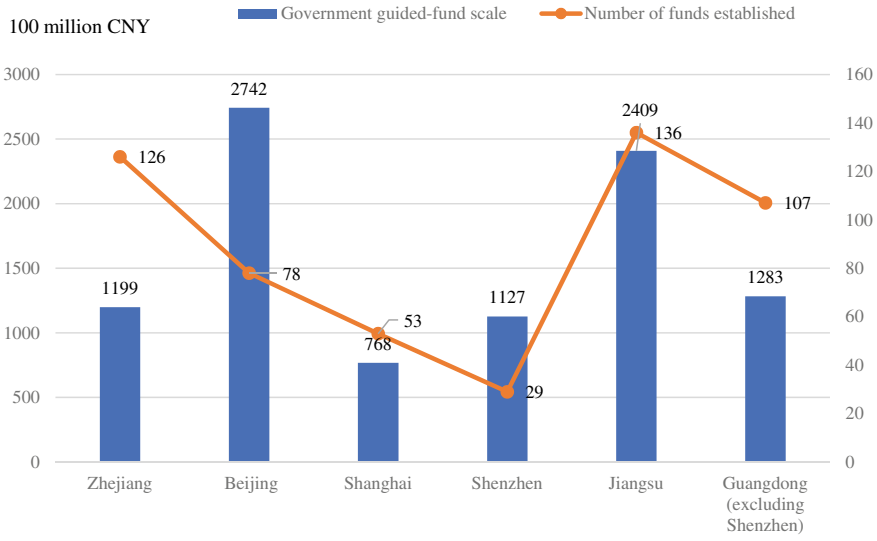

Fig. 2.8 Scale and quantity of government-guided fund in six hot areas in China (*Source* This figure is compiled by the authors using the original data from the Special research report on government-guided fund in 2020 (Chinaventure (2020))

2.4 Experiences and Lessons of Innovation and Technology Ecosystem in China

In the last 70 years since the founding of new China, China's science and technology innovation strategy has gone through five stages, and a series of decisive strategic matrix policies have been issued. Through countless practice and continuous learning, China's science and technology innovation policy system framework has been summarized, and huge scientific investment has been invested, which has formed today's booming science and technology innovation ecosystem. Among them, the government's various policy guidance and strong government-guided funds cannot be ignored. In terms of the use of government-guided funds, BAT has played a positive role in the development of emerging enterprises and local enterprises.

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