Bulletin of Chinese Academy of Sciences

Volume 36 | Issue 5 Article 9

5-20-2021

On Dealing with Openness and Self-reliance in Development of Science and Technology

Yungang BAO
Institute of Computing Technology, Chinese Academy of Sciences, Beijing 100190, China,
baoyg@ict.ac.cn

See next page for additional authors

On Dealing with Openness and Self-reliance in Development of Science and Technology

Abstract

China leaders have been always emphasizing both openness and self-reliance over the past decades. However, it is challenging for institutes and researchers to properly deal with the two requirements which are considered to be unachievable at the same time. In this study, we propose four openness modes as well as two principles for handling openness and self-reliance in the development of science and technology. This paper presents the case study on how Chinese computer pioneers made strategical decisions on the openness and self-reliance in the very early age of Chinese computer history. We also retrospect the practice of openness in the history of the development of science and technology in China. Finally, we discuss the feasibility of adopting the opensource mode to achieve both openness and self-reliance in the processor area.

Keywords

openness self-reliance science and technology

Authors

Yungang BAO and Ninghui SUN

Citation: BAO Yungang, SUN Ninghui. On Dealing with Openness and Self-reliance in Development of Science and Technology [J]. Bulletin of Chinese Academy of Sciences, 2021 (5): 552–556.

On Dealing with Openness and Self-reliance in Development of Science and Technology

BAO Yungang, SUN Ninghui

Institute of Computing Technology, Chinese Academy of Sciences, Beijing 100190, China

Abstract: China leaders have been always emphasizing both openness and self-reliance over the past decades. However, it is challenging for institutes and researchers to properly deal with the two requirements which are considered to be unachievable at the same time. In this study, we propose four openness modes as well as two principles for handling openness and self-reliance in the development of science and technology. This paper presents the case study on how Chinese computer pioneers made strategical decisions on the openness and self-reliance in the very early age of Chinese computer history. We also retrospect the practice of openness in the history of the development of science and technology in China. Finally, we discuss the feasibility of adopting the open-source mode to achieve both openness and self-reliance in the processor area. **DOI:** 10.16418/j.issn.1000-3045.20210420001-en

Keywords: openness; self-reliance; science and technology

1 Two principles of openness and self-reliance in scientific and technological development

On November 3, 2020, Chinese President Xi Jinping mentioned in the note of the proposals for formulating the 14th Five-Year Plan (2021–2025) for National Economic and Social Development and the Long-Range Objectives Through the Year 2035 that we should pay attention to 5 principles in the drafting of the proposals, the third of which is to handle the relationship between openness and self-reliance, and to better take into account both domestic and international situations.

Openness and self-reliance are both important development goals for the country. However, they are always considered to be unachievable at the same time in practice. As a matter of fact, China's national leadership has always taken openness as the general direction of development and the major principle that we cannot abandon. At the APEC CEO Summit on November 19, 2020, Chinese President Xi Jinping pointed out that openness enables a country to move forward, while seclusion holds it back. China has already deeply integrated into the global economy and the international system. We will not go backwards or run against historical trend by decoupling or forming a small circle to keep others out.

The openness of a country involves many aspects including market, economy, culture, and entertainment, and this paper focuses on science and technology. At present, science and technology face many difficulties in the development. Therefore, this paper mainly discusses how to enhance the independent research and development (R&D) ability for core technologies in an open environment when the technology development lags behind.

The openness of a country in the field of science and technology is specifically manifested in importing equipment, technologies, talents, and other essential resources from other countries through trade or assistance. There are four different modes of openness based on the international technology trade in the past few decades, which are ranked in the order of their effects on the development of independent R&D ability. ① Importing products. In this mode, the local market is opened to sell imported products and services without local R&D. ② Introducing foreign capital. In this mode, foreign-funded enterprises or joint ventures are established in China, which can cultivate local talents though it is not easy to acquire core technologies. ③ Introducing intellectual property rights. In this mode, advanced technologies are licensed or technical protocols are imported for local digestion, absorption, and re-innovation in China. ④ Introducing overseas talents. In this mode, overseas talents are introduced to develop key core technologies in China.

While bringing cost effective goods and high-quality services, openness can easily lead to the stagnation of the independent R&D ability of a country. This is also one of the main reasons Latin American countries such as Brazil and Argentina fall into the middle-income trap. Science and technology constitute the primary productive force. For handling openness and self-reliance in the development of science and technology, we put forward two basic principles: ① Talents are the basis for realizing self-reliance, and ②

Received: 2021-05-7
Supported by: Major Consulting and Research Project of Chinese Academy of Engineering (2021-xy-32)

good openness should improve the quality and quantity of talents.

Based on the four modes of openness, we can learn that fostering enough high-level talents is the key to the development of science and technology in China. Therefore, an important goal of openness is to increase high-level talents. However, it is challenging for underdeveloped countries to cultivate high-level talents merely with their own national foundation and conditions. Therefore, it is of positive significance to introduce through openness the talents who got trained in advanced countries to conduct R&D of core technologies, or advanced ideas, technologies, and management modes to accelerate local talent cultivation.

Admittedly, talent is only a necessary condition, and the correct strategies are also essential. These strategies involves strengthening the aggregation and development of local industry chain, using our own strength to encourage the competitors to authorize patents to us, and cooperating with other countries in the world to jointly build new industrial ecology. This paper will not expand the discussion due to limited length.

2 Case study: the starting of computer industry in China

In this paper, we discuss the starting of computer industry in China with the building of the Institute of Computing Technology, Chinese Academy of Sciences (CAS) in the 1950s as an example [1]. At that time, computer industry in China had not yet started, and the computer pioneers also faced an issue about how to deal with the relationship between openness and self-reliance. They made two key decisions as follows.

(1) Imitating before innovation. At that time, the computer pioneers believed that setting up relevant majors in universities to cultivate talents from the theoretical foundation would take too much time to meet the urgent needs of the country. Therefore, they decided to imitate the Soviet ready-made computers and drawings, and learn technology in the process of imitation, so as to lay the foundation for future independent innovation.

(2) Making copies in China instead of sending researchers to the Soviet Union. The older generation of computer experts believed that copying Soviet computers in China could quickly build China's own research, production, application, and management teams, which would be the foundation of Chinese computer industry.

The pioneers of Chinese computer industry made a pragmatic decision by comprehensively considering the disciplinary foundation, the long-term goals, and the funding of the country during that period of time. They followed the principle of talents being the basis for realizing self-reliance to handle openness and self-reliance, and achieved the significant breakthrough from 0 to 1 in Chinese computer industry.

3 Review of openness practice of China

The openness practice of China [2] experiences the mixed implementation of the four openness modes, with different emphases at different stages.

(1) The first three decades after the founding of the People's Republic of China (1949–1978). The establishment of industrial system of China mainly depended on the large-scale introduction of complete sets of technical equipment and products, as well as the introduction and digestion of various relatively backward technical solutions. On the basis of this, it has cultivated a number of backbone talents and formed a certain independent R&D ability, but there was still a big gap with the international advanced level. Unlike the industrial sector, the field of national defense during that period mainly focused on the introduction of talents. A number of talents including Qian Xuesen, Qian Sanqiang, and Deng Jiaxian returned to China and made indelible contributions to the "Two Bombs and One Satellite" project, which enabled China to have self-reliance in the development of strategic national defense force.

(2) The first two decades of reform and opening up (1979–2000). China mainly adopted the "market for technology" route, the goal of which was to introduce products, capital, and intellectual property through opening the local market. During this period, the amount of equipment and technical programs introduced by China increased from 2.485 billion US dollars in 1979 to 18.176 billion US dollars in 2000 [2]. At the same time, a number of technical and management personnel were cultivated through cooperative production as well as establishment of joint ventures and wholly owned branches. However, during the same period, a large number of outstanding talents went abroad to study, which weakened the independent R&D ability to a certain extent at the national level.

(3) After accession to the World Trade Organization (WTO) (2001 to present). The four modes of openness tend to be more balanced at this stage. In particular, the modes of introducing intellectual property rights and talents are improved. While introducing advanced technologies such as high-speed train, 2G/3G communication, liquid crystal display, and open-source software, China attaches importance to the capacity building of "absorption-digestion." Therefore, a large number of local technical talents has been cultivated. These talents have gradually acquired the ability of re-innovation and developed the leading technologies such as 5G communication. In addition, the policy of openness attracts overseas talents to return back to China for business startup as well as the R&D of core technologies. The scientific and technological strength of China has been growing

up, as benefited by the increasing quantity and quality of high-level talents.

The fluctuation of independent R&D ability in the openness practice of science and technology development in China is closely related to the cultivation and flow of talents. This also confirms the principle that talents are the basis for realizing self-reliance.

4 Inspiration for the development of processor chip industry in China

The chip industry is a strategic industry that affects the long-term development of a country. Processor chip is the "brain" of electronic devices, supporting the information industry which accounts for about one-sixth GDP of China. However, Chinese core processor chips still account for less than one percent in the global market, and the electronic products rely heavily on imported processor chips. In 2019, the total import of integrated circuits in China reached 304 billion US dollars, of which the import of processor chips reached 142.3 billion US dollars (46.8%). Furthermore, the import was mainly from the United States, with a risk of stranglehold problems.

Chinese processor chip industry is facing a particularly serious challenge of how to properly handle openness and self-reliance and coordinate the domestic and international situations. On the one hand, the international competitiveness of Chinese exports of electronic products which amounts to trillions of dollars needs to be protected. On the other hand, it is necessary to guarantee the self-reliance in information infrastructure and core equipment in key areas such as the Party, government, and military. Centered on these two goals, the processor chip industry of China has gradually formed three development routes in the past two decades, which are respectively called systems A, B, and C [3].

(1) System A. Domestic processor chip enterprises introduce foreign technologies and integrate the introduced intellectual property rights. For example, Haiguang and Zhaoxin are based on the X86 processor, and Haisi and Feiteng are based on the ARM processor. System A is highly open, and some domestic CPUs are competitive in the international market. However, as X86 and ARM are independently built by American and European enterprises, domestic processors based on system A need to obtain instruction set authorization or CPUIP core authorization. As a result, these domestic processors have weak self-reliance.

(2) System B. The domestic processor chip enterprises represented by Longxin and Shenwei adopted foreign instruction sets MIPS and Alpha respectively in their early age. They realized re-innovation after "digestion and absorption," designed and defined instruction sets independently, and built the ecology independently. System B has the strongest self-reliance while still faces many challenges in ecological construction.

(3) System C. In the recent decade, the open-source chip mode represented by RISC-V, an open instruction set, has become a new trend, attracting leading enterprises including Huawei, ZTE, Alibaba, and UNISOC and a large number of start-up enterprises to invest. The core concept of system C is the same as the development mode of 5G communication technology. That is, countries around the world jointly develop standards and specifications, and enterprises independently manufacture their own products according to the standards and specifications. With more investment and greater contribution, the open-source chip will have greater dominant power worldwide. This system is capable of giving better consideration to openness and self-reliance [3].

In the past, China mainly developed processor chips according to systems A and B and made great progress. However, compared with developed countries, China still lags behind, especially in the cultivation of high-level talents. Through systems A and B, a number of talents have been fostered for processor chip design in China over the past two decades, while it is still far from enough. According to the statistics, from 2008 to 2017, 85% of the talents in the field of processor chip architecture were employed in the United States, while only 4% were employed in China [4]. Therefore, talents are still the fundamental solution for accelerating the improvement of independent R&D ability. It is urgent to accelerate and expand the cultivation of high-level talents.

System C, giving consideration to both openness and self-reliance, greatly reduces the threshold of chip design through open source mode. In 2019, the University of Chinese Academy of Sciences launched the "One Chip per Student" project, and five undergraduates completed the design of a 64-bit RISC-V processor that can run Linux operating system within four months, which aroused positive response from the society. This is benefited by the development of system C which is based on open-source chip ecology and chip agile design. As a matter of fact, system C is still at the early stage of development. Chinese government should increase investment in system C, since it can not only accelerate the cultivation of chip design talents and release the dividend of Chinese engineers, but also make full use of the large market and multiple application scenarios in China. System C will become the dominant force in processor chip ecology in the future.

5 Conclusions

Over the past 70 years since the founding of the People's Republic of China, its scientific and technological strength has been greatly improved. Nowadays, the total number of papers published, the number of cited papers, and the number of International Patent Cooperation Treaty (PCT) patents rank in the forefront of the world. These achievements are

attributed to a series of measures China has taken to bolster openness, as well as strategic resolution to enhance self-reliance in the process of openness. As long as China sticks to the two principles (talents are the basis for realizing self-reliance, and good openness should improve the quality and quantity of talents) and adopts correct strategies, it can improve independent R&D ability of core technologies in the open environment and coordinate openness and self-reliance in the development of science and technology.

References

1 Meng F G. "Task-oriented Discipline" and the Establishment and Early Development of the Institute of Computing Technology of the Chinese Academy of Sciences. Beijing: the Insititute for History of Natural Sciences, Chinese Academy of Sciences, 2009 (in Chinese).

2 Wang X H, Xie L L, Guo X. On the development and innovation of China's technology trade. China Opening Journal, 2021, (1): 24–50 (in Chinese).

3 Sun N H. On the spirit of open source. Communication of China Computer Federation, 2021, 17 (5): 1 (in Chinese).

4 Bao Y G, Sun N H, Zhang K. Thinking and practice of open source design and agile development of processor chip. Communication of China Computer Federation, 2019, 15 (10): 42–48 (in Chinese).

BAO Yungang, Professor and Deputy Director of Institute of Computing Technology (ICT), Chinese Academy of Sciences (CAS), and Director of the Research Center for Advanced Computer Systems (ACS) of ICT, CAS. His research focuses on computer systems and has been adopted by industry companies including Alibaba, Huawei, Intel, Microsoft, etc. He is on the Board of Director of RISC-V International Foundation and is the secretary general of China RISC-V Alliance. He is the Director of the Committee of Young Experts of Bulletin of Chinese Academy of Sciences. He was one of three keynote speakers at ARM Research Summit 2018, the winner of CCF-Intel Young Faculty Award of the year 2013, and CCF-IEEE CS Young Scientist Award of the year 2019. He won China's National Lofty Honor for Youth under 40 in 2019. E-mail: baoyg@ict.ac.cn

SUN Ninghui, corresponding author, PhD, Professor, Academician of Chinese Academy of Engineering. He is the Scientific Director of Institute of Computing Technology (ICT), Chinese Academy of Sciences (CAS). He is also the Director of State Key Laboratory of Computer Architecture, Vice Chairman of Academic Committee of the laboratory. Dr. Sun is the Vice President of China Computer Federation (CCF), and the Director of CCF Technical Committee on High Performance Computing (TCHPC). He serves as Editor-in-Chief of Chinese Journal of Computers. Currently, Dr. Sun is the leader of the expert group on strategic studies of information technology development roadmap in CAS. His main research interests include high performance computing and computer architecture. E-mail: snh@ict.ac.cn