CHAPTER 8

# Development of New Quality Productive Forces and Global Cooperation on Open Innovation

The development of new quality productive forces is a significant measure for China to promote high-quality development and advance modernization with Chinese characteristics. It reflects major trends and tides of current global technological revolution and industrial transformation. New quality productive forces primarily rely on innovation and are birthed from revolutionary technological breakthroughs, innovative allocation of production factors, and profound transformation and upgrading of industries. They are fundamentally characterized by advancements of laborers, means of labor, objects of labor, and optimalization of their combinations, and are in alignment with the new development concepts of innovation, coordination, green, openness, and sharing. Openness is a distinctive feature of new quality productive forces. Deepening global cooperation on innovation and opening-up can enhance economic growth momentum of countries around the world.

## I. Connotation and Characteristics of New Quality Productive Forces

### 1. Connotation of new quality productive forces

The essential connotation of new quality productive forces lies in the advancement of laborers, means of labor, objects of labor, and their optimal combinations, which can be summarized as the following four types of advancements:

- **Advancement of laborers.** Laborers are the human elements in relations of production. Technological progress demands that laborers possess higher educational qualifications, stronger learning capabilities, and cross-disciplinary and all-round skills. Laborers suited for new quality productive forces include both strategic science and technology talents and applied talents.
- **Advancement of means of labor.** Means of labor are material elements in relations of production, encompassing all material elements used by people in production and reproduction, including production tools, buildings, roads, canals, etc., with production tools playing a decisive role. Technological revolution imparts increasingly more technological elements to means of labor. New hard technologies[1] and smart production tools, such as generative AI and big data centers, significantly propel the development of productive forces.
- **Advancement of objects of labor.** Objects of labor are also material elements in relations of production, referring to everything that can be processed during the labor process. Data, as a new production factor, is gradually being integrated into various stages of social reproduction, including production, distribution, circulation, and consumption, playing a crucial role in high-quality development of the economy and society.
- **Advancement of combinations of laborers, means of labor, and objects of labor.** Against the backdrop of new technological development, data, as a new production factor, can be optimally combined with various traditional production factors, leading to continuous improvements in the efficiency of production activities and, subsequently, enhancing total factor productivity. For instance, in road transportation, integrating real-time bus location information, ride-hailing vehicle data, and Internet mapping data, while implementing deep AI training, can quickly optimize commuting solutions for intersections and road segments, effectively improving urban traffic efficiency. This exemplifies optimal combination and advancement of data, technology, and labor.

Any single advancement aforementioned can significantly improve social productivity. Therefore, it is essential to focus on enhancing each production factor as well as their synergistic and optimized combinations, striving to achieve multi-dimensional advancements simultaneously to foster overall development of new productive forces.

## 2. Characteristics of new quality productive forces

New productive forces are characterized by high technology, high efficiency, and high quality, which can be understood from the perspectives of factors, technology, and industry.

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1 Hard technology refers to key core technologies that are based on scientific discoveries and technological inventions, require long-term R&D, continuous accumulation, have high technological thresholds and clear application scenarios, are difficult to replicate and imitate, and play a significant supporting role in economic and social development.

**Factor dimension: Data as a driving force for new quality productive forces development.** Currently, data has emerged as the fifth major production factor after land, labor force, capital, and technology, playing a crucial role in the development of new quality productive forces. The rise of technologies like AI enhances humanity's ability to capture, process, disseminate, and even generate data, accelerating the digitization of objects of labor, the networking of means of labor, and the virtualization of information labor engaged by laborers. The integration of new factors like data with various traditional factors helps improve production efficiency and intelligentization, thereby promoting the development of new quality productive forces.

**Technology dimension: Technological innovation as a core element.** New quality productive forces are the result of the collaborative development of new technologies. First, "original innovation" in technology is the key driver behind the emergence of new quality productive forces and high-quality development. China places great importance on "building international centers for science and technology innovation." There are over 75,000 national-level high-tech enterprises in the Guangdong-Hong Kong-Macao Greater Bay Area. Second, the transformation of scientific and technological achievements serves as an important bridge connecting innovation with industry. Chinese enterprises are positioned at the forefront of the market, possessing keen insights into market demands and technological trends, which can facilitate the implementation of the transformation. Third, China is equipped with a large number of highly qualified engineers, abundant data resources, and well-developed application scenarios.

**Industry dimension: A modernized industrial system as a vital carrier.** New quality productive forces require a scientifically structured modernized industrial system for support, so as to comprehensively upgrade traditional industrial clusters to form efficient, rapid, stable, and secure new quality industrial clusters. Now, China boasts 41 major industrial categories, 207 medium categories, and 666 minor ones, making it the only country worldwide with all industrial categories classified by the UN. Additionally, China possesses the world's largest high-speed railway network, extensive expressway network, a world-class port cluster, and the largest and most technologically advanced 5G network, all of which provide favorable conditions for upgrading traditional industries. China is also striving to create digital industry clusters as an advanced form of digital industrial development. The country aims to cultivate large-scale digital industry clusters worth hundreds of billions in areas such as high-end software, smart photovoltaics, and integrated circuits. Additionally, it is prioritizing the development of the intelligent IoT sector as a trillion-dollar industry cluster that combines competitive advantages and scale effects. The future industries indicate a new round of technological revolution and industrial transformation. China has laid a foundation in areas such as smart equipment, biotechnology, future materials, and cutting-edge technology-driven sectors. It's exploring innovation and fostering future industry clusters that support high-quality development.

# II. Status Quo of and Trends in Global Cooperation on Open Innovation

The development of new quality productive forces and global cooperation on open innovation are mutually reinforcing. To enhance new quality productive forces requires the impetus from global innovation cooperation, while global innovation cooperation is strengthened and deepened by the continuous progress of new quality productive forces. At present, significant progress has been made in global innovation cooperation in fields such as green low-carbon technology, next-generation information technology, and quantum information. However, challenges remain in global cooperation on innovation and opening-up driven by factors such as restrictions on cross-border data flows and certain economies implementing "technology blockade."

## 1. Steady progress in cooperations on green and low-carbon innovation

In terms of green energy innovation, a report released jointly by the IEA and the European Patent Office titled "Patents and the Energy Transition: Global Trends in Clean Energy Technology Innovation" indicates that the number of international patent families (IPFs) in low-carbon energy technology (LCE) has increased for three consecutive years (see fig. 8.1).

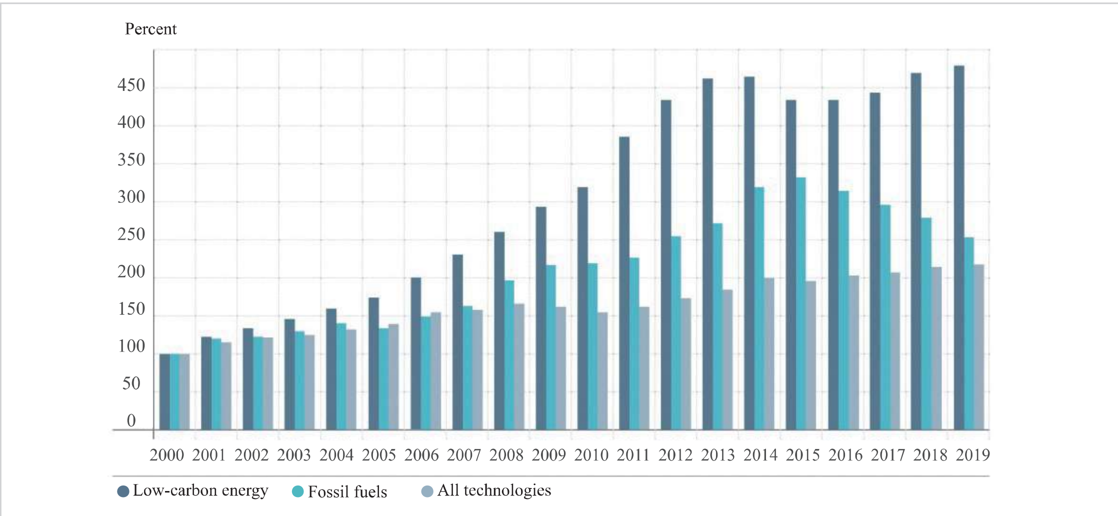


Figure 8.1 Growth rate of IPFs in LCEs: 2000–2019 (base 100 in 2000)

*Source:* IEA (2021).[2]

2 IEA, "Patents and the Energy Transition: Global Trends in Clean Energy Technology Innovation" (2021), https://link.epo.org/web/patents_and_the_energy_transition_study_en.pdf.

Developed economies play a leading role in LCE cooperation. As shown in figure 8.2, among the ten most collaborative fields, the United States and Europe demonstrate a technological advantage in seven areas, and they are primary partners in most major bilateral collaborations.

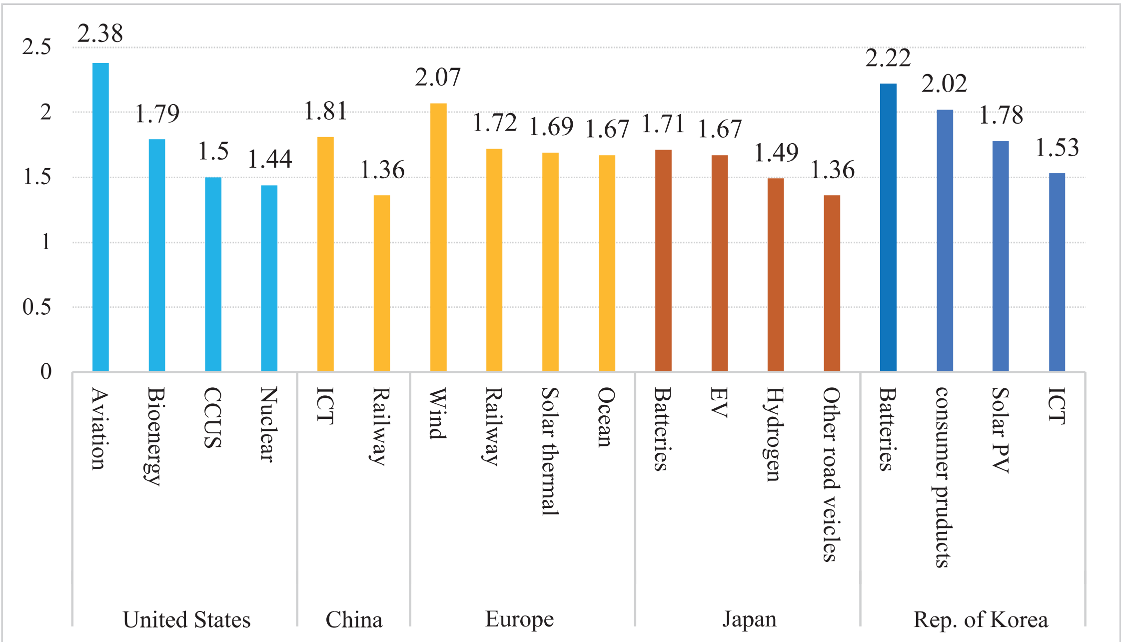


**Figure 8.2 Main revealed technological advantage of global innovation centers: 2010–2019**

*Source:* IEA (2021).[3]

China plays an important role in global clean energy innovation cooperation (see box 8.1).

| **Box 8.1 China deepens international cooperation in clean energy** |
|---|
| China's installed capacity for hydropower, wind power, and photovoltaic power generation has maintained the largest in the world for several consecutive years. Its relatively complete supply chain and industrial system for clean energy equipment provide strong support for the GX of countries involved in the BRI.<br>Within the framework of the BRI, China has engaged in technological innovation cooperation in new energy. Over the years, significant achievements have been made in the field of new energy collaboration. |

3 IEA, "Patents and the Energy Transition: Global Trends in Clean Energy Technology Innovation" (2021), figure E9.

In Africa, under the framework of the FOCAC alone, there are more than 100 green energy projects. The "China-Aid Mali Solar Demonstration Village," constructed by Chinese companies, installed 1,195 off-grid solar home systems, 200 solar streetlight systems, 17 solar pump systems, and 2 centralized solar power supply systems in the villages of Koniobla and Karan.

In Asia, Chinese energy enterprises have leveraged their first-mover advantage in international cooperation to achieve mutual benefits. The Lao "Ban Hat-Ban Na-Attapeu 500-kilowatt high-voltage transmission line" project, with a total investment of nearly $149 million, has an annual electricity transmission capacity exceeding 3.2 billion kilowatt-hours, making it Laos' first cross-border 500-kilowatt high-voltage transmission project.

In South America, green energy is a vital area of bilateral cooperation between China and Colombia. Chinese enterprises provide their support in six new energy generation projects, with a total designed capacity exceeding 170 megawatts, creating hundreds of jobs during the construction phase. Once completed, these projects can provide electricity for approximately 25,000 local households annually.

China plays an essential role in global clean energy cooperation. A report from the IRENA highlights that China's wind and photovoltaic products have been exported to over 200 countries and regions worldwide, with cumulative export values exceeding $33.4 billion and $245.3 billion, respectively. Through long-term open cooperation, the average cost per kilowatt-hour of global wind and photovoltaic projects has decreased by over 60 percent and 80 percent respectively in the past decade.

China continues to practice international cooperation in open innovation within the clean energy sector, disseminating new quality productive forces for energy to various regions, alleviating their energy and environmental pressures, and playing a significant role in promoting their sustainable economic and social development.

New energy vehicles has become a new name card of "Made in China" and opening-up and innovation, featuring a complete industrial chain and stable supply chain. Chinese new energy vehicle manufacturers and the smart automotive industry cluster pursue a cooperation through openness, connectivity and mutual benefits, insisting on creating new platforms for international cooperation and participating in the formulation of international standards and regulations. Through partnerships in Southeast Asia and Europe for factory construction and technological innovation, they showcase open innovation in the new energy vehicle sector, fostering technological advancement and market expansion in the global electric vehicle industry. For example, GAC New Energy and Bosch have collaborated, and Volkswagen and Xiaopeng Motors have signed a technical cooperation agreement for joint development of platform and software, with the first two models set to launch in 2026.

## 2. New changes in innovation cooperation on next-generation of information technology

China continuously promotes global cooperation in information technology. The country has been deepening the progress of the "Digital Silk Road" initiative and establishing a number of

"Digital Silk Road" economic cooperation pilot zones. These collaborations have strengthened cultural exchanges between China and countries along the Silk Road, enhanced mutual recognition among multiple parties and laid a solid foundation for the development of new quality productive forces.

As of 2023, China has signed bilateral e-commerce memoranda of cooperation with 30 countries, creating new channels and highlights for international economic and trade cooperation. In the process of open cooperation, China and partner countries have made significant achievements in digital infrastructure, digital trade and cross-border e-commerce, and digital governance.

In October 2023, at the Third Belt and Road Forum for International Cooperation (BRF), over ten countries, including China, jointly initiated the Beijing Initiative on Belt and Road Digital Economy International Cooperation, reaching 20 consensus agreements on strengthening digital connectivity, promoting industrial digital transformation and other fields. China has also signed multiple memoranda of cooperation with various countries, actively expanding cooperative efforts in the field of data. For example, on August 24, 2021, China proposed the China-Africa Initiative for Building a Community of Shared Future in Cyberspace. On July 5, 2022, China signed a memorandum of understanding on cybersecurity cooperation with Thailand. On May 26, 2024, the Cyberspace Administration of China and Indonesia National Network renewed the MOU on Developing Cybersecurity Capability Building and Technological Cooperation in Denpasar. The achievements of multilateral cooperation in the digital realm between China and partner countries are shown in table 8.1.

Table 8.1 Achievements of multilateral digital cooperations from BRF

| | Title |
|---|---|
| 1 | The Beijing Initiative on Belt and Road Digital Economy International Cooperation |
| 2 | The Global AI Governance Initiative |
| 3 | The Beijing Declaration on Building a Digital Silk Road |
| 4 | The Belt and Road Conference on Science and Technology Exchange |
| 5 | The Belt and Road Ministerial Conference on Science and Technology Innovation |
| 6 | The 5th IKCEST "Belt and Road" International Big Data Competition |
| 7 | The BRI Environmental Big Data Platform annual conference |

**Box 8.2 China promoting international cooperation in information technology**

Since 2016, Chinese companies have gradually entered markets in Eastern Europe, Central Asia, and Africa. Currently, the network service nodes of Chinese enterprises cover five continents and 160 countries and regions, assisting over 3,000 companies in "going global" and developing in China.

To support high-quality development of the BRI and promote the safe and efficient interconnection of information infrastructure, Chinese companies have deeply engaged in connecting information infrastructure with Southeast Asian enterprises, collaborating with governments in Southeast Asian countries to provide cloud computing services and big data analysis technologies. Chinese enterprises plan to open a second data center in Indonesia within the next year, forming a dual availability zone. These collaborations enhance data management and analysis capabilities in Southeast Asian countries and propel the high-quality development of their digital economies.

Chinese companies are collaborating with the Argentine government to provide advanced big data solutions, offering a fully cloud-based core network solution for the telecommunications sector and actively participating in local 5G network construction. This cooperation aims to enhance Argentina's cybersecurity capabilities and data processing capability, assist in modernizing information infrastructure, and promote digital transformation.

## 3. Considerable potential for open innovation in quantum information

International collaboration in the field of quantum information is just beginning to take shape. In 2022, China and Rep. of Korea organized a series of forums on innovation and shared benefits to discuss research methodologies and quantitative analysis in quantum subfields. In January 2024, the University of Chicago (the United States), the University of Tokyo (Japan), and Seoul National University (Rep. of Korea) jointly signed a trilateral quantum partnership agreement, which focuses on the cultivation of quantum talent. In May 2024, the United States and Germany issued a joint statement regarding cooperation in quantum information science and technologies, stating that both sides would strengthen collaboration in areas such as quantum computing, quantum networks, and quantum sensing. This includes jointly organizing academic conferences, sharing research methodologies, infrastructure, and data, and co-developing global markets and supply chains.

## 4. Abundant achievements in international scientific and academic cooperation

In terms of literature composed through international collaboration, the United States, China, the United Kingdom, Germany, France, Canada, Australia, Italy, Spain, and the Netherlands lead the world in the number of internationally cooperated research papers. Notably, the United States and China are fairly dominant, with both countries publishing over one million research collaboration papers each in the past decade, accounting for 37.9 percent and 21.5 percent of the global total of internationally collaborated papers, respectively. Between 2011 and 2020, 149 countries/regions engaged in research cooperation in advanced manufacturing technology based on academic papers. European countries generally exhibit a higher level of international research cooperation. Asian economies such as China, Japan, Rep. of Korea, and India show significant advantages in research scale (see tables 8.2 and 8.3).

Table 8.2 Internationally coauthored papers in advanced manufacturing technology: 2011–2020

| Ranking | Field | Number of papers | Of which: Number of internationally coauthored papers | Of which: Share (percent) |
|---|---|---|---|---|
| 1 | Microelectromechanical systems technology | 64,857 | 10,292 | 15.87 |
| 2 | Laser manufacturing | 27,707 | 4,683 | 16.90 |
| 3 | Additive manufacturing | 22,070 | 3,797 | 17.20 |
| 4 | CNC machine tools | 14,963 | 1,264 | 8.45 |
| 5 | Flexible electronics | 13,124 | 2,103 | 16.02 |
| 6 | Industrial robotics | 12,937 | 1,538 | 11.89 |
| 7 | Very-large-scale integration circuits | 7,247 | 1,082 | 14.93 |
| 8 | Smart sensors | 6,763 | 966 | 14.28 |
| 9 | Wide bandgap semiconductor | 2,111 | 391 | 18.52 |
| 10 | Digital twins | 1,233 | 192 | 15.57 |

Table 8.3 International co-authorship in advanced manufacturing technologies of top 20 economies: 2011–2020

| Ranking | Economy | Number of papers | Of which: Number of internationally coauthored papers | Of which: Share (percent) |
|---|---|---|---|---|
| 1 | China | 49,793 | 7,406 | 14.87 |
| 2 | United States | 29,336 | 8,321 | 28.36 |

*(Continued)*

| Ranking | Economy | Number of papers | Of which | |
|---|---|---|---|---|
| | | | Number of internationally coauthored papers | Share (percent) |
| 3 | Germany | 11,922 | 3,813 | 31.98 |
| 4 | Japan | 9,771 | 2,180 | 22.31 |
| 5 | India | 7,926 | 1,136 | 14.33 |
| 6 | Rep. of Korea | 7,369 | 1,628 | 22.09 |
| 7 | United Kingdom | 7,189 | 3,464 | 48.18 |
| 8 | France | 6,292 | 2,699 | 42.90 |
| 9 | Taiwan, China | 6,281 | 1,016 | 16.18 |
| 10 | Italy | 5,933 | 2,096 | 35.33 |
| 11 | Russia | 4,760 | 790 | 16.60 |
| 12 | Canada | 4,704 | 1,645 | 34.97 |
| 13 | Spain | 3,676 | 1,675 | 45.57 |
| 14 | Australia | 3,256 | 1,558 | 47.85 |
| 15 | Singapore | 3,161 | 1,410 | 44.61 |
| 16 | Switzerland | 2,381 | 1,185 | 49.77 |
| 17 | Iran | 2,275 | 564 | 24.79 |
| 18 | Poland | 2,143 | 599 | 27.95 |
| 19 | Netherlands | 2,082 | 1,004 | 48.22 |
| 20 | Malaysia | 1,904 | 595 | 31.25 |

Regarding international scientific research collaboration, the 2023 Report on the Status of China's International Scientific Research Cooperation estimates that the centrality of international scientific research cooperation of United States far exceeds that of other countries as a global hub for scientific research and cooperation. United Kingdom, Germany, and China rank second to fourth, indicating that these three countries are also significant hubs for global research collaboration. France, Italy, Spain, Australia, the Netherlands, and Canada constitute the third tier in terms of centrality, being key collaborative partners in global scientific endeavors.

In terms of international patent cooperation, search results from the Derwent Database shows that in 2020, approximately 14,800 of the PCT patents applied for globally involved international cooperation among applicants (or institutions), accounting for 5.3 percent of the total PCT patent applications. There is a close patent cooperation relationship among major innovative countries, with United States, China, Japan, United Kingdom, and Germany ranking among the top regarding the number of PCT patents with international cooperation (see table 8.4).

Table 8.4 Centrality of international scientific research cooperation center: 2020

| Countries | Centrality | Countries | Centrality | Countries | Centrality |
|---|---|---|---|---|---|
| United States | 11.5 | Switzerland | 2.7 | Austria | 1.7 |
| United Kingdom | 7.4 | Sweden | 2.4 | Rep. of Korea | 1.6 |
| Germany | 6.4 | Japan | 2.2 | Portugal | 1.4 |
| China | 5.1 | India | 2.2 | Finland | 1.4 |
| France | 4.5 | Belgium | 2.0 | Norway | 1.3 |
| Italy | 4.3 | Brazil | 1.9 | Czech Rep. | 1.3 |
| Spain | 4.0 | Poland | 1.8 | Turkey | 1.2 |
| Australia | 3.4 | Russia | 1.7 | Greece | 1.2 |
| Netherlands | 3.1 | Denmark | 1.7 | Pakistan | 1.0 |
| Canada | 3.0 | Saudi Arabia | 1.7 | South Africa | 1.0 |

## III. Promoting Development of New Quality Productive Forces through Cooperation on Opening Up

Openness is a distinctive feature of Chinese modernization. China adheres to the basic national policy of opening-up, enhances its opening-up capabilities through expanding international co-operation, and builds a new system of a higher-level open economy. As a new round of techno-logical revolution and industrial transformation advances, the international community needs to embrace higher levels of open collaboration to help develop new quality productive forces. This involves transforming and upgrading traditional industries with digital and green technologies, promoting the development of emerging and future industries, and facilitating new opportu-nities for shared innovation and open development (see box 8.3). Erik Solheim, the former UN under-secretary-general and former executive director of the UN Environment Program, stated that China's exploration of developing new quality productive forces will be a significant advancement for humanity. It injected new momentum into achieving the UN SDGs.

## 1. Deepen intergovernmental cooperation

Countries should focus on the global trends of the technological revolution and jointly promote the construction of large scientific facilities and new R&D institutions that meet the needs of future industrial development. Collaborative efforts should be made to formulate and implement plans for scientific and technological cooperation. Major projects that benefit the development of new quality productive forces should be deployed in advance. More partners should be encouraged to pay attention to and participate in the development of future industries. Various enterprises should be guided to increase their investments in emerging industries and establish corresponding exit mechanisms.

## 2. Unleash market vitality

Accelerating the formation of new quality productive forces hinges on cultivating market scale. For instance, China's vast market provides a mature environment for the development of new quality productive forces, including comprehensive support throughout the entire chain such as technology maturation, product pilot testing, and early market applications, along with diverse application scenarios and differentiated niche markets. Partner countries can continually explore regional potentials, accelerate the integration and optimization of production processes and stages, and achieve low-cost, large-scale industrialization, transforming cutting-edge technologies into new quality productive forces.

## 3. Strengthen collaborative innovation mechanisms in science and technology

Countries should explore the "scientists + entrepreneurs" innovation model to better harness the advantages of scientists and entrepreneurs; actively promote scientific cooperation, cultural exchanges, and business dialogues among partners. It is essential to solidify the technological foundation, creating a complete pathway from theoretical research to engineering design, and ultimately to product commercialization and scaling.

## 4. Level up patient capital

It's important to support the development of new quality productive forces and cooperation on innovation and opening-up and to facilitate the convergence of various advanced production factors toward the growth of new quality productive forces. The development of new quality productive forces is a long phase, requiring exploration of numerous industrial types; therefore, it necessitates more patient capital. For one thing, countries should establish effective mechanisms that link government funding for scientific research, industry guidance funds, and market-oriented investment funds to accelerate the development of patient capital. For another thing, efforts should be made to encourage and guide social capital to go to emerging and future industries, urging financial institutions to innovate in supporting the cultivation of new quality productive forces, thereby providing more products and services to ensure the development of future industries and international open cooperation.

### Box 8.3 AI and openness

AI is characterized by its advancement, openness, collaboration, and sustainability. It empowers new quality productive forces and meets the concept of new development and the requirements of high-quality development, serving as an important foundation for open development in the new era. In 2017, the State Council of China issued the Development Planning for a New Generation of Artificial Intelligence, which provides institutional support for the development of AI in China.

Research and innovation in AI should be open, public, and transparent, rather than constructing invisible barriers through intellectual property and patents. Moreover, AI should not be politicized. Leveraging the openness of AI technology is conducive to enhancing scientific progress and social well-being.

First, establishing a legal foundation for the openness of AI should begin with legislation. The AI legislation is still in the exploratory stage. The AI draft law, made public in March 2024, showcases the research efforts of Chinese scholars in areas including general principles, development and promotion, rights protection, safety obligations, supervision and management, special application scenarios, international cooperation, and legal responsibilities, laying the groundwork for the open development of AI.

Second, AI has become an important area of international cooperation. In 2023, China proposed the Global AI Governance Initiative, systematically outlining a Chinese approach concerning the development, safety, and governance of AI, and expressing a willingness to engage in extensive international communication and pragmatic cooperation on global AI governance. In May 2024, the first meeting of the China-US intergovernmental dialogue on AI was held in Geneva, Switzerland, with both parties signaling intents for cooperation.

Third, responsible global AI governance is yet to be established. As more people come into contact with and use AI applications, the global flow of data will be further strengthened. AI applications will promote global openness in daily life. The impact of deepfake misinformation on political and economic security deserves attention.