Translation

The following document, published by China's Ministry of Industry and Information Technology in 2020 on the basis of job posting data and surveys, describes the country's strong demand for—and insufficient supply of—artificial intelligence talent. The authors make several recommendations to increase China's supply of AI talent and to ensure that AI training in universities prepares graduates with the practical skills valued by employers.

Title
Artificial Intelligence Industry Talent Development Report (2019-2020 Edition)
人工智能产业人才发展报告（2019-2020年版）

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Artificial Intelligence Industry Talent Development Report

(2019-2020)

Ministry of Industry and Information Technology (MIIT) Talent Exchange Center

June 2020

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Preface

As the core driver of the new round of industrial transformation, artificial intelligence (AI) is profoundly changing production methods and lifestyles, and injecting new momentum for economic and social development. General Secretary Xi Jinping has pointed out that accelerating the development of new generation AI is a strategic issue that concerns whether China can seize the opportunities presented by the new round of scientific and technological (S&T) revolution and industrial transformation. At present, AI is taking on new features such as deep learning, cross-domain integration, human-computer coordination, the opening up of swarm intelligence (群智开放), and autonomous control. AI is a strategic industry that is ushering in the future, and if China is to maintain a competitive advantage in AI, it must strengthen the construction of its talent cadre.

In our research, we found that China's AI industry talent pool still has the following three problems: First, there is an imbalance in the structure of talent supply and demand. There is currently a large shortfall in AI talent relative to overall demand, and in the supply of talent there is a serious misalignment between the types of jobs and technology directions (技术方向) on one hand and employer demand on the other. Second, there is an imbalance in the quality of talent supplied and demanded. With the continuous advancement of AI technology, its scope of application continues to expand, and the demand of enterprises for innovative, "hybrid" (multidisciplinary) talents has become more prominent, but the current quality of talents is hardly sufficient to meet the requirements of enterprises. Third, there is a regional imbalance in the supply and demand of talent. The Beijing-Tianjin-Hebei region, the Yangtze River Delta region, and the Guangdong-Hong Kong-Macau Greater Bay Area are the three major talent concentrations of China's AI industry at this stage, and they also lead other regions of the country in the number of AI-related enterprises. In some less developed regions, a lack of talents further constrains AI industry localization trends.

General Secretary Xi Jinping has emphasized that "development is the number-one priority, talent is the number-one resource, and innovation is the number-one driving force." For the development of the AI industry, we must firmly grasp talent as a resource, so that everyone can make the most of their talents, talents are put to full use, and their use brings success. The only practical way to solve the talent problem in the industry is to strengthen top-level design, focus closely on actual employment demand, promote development of the "industry-academia-research institute integration" model of AI talent training, and precisely train the talents needed by the industry.

The *Artificial Intelligence Industry Talent Development Report (2019-2020)*, written under the leadership of the Ministry of Industry and Information Technology

(MIIT) Talent Exchange Center, provides a comprehensive analysis of human resource development in the AI industry from a talent perspective, and puts forward recommendations on AI industry talent work. If, due to the time restrictions, there are errors in the report, your corrections are welcome!

Artificial Intelligence Industry Talent Development Report (2019–2020) Editorial Committee

March 2020

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A. Enterprise and job samples

Enterprise type 1: AI enterprises that are focused on AI fields, and provide AI technology products and services in the basic, technical, and application layers of AI. The job sample contains all positions within this type of enterprise.

Enterprise type 2: Enterprises that use AI-related technologies to transform or reshape their products or services, including software enterprises, internet enterprises, and other traditional industrial enterprises. The job sample contains positions involving AI within this type of enterprise.

B. Talent sample

Includes talents who are working in AI enterprises or in relevant AI positions.

II. Sample Size

The enterprise sample for this study includes a total of 2,224 firms, and the job sample totals 92,741 positions. The talent sample totals 383,226 individuals.

III. Definition of Artificial Intelligence Industry Talents

As used in this report, AI industry talents refers to all kinds of talents in AI enterprises or relevant positions who promote the research of AI algorithms and related technologies, and ensure the successful application of AI products and services.

Key perspectives

1. China's AI industry got off to a late start, and basic research is comparatively weak. However, with strong support at all levels of government and the active participation of higher education institutions ("universities"), enterprises, and other sectors, the scale of China's AI industry has displayed a rapid expansion, exceeding $10 billion in 2019, and has become one of the leaders of the global AI industry. In addition, China ranked first in the world in the number of AI patent applications, accounting for 37.1% of the global total. The total number of research papers reached 141,840, which ranked second in the world. At this stage, China is also one of the most active countries in the global AI industry in terms of investment and financing, with the total number of investment and financing events accounting for 31.7% of the world total, and total AI

investment and financing funds in China accounting for 60.0% of the world total. Amid the booming digital economy development wave, AI is becoming the core force leading China's technological innovation and industrial development.

2. In China's powerful wave of AI industry development, the number of enterprises researching and applying AI technologies has been growing constantly, and demand for talents has skyrocketed in a short period of time. However, due to the late start and short development history of AI in China, AI talent reserves are insufficient and training mechanisms are imperfect. The result is that the current rate of talent training in universities, enterprises, and other sectors is unable to match the rate at which the industry's demand is expanding, and the effective concentration of talent in the industry is insufficient to meet the demand. Given the goal established in the *State Council Notice on the Issuance of the New Generation Artificial Intelligence Development Plan*[1] of achieving a core AI industry scale of more than 150 billion Chinese yuan Renminbi (RMB) by 2020, it is estimated that China's AI industry currently has an effective talent shortfall of 300,000 talents.

3. The talent supply-to-demand ratio in the AI industry is seriously unbalanced: First, there is an imbalance in supply and demand for different types of positions, with current enterprise demand being strongest for technical positions such as algorithm research positions, application development positions, and tech support (实用技能) positions, accounting for 12.2%, 19.8% and 34.8% of the overall demand for positions, but the talent supply-demand ratios are only 0.13, 0.17 and 0.98, respectively. Second, there is an imbalance in supply and demand for different technology directions, with demand for talents in machine learning and computer vision being the most prominent at the current stage, accounting for 39.1% and 33.4% respectively of overall demand in terms of positions. Talents in these relevant technology directions are extremely scarce, however, with the talent supply-demand ratios being only 0.23 and 0.09, so the effective supply is seriously insufficient.

4. The industry has high standards and requirements for talent quality. What enterprises need are application-oriented talents to assure that AI technology programs bear fruit, hybrid talents (复合型人才) with multi-industry experience or multi-position capabilities, innovative talents to promote algorithm research or product development, and localized talents with specific regional localization service capabilities. At the same time, enterprises have set high entry barriers for talents in terms of educational background and work experience: For education, 17.9% of positions in 2019 required a

[1] Translator's note: For an English translation of the New Generation Artificial Intelligence Development Plan, see: https://www.newamerica.org/cybersecurity-initiative/digichina/blog/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/.

master's degree or above, and only 11.9% of positions accepted junior college[2] degrees; for work experience, only 5.4% of positions in 2019 accepted job-seeking talents with less than one year of work experience, and only 3.3% of positions accepted fresh graduates.

5. In order to accelerate construction of the AI talent pool, the central government, local governments at all levels, universities, and enterprises are actively creating a good environment for talent development and training, and accelerating the construction of a talent ecosystem that is guided by policy, driven by industrial development, and characterized by collaborative education through school-enterprise cooperation. Local governments all over China have introduced a succession of special AI industry talent policies to guide and regulate the industry's training and recruitment of talents. AI majors were also officially approved to be included in the list of undergraduate majors in 2019, and a host of universities have also started to build AI schools (or research institutes), either on their own or jointly with enterprises, to specially train talents in basic research and application development, and multiple other types of talents. On the whole, construction of an AI "government-industry-academia-research institute integration" talent training ecosystem is still in the initial stage. Participation by government, universities, enterprises, and other sectors remains inadequate, and the teaching, talent evaluation, and talent service systems, as well as faculty, and talent exchanges with foreign countries, need to be further improved and strengthened.

Chapter One Overview of the AI Industry's Development

The digital economy has become an important driving force for boosting economic efficiency and optimizing the economic structure. An array of innovative technologies and applications represented by AI will serve as important cornerstones of the digital economy era, driving the transformation and upgrading of the traditional economy and the rapid growth of the emerging economy. It is foreseeable that the digital economy will be a brand-new socioeconomic form, following the agricultural economy and industrial economy. In 2018, during the ninth collective study session of the Central Committee Politburo on the status and trends of AI development, General Secretary Xi Jinping pointed out that AI is an important driving force of the new round of S&T revolution and industrial transformation, and that accelerating the development of new generation AI is a strategic issue that concerns whether China can seize the

[2] Translator's note: In China, students who do not score well enough on the university entrance exam (gaokao; 高考) to attend a regular four-year university have the option to attend a three-year junior college (专科 or 大专). Such schools typically teach vocational skills. Some junior colleges also offer continuing education for adult learners.

opportunities presented by this new round of S&T revolution and industrial transformation.

1.1 The development and industrial landscape of AI globally

The rapid iteration of information technology (IT), represented by cloud computing, big data, and the Internet of Things (IoT), has also accelerated the possibilities for AI to move towards practical applications, and various data and graphics processor technologies, as well as technologies represented by deep neural networks, have been integrated into AI systems, all of which is contributing to a new wave of AI technology development. The gap between technology and practical applications is rapidly narrowing. A number of application sub-fields within AI technology, such as speech recognition, image classification, and autonomous driving, have moved into the "available and useful" stage. In the future, the process of implementing AI technology applications in different scenarios is certain to usher in a new upsurge of explosive growth.

1.1.1 The Three Waves of AI Development

In 1956, the Dartmouth Workshop proposed the concept of "artificial intelligence" for the first time, raising the curtain on the development of the AI industry.

In its more than 60 years of development, AI has experienced three development waves, and global AI is currently in the third wave.

First wave: In 1956, the concept of "artificial intelligence" was proposed, setting off the first wave of AI development. In this period, the focus was on giving machines the ability to reason logically, and the first perceptron software and chat software were developed. Second wave: The second wave of AI began in the mid-1970s. During this period, Hopfield neural networks and behavior tree (BT) training algorithms were proposed. At the same time, expert systems for solving domain-specific problems saw widespread application. Third wave: In 2006, breakthroughs in deep learning theory gave rise to the third wave of AI. In this stage, the internet, cloud computing, big data, chips, and other emerging technologies provide sufficient data support and computing power ("compute") support for the development of various AI technologies, and business model innovation (represented by "AI+") has also became increasingly mature as the AI industry has developed. This promises to greatly improve the productive forces (生产力) of society, and to have far-reaching effects on the structural transformation of existing industries.

First Wave	Second Wave	Third Wave

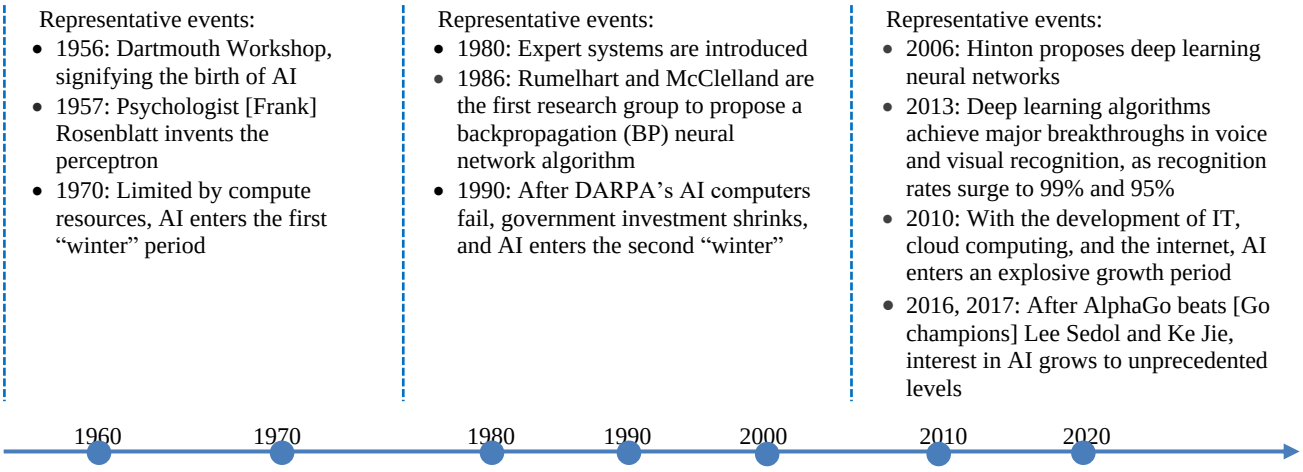


Figure 1 AI industry pattern—3 waves of AI development

With the rapid development of the AI industry, a relatively complete ecosystem for AI has formed globally, and a host of leading S&T innovation-oriented enterprises have emerged from the AI industry's basic layer, technology layer, and application layer.

(1) Basic layer: Provides computer and data services support to the AI industry chain. Enterprises, represented by industry giants such as Amazon Web Services (AWS), Azure, Alibaba Cloud (Aliyun), Tencent Cloud, and Baidu Cloud, provide sufficient compute resources for the development of AI; traditional chip giants NVIDIA and Intel, and domestic technology newcomers Cambricon, Horizon [Robotics], etc., are dedicated to providing special chips for AI computing needs. In addition, there are also a great many companies in the data services field, such as Datatang and Speechocean domestically, as well as Saagie, etc., abroad.

(2) Technology layer: Provides general technical capabilities for the AI industry chain. Internet giants, represented by Google, Facebook, Alibaba, and Baidu, have used their capital and talent advantages to lay out comprehensive positions in AI-related technology fields earlier than others. At the same time, there are also large numbers of innovative companies working on niche technologies. Examples include iFlytek, which specializes in intelligent speech, SenseTime, which is dedicated to computer vision, and 4Paradigm in the machine learning field. Outside of China, enterprises such as Proxem and XMOS are also actively engaged in the practice and exploration of the natural language processing and intelligent speech fields, respectively.

(3) Application layer: Provides service users various kinds of specific applications, and products or services adapted to industrial application scenarios. At present, most of the world's innovative technology companies in AI fields are concentrated in this layer. Typical enterprises include Verdigris and Terminus in the field of smart buildings, Genetec and Uniview in the field of smart security, and Flatiron and Infervision in the field of intelligent healthcare.

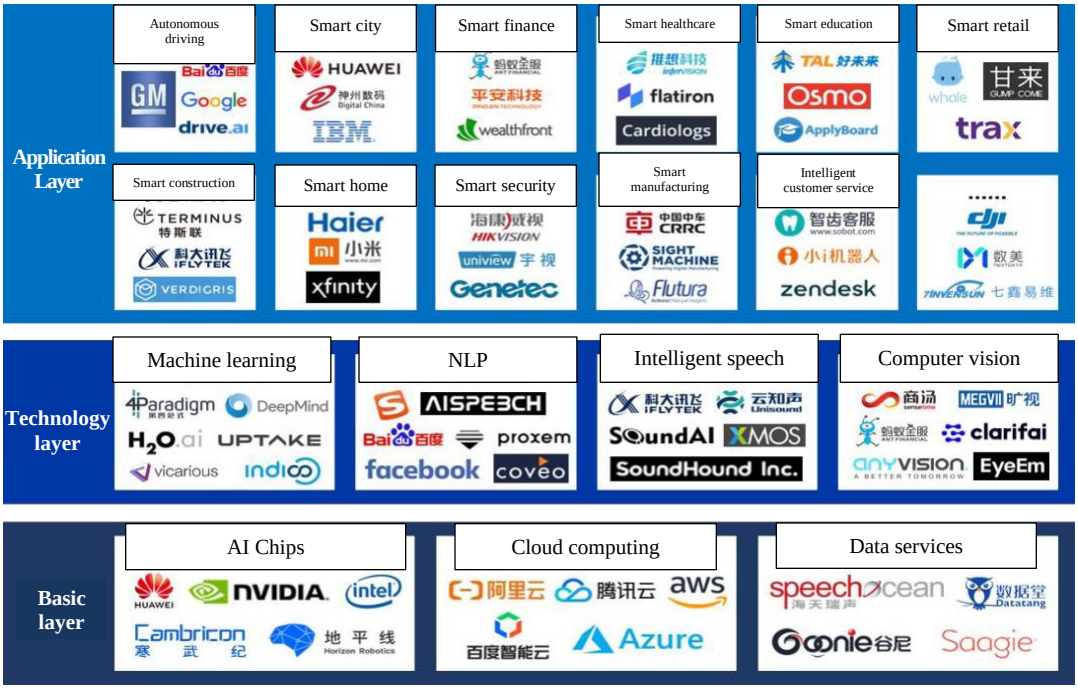


Figure 2 AI production chain and representative manufacturing industries

1.1.2 Overview of global AI Industry development

AI has now become a focus of international competition in technology innovation. Many countries around the world, including China, have incorporated AI in deployments for their national S&T strategies. From 2016 to 2019, major countries such as China, the United States, the European Union, the United Kingdom, Germany, Russia, Japan, South Korea, and India issued a profusion of special policies and action plans for AI. Guiding and promoting AI industry development has become an important consensus in the global economy.

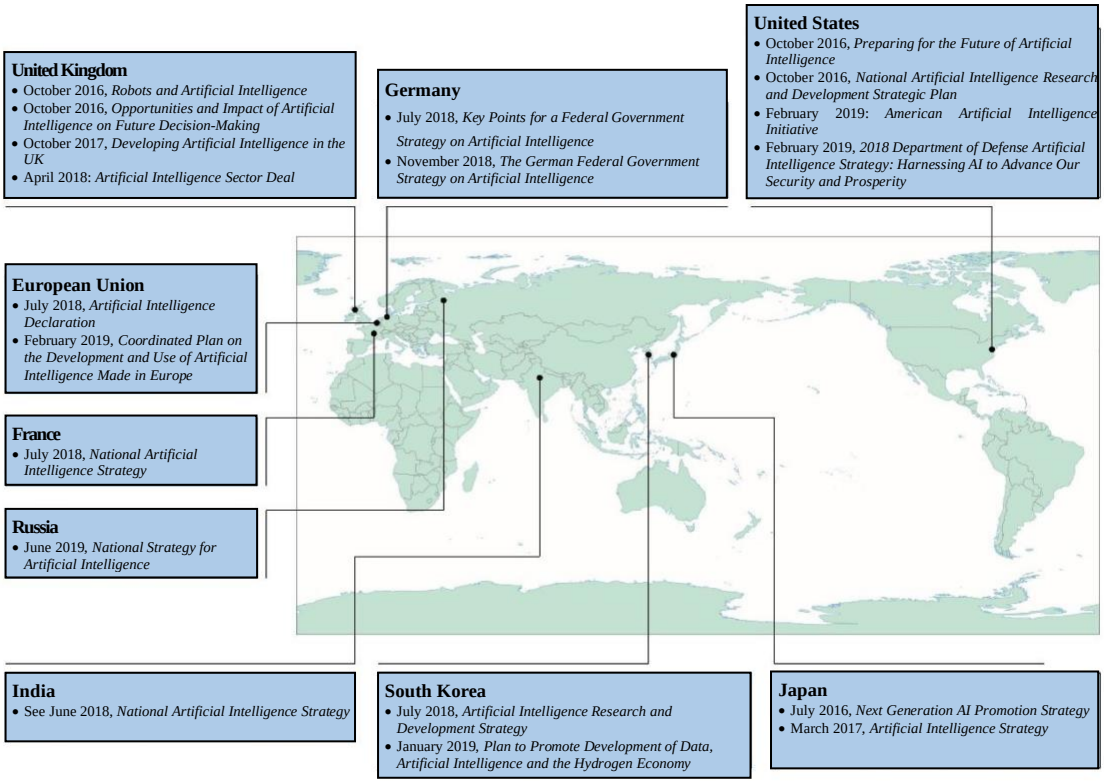


Figure 3 Artificial intelligence industry policies of major countries (partial list)

New generation AI is undergoing booming development on a global scale, and the world is ushering in an "age of intelligence" with human-computer coordination, interdisciplinary integration, and co-creation and sharing, that is profoundly affecting the political, economic, and social development of all countries. Guided by their AI strategies and based on their respective advantages, the United States, the United Kingdom, Germany, and other major countries around the world are following AI industry development paths with their own characteristics.

(1) The United States: With a deep AI foundation and formidable scientific research strengths, it holds the leading position in AI worldwide.

As the birthplace of artificial intelligence, the United States has been the world leader throughout the course of AI's 60-plus years of development. The United States has always shown initiative and foresight in AI development, whether it is in AI basic research or implementing applications, or in the civilian or military fields. In the core basic areas of AI in particular, such as AI chip research and development (R&D), AI algorithm research, and training top talents, the United States firmly occupies the leading positions in the world. This would not have been possible without joint promotion by the U.S. government, universities, and enterprises. The U.S. National Science and Technology Council (NSTC), the White House Office of Science and Technology Policy (OSTP), the

National Budget Office,[3] and other top government agencies regarded AI development as a key focus of national development strategy; MIT, Stanford University, Carnegie Mellon University, and other world-leading schools, along with tech giants such Google, Microsoft, and Facebook, are committed to R&D and practice; and traditional industry giants like General Motors (GM) and Ford closely follow the pace of development. This three-way combining of forces has achieved remarkable results. According to the all-new *National Artificial Intelligence Research and Development Strategic Plan* updated in 2019, the United States will continue to focus on and invest in "basic AI research," "AI systems that complement and enhance human capabilities," "artificial intelligence ethics," "the security and health of artificial intelligence systems," and other areas of research and exploration.

(2) The United Kingdom: Numerous strong and influential AI startups ensure the UK's continued presence at the heart of global AI innovation.

The UK has a long history of AI development—from Alan Turing, the "father of AI," to AlphaGo, which has attracted worldwide attention—supporting the UK's long-held advantageous position in global AI development. Moreover, the UK government has created a good and healthy development environment for AI through policy guidance, financial support, and talent training. At the same time, the "Golden Triangle" formed by London, Oxford, and Cambridge guarantees the basic research strength and talent output quality of AI in the UK. Also, the "2+5 model" formed by the Alan Turing Institute, the Engineering and Physical Sciences Research Council (EPSRC) AI institute, and five of the UK's best universities—Cambridge, Edinburgh, Oxford, University College London, and Warwick—has become an important powerhouse of AI innovation and entrepreneurship in the UK. The favorable ecosystem formed by the UK government, universities, and enterprises assures that the UK will remain at the center of global AI innovation. Within this world-leading innovation environment, the UK government has focused on the layout and exploration of innovative solutions that combine AI with life sciences, services, agriculture, and government public services, and is committed to developing an AI- and data-driven economy.

(3) Germany: The Industry 4.0 [strategic initiative] is helping promote the development of AI in Germany, and in the new era, Germany is committed to becoming a world-leading center in AI research.

Germany's "Industry 4.0" plan released in 2013 relies on its world-leading industrial base, and AI is listed as one of the core support technologies of Industry 4.0. KUKA industrial robots in particular are representative of German intelligent industrial

[3] Translator's note: It is unclear whether "National Budget Office" (国家预算办公室) refers to the U.S. Office of Management and Budget (OMB) or the Congressional Budget Office (CBO).

products known worldwide. Germany has not limited the development of its AI to industrial fields, however. Rather, it is promoting the integration of AI with more industries through a number of national strategies, and is committed to building itself into a world-leading center of AI research. At the same time, the world's largest AI non-profit research institution—the German Research Center for Artificial Intelligence—together with five AI research centers in Berlin, Munich, Tübingen and other locations, have joined to form a German AI research network,[4] which is an important driver of AI research and innovation in Germany. The German government's AI strategy makes a clear distinction between "strong AI" and "weak AI," and focuses its future strategic direction on "weak AI," mainly targeting five research fields: "machine theorem proving and automated reasoning," "knowledge-based systems," "pattern recognition and analysis," "robotics," and "intelligent multimodal human-computer interaction."

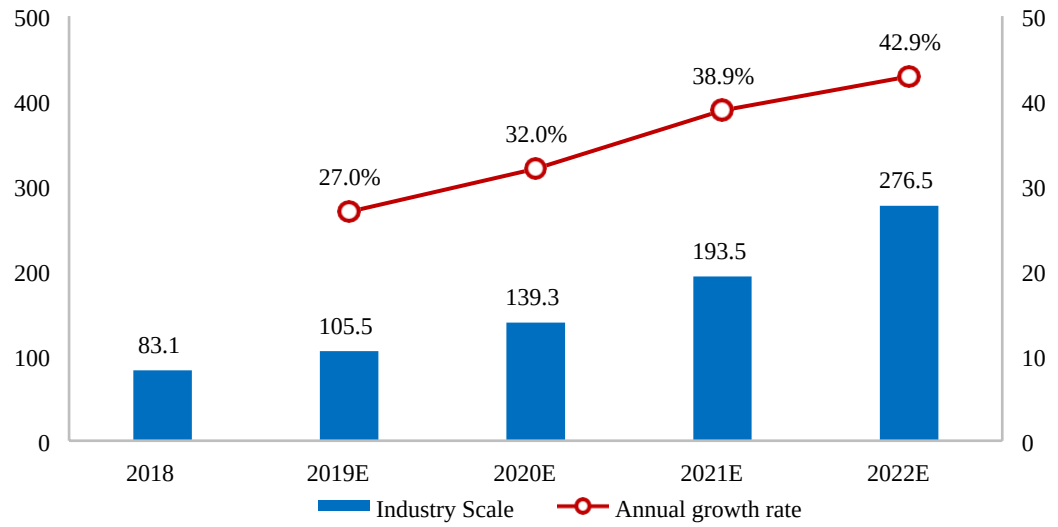
1.2 AI industry development in China

The rapid development of AI technology has promoted the rapid emergence of intelligence-based industries across multiple industry sectors and regions, injecting new momentum for economic and social development. The scale of the AI industry has also continued to expand accordingly at a rapid pace. China, with its advantages in policy, data, and application scenarios, has the strength to compete in the global AI industry.

1.2.1 The scale of China's AI industry

With the in-depth development of AI industry practices, AI has become an important symbol of the digital economy era, and the digital economy as represented by AI will become a new engine for China's economic development. In the enterprise services market, AI makes internal and external governance smarter and more efficient in a host of industries, including government, security, manufacturing, finance, healthcare, logistics and warehousing, and more, greatly promoting the digital transformation of companies in these industries. In the personal consumption field, products and services containing AI elements have also entered the rapid development stage, with smart speakers, home robots, wearable devices, and other intelligentized (智能化) devices being highly sought after and favored by consumers. In various consumer scenarios, AI is helping firms "understand consumers better and know more about them," improving the quality of service interactions between the two sides. According to research institute estimates, China's AI industry is expected to reach nearly U.S. $14 billion in size by 2020, and more than U.S. $27 billion by 2022.

[4] Translator's note: The German AI network in question is probably the Network of German Centres of Excellence for AI Research.



Data source: Chinese Institute of Electronics, *2019 White Paper on the New Generation Artificial Intelligence Industry*

Figure 4 Scale of China's artificial intelligence industry (units: U.S. $100 million)

1.2.2 Features of AI industry development in China

(1) The basic research ability of China's AI industry is in urgent need of improvement. AI research capacity is the driving force that ensures the sustainable development of the AI industry, at this stage. China's AI patent applications currently account for 37.1% of the global total number,[5] ranking it first in the world. The output of related research papers has also reached a high of 141,840 papers.[6] Although China has been among the global leaders in terms of patent applications and research paper output, the number of scholars engaged in basic AI research in China only accounts for 11%[7] of the global total, and with only 5% of the world's AI research institutions,[8] it still lags behind the global top level. From this it is clear that China needs to continue to increase investment in basic research and top talent training to narrow the gap between China's weak links and the global top level, and continue to seize the high ground in the global development of new generation AI industry.

(2) China's AI enterprises are numerous, and applications are wide-ranging. In 2018, the number of Chinese enterprises focusing on AI exceeded 1,000[9], ranking

[5] *2018 World AI Industry Development Blue Book*, China Academy of Information and Communications Technology (CAICT), Gartner
[6] *2018 World AI Industry Development Blue Book*, CAICT, Gartner
[7] *2018 World AI Industry Development Blue Book*, CAICT, Gartner
[8] *2018 World AI Industry Development Blue Book*, CAICT, Gartner
[9] *2018 World AI Industry Development Blue Book*, CAICT, Gartner

second in the world, and it is still growing rapidly. In addition, thanks to the rapidly developing digital economy environment and huge numbers of AI users, software and internet enterprises are not the only main players in the AI market. Traditional industries, the financial industry, and service industries are also accelerating their participation in the AI implementation process.

(3) China's AI industry is receiving a high level of attention from the capital markets. Funding provides important assurance for the continued positive development of the AI industry. China at this stage is one of the most active countries in the world in terms of AI industry investment and financing. The total number of investment and financing events in China accounts for 31.7% of the world total,[10] and its total investment and financing funds account for 60.0% of the world total,[11] which helps support and promote China's AI industrialization and the deepening development of its digital economy.

1.2.3 China's AI industry development advantages

(1) Cohesive policy advantage: With linking of multiple national ministries and commissions (国家多部委联动), AI development planning is based on top-level design. General Secretary Xi Jinping has emphasized that AI is a strategic technology leading this round of S&T revolution and industrial transformation, and has strong "lead goose" (头雁) spillover stimulation effects. Accelerating the development of new generation AI is an important strategic means for China to gain the initiative in global S&T competition, and an important strategic resource for promoting China's leapfrog S&T development, industrial optimization and upgrading, and overall improvements to our productive forces. Against this macro-level background, in May 2016, the National Development and Reform Commission (NDRC), the Ministry of Science and Technology (MOST), Ministry of Industry and Information Technology (MIIT), and the Office of the Central Cyberspace Affairs Commission[12] jointly issued a notice on the *Three-Year Action and Implementation Plan for "Internet+" Artificial Intelligence*. In July 2017, the State Council released the *Notice on the Issuance of the New Generation Artificial Intelligence Development Plan*. And in December 2017, MIIT issued a notice on the *Three-Year Action Plan for Promoting Development of a New Generation Artificial Intelligence Industry (2018–2020)*.[13] On the basis of the central

[10] *2018 World AI Industry Development Blue Book*, CAICT, Gartner

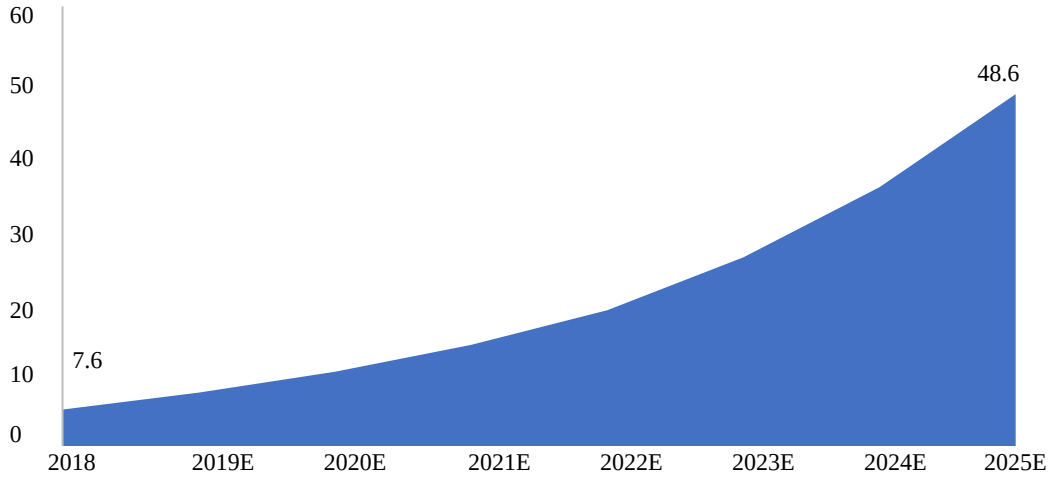
[11] *2018 World AI Industry Development Blue Book*, CAICT, Gartner

[12] Translator's note: The Office of the Central Cyberspace Affairs Commission (中央网络安全和信息化委员会办公室; 中央网信办) is effectively the same organization as the Cyberspace Administration of China (CAC; 国家互联网信息办公室; 国家网信办), as they share the same personnel and the same offices.

[13] Translator's note: An English translation of the Three-Year Action Plan for Promoting Development of a New Generation Artificial Intelligence Industry (2018-2020) is available online at:

government's top-level system design, local governments have issued corresponding industrial development plans and policy guidelines according to the actual industrial development requirements of their respective regions, providing a favorable social policy environment for AI industry development.

(2) Data accumulation advantage: Boosted by the digital era, a vast market is paired with advanced IT. Data is one of the three core elements required for the new round of AI development. Abundant market data provides the basic conditions for in-depth implementation of AI applications. With China's entry into the digital economy era, and the deepening of modern IT in various fields, including the internet, cloud computing, and big data, large amounts of consumer-level and enterprise-level data have been accumulated. According to data from IDC and Seagate, China's total data of 7.6 zettabytes (ZB; 1 ZB = about 1 trillion GB) accounted for 23.4% of the world total in 2018, and it is expected to increase to 48.6 ZB by 2025, which will then account for 27.8% of total data worldwide.



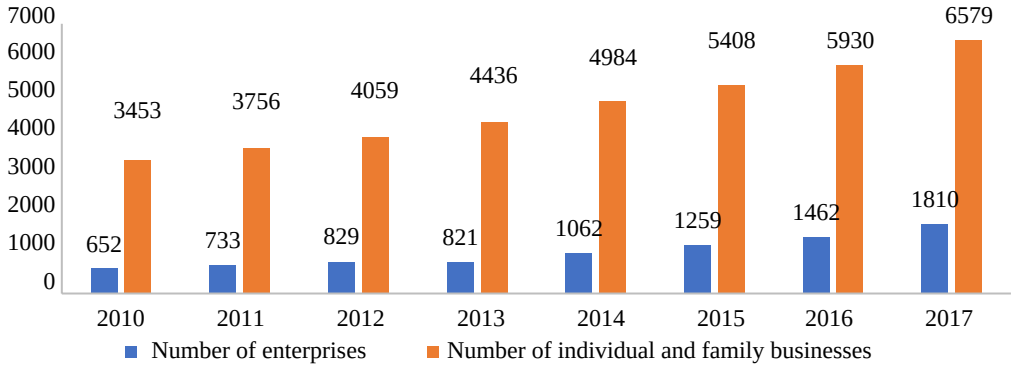
Data sources: IDC, Seagate

Figure 5 Total amount of data in China, 2018-2025 (units: ZB)

(3) A large internet user base and many small and medium-size enterprises enhance China's advantages when it comes to development scenarios: China's huge population and enterprise base provide rich application scenarios for AI, and this gives rise to a large number of innovations in business and application models based on AI technology. In 2017, there were 18,097,700 enterprises with legal person status in China, while the total number of individual and family businesses (个体工商户) reached 65,793,700. In addition, China's total population reached 1,395.38 million people in 2018, 828.51 million of which had internet access. AI technology is an important

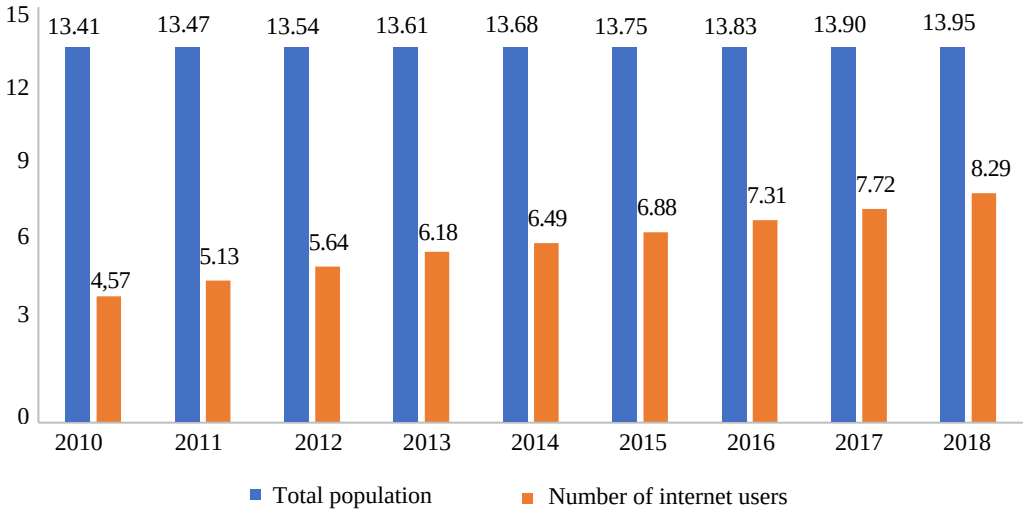
https://www.newamerica.org/cybersecurity-initiative/digichina/blog/translation-chinese-government-outlines-ai-ambitions-through-2020/.

component and cornerstone of the digital economy in practice, and it is gradually being integrated with the internet era's social e-commerce services, sharing economy services, webcasting services, and internet financial services, as new application models are explored.



Data source: National Bureau of Statistics

Figure 6 Number of enterprises and individual and family businesses in China, 2010-2017 (units: 10,000s)



Data source: National Bureau of Statistics

Figure 7 Total population and number of internet users in China, 2010-2018 (units: 100 million people)

Chapter Two Overall AI Industry Talent Development Situation

In the digital economy era, AI is becoming the core force driving technological innovation and industrial development. AI products and services are continuously penetrating people's daily work, life, learning, and social interaction areas, and they are also pushing all types of domestic technology enterprises and traditional industrial enterprises in all regions to develop AI fields. After years of sustained development, China has made important progress in AI fields. It is in the world's top ranks in the

number of international S&T research papers published and invention patents granted, and important breakthroughs have been made in key and core technologies in some fields. However, talent issues are still the key constraints on the industry's development.

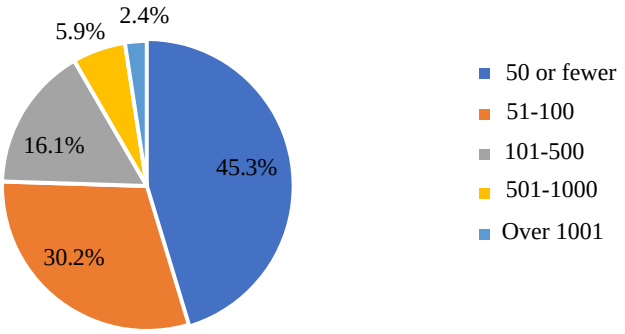
In the *New Generation Artificial Intelligence Development Plan*, the State Council clearly stated that cutting-edge AI talent is far from being able to meet demand, and that in overall deployments, strengthening construction of the talent cadre will be one of the four main pillars of building an open and collaborative AI S&T innovation system. In actual industry practice, the demand for AI talents is more refined and diversified. A great deal of talent support is required, for everything from technology R&D, application development, and application delivery, to operations and maintenance (O&M). From the industry's perspective, on the one hand, AI industry talent has begun to expand in terms of coverage. On the other hand, the overall concentration of talent in the domestic AI industry is low, and the problem of insufficient supply of effective talent is pronounced. Consequently, discrepancies between the supply and demand of AI industry talents will seriously affect the further development of China's AI industry. In view of this, universities, AI-related enterprises, and private training institutions (社会培训机构) have taken many measures at this stage to accelerate the scaling up of AI industry talent training.

2.1 Enterprises in this study

The total sample of enterprises in this study is 2,224 firms. It includes both AI technology enterprises that focus on AI fields and provide basic layer, technology layer, and application layer AI products and services, as well as enterprises that use AI-related technologies to transform or refashion their own products and business, such as software enterprises, internet enterprises, and traditional industry enterprises. In general, the enterprises in this study are concentrated in the more economically developed regions such as Beijing, Shanghai, Guangdong, Jiangsu, Zhejiang, and Sichuan. The number of application layer enterprises is the largest, and most of them are startup AI S&T enterprises.

2.1.1 Enterprise staff size

In terms of staff size, 45.3% of surveyed enterprises have fewer than 50 employees, 30.2% have 51-100 employees; 16.1% have 101-500 employees; 5.9% have 501-1000 employees; and 2.4% have more than 1000 employees.

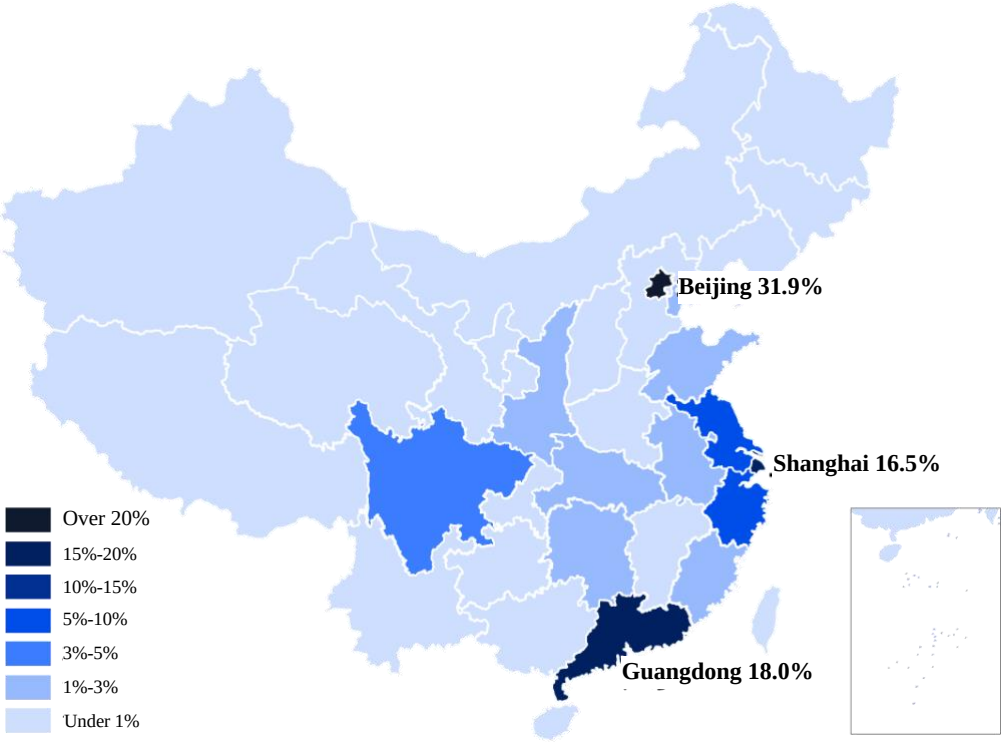


Data sources: Research database of the report writing team, BOSS Direct Hire (BOSS 直聘)

Figure 8 Staff sizes of the enterprises in this study

2.1.2 Regional distribution of enterprises

Among municipalities and provinces, Beijing, Guangdong, and Shanghai have the greatest concentrations of enterprises in this study, with Beijing having the largest number of enterprises, accounting for 31.9% of the total number of enterprises surveyed, followed by Guangdong and Shanghai, with 18.0% and 16.5% respectively. Zhejiang, Jiangsu, and Sichuan are also main provinces in the distribution of the surveyed enterprises, in addition to Beijing, Guangdong, and Shanghai.

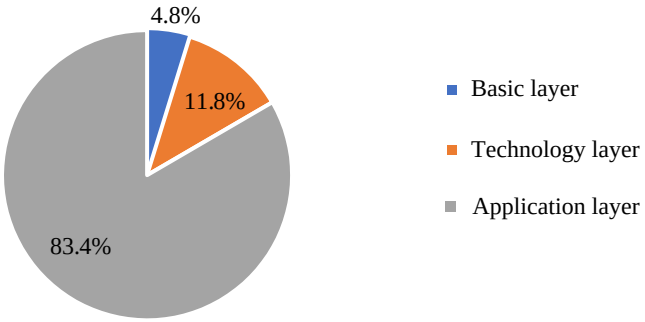


Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 9 Regional distribution of the enterprises surveyed for this report

2.1.3 Distribution of enterprises by production chains (“layers”)

In this study, enterprises are divided into basic layer, technology layer, and application layer enterprises. Application layer enterprises are the main enterprises in this study, accounting for 83.4% of firms. In this report, “application layer enterprises” refers both to AI enterprises that focus on AI fields and produce AI end products or industry solutions for the outside world, as well as the numerous information technology, internet, and traditional industry enterprises that use AI to refashion and transform their own products and businesses. The basic layer enterprises and technology layer enterprises in this study account for 4.8% and 11.8% of surveyed enterprises, respectively.



Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 10 Distribution of the enterprises in this study by industry layers

2.2 Types of job positions of AI industry talents

Based on the demand for talents for AI enterprise jobs, job positions can be summarized as senior management positions, high-end technical positions, algorithm research positions, application development positions, tech support positions, product manager positions, and other types of positions, as shown in Figure 11. This job demand classification also fits the many aspects of AI, from R&D to applications. Synergy between multiple types of talents, such as management, technical, and service talents, promotes the hands-on application of AI, and has become characteristic of AI industry talents in the context of the digital economy.

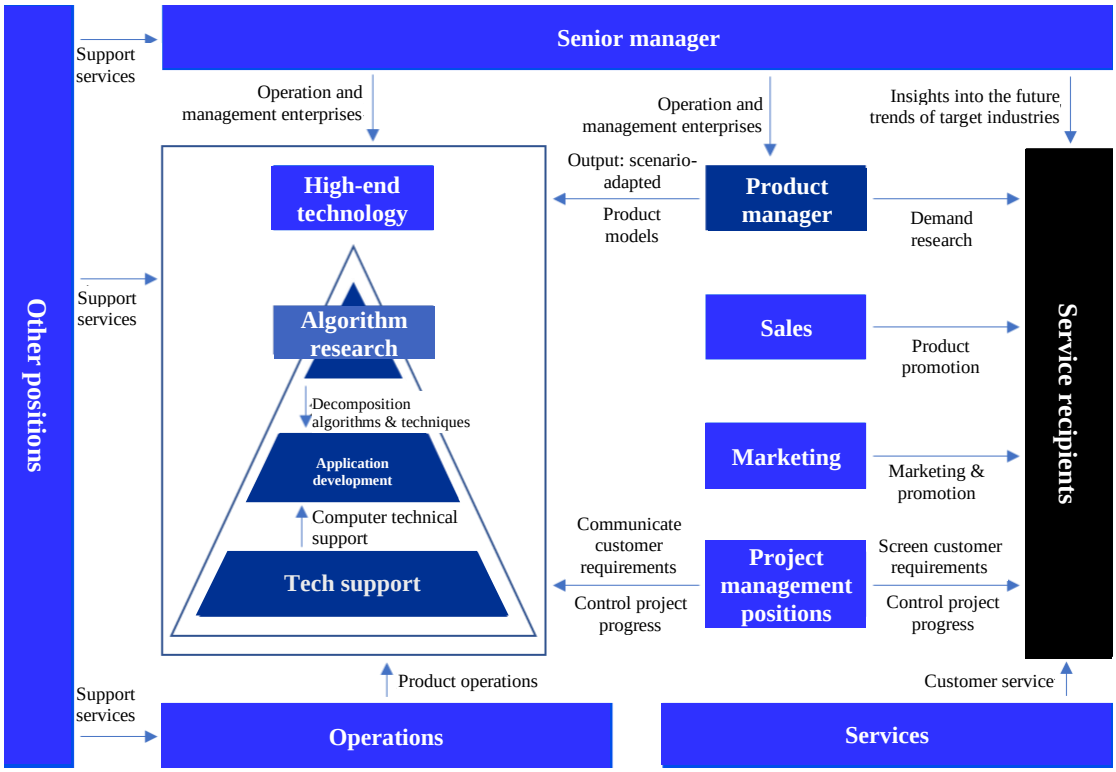


Figure 11 Types of AI industry positions

Profiles of typical job positions:

(1) Algorithm research positions: Positions that study innovative, breakthrough AI algorithms and technologies, and combine cutting-edge AI theory with practical algorithm model development.

(2) Application development positions: Positions that combine AI algorithms and various technologies (such as machine learning, natural language processing, intelligent speech, computer vision, etc.) with industry requirements, to achieve the engineering implementation of relevant applications.

(3) Tech support positions: Positions that require an understanding of basic AI technology concepts, and the ability to take into account specific usage scenarios, to ensure the rapid and efficient large-scale output and stable operation of AI-related applications.

Table 1 Ten positions in AI fields with critical shortages

No.	Position Title
1	AI algorithm R&D engineer
2	AI development engineer
3	AI algorithm researcher
4	AI system and platform development engineer
5	AI application development engineer
6	Product manager
7	AI testing engineer
8	Software development engineer
9	Model-building application engineer
10	Data annotation specialist

2.3 Supply and demand for AI industry talent

2.3.1 Overall supply and demand for AI industry talents

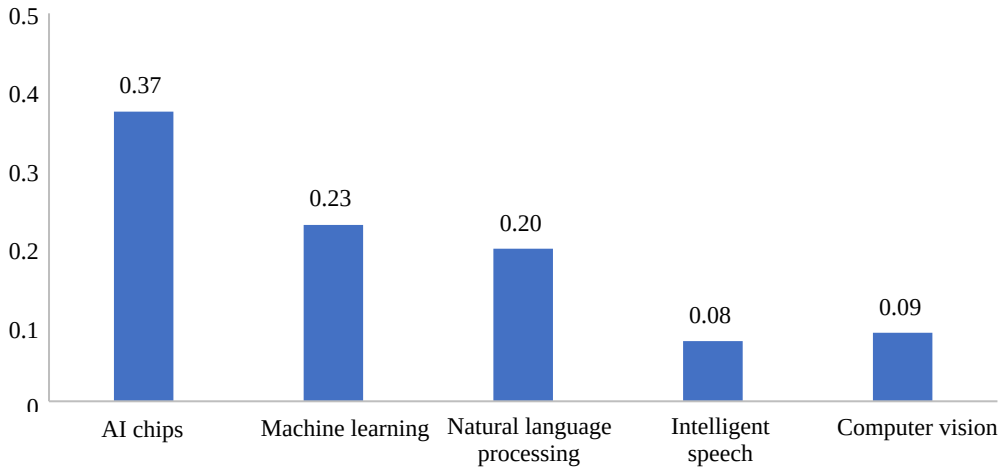
Limited by the domestic AI industry's late start and insufficient accumulation early on, China's AI industry is facing a predicament in the inadequate supply of effective talent. The *State Council Notice on the Issuance of the New Generation Artificial Intelligence Development Plan* proposes the goal of achieving a core AI industry scale of more than 150 billion yuan by 2020. Based on this industry scale goal, it is estimated that China's AI industry has an effective talent gap of 300,000, and the imbalance between supply and demand in specific technology directions and positions is especially striking.

This report reflects the talent supply and demand situation of different technology-oriented positions and functional positions (职能岗位) in the AI industry through the talent supply-demand ratios for those positions. The higher a job position's talent supply-demand ratio is, the more adequate the supply of talent for the position is.

Calculation of job position talent supply-demand ratio: job talent supply-demand ratio = $\frac{\text{number of talents intending to take such job positions}}{\text{Number of job positions}}$

(1) Talent supply and demand for AI technology-oriented positions: Typical AI technology directions were selected for this report, including AI chips, robotics, and natural language processing. The data show that the talent supply-demand ratios for the different AI technology-oriented positions are all lower than 0.4, indicating that the supply of talents for those technology directions is seriously inadequate. In terms of industry subsectors, the talent supply-demand ratios for intelligent speech and

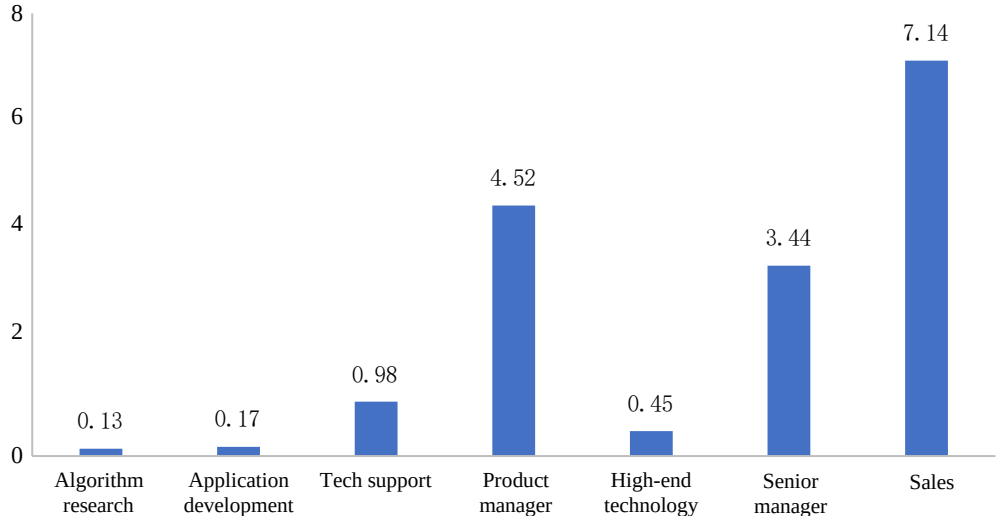
computer vision positions are 0.08 and 0.09 respectively, so relevant talents are in critically short supply.



Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 12 Talent supply-demand ratios for AI technology-oriented positions

(2) Talent supply-demand ratios for AI functional positions: At the current stage, the talent supply-demand ratios for algorithm research positions, application development positions, tech support positions, and high-end technical positions are 0.13, 0.17, 0.98, and 0.45 respectively, showing that the talent gaps for technical positions are large, while the supply of talents for tech support positions is relatively sufficient. In contrast, the talent supply-demand ratios for product manager positions, sales positions, and senior management positions responsible for enterprise operation and management are 4.52, 7.14, and 3.44 respectively, so the supply of talents is relatively sufficient.



Data sources: Research database of the report writing team, BOSS Direct Hire

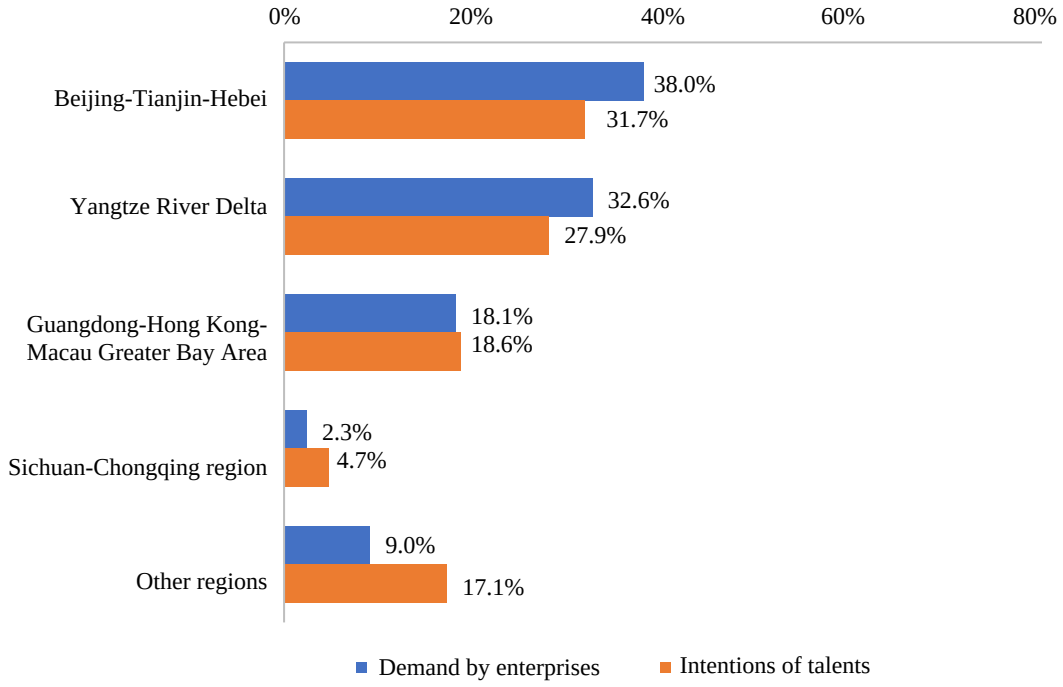
Figure 13 Talent supply-demand ratios for AI functional positions

2.3.2 Supply and demand situation of AI industry talents in major regions

For AI industry talents, the regional agglomeration effect is particularly prominent when it comes to supply and demand. This is mainly a function of regional industrial bases and talent accumulation gaps. The Beijing-Tianjin-Hebei region, Yangtze River Delta region, Guangdong-Hong Kong-Macau Greater Bay Area, and Sichuan-Chongqing region are currently the main centers of AI industry development, and also have the main concentrations of AI industry talent resources. The talent demand of these regions accounts for 90.9% of the total national demand, and their talent supply accounts for 82.9% of the total national supply.

(1) In terms of talent demand, the above four regions account for 90.9% of overall national demand for talent. On one hand, because most of the S&T innovation enterprises in AI fields, and internet and software enterprises with access to AI technology, are concentrated in these regions, they generate a large amount of talent demand accordingly. On the other hand, because traditional industries in these regions are accelerating digital reform, they are at the forefront of the country in the process of integrating AI and traditional industries, and a large number of relevant talents are needed to support the rapid implementation of AI in practice.

(2) In terms of talent supply, these regions have top-level AI technology, wide latitude for career development, and considerable salaries and benefits, all of which exerts a strong attraction for concentrating talents. Currently, on the supply side, 82.9% of talents intend to work in these four regions, while other regions are only able to attract the attention of 17.1% of talents.



Data sources: Research database of the report writing team, BOSS Direct Hire

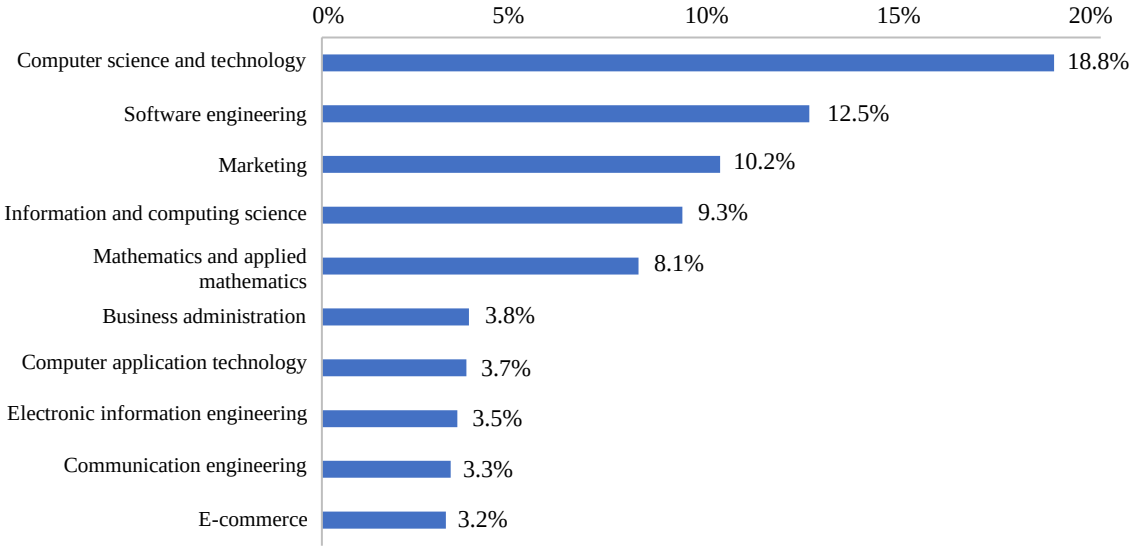
Figure 14 Talent demand of major regions in China and the regional intentions of job-seeking AI talents

2.4 AI industry talent training situation

Against the larger background of an insufficient supply of domestic AI industry talent, universities, enterprises, and training institutions have responded by relying on their own advantages and taking a number of measures to actively promote the training of AI industry talents based on the actual needs of the industry.

2.4.1 Talent training in universities

(1) In accordance with industry requirements, AI talent training in universities exhibits a multidisciplinary character. Among existing academic majors, the main majors (directions) that breed AI technical talents include computer science and technology and electronic information engineering. Moreover, in the context of industry integration, universities have also created cross-disciplinary "AI+" majors which cover many professional fields such as computers, mathematics, electronic information, statistics, and psychology. The establishment of AI majors has accelerated the integration of AI with basic education curricula, helping to train growing numbers of hybrid (复合型) AI industry talents with multidisciplinary and cross-disciplinary knowledge. Data on demand for majors based on employment websites show that, in the AI field, the top ten most sought-after majors include computer science and technology, software engineering, mathematics, and applied mathematics.



Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 15 Most sought-after majors in the AI industry

(2) Officially including AI industry majors in the list of undergraduate majors has

accelerated the process of developing specialized talents for the AI industry. On the basis of traditional electronic information, computer, and mathematics majors, in March 2019, the Ministry of Education issued the *Notice on the Results of Filing and Approval of Undergraduate Majors in Ordinary Institutions of Higher Education in 2018*. AI was included in the list of newly approved undergraduate majors, with 35 universities nationwide receiving the first batch of construction qualifications. In February 2020, the Ministry of Education issued the *Results of Filing and Approval of Undergraduate Majors in Ordinary Institutions of Higher Education in 2019*, with the number of universities that received approval for newly added AI majors reaching 180. With regard to the number of schools, Beijing, Jiangsu, Shandong, and Sichuan have relatively more new institutions. In terms of school education level, schools that have added new AI undergraduate majors in the past two years include traditional older schools such as Beihang University, Beijing Institute of Technology, Harbin Institute of Technology, Zhejiang University, Nanjing University, Shanghai Jiao Tong University, Fudan University, Tongji University, and Wuhan University, as well as ordinary universities such as Anhui Institute of Information Engineering, Quanzhou Institute of Information Engineering, and East China University of Technology. Together, they are promoting the training of AI basic research talents and application-oriented talents.

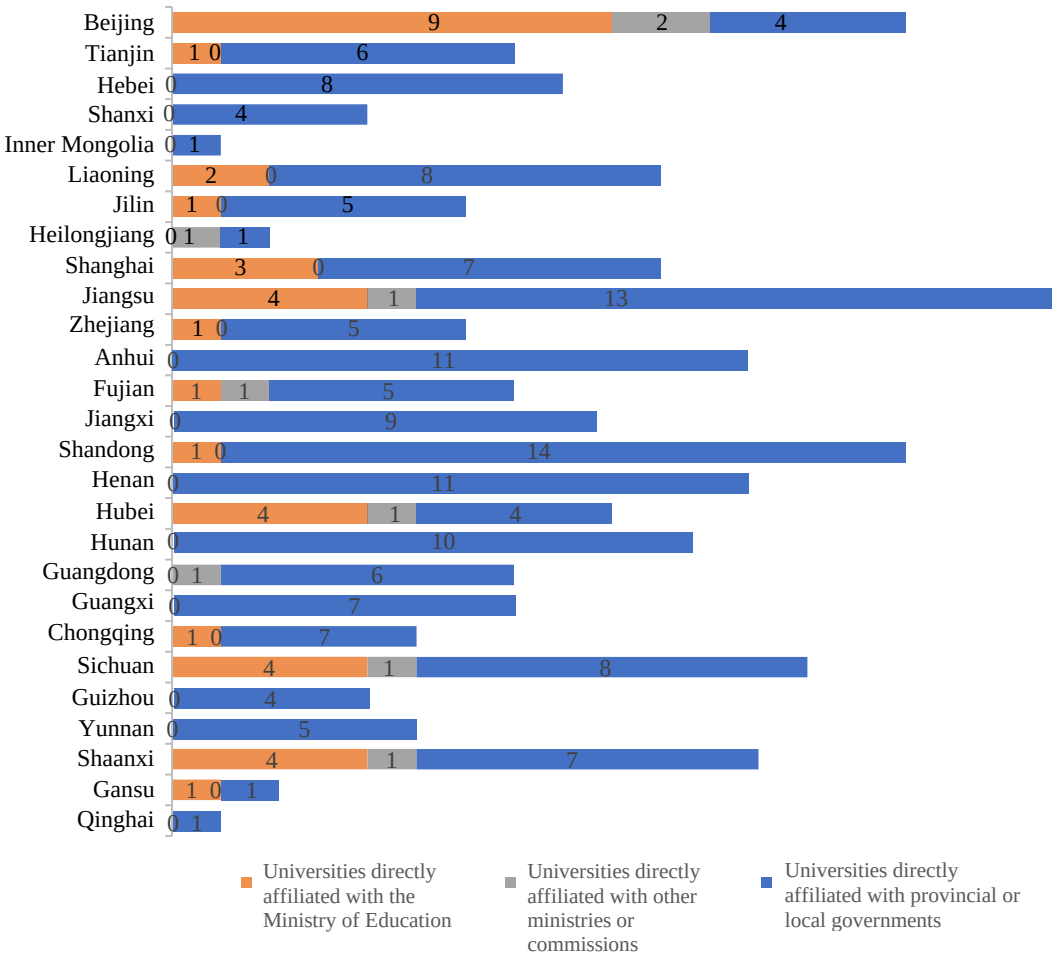


Figure 16 Regional distribution of universities with newly added undergraduate AI majors

(3) Universities establishing AI schools and institutes are focusing on training talents oriented toward basic research and application development. In addition to establishing AI majors, various types of domestic universities have started to establish AI schools and research institutes during this period.[14] Top domestic universities such as Peking University, Tsinghua University, Zhejiang University, and Fudan University have established AI teaching and research institutions focusing on basic AI research, including mathematical and scientific foundations, cognitive science foundations, intelligent perception, machine learning, brain-inspired computing (类脑计算), AI governance, smart healthcare, and smart society. The aim is to train and produce research talents with the ability to do basic research in AI. Many domestic undergraduate universities and colleges have also started to plan and build AI schools and research institutes. By linking up with leading enterprises in various parts of the AI production chain, such as Baidu, Tencent, and iFlytek, they have strengthened

[14] In this report, “AI schools and research institutes” refers exclusively to those schools and research institutes that use "artificial intelligence" in their name

cooperation in talent development, practical training courses, project sharing, and practice opportunities, with the focus on training application development talents with practical experience in AI.

Table 2 AI schools and research institutes established by universities (partial list)

"Double world class" universities[15] (partial list)	Ordinary universities (partial list)
Peking University – Institute for Artificial Intelligence	Shanghai University of Electric Power – Shangdian-Lin'gang Artificial Intelligence Institute
Tsinghua University – Institute for Artificial Intelligence	Anhui Institute of Information Technology – School of Big Data and Artificial Intelligence
Zhejiang University – Artificial Intelligence Collaborative Innovation Center	Chongqing University of Posts and Telecommunications – College of Artificial Intelligence
Fudan University – Institute of Science and Technology for Brain– inspired Intelligence	East China Jiaotong University – Institute of Artificial Intelligence
Harbin Institute of Technology – AI Research Institute	Dongbei University of Finance & Economics – School of Data Science and Artificial Intelligence
Huazhong University of Science and Technology – School of Artificial Intelligence and Automation, Institute of Artificial Intelligence	Sichuan University Jinjiang College – School of Artificial Intelligence
Tongji University – Artificial Intelligence Institute	Nanning University – [iFlytek] School of Artificial Intelligence
Shanghai Jiao Tong University – [Suzhou] Institute of Artificial Intelligence	Hangzhou Dianzi University – Baidu Cloud School of Artificial Intelligence
Nanjing University – School of Artificial Intelligence	Henan Finance University – College of Artificial Intelligence
Nankai University – College of Artificial Intelligence	Shenzhen University and Tencent Cloud – College of Artificial Intelligence
Jilin University – School of Artificial Intelligence	Liaoning Technical University and Tencent Cloud – School of Artificial Intelligence
Dalian University of Technology Artificial Intelligence Institute	Shandong University of Science and Technology and Tencent Cloud – School of Artificial Intelligence
Xi'an Jiaotong University – College of Artificial Intelligence	Liaocheng University and Tencent Cloud – College of Artificial Intelligence
Sun Yat-sen University – School of Intelligent Systems Engineering	Dongying Vocational College of Science and Technology – Artificial Intelligence Institute
Beijing Institute of Technology – Institute for Artificial Intelligence	Hefei College of Finance and Economics – Institute of Artificial Intelligence
Tianjin University – School of Artificial Intelligence	Bozhou Vocational and Technical College – School of Artificial Intelligence
University of Chinese Academy of Sciences – School of Artificial Intelligence	Fuzhou Polytechnic – Baidu Cloud Artificial Intelligence Application Technology Collaborative Innovation Center and Baidu ABC Institute (school of artificial intelligence)
China University of Petroleum (Beijing) – College of Artificial Intelligence	Nanning College for Vocational Technology – School of Artificial Intelligence
University of Science and Technology Beijing – Institute of Artificial Intelligence	Hunan Vocational College of Science and Technology – Artificial Intelligence Institute
Beijing University of Posts and Telecommunications – School of Artificial Intelligence	Shenzhen Polytechnic – School of Artificial Intelligence, Institute of Applied Artificial Intelligence of the Guangdong-Hong Kong-Macau Greater Bay Area

[15] Translator's note: The Chinese government launched the "world-class universities and world-class curricula" (世界一流大学和一流学科) initiative, abbreviated "double world-class" or "double first-class" ("双一流"), in 2017 with the aim of increasing the number of Chinese universities that rank among the world's best. As of September 2022, the government had bestowed the "double world-class" label on 147 universities in China.

Beijing Jiaotong University – School of Artificial Intelligence	ZhengZhou Vocational College of Commerce and Tourism – Artificial Intelligence Institute

2.4.2 Talent training in private training institutions

AI training carried out by private training institutions is an important supplement for solving the current short supply of AI industry talents. At this stage, the government is focusing on implementing universal education on intelligence (全民智能教育), and has also made clear its support for private institutions carrying out AI training.

(1) As for the types of training institutions, at present there are older traditional vocational training schools such as Beida Jade Bird Vocational Education, Tedu.cn, and Guanghua International [Education], as well as new types of training institutions such as ChinaHadoop.cn, shenlanxueyuan.com, and Gupao Academy. Training institutions of various kinds have developed a comprehensive AI training approach that combines online and offline teaching methods.

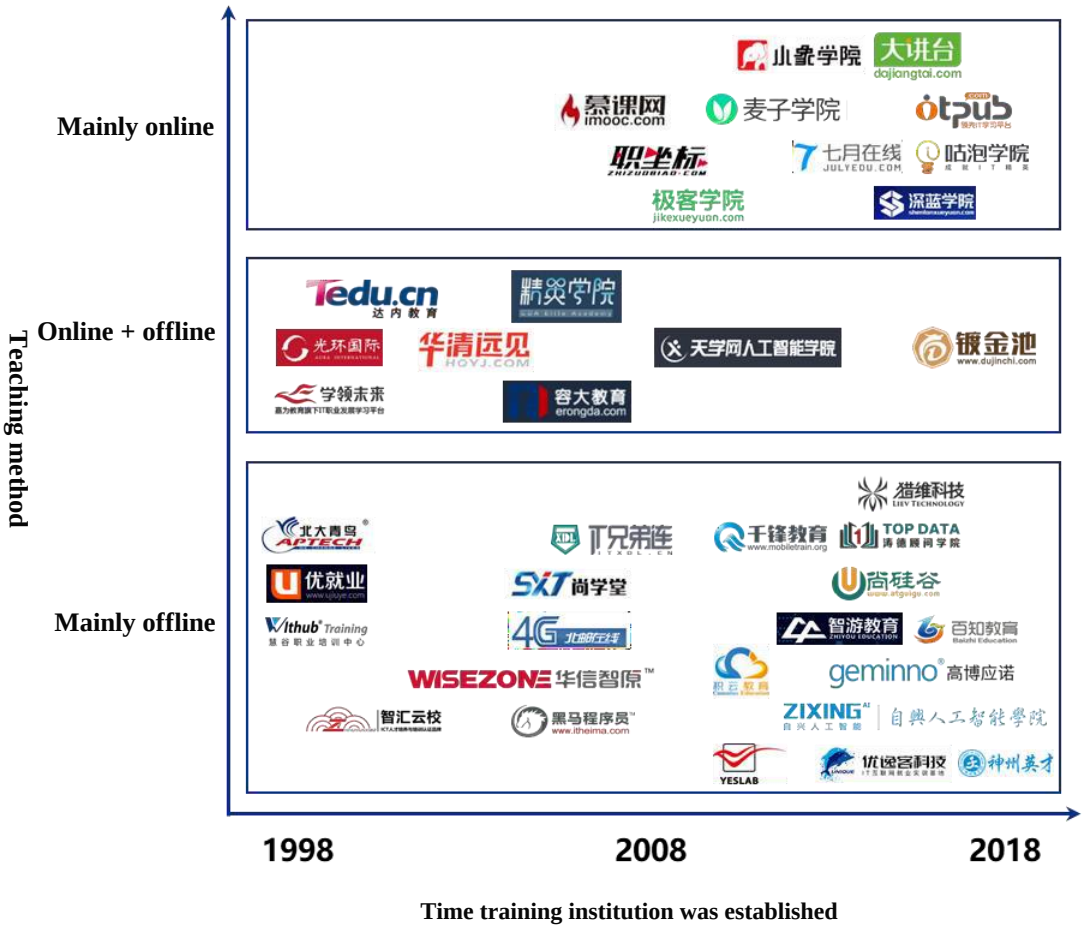


Figure 17 Private training institutions that conduct AI training (partial list)

(2) As for training content, the AI-related courses of existing training institutions, which focus on training students in application development skills, mainly

include three types of courses: Python training, basic introductory AI training, and professional training in AI subsector technologies. In addition, training institutions are now providing students practical project-based teaching phase-by-phase, and many institutions have access to the practical experience and practice opportunities of technology giants such as Huawei, Baidu, and Alibaba. However, due to the lack of mathematical and scientific knowledge course content and short training times, most of the talents produced by the current training institutions are talents with elementary tech support potential.

Chapter Three AI Industry Talent: Overview of competency and quality requirements and salaries

AI is a highly knowledge-intensive industry and has high requirements for talents in terms of business capabilities, work experience, and educational background. With the continuous iteration of AI technology and the rapid advancement of application implementation, industry talents with only a single competency cannot match the actual needs of enterprises. The industry urgently needs a talent cadre that possesses multi-dimensional competencies: comprehensive capability, professional knowledge, technical abilities, and project-oriented practical ability.

3.1 By Type of Job Position

3.1.1 Job position competency requirements

The focus of work differs in practice for different positions—algorithm research, application development, tech support, and product manager positions—and the professional competency requirements of enterprises for the different typical positions also differ greatly.

Table 3 Competency requirements for algorithm research positions

Job position competency type	Job position competency requirements
Comprehensive ability	A solid theoretical foundation, proficiency in the modeling methods of their technology direction, and the ability to solve more complex application problems by reasonably combining, transforming, and innovating relevant algorithms. Ability to extract general purpose components from different scenarios, improve the migration and expansion capability of algorithms, and reduce training costs. Strong self-learning ability, always keeping an eye on cutting-edge research areas, being able to reproduce and improve the relevant work in them, and compare new technologies horizontally with the established baseline system.
Professional knowledge	A solid foundation in algorithms and agility in the use of data structures; In-depth knowledge of the common algorithms in machine learning and other technical directions to which they belong; Ability to handle data in a big data environment, such as importing, processing, and transforming data from text, images, documents, web pages, etc.;

Tool skills	A solid foundation in programming development, including but not limited to proficiency in programming languages such as C/C++, Python, Java, Shell, and MATLAB; Familiarity with big data computing tools such as Linux, Hadoop, Spark, and Hive; Proficiency in performing data flow and algorithm version management based on message-oriented middleware or scheduling engines; ability to actually implement algorithms and systems, and conduct repeatable experiments; and ability to validate, develop, and iterate algorithms and bring them online.
Practical engineering skills	Extensive experience in algorithm projects and system development in their technical direction; ability to conduct analyses incorporating the actual business problems faced by customers; Ability to answer questions in the model-building process, find deficiencies in existing systems, and propose reasonable improvement solutions.

Table 4 Competency requirements for application development positions

Job position competency type	Job position competency requirements
Comprehensive ability	Ability to accurately understand AI algorithm models and carry out their training and application, and understand the practical application value of different algorithms for different business domains; Ability to translate a given model or algorithm into content achievable in actual AI application scenarios, and the ability to distill concrete solutions from abstract algorithms; Ability to communicate and interact effectively with scientists, researchers, algorithm development engineers, etc., respond actively to the problems and needs of the above types of positions, and help realize the business implementation of AI application scenarios.
Professional knowledge	Mastery of the fundamentals of their technical direction, and familiarity with processes such as software engineering design, development, testing, online deployment, and O&M; A foundation in data mining; proficiency in the principles and scope of application of common model algorithms such as logistic regression and decision trees, and the ability to skillfully apply them to practical scenarios.
Tool skills	Good programming development abilities, including C/C++, Python, Java, etc.; Familiarity with mainstream operating system development environments such as Mac, Linux, Windows, and related operating system scripting languages; Proficiency in relational database principles and the SQL language, and proficiency in mainstream databases such as MySQL, Oracle, and DB2; Familiarity with basic principles of parallel computing and distributed computing architectures, and familiarity with distributed development environments such as Hadoop and Spark; Understanding of various commonly used open source frameworks, components, or middleware; Good mastery of computing framework tools for big data stream processing, such as Storm, Kafka, etc.; Familiarity with container technologies, such as Docker, K8s, and Mesos.
Practical engineering skills	Relevant product and project implementation experience; Rich experience in industry application development, and ability to develop industry applications based on Java, PHP, Android, and other development platforms; Large, complex business application design and architecture abilities. Ability to provide solutions to performance optimization issues in the architecture selection, data processing, application system interfacing, and application running process; Ability to select and implement common algorithm models, and to accurately understand business requirements, and convert them into achievable technical solutions.

Table 5 Competency requirements for tech support positions

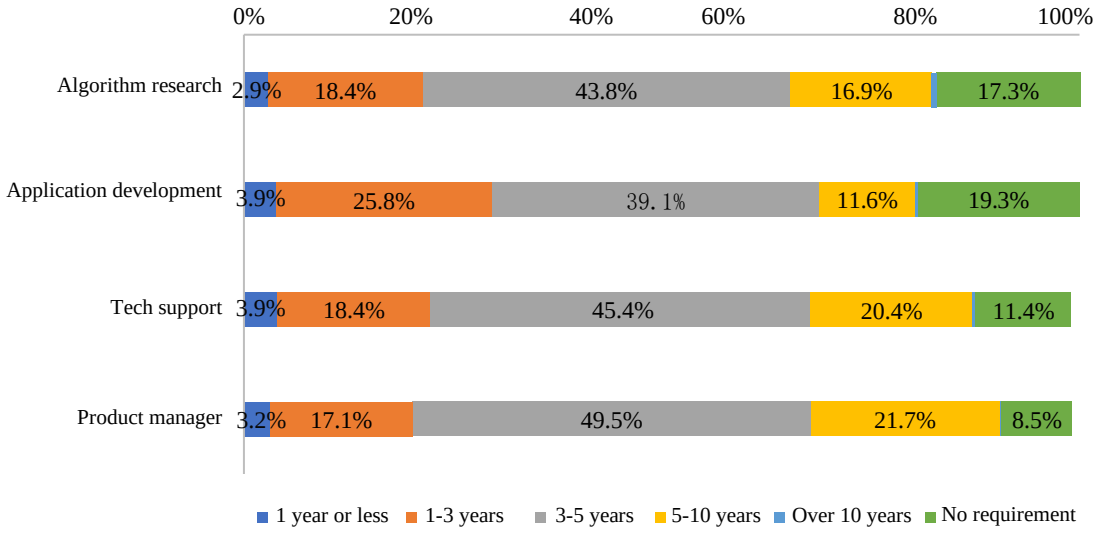
Job position competency type	Job position competency requirements
Comprehensive ability	Ability to analyze and troubleshoot customers' specific issues, provide technical guidance to customers in a targeted manner, and ensure that relevant platform-based issues of customers are resolved, so that the smooth operation of products is guaranteed; Ability to communicate effectively across teams and work with relevant technical or product teams to drive issues to resolution; Ability to analyze and summarize technical events, analyze and precipitate out problems involving features, processes, tools, etc., and make constructive suggestions to help improve the customer service experience.
Professional knowledge	Familiarity with the basic principles of parallel computing and distributed computing frameworks, and familiarity with distributed development environments such as Hadoop, Spark, etc.; understanding of various commonly used open source frameworks, components, or middleware; Familiarity with TCP/IP protocols and experience in troubleshooting network environment problems; Familiarity with common databases such as MySQL and Oracle.
Tool skills	A foundation in programming development, and proficiency in programming languages such as C/C++, Python, Java, Shell, and MATLAB; Proficiency in the use of Linux systems, and extensive Linux and Windows system maintenance experience; Familiarity with container technologies such as K8s, Docker, etc.
Practical engineering skills	Some project experience in enterprise customer service, and the ability to resolve particular customer issues at multiple levels; Experience in engineering project implementation, and the ability to quickly locate customer requirements and identify key issues;

Table 6 Competency requirements for product manager positions

Job position competency type	Job position competency requirements
Comprehensive ability	Ability to do overall planning, design, and promotion of AI products; Practical experience and accumulation of knowledge in target industries and target scenarios; Ability to collaborate across teams, and fully communicate and collaborate with products, algorithms, engineering, editors, and teams to ensure smooth implementation of product features; Ability to innovate products, analyze usage data after product launch, refine usage scenarios, find areas for product improvement and breakthroughs, and use rich interaction scenarios to promote AI product innovation; Industry analysis abilities, including market analysis, user demand research, and competitor analysis.
Professional knowledge	Familiarity with AI technology fundamentals and the limits of current capabilities; A firm grasp of the extent to which external environmental variables affect AI technologies.
Tool skills	Proficiency in the use of prototyping tools such as Axure, Mockups, and Pencil; Knowledge of and familiarity with mind mapping, data processing, and image manipulation tools; Knowledge or understanding of common programming languages such as C/C++, Python, Java, Shell, and MATLAB.
Practical engineering skills	Experience in successfully implementing AI-related products, and the ability to quickly locate industry requirements and impact variables.

3.1.2 Requirements on years of work experience

Requirements for work experience and years of experience are relatively lenient for application development positions. Some 29.7% of positions require less than 3 years of work experience, and 19.3% of positions do not require any work experience; product manager positions usually require practitioners to have rich practical experience and industry knowledge accumulation, so 49.5% of positions require 3-5 years of work experience, and 21.7% require more than 5 years of work experience.

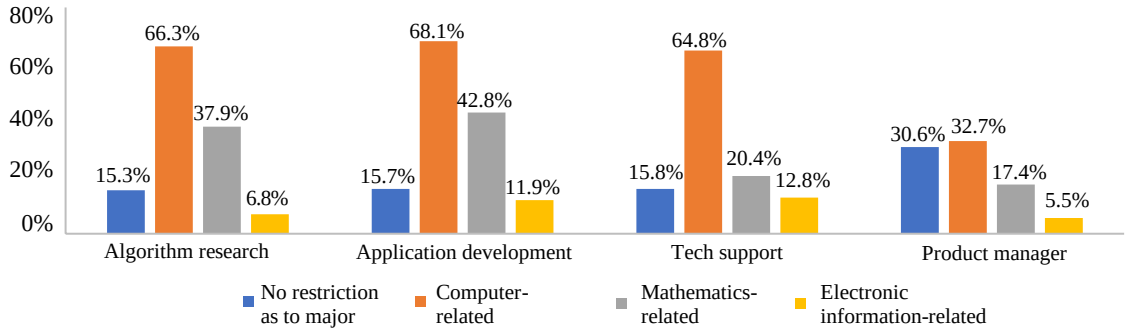


Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 18 Years of work experience requirements for main positions

3.1.3 University major requirements

Among the university major requirements of the typical positions, most seek computer-related majors. In particular, more than 60% of the algorithm research positions, application development positions, and tech support positions require computer-related majors. In addition, mathematics-related majors are required to a greater extent for algorithm research and application development positions, with 37.9% of algorithm research positions and 42.8% of application development positions requiring a background in a mathematics-related major. In contrast, the major requirements for product manager positions are less restrictive, with 30.6% of product manager positions having no restrictions as to university majors.

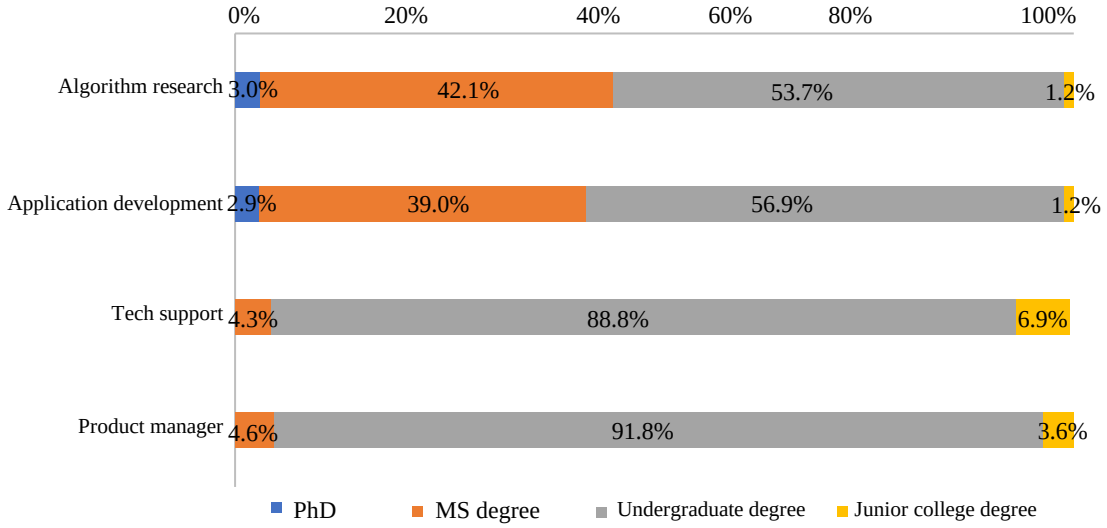


Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 19 University major requirements for main positions

3.1.4 Academic degree requirements

The academic degree entry thresholds of algorithm research positions and application development positions are much higher than other positions, with 45.1% of algorithm research positions and 41.9% of application development positions requiring candidates to have a master's degree or above. The entry threshold for tech support positions and product manager positions is a bachelor's degree or above, with 88.8% and 91.8% of related positions respectively requiring one. In addition, 6.9% of the tech support positions currently allow entry by talents with a community college degree, which is due to the fact that tech support positions are generally dominated by talents with computer-related skills, and this proportion is higher than with other positions.



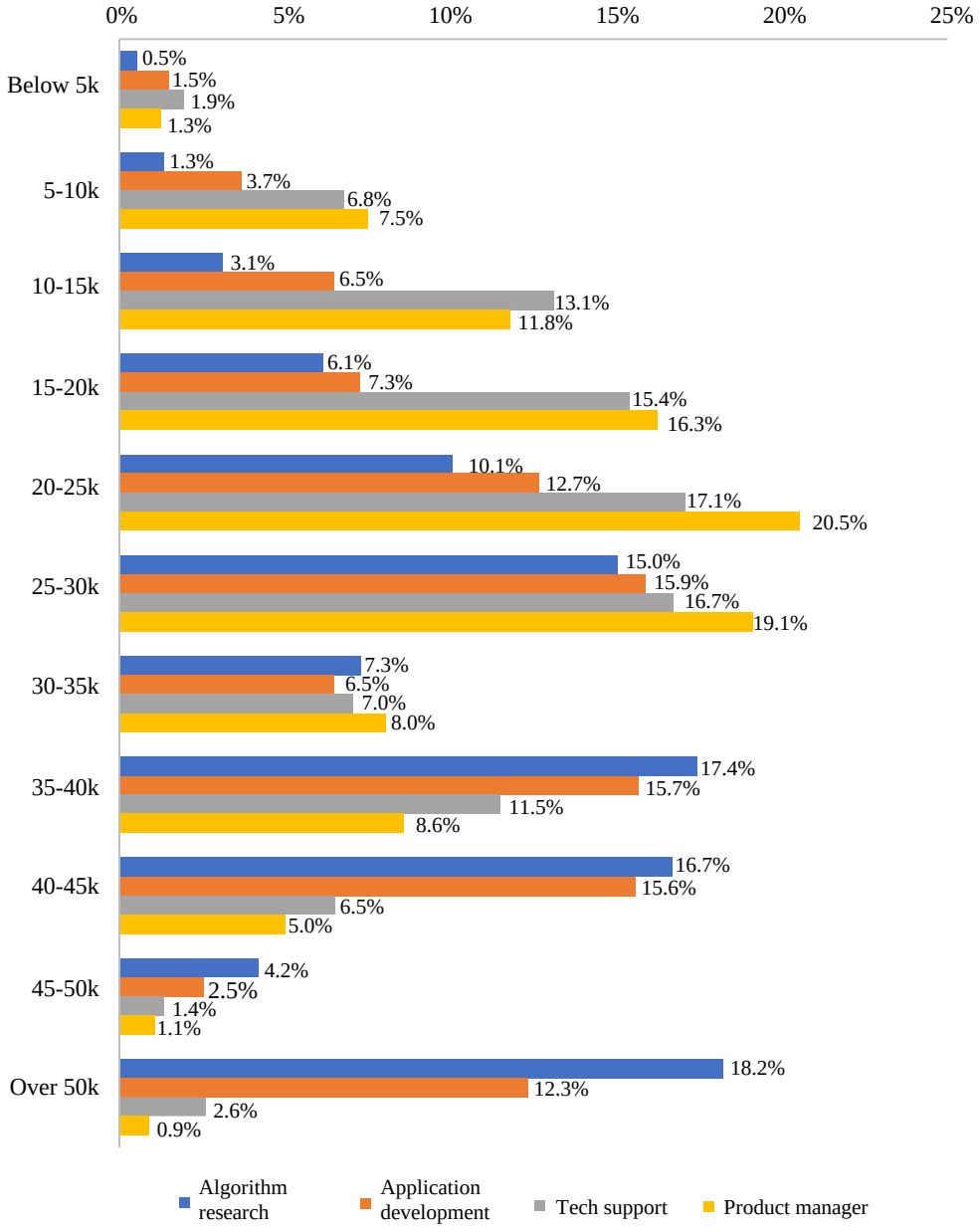
Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 20 Academic degree requirements for main positions

3.1.5 Monthly salaries

At present, the monthly salaries of 56.5% of algorithm research positions and

46.1% of application development positions are 35K [RMB] or more. The salary levels of algorithm research positions and application development positions are far higher than those of tech support positions and product manager positions, and it is not uncommon for many enterprises to offer annual salaries of a million or more [RMB] to sign up doctoral graduates from top universities with AI basic research ability. The monthly salaries of tech support and product manager positions are generally concentrated below 30K, and 20-30K is currently the main salary range, accounting for 33.8% and 39.6% of the relevant positions respectively.



Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 21 Monthly salary situation of typical job positions

3.2 By Technology Directions

3.2.1 Job position competency requirements

As regards the five typical AI technology directions of AI chips, machine learning, natural language processing, intelligent speech, and computer vision, there are slight differences at present in their technical characteristics, development stage, and business focus, and so enterprises also place different requirements on the professional competencies of different technology-related industry talents.

Table 7 Competency requirements for AI chip-related positions

Job position competency type	Job position competency requirements
Comprehensive ability	Familiarity with smart chip implementation principles and technical architectures; Good internal and external communication skills, understanding of the business requirements of applications in the smart chip field, and the ability to provide corresponding solutions.
Professional knowledge	Basic knowledge of machine learning and deep learning; Familiarity with common intelligent processing algorithms for images, speech, and natural language understanding; Basic knowledge of general-purpose processor design.
Tool skills	Mastery of Verilog programming skills, and C/C++, Python, Bash, Tcl, Perl, and other common programming languages; familiarity with UNIX and Linux operating environments, and with common vi and vim commands; Familiarity with mainstream deep learning frameworks such as Caffe, TensorFlow, and PyTorch.
Practical engineering skills	Familiarity with heterogeneous system on a chip (SoC) chip design flow and experience in chip development; Some project experience and familiarity with the entire smart chip workflow, including logic design, physical design, and verification; Some project experience in component improvement, performance tuning, etc.

Table 8 Competency requirements for machine learning-related positions

Job position competency type	Job position competency requirements
Comprehensive ability	Strong ability to analyze requirements and to use machine learning methods to solve complex problems faced in practice; Good ability to analyze the business of machine learning application scenarios, and to translate AI capabilities into practical machine learning applications; Ability to learn applications quickly, and to quickly build prototypes and explore new solutions based on new technologies and products.
Professional knowledge	Foundation in mathematical structures and algorithms; In-depth knowledge of machine learning algorithms, including traditional machine learning algorithms and deep learning algorithms; Familiarity with computer principles, parallel computing, and the theoretical foundations of distributed systems.

Tool skills	Proficiency in mainstream programming languages such as C/C++, Python, and Java; Familiarity with development environments and scripting languages under operating systems such as Linux and Windows; Proficiency in using deep learning frameworks such as Caffe, TensorFlow, MXNet, PyTorch, and Keras; Proficiency in using mainstream databases such as MySQL, Oracle, and DB2; Familiarity with distributed development environments such as Hadoop, Spark, etc.
Practical engineering skills	Engineering experience in areas such as system architecture design and project development, and the ability to accurately train and apply AI algorithm models; Experience in project implementation, and in application development for large-scale commercial AI scenarios; Ability to select and implement common algorithm models, and to accurately understand business requirements, and convert them into achievable technical solutions.

Table 9 Competency requirements for natural language processing-related positions

Professional competency type	Professional competency requirements
Comprehensive ability	Ability to understand the working principles of natural language products, and to understand the principles and inputs and outputs of models; Ability to deeply analyze the needs of personalized natural language processing business, and understand the principles and applicable scenarios of relevant evaluation indicators and algorithms for the corresponding direction; Understanding of process specification for AI engineering implementation, and the ability to meet actual business needs by integrating mature AI technologies into systems corresponding to various types of practical application scenarios for natural language processing.
Professional knowledge	Foundation in mathematical structures and algorithms; Basic knowledge of machine learning and data mining, and familiarity with the construction and application of relevant algorithm models based on rules or statistics; Familiarity with common natural language processing and deep learning algorithms and common frameworks.
Tool skills	A solid foundation in programming development, proficiency in programming languages such as C/C++, Python, and Java, and familiarity with the Linux development environment; Proficiency in the use of mainstream databases such as MySQL, Oracle, and DB2; Familiarity with basic principles of parallel computing and distributed computing architectures, and familiarity with distributed development environments such as Hadoop and Spark.
Practical engineering skills	Experience in project implementation, and in applications for large-scale commercial AI scenarios; Ability to apply natural language processing algorithms in business contexts to solve practical problems, such as in common areas like text analysis, error correction, and machine translation; Ability to select and implement common algorithm models, and to accurately understand business requirements and translate them into achievable technical solutions.

Table 10 Competency requirements for intelligent speech-related positions

Job position competency type	Job position competency requirements
Comprehensive ability	Ability to deeply analyze the requirements of various aspects of speech synthesis applications, and an understanding of the principles of digital signal processing, language models, and acoustic mechanisms; Ability to rationally combine, modify, and innovate language models and acoustic models to solve more complex problems; Ability to build speech synthesis models for a variety of usage scenarios.
Professional knowledge	Foundation in mathematical structures and algorithms, and in machine learning; Proficiency in basic speech-related algorithms, speech recognition deep learning algorithms, and neural

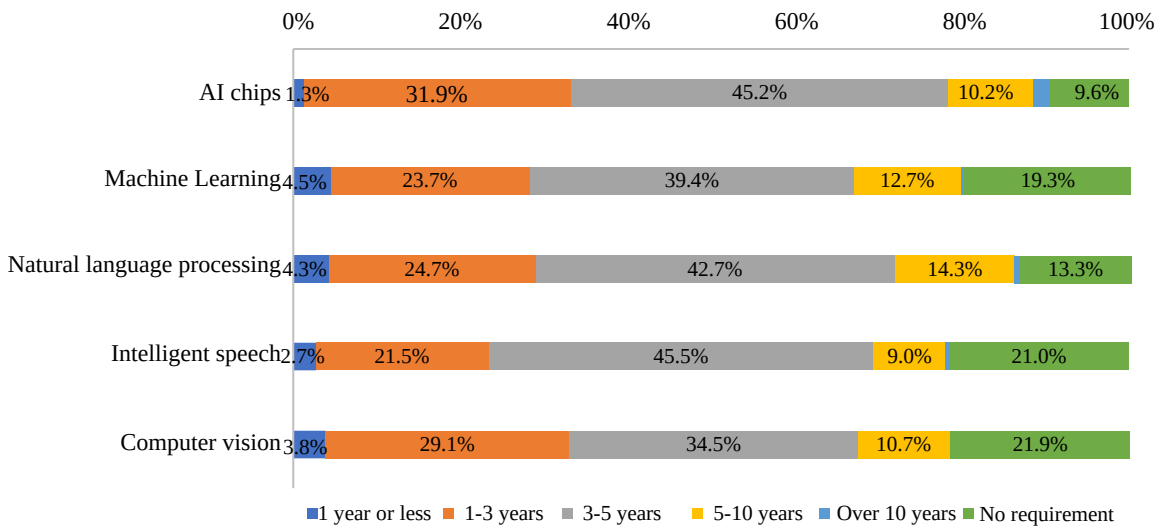
	network models; Familiarity with, and in-depth understanding of, the practical algorithm principles for acoustic modeling.
Tool skills	Proficiency in programming languages such as Java, Python, and C++; Familiarity with, and understanding of, speech recognition models, and the ability to develop speech-oriented professional tools or industry applications using mainstream development languages; Familiarity with mainstream operating systems, and the basic principles and basic models of machine learning and deep learning; and proficiency in the use of common deep learning frameworks.
Practical engineering skills	Some project experience, and ability to adjust and optimize algorithm models; Ability to design and build speech industry applications, and experience developing industry applications; Ability to accurately understand business requirements, and to provide more appropriate solutions for speech application scenarios such as voice translation, voice control, speech-to-text, emotion recognition, and voiceprint recognition.

Table 11 Competency requirements for computer vision-related positions

Job position competency type	Job position competency requirements
Comprehensive ability	Ability to use computer vision methods to solve complex problems faced in practice through steps such as problem analysis, data collection, feature extraction, modeling, algorithm design, and improvement evaluation; Ability to focus continuously on the current state of computer vision research and practice, and promote the performance optimization and implementation of computer vision algorithms and deep learning in numerous practical application fields.
Professional knowledge	Familiarity with common machine learning and deep learning algorithms closely related to computer vision; Understanding of computer vision-related problems and solutions, such as detection, tracking, classification, semantic segmentation, reinforcement learning, 3D vision, and image processing; Ability to handle data in a big data environment.
Tool skills	A solid foundation in programming development, including but not limited to proficiency in programming languages such as C/C++, Python, Java, Shell, and MATLAB; Mastery of deep learning frameworks and libraries such as Caffe, TensorFlow, Parameter Server, MXNet, PyTorch, and Keras; Familiarity with big data computing tools such as Linux, Hadoop, Spark, and Hive.
Practical engineering skills	Experience in algorithm projects and development of computer vision and deep learning systems; Ability to analyze practical business problems, sort out data, and design feature solutions and modeling processes.

3.2.2 Requirements on years of work experience

Three to five years of work experience is currently a common requirement for talents in each of the typical technology directions. In addition, AI chips and computer vision are relatively more receptive to “younger” talents. Some 33.2% of AI chip-related positions and 32.9% of computer vision-related positions do not have excessively high requirements for years of work, accepting talents who have worked less than three years. The natural language processing technology direction tends to seek talents with longer years of service. Nearly 15% of the natural language processing related positions are looking for talents with more than five years of work experience.

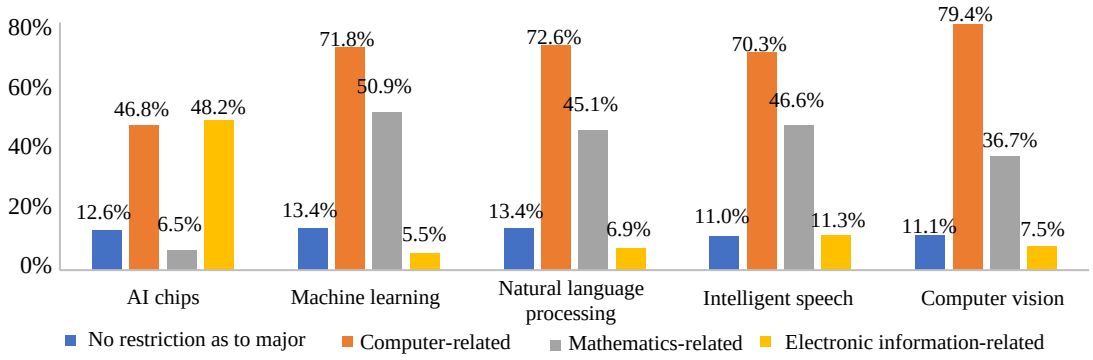


Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 22 Years of work requirements for main technology directions

3.2.3 University major requirements

The requirements of enterprises for talents in terms of their university major backgrounds are closely related to technology directions. In particular, the AI chip and integrated circuit industries are closely linked, so 48.2% of AI chip-related positions currently require candidates to have a major background related to electronic information. Machine learning tends more toward the basic layer, compared with other technology directions, so the extent of their demand for mathematics-related major backgrounds is higher, with 50.9% of positions requiring mathematics-related majors.



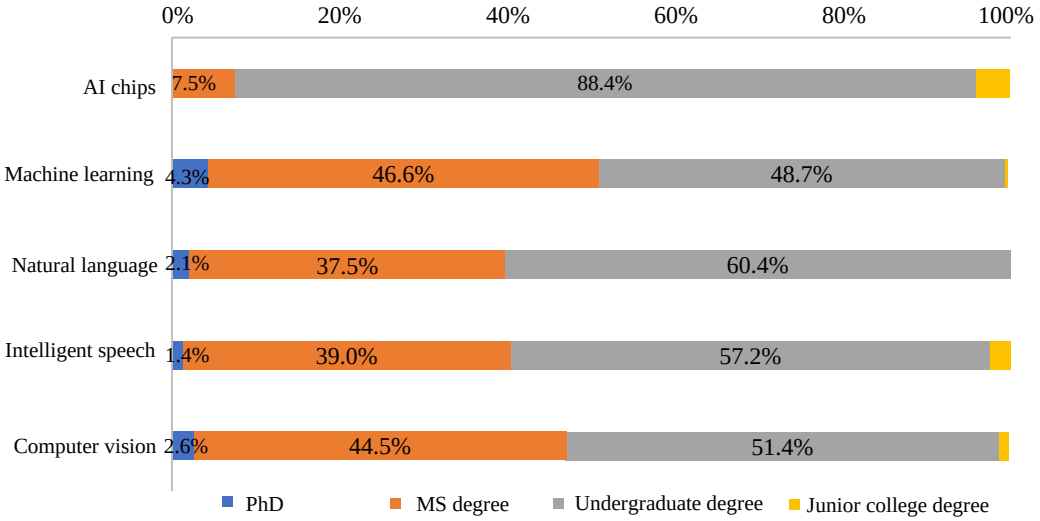
Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 23 University major requirements for main technology directions

3.2.4 Academic degree requirements

A bachelor's degree is the basic degree required by enterprises for AI-related talents, especially in the field of AI chips, where 88.4% of the positions require a

bachelor's degree. A great many positions in the machine learning, natural language processing, intelligent speech, computer vision, and other technology directions require a master's degree or above: Some 50.9% of machine learning-related positions, 39.6% of natural language processing-related positions, 40.4% of intelligent speech-related positions, and 47.1% of computer vision-related positions require a master's degree or above.

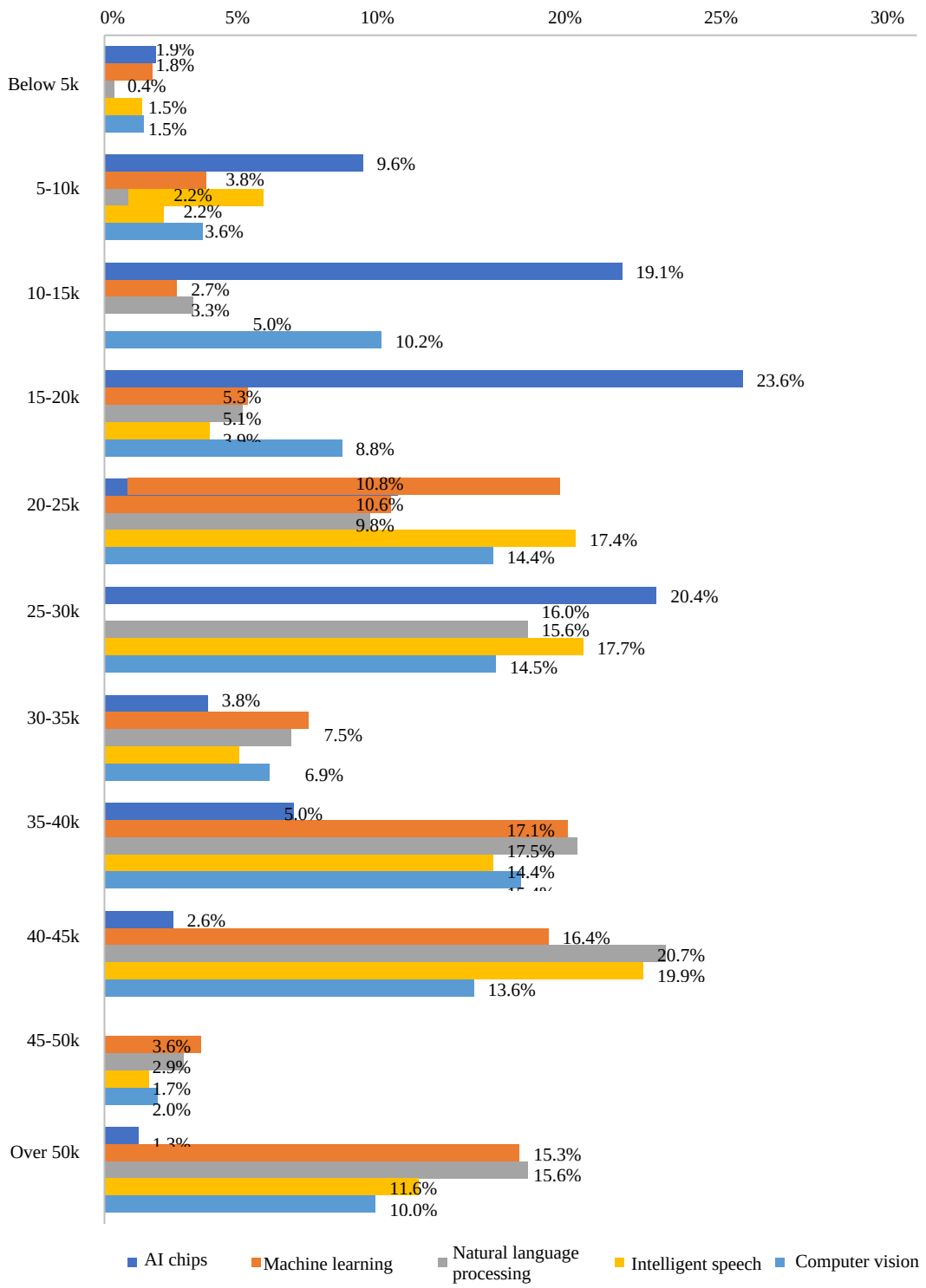


Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 24 Degree requirements for main technology directions

3.2.5 Monthly salaries

The monthly salary level of AI chip-related positions is relatively low, with 85.4% of positions having a monthly salary of 30K [RMB] or less. Monthly salaries of positions related to machine learning, natural language processing, intelligent speech, and computer vision are significantly higher, concentrated mainly in the 35K or above salary range. In addition, for machine learning and natural language processing-related positions, there is a higher degree of concentration in the ultra-high salary range of 50K or more, compared with intelligent speech and computer vision-related positions.



Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 25 Monthly salary situation [in RMB] of main technology directions

3.3 Professional ethics

The ethical and moral issues and safety problems brought about by the

development of AI technology have received widespread attention in countries around the world. As the developers and appliers of AI technologies and applications, AI industry talents must take the initiative to establish ethical requirements and constraints to guide the reasonable and compliant R&D of AI technologies and applications, in order to push AI development to continuously conform to the legal and ethical standards of human society.

Table 12 Ethics requirements of AI industry talents

Ethics requirement type	Ethics requirement content
Preservation of safety	AI industry talents must make benefiting the development of human civilization the basic criterion when conducting basic research and application development. For AI-related products, especially intelligent products that can threaten human life and safety, they should make prospective moral, ethical, and safety assessments, always be on the alert to technology risks, guarantee that AI-related products operate in accordance with human legal and ethical standards, and ensure that humans always hold the dominant position in human-machine relations.
Respect for human rights	AI industry talents must take respect for human rights, fairness, and justice as their basic professional ethics. They must respect human dignity, rights, and cultural diversity, eliminate prejudice and discrimination, and ensure that AI benefits more people. During basic research and application development, they must always adhere to the principle of fairness, fully consider the pros and cons of various factors such as ethnicity, region, and beliefs, as well as the needs of the majority of people, and avoid inequalities caused by human factors, so that AI benefits all of humanity.
Protection of privacy	AI industry talents should always focus on protecting data security in data collection, processing, application, storage, etc. Data collection requires that they obtain consent and authorization from relevant users, and they should strengthen the whole cycle of data management and strictly comply with relevant laws and regulations. Industry talents should also strengthen mutual supervision to jointly ensure the privacy and security of users.
R&D transparency	When conducting basic research and application development, AI industry talents need to disclose the purpose, objectives, and functions of R&D to their companies, other related organizations, and even to the public, and accept external supervision, so as to prevent the R&D process from taking the wrong direction.
R&D prudence	AI industry professionals need to be prudent at all times. They must not only assess the risks of R&D efforts in a timely and effective manner, but must also carry out their work cautiously when potential risks are difficult to assess, and not act rashly.
Courage to take responsibility	AI industry talents need to have a strong sense of responsibility for AI technology and applications. On one hand, they need to discover and point out the security flaws of related technologies or applications in a timely manner, and on the other hand, after adverse effects occur, they need to have the courage to take responsibility, identify the causes, and avoid the continuous expansion of adverse effects, as well as share relevant experiences to prevent similar mistakes or damages from happening again.

Chapter Four AI Industry Talent Training Issues

As a new engine of economic development, AI is beginning to be widely permeated and applied in various fields, and shows enormous potential. However, compared with developed countries, China's AI industry has large gaps in basic theory, core algorithms, key equipment, high-end chips, talent training, etc. The AI talent problem is especially pronounced, and is manifested mainly in the following three aspects: First, the supply and demand of talent is unbalanced, making it difficult to support the industry's rapidly expanding scale. Second, the talent structure is unbalanced, with structural imbalances

among different layers, different technology directions, and different job positions. Third, there is a mismatch when it comes to talent quality. The industry side and the education side have not achieved effective linkage, making it difficult for the quality of talent training to meet the industry's requirements.

4.1 Talent supply-demand imbalance

At this stage, the supply and demand of talent in China's AI industry are seriously unbalanced. On the demand side, under the pressure of digitalization and intelligentization (智能化), the demand for AI industry talents in various industries has developed to a stage of high concern and high demand. First, as technology providers, emerging AI enterprises urgently need large numbers of high-quality, high-level talents to enhance their technological competitiveness. Second, various enterprises in traditional industries on the industrial demand side need to embrace the AI wave in response to industrial upgrading and transformation. Data from China's National Bureau of Statistics show that there were 6.43 million practitioners in the software and information technology service industry nationwide in 2018. That figure only shows the employment of people engaged in the software and information technology service industry. If those engaged in digitalization and intelligentization in traditional industries are taken into account, the demand for such talents shows explosive growth.

On the supply side, the main sources of talent supply currently are the following two types: 1. University talent training. At this stage, the university majors involved in AI fields include computer science and technology, intelligence science and technology, automation, software engineering, electronic information engineering, communications engineering, statistics, and applied mathematics. 2. Talent stock accumulation by industry. This is mainly due to technicians engaged in traditional electronic information, software services, mobile internet, and other fields gradually transitioning to AI fields through learning and accumulation. The scale of engineering education in China is the largest in the world, but the total number of AI talents in China is only about 50% of the total number of talents in the United States, and the number of talents engaged in basic research work is even more limited. The current number of basic layer AI practitioners in the United States is about 14 times that in China.[16]

The main reason for the serious talent supply shortage in China's AI industry can be attributed to its late start in research and an insufficient accumulation of industrialization. The result is that the pace of talent training has failed to keep up with the industry's development requirements. China's AI research began in the 1980s, but due to the unstable foundation and the limited number of research institutes and universities involved in research, it was not possible to achieve large-scale training and

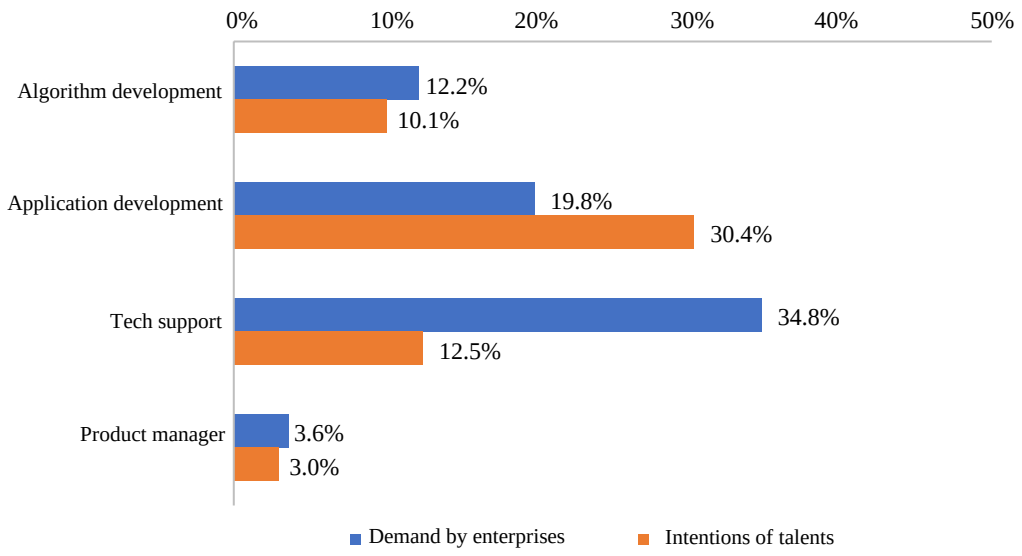
[16] *2017 Global AI Talent White Paper*; Tencent Research Institute; BOSS Direct Hire

output of talents, leading to an inherent shortage of talent resources for China's AI industry. After 2017, AI-specialized talent training, represented by AI colleges and AI majors, has been rapidly launched across the country. However, it is currently still in the initial stage of exploring talent training methods, and the speed of training AI industry talents is still slow. Meanwhile, spontaneous talent training within the industry has yet to develop systematically. As a result, the supply of high-quality talents at the university end and the industry end remains at a very low level in China at this stage.

4.2 Unbalanced talent structure

The imbalance in the AI industry's talent structure is mainly reflected in three aspects: First, there is an imbalance in the structure of talents for the different layers. In particular, there is a shortage of top basic research talents and innovation-based application talents. Second, there is an imbalance in the structure of talents for different types of job positions, with most talents concentrated in application development positions. At the same time, there is a shortage of talents for tech support positions, for which the demand is truly great. Third, there is an imbalance in the structure of talents for different technology directions. When relevant talents are making career choices, they are easily persuaded by public opinion to chase after market hotspots, ignoring their own positioning and abilities. This leads to a significant misalignment between different technology directions and the requirements of enterprises.

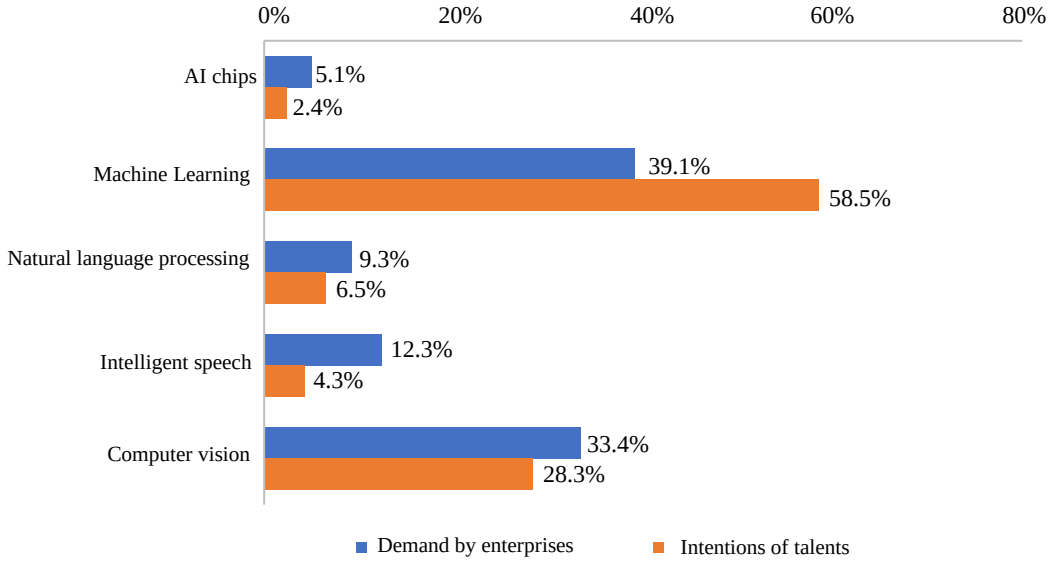
In the choice of job types, most of the talent supply is concentrated in application development posts. While demand for tech support positions is great, their attractiveness to talents is limited. While application development positions represent 19.8% of enterprise demand for job positions, 30.4% of talents lean toward this type of position when choosing their career. For tech support positions, however, which account for 34.8% of the overall job demand, only 12.5% of the talents intend to enter positions of this type.



Data sources: Research database of the report writing team, BOSS Direct Hire

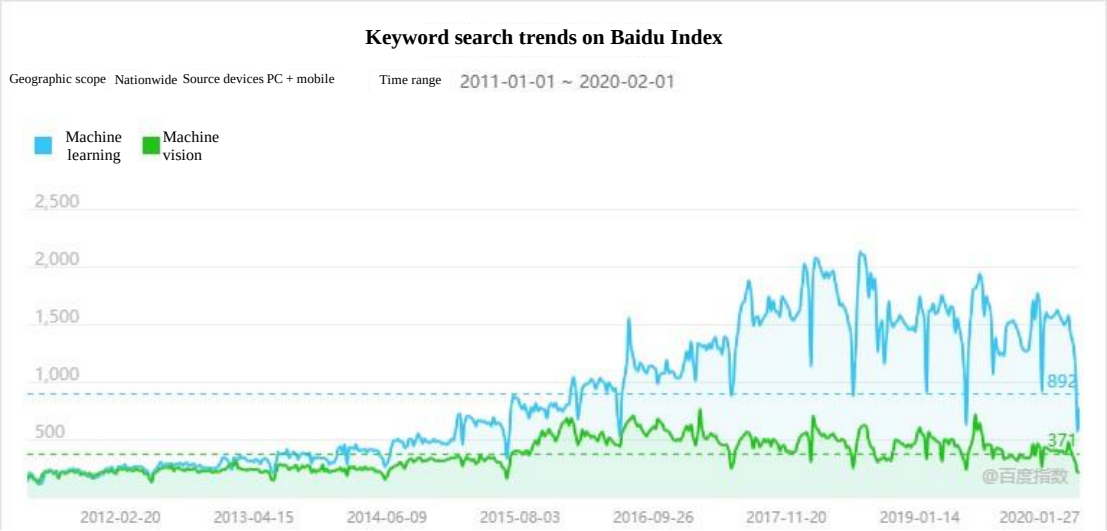
Figure 26 Talent demand for different types of job positions, and job intentions of employment-seeking talents

In terms of the choice of AI technology direction, the machine learning direction, which has received a high degree of attention, gathers in nearly 60% of the supply of talents. Machine learning positions and computer vision positions account for 39.1% and 33.4% of positions in enterprise demand, respectively, making them the two technical directions in which talent demand is most concentrated. However, due to the high degree of exposure of key terms such as “machine learning” and “deep learning,” the supply of talents is to a certain extent induced to gravitate toward the machine learning direction. Computer vision positions, which similarly have high demand, face a relatively meager supply of talents.



Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 27 Talent demand for various technology directions, and technology direction intentions of job-seeking talents



Data source: Baidu Index

Figure 28 Baidu Index search trends for “machine learning” and “machine vision”

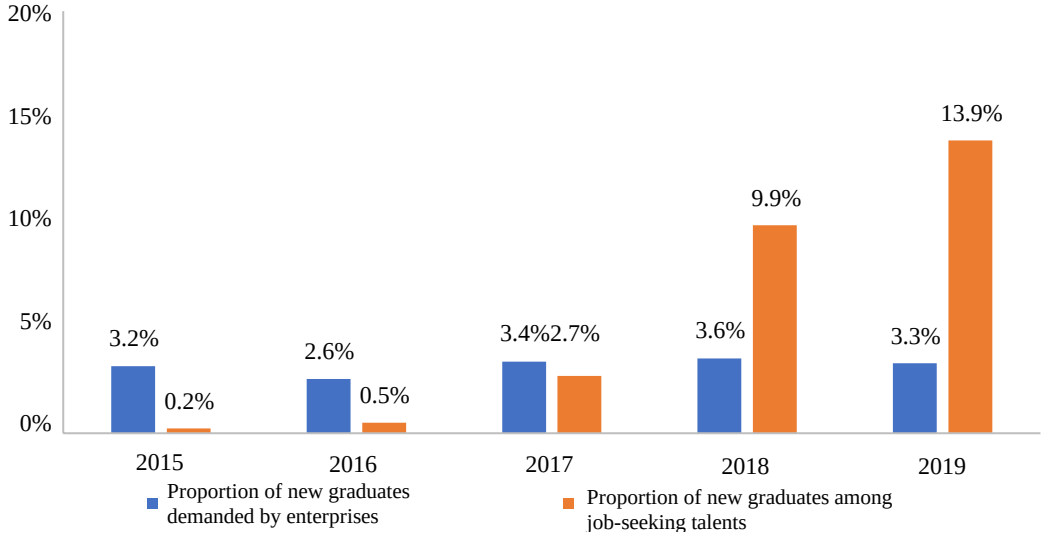
4.3 Talent quality mismatch

The current quality of talents trained by universities is not well matched with the actual requirements of the AI industry. This is reflected in two aspects of the selection and recruitment of talents by enterprises. First, since 2015, enterprise demand for new graduates for AI-related positions has always been limited, with the average annual recruitment of fresh graduates accounting for only around 3% of the overall demand; second, the proportion of new graduates among AI job-seeking talents is still growing year by year, growing to 13.9% in 2019.

(1) University side. The scaling up and systematization of AI industry talent training have just gotten underway, and talents trained by universities in the past have been unable to meet the AI industry’s actual requirements directly. At the same time, with AI-related faculty and courses in universities still in need of improvement, it will be difficult for AI industry talent training to adapt quickly and match the pace of the industry’s development and the requirements of enterprises.

(2) Enterprise side. The AI industry’s knowledge-intensive, cross-disciplinary nature, and other characteristics, set high entry barriers for talents, and companies have high requirements for the job competencies of talents. New graduates lack knowledge reserves and practical experience in AI, however, so it is very difficult for them to match the employment needs of enterprises directly. According to feedback in the enterprise research results, it generally takes more than a year to train new

graduates on the job. The result is that the vast majority of AI startup enterprises lack the manpower, funds, and motivation to train new graduates, which directly reduces the demand for new graduates.



Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 29 The proportion of new graduates in enterprise demand and the proportion of new graduates among job-seeking talents

Chapter Five Analysis of Policy Documents Related to AI Industry Talent

Faced with the AI industry's rapid development and the demand for high-quality talents in various parts of its ecosystem, national and local governments have introduced numerous policies related to AI industry talent development, and have taken the training and recruitment of AI industry talents as an important undertaking for promoting AI industry development.

5.1 Outline of national-level AI industry talent policies

Technological innovation and application implementation are the main driving forces currently leading the development of the AI industry, and talents are at the core of those forces. Since May 2016, when the NDRC, MOST, and two other departments jointly issued the "*Internet+" Artificial Intelligence Three-Year Action and Implementation Plan*, many AI industry policies have included talent development among their main tasks. These have established explicit and feasible strategic directions for AI industry talent development in terms of high-end talent training, recruitment of outstanding talents, construction of related academic programs, industry-education integrated development, domestic and foreign exchanges, and introduction of incentive policies.

Table 13 Talent-related content in AI policy documents

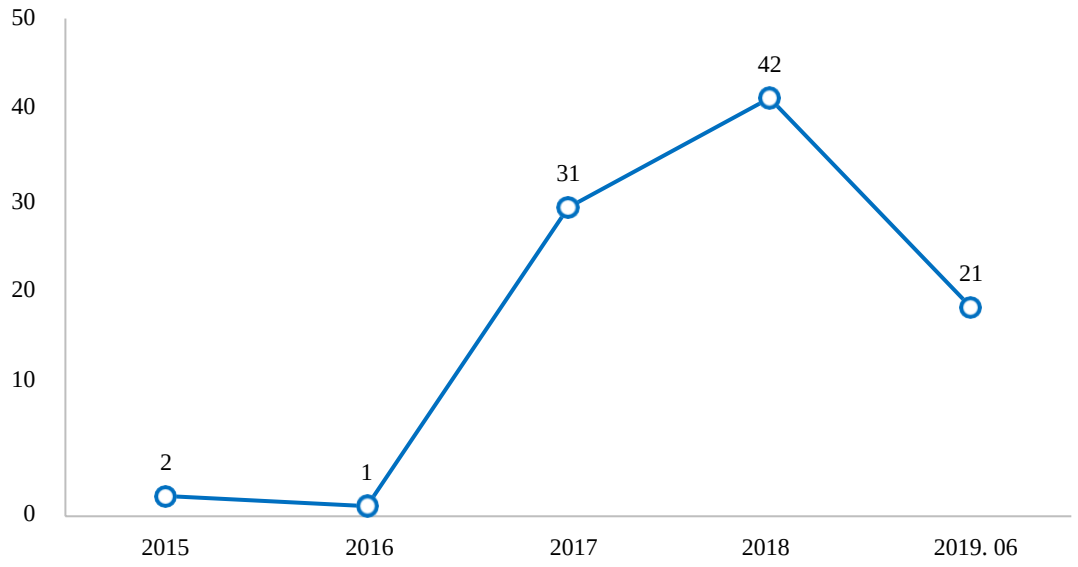
Year	Name of policy and partial content
May 2016	*'Internet+' Artificial Intelligence Three-Year Action and Implementation Plan*
	Encourage relevant research institutes, universities, and experts to carry out training in basic AI knowledge and applications; Relying on major national talent projects, accelerate the training and recruitment of a group of high-end and hybrid talents.
July 2017	*New Generation Artificial Intelligence Development Plan*
	Accelerate development and aggregation of high-end talents; Cultivate high-level AI innovation talents and teams, and step up efforts to recruit high-end AI talents; Construct AI-related academic programs.
December 2017	*Three-Year Action Plan for Promoting Development of a New Generation Artificial Intelligence Industry (2018-2020)*
	Use various ways to attract and train high-end AI talents and innovation and entrepreneurship talents, and support the growth of a group of leading talents and top young talents; Relying on major projects, encourage school-enterprise collaboration, support higher education institutions in strengthening construction of majors in related disciplines, and guide vocational schools in training the skilled personnel urgently needed for industrial development; Encourage leading enterprises, industry service institutions, etc., to cultivate high-level AI talent teams, provide industry solutions to key industries, and promote the best application practices of industries.
April 2018	*Artificial Intelligence Innovation Action Plan for Institutions of Higher Education*[17]
	Accelerate the construction of academic programs in AI fields, and support universities in setting up AI majors and directions within computer science and technology disciplines; Strengthen construction of university majors in AI fields, promote the construction of "education in emerging engineering fields" ("新工科"), and form a new "AI+X" hybrid major training model; strengthen the training of talents in AI fields, strengthen the integration of talent training and innovative research bases, and improve multi-party collaborative education mechanisms. Create a multi-level AI education system.
January 2020	*Certain Opinions on the Construction of "Double World-Class" Institutions of Higher Education to Promote the Integration of Disciplines and Accelerate the Training of Graduate Students in the Field of Artificial Intelligence* encourage leading AI enterprises to provide experimental and practical environments and train college instructors, based on the latest developments in industrial technology and the latest talent training needs; Attract outstanding talents from enterprises and research institutes to carry out scientific research and talent training in institutions of higher education through flexible employment methods such as dual employment; Relying on "double world-class" construction of universities, construct a national-level AI industry-education integration and innovation platform, encourage enterprises to participate in joint construction, and give priority support through funding, projects, etc.

5.2 Outline of local government-level AI industry talent policies

Echoing the top-level design for AI industry talents at the national level, local governments have also been active in the exploration and practice of AI industry talent training and recruitment, and linkage effects between the central and local governments are being formed. Since 2017, local governments have introduced AI industry talent

[17] Translator's note: An English translation of the Artificial Intelligence Innovation Action Plan for Institutions of Higher Education is available online at: https://cset.georgetown.edu/wp-content/uploads/Notice-of-the-Ministry-of-Education-on-Issuing-the-Artificial-Intelligence-Innovation-Action-Plan-for-Institutes-of-Higher-Education.pdf.

policies and implementation details that conform to their current local industry development situations, seeking to control and lead the direction of regional talent development and promote the training and recruitment of AI industry talents in their regions.



Data sources: Research database of the report writing team

Figure 30 Issuance of AI industry talent policies by local governments (units: policies)

Beijing, Tianjin, Shanghai, Zhejiang, Jiangsu, Guangdong, and Sichuan have led the country in introducing a number of AI industry talent policies based on their own AI industry development situations and local industrial layout characteristics. Their aim is to encourage and promote the construction of talent training mechanisms that combine industry, academia, and research institutes, as well as to formulate feasible incentive mechanisms for recruiting relevant talents, involving talent settlement, housing subsidies, and other aspects. They have promoted the construction of AI industry talent training environments in national key regions, while providing other regions experience and points of reference for the formulation of AI industry talent policies and industry talent training.

Table 14 AI industry talent policies issued by local governments

Region	Name of policy and partial relevant content
	Guiding Opinions on Accelerating Science, Technology, and Innovation to Cultivate the Artificial Intelligence Industry in Beijing
Beijing Municipality	Build a “bastion” of talent (人才高地). Strengthen international cooperation, pay close attention to the world’s top experts and scholars in the AI field, and precisely recruit leading AI talents and their teams to come to Beijing for innovation, entrepreneurship, etc.
Tianjin Municipality	*Overall Action Plan for Accelerating the Development of the Intelligent Technology Industry in Tianjin*

	(1) Strengthen talent recruitment; (2) Accelerate talent cultivation; (3) Enhance talent services.
Shanghai Municipality	*Implementation Measures for Accelerating Promotion of the High-Quality Development of Artificial Intelligence*
	(1) Accelerate construction of an AI talent peak (人才高峰); (2) Support local universities, scientific research institutes, and enterprises in jointly training AI talents; (3) Strengthen the coverage and application of the city's talent-related policies; (4) Support key AI institutions in the city in recruiting various kinds of outstanding talents.
Zhejiang Province	*Twelve New Artificial Intelligence Talent Policies*
	Plans call for gathering together 50 top international AI talents, 500 talents in S&T entrepreneurship, 1,000 high-end R&D talents, 10,000 engineers and technicians, and 100,000 technical talents in 5 years.
Jiangsu Province	*Opinions on the Implementation of the New Generation AI Industry in Jiangsu Province*
	Enhance talent support. Put into effect the provincial Party committee's *Opinions on Focusing on Innovation and Deepening Reform to Create an Internationally Competitive Talent Development Environment*, adhere to combining recruitment and training, and link the use of talents with the retention of talents, so as to seize the high ground in AI industry talent, etc.
Guangdong Province	*Guangdong Provincial New Generation Artificial Intelligence Development Plan (2018-2030)*
	Bring together high-end talents. This policy formulates a special talent recruitment plan for AI and vigorously recruits scarce high-end talents and high-level innovative teams in fields such as the basic theory and key technologies of AI.
Sichuan Province	*Sichuan Provincial Implementation Plan for the Development of New Generation Artificial Intelligence*
	(1) Step up efforts to recruit high-end AI talents; (2) Improve the construction of academic programs in AI fields; (3) Strengthen the training of AI teams and talents.

Chapter Six Trends in AI Industry Talent Training

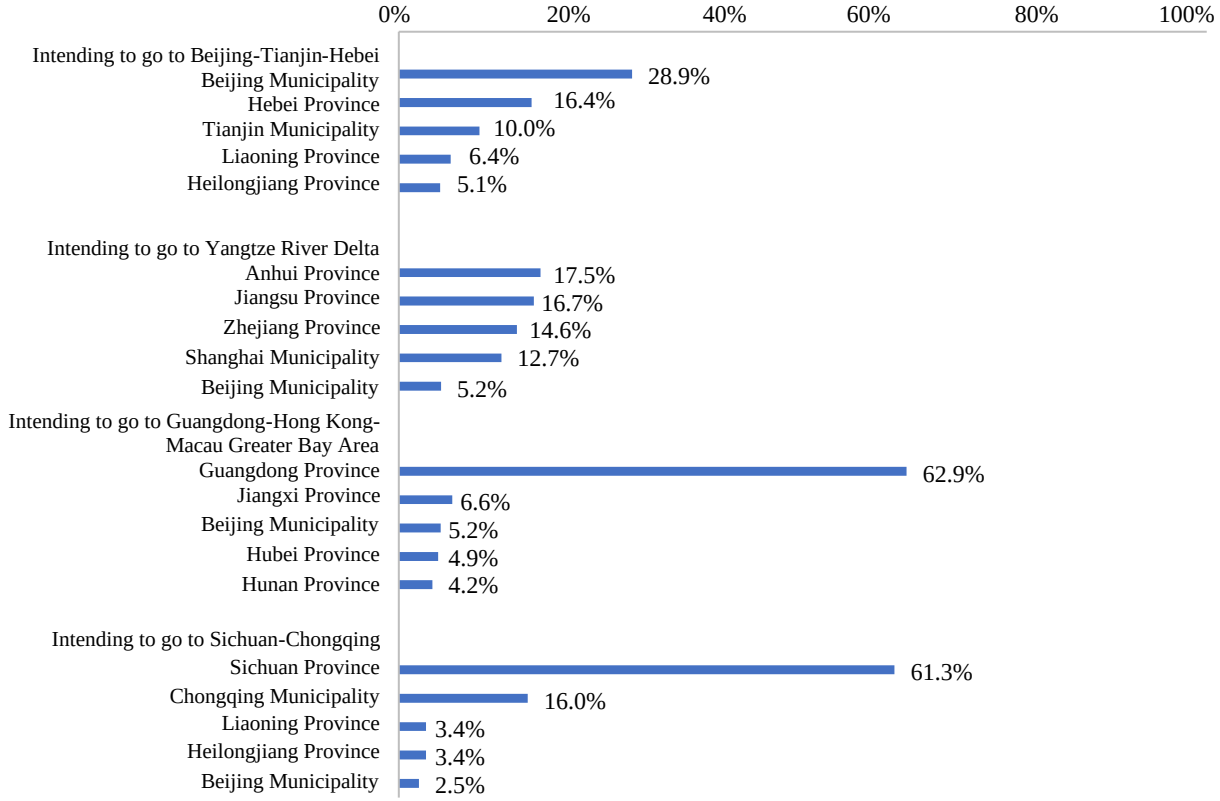
As AI technology matures, the implementation of AI industry applications inevitably leads to demand for local services. It directly stimulates the demand of AI-related enterprises for application-oriented, innovative, and hybrid talents, with the focus being on local services. In this context, an "industry-academia-research institute integration" ("产学研一体化") talent training ecosystem, led by governments at all levels and jointly undertaken by universities and enterprises, is gradually becoming clear, and the importance of the ecosystem-based talent training model is becoming increasingly apparent.

6.1 The trend toward AI industry talent localization services is obvious

The accelerated implementation of AI applications in multiple regions has gradually highlighted the importance of talent localization service ability. AI localization service ability is reflected in understanding the local industrial structure and the intelligentization requirements of local enterprises in a certain region, quickly responding to customer service requests, and providing customers with AI-related consulting,

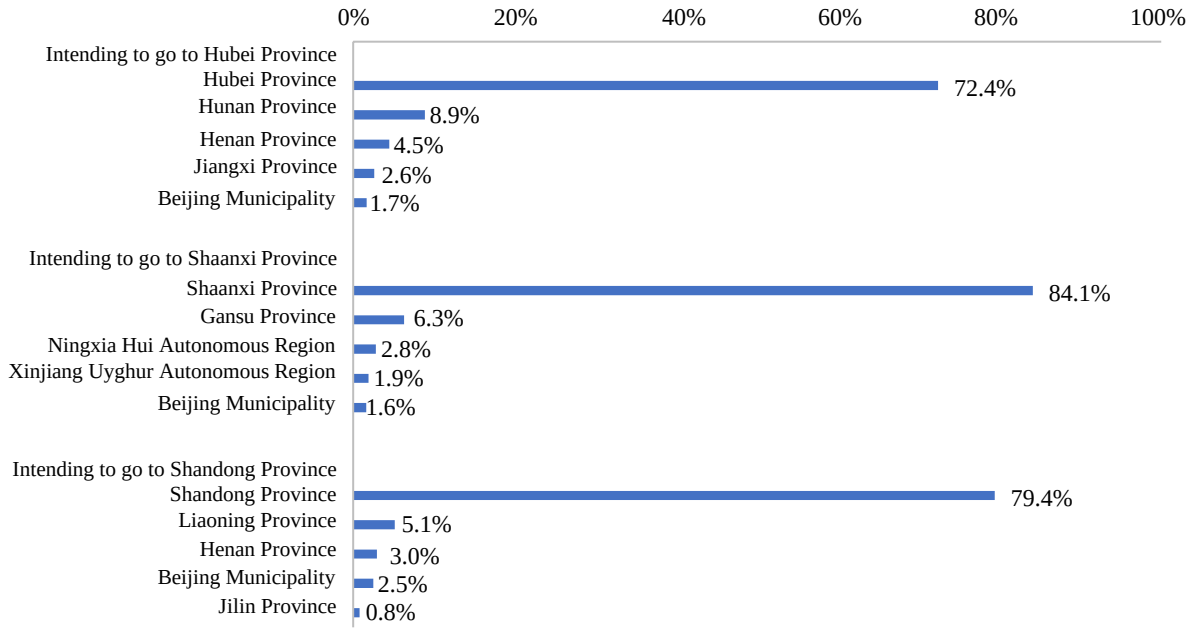
development, O&M, and after-sales services. Unlike the traditional internet era, the rise of the digital economy has brought significant opportunities for the economic development of all regions nationwide. As a result, AI companies are actively making strategic adjustments, shifting from a single core regional model to a nationwide model of providing localized services, which has stimulated AI companies' demand for local AI talent.

The AI industry in regions across China has shown a trend toward meeting demand for industry talents locally. In centers of AI industry development such as the Beijing-Tianjin-Hebei region, Yangtze River Delta region, Guangdong-Hong Kong-Macau Greater Bay Area, and Sichuan-Chongqing region, AI industry talents are mainly supplied locally by their regional provinces and cities. In addition to the above regions, provinces that are relatively strong in S&T, such as Hubei, Shaanxi, and Shandong, all have high concentrations of local talent from their provinces in their supply of AI industry talents, which reflects the importance of localizing talent training work.



Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 31 Places of origin of talents intending to go to the Beijing-Tianjin-Hebei, Yangtze River Delta, Guangdong-Hong Kong-Macau, and Sichuan-Chongqing regions



Data sources: Research database of the report writing team, BOSS Direct Hire

Figure 32 Places of origin of talents intending to go to Hubei Province, Shaanxi Province, and Shandong Province

6.2 An industry-education integration talent training model has begun to take shape

6.2.1 The industry-education integration model of talent training is forming gradually, with enterprises and university as "co-stars"

Along with the deepening implementation of AI applications, the demand for talents has changed from basic research-driven to application-driven, and an industry-education integration-based talent training model is plainly important and urgently needed. The State attaches great importance to industry-education integration, and it has actively improved top-level design. In December 2017, the General Office of the State Council issued the *Several Opinions of the General Office of the State Council on Deepening Integration of Industries into Education*; in September 2019, the NDRC issued the *Notice on the Implementation Plan of the National Pilot Program for the Integration of Industry and Education*, which focuses on (1) promoting the better incorporation of industrial requirements in the talent training process, (2) building a system for developing technically skilled talents and innovative and entrepreneurial talents to serve and support the major requirements of industries, and (3) forming a development pattern of overall integration and positive interaction between education and industry. The need for industry-education integration is especially urgent in the field of AI, and the traditional talent training model can no longer adapt to rapidly changing

industry requirements. Against this background, universities can rely on their resource advantages in academic research and experts, while enterprises have a firm footing in accumulated practical experience and frontline market demand. Driven by policies and markets, the two sides are actively building and starting to form an industry-education integration-based talent training model with complementary advantages and resource sharing, and it is gradually developing into a leading force of talent training for the domestic AI industry.

6.2.2 The industry-education integration talent training model still needs continued improvement

At present, the institutions related to the industry-education integration talent training model for the AI industry are still limited to a few universities and a limited number of AI industry giants, and the existing faculty strength, curriculum, and practical training system are still ill equipped to cover a sufficiently broad range of application scenarios. Therefore, as the integration of AI with other industries continues to accelerate, the industry-education integration talent training model needs to widely absorb AI-related enterprises of various types and fields, and more universities need to be provided with practical experience, practical training courses, and front-line practice experts in multiple scenarios, in order to ensure that AI industry talents trained by universities can more widely adapt to the requirements of multiple types of scenarios and industries, and to promote the further improvement of the industry-education integration model of talent training in terms of participating actors and training methods.

6.3 The importance of constructing the AI industry talent training ecosystem is becoming more and more evident

Competition among major countries in AI fields is seen mainly in competition for talent. China has natural advantages in this global competition, especially in terms of human resource reserves. China has a population of nearly 1.4 billion, a workforce of 900 million, 170 million people with higher education and professional skills, and nearly 40 million college students, giving it strong endogenous drivers for AI talent competition. However, merely possessing abundant human resources is not enough to cope with today's increasingly fierce innovation-based competition. To promote the conversion of AI human resources into AI industry talent resources, it is necessary to maximize conversion of the "demographic dividend" into a "talent dividend," establish an open and inclusive talent training ecosystem, and fully leverage the resources, capabilities, and advantages of the various entities in the society.

However, the growing demand for talents can hardly be met just by relying on the power of universities or enterprises. Governments, universities, research institutes, and enterprises need to cooperate to build knowledge networks, promote the innovation and

application of knowledge among industrial, academic, and research sector entities, and at the same time build and refine the talent system to cope with rapidly developing industrial demand. Differences or even conflicts exist between different entities in terms of mechanisms, systems, and value orientations. Therefore, the following three[18] tasks are key to building the AI industry talent training ecosystem: First, the main oversight departments (主管部门) for industry and the main oversight departments for education should strengthen their working relationships, do a good job of top-level design, fully guide, organize, coordinate, and motivate universities, research institutes, enterprises, talent service agencies, etc. to better integrate the industry's requirements into the talent training process, forming a development pattern of overall integration and positive interaction between education and industry. Second, universities, enterprises, and talent service agencies should clarify their respective positioning and rights and obligations, actively participate in building the talent training ecosystem, and improve efficiency in the flow and sharing of resources such as capital, technology, and talent, to assure that talent training can truly keep pace with the industry's development.

Chapter Seven Recommendations for AI Industry Talent Development Policies

Current AI industry talent development should be based on the popularization of AI-related knowledge, with training of AI industry talent at its core, and construction of a demand-oriented "government-industry-academia-research institute integration" talent training system should be promoted, in which governments, enterprises, universities, and research institutes cooperate with each other. Specifically, efforts should proceed from the following three aspects: First, the government should strengthen the top-level planning of AI industry talent training, steadily guiding AI industry talent development. Second, construction of the "government-industry-academia-research institute integration" AI talent training ecosystem should be accelerated, so as to promote the matching of AI industry talent supply with industry development demand. Third, international talent exchange and cooperation should be strengthened, and inter-regional talent flows should be encouraged.

7.1 Strengthen top-level design, and promote the orderly development of AI industry talent work in a coordinated manner

Taking the *New Generation Artificial Intelligence Development Plan* as the standard and industry demand as the orientation, we should strengthen the top-level design of AI industry talent work and incorporate AI industry talent training into national key work plans. On one hand, we should strengthen the construction of AI majors and

[18] Translator's note: Although this sentence of the report mentions three tasks, the section below it only describes two.

disciplines, improve the construction layout of majors and disciplines, from "double world-class" universities to application-oriented schools, and strengthen the coordinated training and development of basic research talents and practical industry talents. On the other hand, we should strengthen the "co-starring" role of enterprises and universities in talent training, and achieve linkages and synergies among central and local governments, universities, and enterprises. At the same time, an AI industry talent work coordination mechanism should be established, from the top level of national design, to coordinate all participating parties such as governments, universities, and enterprises, and provide broad incentives, pay close attention to the implementation of AI industry talent training, and promote the development of the "government-industry-academia-research institute integration" AI industry talent training model.

7.2 Accelerate construction of the "government-industry-academia-research institute integration" AI talent training ecosystem

In order to ensure that AI industry talent training attains the expected goals and the supply of talents matches the industry's demand, governments, universities, research institutes, enterprises, and other participating entities should make the most of their respective advantages, and promote construction of the "government-industry-university-research institute integration" AI talent training ecosystem through school-enterprise cooperation, industry-education integration, joint construction of university majors, etc. Specifically, work needs to proceed in six areas: job position competency standards, curriculum systems, practical teaching systems, talent evaluation systems, faculty, and employment services.

7.2.1 Develop job position competency standards for AI industry talents

Developing job position competency standards for AI industry talents is of major significance. On one hand, it lays the foundation for promoting the standardization of AI industry talent training, and on the other, it helps guide enterprises in selecting AI-related talents, and provides a reference for AI industry talent training and curriculum setting for all types of higher education institutions. Therefore, job competency standards for AI industry talents should be based on the current situation and trends in international and domestic AI industry development, taking into account the actual talent demand of domestic enterprises in different technology directions and different positions, systematically sorting out the talent structure, job types, knowledge and skill requirements, etc., so as to form a comprehensive and multifaceted set of job competency standards for AI industry talents based on job types and oriented around competency standards.

7.2.2 Establish curriculum systems that are adapted to the AI industry's development

In order to meet the AI industry's demand for various types of talents, universities need to build curriculum systems that can be carried out quickly and are adapted to the needs of the industry's development, according to their own disciplinary strengths and talent training objectives. In particular, it is necessary to distinguish differences in the directions of curriculum systems at different academic stages such as doctoral, master's, undergraduate, and vocational, and in different types of universities, such as double first-class universities and ordinary universities. The training of AI industry talents at the doctoral, master's, or undergraduate levels of double first-class universities should focus on basic theoretical research, with an eye to internationalization, and emphasizing mathematical foundation and research ability improvement. Talent training at the undergraduate level of ordinary universities and colleges should focus on the introduction of enterprise projects and practical courses, based on a solid knowledge of basic theory, in order to cultivate practical, hybrid types of engineering-oriented talents.

7.2.3 Build an in-depth industry-education integration AI teaching system

The key to building an AI teaching system based on in-depth industry-education integration is to integrate the industry's needs into the talent training process, and integrate the power of the industry's technology into teaching and implementation, achieving positive interaction between education and industry. AI enterprises are naturally well-positioned to understand the industry's cutting-edge technology and practical applications, while schools have a great deal of experience in the construction of talent training systems. Both sides should give full play to their respective comparative advantages, form deep-level educational partnerships, and explore feasible models of collaborative operation, ensuring that training methods and curriculum systems for AI industry talents at all levels can continue to meet the current development needs of the AI industry. The construction of AI laboratories, innovation centers, and training bases in universities should be encouraged on the basis of school-enterprise cooperation, so that a teaching system combining teaching, research, and production gradually takes shape.

7.2.4 Improve the AI industry talent evaluation system

In order to further implement the Party Central Committee and State Council's *Guiding Opinions on the Differentiated Promotion of Talent Evaluation Mechanism Reform* and solve the problem that the current talent evaluation system is not suitable for talent team development in the AI industry, talent evaluation efforts in the AI industry should be accelerated, and a talent evaluation work plan based on job position competencies should be formed. On one hand, it is necessary to strengthen construction of the talent evaluation standards system, design reasonable evaluation indicators according to the principles of differentiation and stratification, and carry out

comprehensive examination and evaluation of AI industry talents in terms of professionalism, technical ability, practical ability, and creativity. On the other hand, an evaluation system with diversified participants should be established, giving full play to the roles of government, universities, enterprises, and other professional organizations serving as main actors, assuring that talent evaluation is authoritative and objective, and that the evaluation system established for AI industry talents is one with equal rights, equal conditions, and equal opportunities.

7.2.5 Strengthen the construction of AI faculty

Faculty construction is the foundation of talent training. To promote the orderly progress of talent training work, it is necessary to assure that the faculty team is sufficient in quantity, rationally structured, and of good quality. Faculty construction needs to be promoted in a graded and hierarchical manner. Double world-class universities may initially rely on the faculty resources of majors similar to AI to build their AI faculty teams, and will need to hire external enterprise-based AI technical experts as adjunct professors of their schools to make up for the faculty's lack of practical experience. The talent training of ordinary undergraduate colleges and universities needs to give greater weight to practical abilities. These types of universities need to strengthen the training of their own teachers, especially in cutting-edge theory and industrial practice. They will also need to hire practice-oriented teachers externally, recruiting the front-line practical technical experts of AI enterprises to consolidate the faculty team.

7.2.6 Create a talent service system for precision employment

To assure the rapid and precise integration of talents into the AI industry, a precision employment service system should be established featuring rapid response, synchronous follow-up, and dynamic adjustment, so as to promote the closed-loop construction of the talent training system. Specifically, the following three aspects can serve as starting points: The first is to establish an employment guidance service system throughout the talent training cycle. Universities need to conduct career planning and employment guidance courses for talents throughout the AI industry talent training lifecycle to help talents clarify their own development orientations. The second is to establish a service system for precise job market linkage and precise matching of employment information. On the one hand, enterprises can appropriately shorten the talent selection cycle by building talent training systems jointly with universities and carrying out key training work for talents who intend to work for [said enterprises]. On the other hand, universities need to grasp the employment inclinations of talents in real time, vigorously expand matching employment channels, and achieve the scientific linking of the job-seeking intentions of talents with the requirements of enterprises. The

third is to establish a service system for feedback on the employment status of talents and for real-time tracking of employment data. The internet, big data, and other technologies can be used to quickly and accurately track the employment status of AI industry talents; and enrollment plans, curricula, and other talent training content can be optimized based on feedback results, thereby assuring the positive development of the AI industry talent training system toward higher quality.

7.3 Encourage inter-regional talent flows, and strengthen international talent exchanges and cooperation

The AI industry needs to continuously strengthen inter-regional talent flows and talent cultivation cooperation. On the one hand, market demand should be used to optimize the spatial allocation of talents, support the development of AI-related enterprises in different regions, and encourage well-positioned enterprises (优势企业) to set up branches in multiple regions, providing job opportunities for the flow of talents between multiple regions. On the other hand, in order to achieve unified talent standards, mutual recognition of talent evaluation results, and information sharing among regions, the many unreasonable barriers to the flow of talents across regions should be broken down. At the same time, AI industry talent training requires strengthening international exchanges and cooperation, adhering to the principle of combining "going global" (“走出去”) and "bringing in," selecting outstanding technical talents and students and sending them to top international laboratories and universities to learn leading international AI technologies, and recruiting top international talents to enter our universities and enterprises, thereby promoting the training of domestic AI industry talents.