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INTERNATIONAL FINANCE FORUM

IFF Global Artificial Intelligence Competitiveness Index Report

Part 2: Analyzing AI Competitiveness From the Research Innovation Perspective

ISSN 3005-4710

國際金融論壇
INTERNATIONAL
FINANCE FORUM
Since 2003

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IFF2024
《IFF Global Artificial Intelligence Competitiveness Index Report》
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International Finance Forum (IFF)
UIA International Organization ID: AA2980

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About the IFF Global Artificial Intelligence Competitiveness Index Series Report

As the core driving force of the new round of scientific and technological revolution and industrial transformation, artificial intelligence (AI) is ushering in a sea change in the global innovation terrain and patterns of competition. In this regard, scientifically evaluating and grasping the development trends and competitive strengths of various countries in the field of AI is of great practical significance for understanding the development trends of global AI and formulating relevant policies. The International Finance Forum (IFF) has launched the Global Artificial Intelligence Competitiveness Index project, dedicated to building a comprehensive, objective and quantifiable global AI competitiveness assessment system, and systematically assessing and comparing the comprehensive strength and development potential of various countries in the field of AI through multi-dimensional indicators.

This research project is based on the principles of multi-dimensional assessment, objective data quantification, and forward-looking analysis. It builds a comprehensive assessment framework to ensure the systematic and comprehensive character of the indicators. Furthermore, all data is collected, cleaned, and normalized to ensure the objectivity of quantitative results. Case analysis of some countries not only evaluates the current situation, but also pays more heed to development potential and judgment of trends.

This study will devise a system of evaluation from five core dimensions:

Technology development and application (as represented by AI companies)

Research and innovation

Human Capital

Policy and regulatory environment

Market acceptance and infrastructure

Each dimension has several secondary indicators that are assessed by combining quantitative and qualitative means. As the second in a series of studies and one of the five core dimensions of the competitiveness index, this report will concentrate on the development state of global AI research and innovation, and engage in an in-depth analysis of AI-related scientific research papers, and patents in various countries. The analysis reports of the remaining three dimensions will be subsequently issued to together form a consummated global AI competitiveness index map.

Abstract

This paper analyzes more than 2 million AI-related scientific research papers and AI invention patents from countries around the globe. Mainland China has become the region with the greatest total number of AI papers globally at 769,000 in a 696 percent rise over the past 10 years. Japan and South Korea entered the global top 10, thus demonstrating East Asia's contribution to global AI research. Calculated per million in population, Singapore, Switzerland, the UK, and Australia all contribute over 2,000 AI papers per million in population, and these four nations have a strong AI research density. This article normalizes data from two dimensions -the average number of citations of papers, and the average impact factor of journals - and comprehensively evaluates AI papers' impact in various countries. Switzerland and Canada rank first and second globally, with values exceeding 0.8, the results indicate. The United Kingdom, the Netherlands, the United States, and Australia rank 3-6, with values exceeding 0.7, which shows the considerable impact on AI research countries in Europe and America have. An analysis of the international cooperation of AI papers found Chinese scholars as the most important partners in papers published as first authors by scholars from the US, France, and Germany. Chinese scholars are thus impacting AI research globally. A co-occurrence analysis of AI patents in China and the US found that US companies focus more on AI's underlying foundation and intermediate technology layers, e.g., processor architecture and configuration, baseband system components, and machine learning. China has a long way to go to catch up.

Keywords:

artificial intelligence, competitiveness index, research, innovation, papers, patents

Contents

I. Global AI Scientific Papers Research

As to the definition of AI-related research papers, we preliminarily define all research papers involving machine learning, deep learning, supervised learning, reinforcement learning and other technologies (for specific keyword groups, see Reference 1) , research papers using AI-representative neural networks, and other algorithms - among them AI-related tools, industry applications, and other ethical and interdisciplinary research - as AI-related research papers.

The above keyword groups are used to search and query in the three major databases of Web of Science, IEEE Xplore, and Google Scholar, and the search results are statistically deduplicated. For those databases, there are two options: conference papers and journal papers. Before starting our research, we sampled a batch of data for comparison and found that many conference papers come from ordinary academic conferences and are not of particularly high quality. Furthermore, very high-quality conference papers have already been published in journals. To facilitate our research, we have decided to include only journal articles from the databases. A total of 3.828 million papers were able to be obtained as of February 14, 2025, of which 2.421 million are journal papers and 1.407 million are conference papers (generally compiled into conference proceedings). To ensure the rigor of the research, we used the official 2.421 million journal papers as the data sample for this study. Journal papers usually undergo strict peer review and thus are of a stable quality.

When studying AI papers from countries worldwide, the first question is: What is the total amount and distribution of AI papers globally? From a time series perspective: What trends are undergoing changes? We endeavor to answer the foregoing questions.

Number of AI research papers in various countries (selection of the top 30 countries/regions)

Table 1 - Top 30 countries/regions globally for AI research papers

Rank	Name of country/region	Number of AI publications	Number of AI publications/million in population
1	Mainland, China	768,643	549.0
2	US	368,104	1,082.7
3	India	118,513	84.7
4	UK	107,692	1547.3
5	Germany	85,132	1,025.7
6	Japan	75,569	604.6
7	South Korea	71,004	1,365.5
8	Canada	66,186	1,741.7
9	France	58,034	892.8
10	Italy	57,323	955.3
11	Australia	53,592	2,061.2
12	Spain	48,084	1,023.1
13	Taiwan, China	38,565	1,641.1
14	Iran	36,289	437.2
15	Saudi Arabia	29,639	823.3
16	Netherlands	29,213	1,622.9
17	Singapore	25,393	4,378.1
18	Russia	25,129	174.5
19	Switzerland	25,062	2,880.7
20	Brazil	23,844	111.4
21	Turkey	23,459	279.3
22	Malaysia	20,689	626.9
23	Poland	20,100	528.9
24	Pakistan	17,389	75.6
25	Sweden	16,663	1,666.3
26	Belgium	15,564	1,353.4
27	Greece	14,143	1,414.3
28	Egypt	13,666	128.9
29	Austria	12,806	1,422.9
30	Israel	12,260	1,290.5

Figure 1 - Heat map of the top 30 countries/regions globally for AI research papers

1 . With 769,000 papers, Mainland, China has become the region with the highest number of AI papers globally, nearly twice as many as the second-place US;

2 . Japan and South Korea are both in the top 10 globally in the total number of AI papers, demonstrating East Asia's fervor for AI research and great contribution to the global total. In Europe, the UK and Germany rank fourth and fifth globally. Additionally, France and Italy are in the top 10;

3 . Calculated per million population, Singapore, Switzerland, the UK, and Australia all contribute over 2,000 AI papers per million in population, indicating these four nations' robust AI research capabilities. Singapore, which ranks first, has over 4,000 papers, putting it far in advance of other countries;

4 . In our Part 1 Report, Hong Kong, China and the UAE stood out with a high number of AI companies. In this part, their AI research papers totaled 6,532 and 3,126, ranking them 39 & 55 globally;

5 . The top 30 journals for AI paper publications worldwide show that the influence of the United States and Europe is significant, especially IEEE related.

Table 2 - Top 30 journals for AI research papers

Rank	Name	Number of AI publications	Host Country
1	arXiv	105,871	US
2	IEEE Access	38,443	US
3	Sensors	23,869	Switzerland
4	Applied Sciences	18,806	Switzerland
5	Remote Sensing	16518	Switzerland
6	Neuro Computation	13872	US
7	Expert Systems with Applications	12,426	Netherlands
8	Computer Engineering and applications	11,328	Mainland, China
9	IEEE Transactions on Geoscience and remote sensing	9628	US
10	Pattern Recognition	9186	Netherlands
11	IEEE Transactions on Image Processing	8974	US
12	Electronics	8,899	Switzerland
13	IEEE Transactions on Pattern analysis and Machine Intelligence	7509	US
14	Medical Physics	7030	US
15	Neural Computing & Applications	6,711	UK
16	IEEE Sensors Journal	6337	US
17	Magnetic Resonance in Medicine	6041	US
18	IEEE Transactions on Instrumentation and Measurement	5812	US
19	IEEE Transactions on Neural networks and learning systems	5642	UK
20	Information Sciences	5,624	Netherlands
21	Computers in Biology and Medicine	5449	UK
22	Knowledge based systems	5438	Netherlands
23	IEEE Transactions on Medical Imaging	5391	US
24	Neural Networks	5324	UK
25	Diagnostics	5192	Switzerland
26	Advanced Materials	4858	Germany
27	Biomedical Signal Processing and Control	4825	UK
28	Computers and Electronics in Agriculture	4425	Netherlands
29	IEEE Transactions on Multimedia	4154	US
30	Journal of the Acoustical society of America	4100	US

**arXiv is not a journal. However, in databases such as Web of Science, when it comes to the sources of papers, the database still lists arXiv as a category. Therefore, we have included it here.*

II. Time series analysis

Figure 2-1 - Number of papers published by the top 10 countries/regions globally for AI research papers

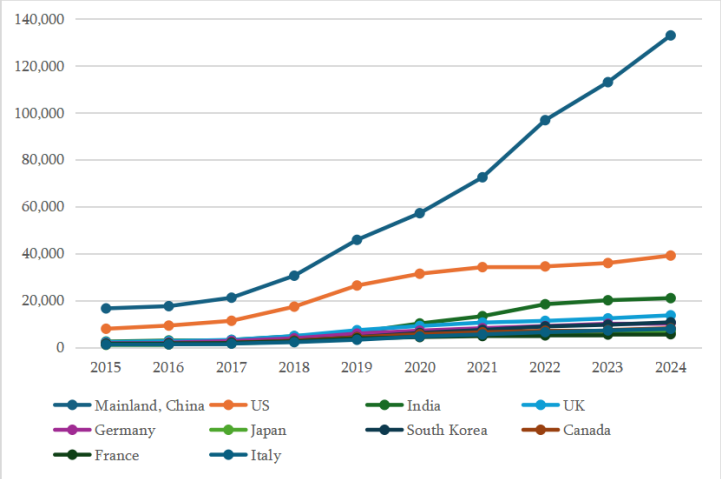
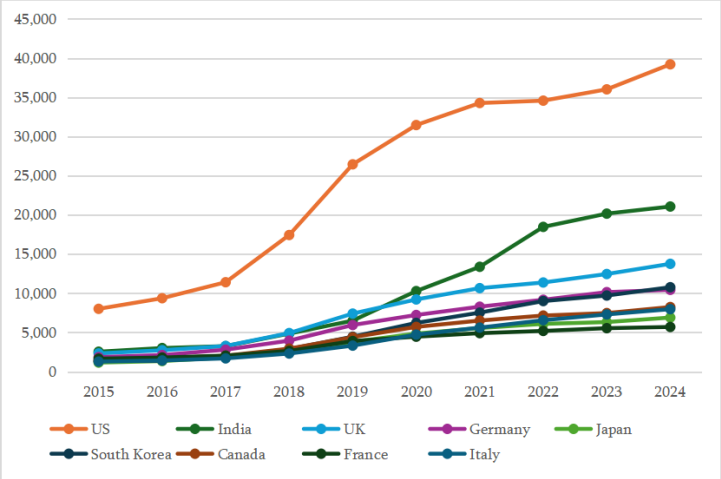


Figure 2-2 - Number of papers published by the top 10 countries/regions globally for AI research papers(without Mainland, China)



1 . Per the year-by-year data in the figure, we were able to find that:

2 . Mainland, China has become the country with the swiftest growth in the number of AI research papers published over the last decade, with 133,000 papers published in 2024, as against 16,700 in 2015, a 696 percent rise over 10 years. In the US, this number climbed by 390 percent in 10 years;

3 . Compared with other countries and regions such as the US, the growth in the number of AI research papers in Mainland, China primarily concentrated in 2019 and after, in particular since 2022, greatly extending its leading advantage, while India also manifests a similar trend;

4 . The total number of AI research papers presently published by Mainland, China every year has outstripped the total number of papers the 2nd to 10th countries have published.

For us to understand the development state of AI papers in various countries worldwide, the total number of papers is a dimension to gauge a country's AI scientific research competitiveness but, even more importantly, the level of scientific research papers, that is, the level of competitiveness. The number of papers is not the sole evaluation criterion, but its influence in academia and practice also warrants attention. The second portion of this study will concentrate on an analysis of the impact of AI papers in various countries worldwide, including the number of citations to the papers, the impact factor of the journals in which they are published, and the influence of international collaboration. Via these indicators, we will reveal the distribution of academic influence in the field of AI in various nations and the underlying factors driving it.

III. Impact Analysis

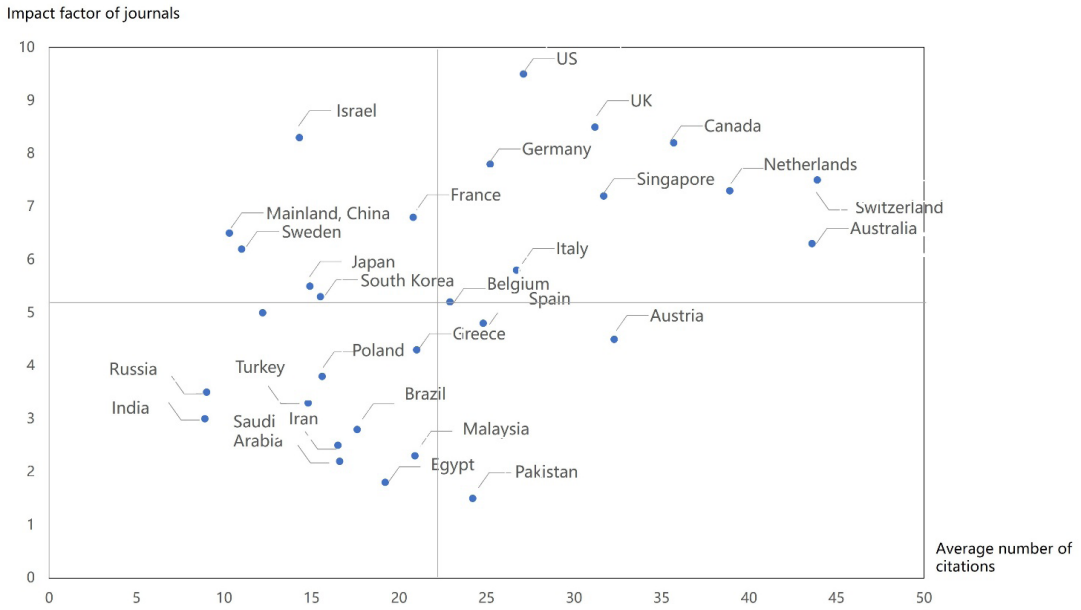
Table 3 - Average number of citations of papers from among the top 30 countries/regions globally in number of AI research papers

Rank	Name of country/region	Average number of citations of AI papers
1	Mainland, China	10.3
2	US	27.1
3	India	8.9
4	UK	31.2
5	Germany	25.2
6	Japan	14.9
7	South Korea	15.5
8	Canada	35.7
9	France	20.8
10	Italy	26.7
11	Australia	43.6
12	Spain	24.8
13	Taiwan, China	12.2
14	Iran	16.5
15	Saudi Arabia	16.6
16	Netherlands	38.9
17	Singapore	31.7
18	Russia	9.0
19	Switzerland	43.9
20	Brazil	17.6
21	Turkey	14.8
22	Malaysia	20.9
23	Poland	15.6
24	Pakistan	24.2
25	Sweden	11.0
26	Belgium	22.9
27	Greece	21.0
28	Egypt	19.2
29	Austria	32.3
30	Israel	14.3

Table 4 - Average impact factors of journals published by the top 30 countries/regions globally in number of AI research papers

Rank	Name of country/region	Impact factor of journals in which published
1	Mainland, China	6.5
2	US	9.5
3	India	3.0
4	UK	8.5
5	Germany	7.8
6	Japan	5.5
7	South Korea	5.3
8	Canada	8.2
9	France	6.8
10	Italy	5.8
11	Australia	6.3
12	Spain	4.8
13	Taiwan, China	5.0
14	Iran	2.5
15	Saudi Arabia	2.2
16	Netherlands	7.3
17	Singapore	7.2
18	Russia	3.5
19	Switzerland	7.5
20	Brazil	2.8
21	Turkey	3.3
22	Malaysia	2.3
23	Poland	3.8
24	Pakistan	1.5
25	Sweden	6.2
26	Belgium	5.2
27	Greece	4.3
28	Egypt	1.8
29	Austria	4.5
30	Israel	8.3

Figure 3 - Top 30 Countries Research Paper Impact Matrix Chart



** The vertical and horizontal lines in the matrix plot indicate the average values of two data sets.*

It can be analyzed from the above figure, countries such as the Netherlands, Switzerland, Australia, Singapore, the United Kingdom, Germany, and the United States have published AI-related research papers that not only maintain high citation counts but are also published in journals with high impact factors.

When we evaluate the influence of AI papers in a country or region, to rely solely on the average number of citations of all papers is rather one-sided. Similarly, to conduct a comprehensive evaluation by only looking at the average impact factor of all journals which publish papers is impossible. Here, we used statistical methods to normalize the data of two dimensions, and then calculated a comprehensive impact coefficient based on a ratio of 50 percent per dimension to gauge the impact of AI papers in various countries and regions:

Supposing the average number of citations is X, the maximum value in the sample is , and the minimum value is ; the average impact factor is , the maximum value in the sample is , and the minimum value is.

1 . Average citation count data normalization:

$$\text{Formula: } x_{norm} = \frac{x - x_{\min}}{x_{\max} - x_{\min}}$$

2 . Average impact factor data normalization:

$$\text{Formula: } y_{norm} = \frac{y - y_{\min}}{y_{\max} - y_{\min}}$$

3 . Comprehensive impact formula:

$$\text{Formula: } Z = 0.5x_{norm} + 0.5y_{norm}$$

Substituting the above data normalization formula into the comprehensive influence formula enabled us to derive:

$$Z = 0.5 \times \frac{x - x_{\min}}{x_{\max} - x_{\min}} + 0.5 \times \frac{y - y_{\min}}{y_{\max} - y_{\min}}$$

This is the ultimate comprehensive indicator gauging the influence of AI papers in various countries or regions. It is acquired through normalizing the average number of citations and the average impact factor of the journals in which the papers are published, while weighting each at 50 percent.

Table 5 - Impact values of the top 30 countries/regions in number of AI research papers worldwide

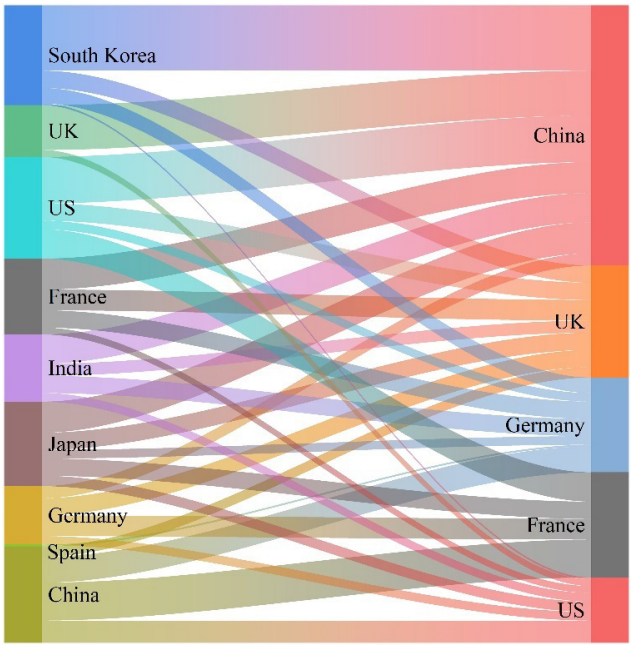
Rank	Name of country/region	AI paper impact value
1	Mainland, China	0.3163
2	US	0.7389
3	India	0.0864
4	UK	0.7629
5	Germany	0.6358
6	Japan	0.3333
7	South Korea	0.3296
8	Canada	0.8103
9	France	0.4641
10	Italy	0.5019
11	Australia	0.7156
12	Spain	0.4085
13	Taiwan, China	0.2497
14	Iran	0.1654
15	Saudi Arabia	0.0986
16	Netherlands	0.7506
17	Singapore	0.6494
18	Russia	0.1378
19	Switzerland	0.8523
20	Brazil	0.1930
21	Turkey	0.2129
22	Malaysia	0.1926
23	Poland	0.2563
24	Pakistan	0.2153
25	Sweden	0.3165
26	Belgium	0.4205
27	Greece	0.3091
28	Egypt	0.1435
29	Austria	0.5003
30	Israel	0.4969

We thus obtained the comprehensive influence data of the top 30 countries globally in the number of AI papers. Switzerland and Canada ranked first and second, with values exceeding 0.8. The UK, the Netherlands, the US, and Australia ranked 3-6, with values exceeding 0.7. Aside from Canada ranked 2nd, the US ranked 5th, Australia ranked 6th, and Singapore ranked 7th, the other six countries in the top 10 are all European, showing the strong scientific research strength of European countries, mainly the German-speaking countries of Switzerland, Germany, and Austria. Although Mainland, China leads the other countries by far in number of papers, its comprehensive influence ranking varies considerably from that of the countries ahead of it, ranking 17th, so much room for improvement exists; India and Saudi Arabia rank low in this list, with scores of under 0.1, indicating that the AI research papers of these two countries lie at a low level in average number of citations and journal impact factors.

IV. Analysis of Authors' Collaboration

Collaboration is a key feature of modern scientific research. When analyzing the competitiveness of AI research papers in various countries, one must undoubtedly set the cooperation of the authors of the papers as a key research dimension. We endeavor to offer a perspective to help everyone analyze from which countries the cooperating scholars of the major countries that publish AI papers come, and what are their manifestly common characteristics?

Figure 4 - Collaboration between authors from China and other leading AI paper publishing countries - Sankey diagram



We took a random sampling of equal proportions from the database of papers, then extracted the papers, with the first author from China, then the UK, Germany, France, and the US, analyzed the sources of the remaining co-authors, and presented them in the form of a Sankey diagram:

We were able to find that, among the leading countries in global AI paper publishing, their co-authors show evident geographical features. For instance, those between China and South Korea and Japan, and between the UK and France;

In articles with Chinese scholars as first author, the other co-authors come from the most extensive sources, with comparatively more from South Korea, and the rest coming from the UK, the US, France, etc., being relatively equal. In articles with British scholars as first author, French scholars are very important partners;

In papers published by American, French, and German scholars as first authors, Chinese scholars have become the most important partners of the papers of scholars from the aforesaid three countries. We presume this closely relates to Chinese overseas students, as large numbers of Chinese overseas students conduct scientific research in the above three countries, so the publication of papers largely reflects this;

The internationalization of French scholars' papers has much room for improvement compared with those from the UK and Germany.

V. Research fields and thematic analyses

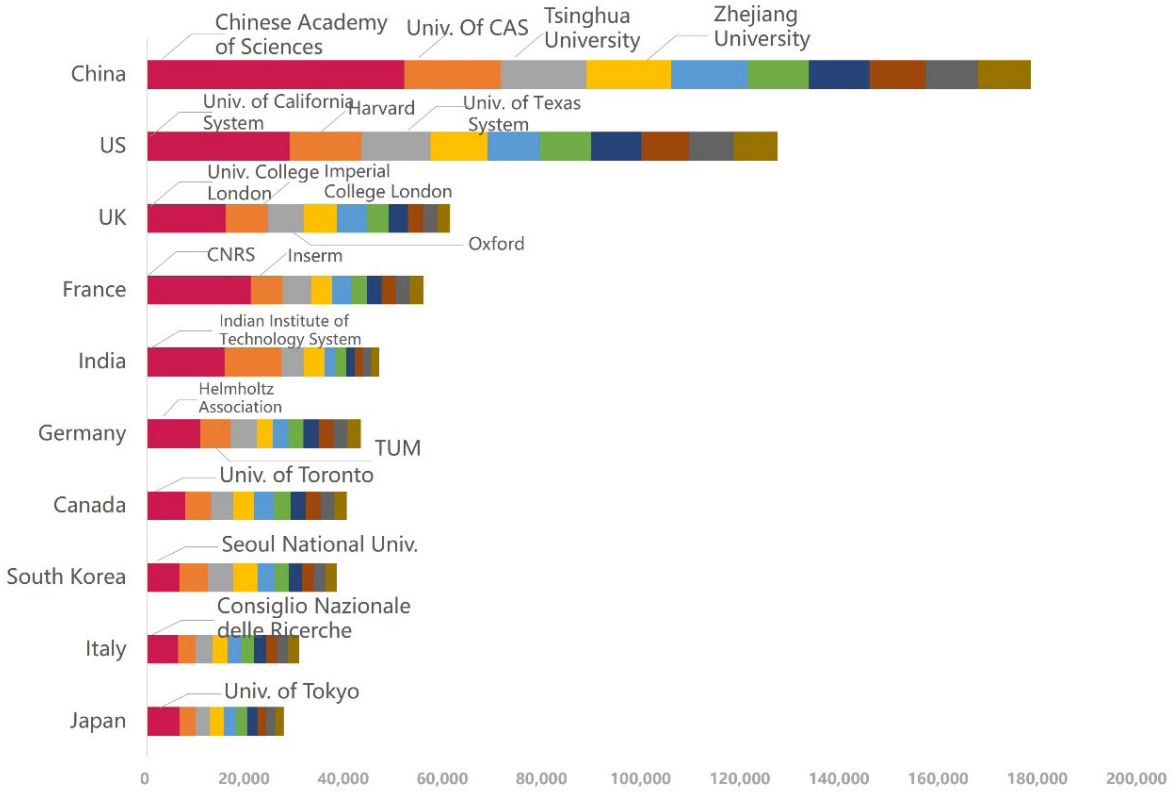
Table 6 - Distribution of research topics published by the top 10 countries/regions globally for publishing AI papers

Country/ TOPIC	Mainland, China	US	India	UK	Germany	Japan	South Korea	Canada	France	Italy
Computer-Science	76.5%	74.6%	77.9%	76%	73%	81.8%	76.1%	75.3%	78.5%	74.5%
Engineering	48.6%	45.6%	49.6%	46.0%	43%	42.2%	58.1%	50.6%	45.1%	45.3%
Communication	42.4%	39.6%	39.8%	37.2%	39.9%	45.7%	42.1%	39%	45.5%	36.3%
Mathematics	39.7%	38.9%	41.4%	38.5%	36.5%	34.3%	37.4%	41.2%	42.3%	35.2%
Automation Control Systems	19.1%	29.8%	13.5%	17.7%	13.4%	14.9%	14.9%	16.7%	16.1%	16.3%
Mathematical Computational Biology	13.8%	29.8%	26.4%	26.8%	30.5%	22.1%	20.7%	27.9%	26.3%	24.7%
Instruments Instrumentation	13.7%	10.8%	9.5%	11.5%	13.1%	11.8%	14.1%	11.7%	12.8%	15.5%
Robotics	11.9%	10.2%	9.8%	14.4%	10.3%	12.3%	11.5%	12.8%	13.6%	13.1%
Medical Imaging	8.5%	21.8%	16.0%	17.9%	23.5%	15.8%	15.0%	20.8%	19.5%	17.2%
Neurosciences Neurology	4.0%	12.3%	5.5%	11.3%	13%	8.3%	6.6%	11.3%	10.3%	9.5%

We extracted relevant paper data of the top 10 countries globally in total number of AI papers, analyzed the keywords and themes of all papers, and defined the following 10 key topics, including: Computer-Science, Engineering, Communication, Mathematics, Automation Control Systems, Mathematical Computational Biology, Instruments and Instrumentation, Robotics, Medical Imaging, and Neurosciences and Neurology. Naturally, these themes do not cover all the research directions of all AI papers globally but, after data comparison, we found that these 10 themes appear most frequently in all papers. We set this as the scope of our research direction. By comparing the data, we were able to find that:

1 . Germany is the world leader in AI research in medicine. It has invested large resources in the study of Mathematical Computational Biology, Medical Imaging, and Neurosciences and Neurology. The proportion of German scholars in the study of these three topics is considerably ahead of the other top 10 countries globally. Japan's attention to computer science and communication, France's attention to mathematics, and Italy's attention to instruments and instrumentation are ahead of other countries globally. A head-to-head comparison between the two major AI countries of China and the US indicates a similar proportion of major research orientations, such as computer science and engineering, but China's proportion of AI research in medical-related fields, automated control systems, and controllers lags greatly behind that of the US. Much room is thus present for improvement.

Figure 5 - Distribution of publishers in the top 10 countries/regions for publishing AI papers



1 . We performed a statistical survey of all the research institutions in the top 10 countries and regions globally for AI research papers. We selected the top 10 research institutions in each country and presented the number of AI research papers they have published in the form of a horizontal column stacking chart. We found that:

2 . Among all the research institutions in China, the Chinese Academy of Sciences and the University of the Chinese Academy of Sciences account for nearly 50 percent of the top 10, and are the most important forces in China's AI research. In addition, Tsinghua University and Zhejiang University also carry a heavy weight.

3 . In the US, the University of California system, Harvard, and the University of Texas system are the main participants in American AI research. In the UK, the focus rests on three institutions: University College London, Imperial College London, and Oxford University.

4 . It warrants mention that many public research institutions in European countries have become the main force in their national AI research, among them the Helmholtz Association of German Research Centres, the National Centre for Scientific Research in France, and the National Research Council of Italy.

Here, we conduct case analyses on the key universities and institutions mentioned above:

China

Chinese Academy of Sciences and University of Chinese Academy of Sciences

(1) Research System and Resource Concentration Driven by National Strategies

As China's leading national research institution in science and technology, the Chinese Academy of Sciences (CAS) aligns its research agenda closely with national strategies. Artificial intelligence (AI) has been designated as a key initiative under China's Science and Technology Innovation 2030 Major Project, and CAS, as a core participant, receives continuous support in areas such as computing infrastructure, algorithm innovation, and interdisciplinary research. Institutions like the Institute of Automation and the Institute of Computing Technology under CAS have been deeply engaged in fundamental AI research and applications, forming a complete ecosystem from basic algorithms to industrial implementation.

1. Policy and Financial Support

Many research projects at CAS are funded by the National Natural Science Foundation of China (NSFC) and the Science and Technology Innovation 2030 Major Project, among other government-backed programs. These funds not only ensure investment in essential infrastructure—such as National Supercomputing Centers—but also provide flexibility for interdisciplinary collaboration.

2. Integration of Data and Computing Resources

China's vast data resources offer a unique advantage for AI research. CAS coordinates national research data platforms, including the National Astronomical Observatories and the Bioinformatics Center, to create extensive multi-domain data pools that support the training and validation of deep learning models. Additionally, the Institute of Computing Technology, which spearheaded the development of the "Cambricon" neuromorphic chips, has significantly advanced China's independent computing power.

(2) Research Paradigm Innovation Through Interdisciplinary Integration

Breakthroughs in AI often emerge from deep interdisciplinary collaboration. CAS and the University of Chinese Academy of Sciences (UCAS) leverage their comprehensive research system to promote the new paradigm of "AI for Science" (AI4S), applying AI to fields such as physics, chemistry, and biology, creating a mutually reinforcing ecosystem.

1. Interdisciplinary Mechanisms

For instance, both the 2024 Nobel Prize in Physics and Chemistry were awarded for groundbreaking research at the intersection of AI and fundamental sciences—an area where CAS has demonstrated strong performance. Through joint laboratories, such as collaborations between the Institute of Automation and the Institute of Physics, CAS researchers are applying generative AI to quantum computing simulations and protein structure predictions, significantly enhancing research efficiency.

2. Transformation of Research Paradigms

Traditional scientific research relies heavily on experimentation and theoretical deduction, but AI-driven data modeling and simulation are revolutionizing this approach. CAS teams working on quantum optical computing exemplify this shift: they have integrated superconducting nanowire technology for multi-photon detection with AI-driven experimental design optimization, dramatically shortening the research cycle.

(3) High-End Talent Development and Training Mechanisms

CAS and UCAS hold a significant advantage in AI talent development. Their research-education integration model has produced a steady pipeline of top-tier scientists for China's AI and technology ecosystem.

1. Leadership of Academicians and Key Scholars

The Chinese Academy of Sciences (CAS) benefits from the expertise of leading academicians such as Yao Qizhi (Andrew Yao), who has driven breakthroughs in AI fundamental theories, including neuromorphic computing and multimodal learning. Beyond research, CAS academicians shape AI's strategic direction. For instance, Academician Wang Jian has emphasized that "AI is a tool for scientific revolution", advocating for the dismantling of disciplinary barriers to foster interdisciplinary collaboration.

2. Development of Interdisciplinary Talent

The University of Chinese Academy of Sciences (UCAS) nurtures interdisciplinary AI talent through its "Science-Education Integration" model. Specialized institutions such as the School of Artificial Intelligence provide courses covering mathematics, computer science, and neuroscience, ensuring a well-rounded AI education. Additionally, CAS collaborates with leading enterprises like Huawei and Alibaba to establish joint laboratories, enabling students to work on industry-grade projects and accelerate the transition from research to real-world applications.

Zhejiang University

In recent years, Zhejiang University (ZJU) has seen a steady rise in AI research output on the global stage, producing top-tier talent and entrepreneurs, such as Liang Wenfeng, founder of DeepSeek. Analyzing the university's AI research strategy provides valuable insights for other institutions aiming to advance in this field.

(1) Strong Academic Foundation and Interdisciplinary Education

1. Cross-Disciplinary Integration

Zhejiang University has long prioritized multidisciplinary research, excelling in computer science, control science, information & communication engineering, statistics, and even medical sciences. Effective collaboration between its departments has enabled researchers to tackle AI's core challenges from diverse perspectives. Examples include:

- The College of Computer Science and the College of Electrical Engineering working together on smart grids and big data analytics.

- The Medical School and the Institute of Artificial Intelligence jointly researching intelligent diagnostics and medical imaging recognition, transforming interdisciplinary advantages into tangible research achievements.

2. Forward-Looking Research Directions

Zhejiang University has strategically aligned its AI research with global frontier technologies, establishing dedicated research teams and laboratories in deep learning, intelligent perception, natural language processing (NLP), robotics, and autonomous driving. The university actively participates in national technology initiatives, further solidifying its academic influence and research impact.

(2) Regional Advantages and Policy Support

(1) Leveraging Hangzhou's Digital Economy Hub

Located in China's Yangtze River Delta Economic Zone, Zhejiang benefits from a highly developed industrial ecosystem and logistics network, facilitating the rapid commercialization of AI technologies. Hangzhou, in particular, serves as a digital economy stronghold, with Alibaba laying a solid foundation during the internet boom. Emerging sectors like cloud computing, big data, and fintech now flourish, creating synergistic interactions between industry and academia, driving technological iteration and adoption.

(2) Government Support and Policy Incentives

Hangzhou has launched specialized technology innovation funds to support AI companies in core technology R&D, product commercialization, and market expansion. Enterprises meeting specific criteria can access substantial financial incentives, including:

- Hangzhou Intelligent Computing Center: A public computing power platform offering AI companies Ascend AI cluster resources. Firms can apply for "compute power vouchers", covering up to 30% of contract costs (higher for multimodal foundation model companies). The annual maximum subsidy per company is ¥8 million, with a city-wide budget of ¥250 million.

- High-level AI startup projects, such as the "5213 Plan," can receive up to ¥15 million in support. Leading AI teams can receive up to ¥20 million in funding.

- State-owned and private capital is guided to increase angel investment in AI projects through the "3+N" Hangzhou Fund Cluster. Publicly listed AI companies can receive up to ¥10 million in financial rewards.

Hangzhou has built a comprehensive support system from fundamental research to industrial implementation through a multi-dimensional policy combination of "compute power vouchers + financial subsidies + application deployment + talent ecosystem." Its core features include a balance of inclusiveness and precision, reducing costs for enterprises through public computing power while providing targeted incentives for leading companies and niche sectors; an application-driven focus, promoting deep integration of AI with industries such as manufacturing, healthcare, and cross-border e-commerce; and ecosystem collaboration, fostering an innovation loop through coordinated efforts among the government, enterprises, universities, and capital investors. These policies have not only accelerated technological breakthroughs among local AI companies, such as Shizai Intelligent's 70B model training, but have also attracted national and global industrial resources, reinforcing Hangzhou's position as China's leading AI city.

United States

University of California System

The University of California System (UC System) is composed of several world-renowned research universities, including Berkeley (UC Berkeley), Los Angeles (UCLA), San Diego (UCSD), and Santa Barbara (UCSB). These institutions consistently rank among the top globally in AI research publications and hold significant influence in academic impact, technological innovation, and industry incubation. This section analyzes the advantages of the UC System from a data-driven, quantifiable perspective.

(1) Massive Research Funding and Project Support

1. Federal Funding

- NSF (National Science Foundation): According to publicly available 2022 data, the UC System received approximately $630 million in NSF grants, with AI-related research accounting for about 15% ($94.5 million). For example, UC Berkeley's Berkeley Artificial Intelligence Research (BAIR) Lab received $18 million in NSF funding in 2021 for research on robotic learning and computer vision.

- DARPA (Defense Advanced Research Projects Agency): In 2023, UC San Diego's Machine Learning and Autonomous Systems Lab received $25 million from DARPA to develop AI systems for autonomous decision-making in battlefield environments.

- Department of Energy (DOE): UC Berkeley led the AI for Climate initiative, securing $32 million in DOE funding in 2022 to optimize energy distribution and carbon emission forecasting using AI.

2. Corporate Sponsorship

- Google: In 2020, UC Berkeley entered a five-year partnership with Google, securing a total investment of $50 million to advance research in natural language processing (NLP) and large-scale pre-trained models, including improvements to BERT.

- NVIDIA: Multiple UC campuses, including UCLA and UCSD, partnered with NVIDIA to establish a GPU-Accelerated Computing Joint Lab. In 2023, NVIDIA provided $20 million in research funding and hardware support to improve the parallel computing efficiency of deep learning frameworks.

3. California State Government Budget

The California AI Initiative: In 2021, the California state government allocated $250 million to support AI research, with the UC System receiving approximately 40% ($100 million). Funding was primarily directed toward research in medical AI, autonomous driving, and AI ethics.

(2) Leading Research Teams and Breakthroughs

1. Core Research Institutions and Labs

● UC Berkeley BAIR Lab: With over 50 full-time faculty members and 300 graduate students/postdocs, BAIR publishes more than 200 papers annually in top AI conferences (NeurIPS, ICML, CVPR). In 2023, it ranked first globally among universities in AI paper citations.

● UCLA VCLA Lab (Vision, Cognition, and Learning Lab): Over the past five years, it has published 120 papers in CVPR and has played a leading role in developing major international dataset competitions, including ImageNet and COCO.

● UC San Diego CSE Department: The deep learning team co-developed the AlphaFold 2.0 algorithm with DeepMind, achieving 92.4% accuracy in protein structure prediction. The research was recognized by Nature as the "Breakthrough of the Year."

2. Key Figures and Research Commercialization

● Turing Award Winners: UC Berkeley professors Stuart Russell, a pioneer in AI ethics and explainability research, and David Patterson, an expert in computer architecture and AI hardware optimization, have led multiple national AI projects.

● Patents and Technology Transfer: Over the past five years, the UC System has filed 1,500 AI-related patents, with a commercialization rate of approximately 20%. For example, UC Berkeley's autonomous driving patents were licensed to Cruise, generating $120 million in revenue.

(3) Talent Development and Industry Incubation

● Graduate Career Outcomes: Among UC Berkeley computer science graduates, approximately 35% join top Silicon Valley tech companies such as Google, Meta, and OpenAI, while 15% start their own ventures, including OpenAI co-founder Wojciech Zaremba, a UC Berkeley alumnus.

● Startup Support: The UC System's SkyDeck incubator at UC Berkeley fosters 50 AI startups annually, with total funding exceeding $1 billion. Notably, Aurora Innovation, an autonomous driving company from UC Berkeley, secured $530 million in investment from SoftBank.

● California AB 1576 Bill: Passed in 2022, this law mandates an annual $50 million budget to support AI joint labs between universities and enterprises, with the UC System receiving approximately 60% of the funding.

● UC Ventures Fund: The UC System's venture capital fund manages $250 million, focusing on AI and biotech investments, with individual investments ranging from $500,000 to $5 million.

(4) Policy and Infrastructure Support

1. California Government Policies

● Open Data Policy: Under the Public Data Access Act (AB 1360), the California government requires the release of over 100 public datasets in fields such as transportation, healthcare, and environmental science for AI research within the UC System.

● Tax Incentives: AI companies conducting R&D in California receive a 15% tax credit, while UC-affiliated startups receive an additional 10%. For example, Tempus Labs, a medical AI company, saved $12 million in taxes through its partnership with the UC System.

2. Computing Resources

● Supercomputing Centers: The UC System operates one of the largest academic computing clusters in the U.S., including UC Berkeley's Savio Cluster, which has a peak performance of 5.2 PetaFLOPS, and UCSD's Expanse Cluster, with a peak performance of 8.1 PetaFLOPS. These resources provide free or low-cost computing power for AI training.

● Quantum Computing Initiatives: UC Berkeley and IBM have partnered to establish the Quantum Computing and AI Integration Center, featuring an IBM quantum computer with 433 qubits. The center supports 50 AI-quantum crossover research projects annually.

The UC System secures over $300 million in annual AI research funding from federal, state, and corporate sources. Over the past five years, it has published more than 1,800 papers in NeurIPS, ICML, and CVPR, accounting for 12% of all AI papers from global universities. According to CSRankings, the UC System boasts five Turing Award winners, 120 academicians, and 18% of the world's top 100 AI scientists. Its success is driven by significant funding, world-class talent, and precise policy support. Most importantly, its deep integration with the Silicon Valley ecosystem cements its status as a global AI research powerhouse.

Germany

The Helmholtz Association is one of Germany's largest research institution networks, comprising 18 research centers and maintaining a globally leading position across multiple disciplines. As artificial intelligence (AI) becomes a core field in global technological competition, the Helmholtz Association has made significant advances in AI research. Over the past few years, its contributions to AI-related research, including high-impact publications, core algorithm development, and practical applications, have steadily increased. The association ranks among the top globally in AI research contributions in leading journals such as Nature and Science, as well as at major academic conferences such as NeurIPS, ICML, and CVPR.

(1) Multiple Sources of Funding

The Helmholtz Association receives substantial financial backing from national and European funding programs, industry collaborations, and specialized research funds.

Germany's federal funding plays a crucial role, with the Helmholtz Association accounting for 20% of the total federal research budget, making it one of Germany's key innovation drivers. In 2022, its annual budget was approximately €5.1 billion, a significant portion of which was allocated to AI research. The German government's National AI Strategy recognizes the Helmholtz Association as a pillar of AI development and provides comprehensive policy support. By 2025, the German government will invest €5 billion in AI research, with the Helmholtz Association expected to receive over 25% of this funding. By 2030, Germany aims to lead in industrial AI standardization to strengthen its global influence. Additionally, the government is providing access to over 10,000 specialized datasets, including European Earth observation data and high-speed medical data, for Helmholtz AI research.

Germany also provides dedicated research funds through the AI+X funding program, which is part of the National AI Strategy. Under this initiative, the Helmholtz Association receives approximately €50 million annually for research in AI fundamental algorithms and industrial applications.

The Helmholtz Association is also actively engaged in European funding programs, participating in Horizon Europe, from which it secured over €200 million in 2022 for AI research projects in collaboration with European universities and research institutions.

Industry partnerships also play a significant role. The association collaborates with major German industrial leaders such as Siemens, Bosch, and SAP to develop industrial AI and automation systems, attracting around €100 million in corporate research funding each year.

(2) Resource Integration and Interdisciplinary Collaboration

The Helmholtz Association is known for its strong interdisciplinary research approach, integrating AI into physics, life sciences, earth and environmental sciences, and energy research.

The Jülich Supercomputing Center operates JUWELS, one of Europe's most powerful supercomputers, with a computing capacity of 85 PetaFLOPS, providing robust infrastructure for AI algorithm training and large-scale data processing.

The Helmholtz AI Platform unifies resources across 18 research centers, forming a collaborative AI network focused on energy, healthcare, transportation, environment, and computational science.

Each research center has a distinct specialization:

German Cancer Research Center (DKFZ) focuses on medical AI, particularly in cancer image diagnostics.

German Aerospace Center (DLR) specializes in AI applications for autonomous driving and unmanned aerial systems.

Karlsruhe Institute of Technology (KIT) conducts research on deep learning algorithms and AI for strategic decision-making.

(3) Open Academic System

- The Helmholtz Association attracts top global researchers through the Helmholtz International Talent Program. Its AI research teams include scientists from over 40 countries, among them recipients of national scientific awards and internationally recognized AI experts.

- Each year, approximately 150 PhD students and postdoctoral researchers undergo training at the Helmholtz AI Research Platform, significantly enhancing its research and innovation capacity. A notable figure is Prof. Klaus-Robert Müller, a pioneer in deep learning and AI-driven medical diagnostics, who has led research in Explainable AI (XAI) for cancer diagnosis.

(4) Application-Driven Research

1. Medical AI

The German Cancer Research Center (DKFZ) has developed an AI-based early cancer detection tool that improves diagnostic accuracy by 30% through MRI and CT image analysis, significantly reducing misdiagnosis rates. This research, published in Nature Medicine (2022), has been cited over 500 times.

In genomics and AI analysis, the Helmholtz Research Center has developed AI models capable of processing genomic data at an accelerated rate, reducing the time required for large-scale genomic analysis from several months to a few days.

2. Energy and Climate AI

The Karlsruhe Research Center applies AI modeling to optimize wind and solar energy distribution, increasing renewable energy utilization by 15% annually. The German Research Centre for Geosciences (GFZ Helmholtz) uses deep learning and climate science datasets to develop AI-powered climate models, significantly improving the accuracy of global extreme weather predictions.

Industrial and Automation AI: The German Aerospace Center (DLR) has developed an AI navigation system for autonomous vehicles and drones, improving navigation accuracy in complex urban environments by 25%. The Helmholtz Association also collaborates with Bosch and Siemens in developing "Industry 4.0" AI-powered smart factories, where AI-driven automation has improved production efficiency while reducing labor costs by 30%.

United Kingdom

IMPERIAL

Imperial College London, a world-leading institution founded in 1907, consistently ranks among the top 10 global universities. Renowned for its cutting-edge research ecosystem, Imperial has emerged as a powerhouse in artificial intelligence innovation through its Data Science Institute, Hamlyn Centre for Robotic Surgery, and AI-driven healthcare initiatives. Notable achievements include developing neural networks for early cancer detection through medical imaging analysis, creating autonomous systems for urban mobility solutions, and advancing reinforcement learning models that outperform human operators in complex simulations. The college hosts the UK's first dedicated AI research accelerator, fostering collaborations between 50+ research groups across robotics, computational finance, and climate modeling. We propose a multidimensional analysis of Imperial College's AI capabilities using measurable performance metrics.

(1) Academic Excellence: Rankings, Output, and Influence

Imperial College London dominates global AI research through exceptional academic performance. Ranked 6th globally in the 2024 QS World University Rankings, its computer science programs attract elite talent. In 2023 alone, ICL published 1,142 AI papers (18.3% of total institutional output), with an average 28.1 citations/paper, more than double the global average. Key journals like Nature Machine Intelligence feature ICL contributions (38 papers in 3 years), while its researchers secured 23 spots on Clarivate's 2023 Highly Cited Scientists list. Collaborative labs amplify impact: the ICL-DeepMind Joint Lab produced 42 NeurIPS papers in three years, including two award-winning studies.

(2) Resource Investment: Funding and Infrastructure

Strategic funding underpins ICL's AI leadership. Annual research expenditure reached £117 million in 2022-2023, sourced from UK Government (48%), EU Horizon (20%), and industry partnerships (32%). Per-researcher funding (£386,000/year) far exceeds the UK average (£214,000). Major projects include the £32 million UKRI National AI Initiative (96.5% accurate lung cancer detection models) and NVIDIA's £15 million GPU cluster for training trillion-parameter models. The university also leverages 14 ERC Advanced Grants (€2.5-3.5M each) for cutting-edge projects like explainable surgical robotics AI.

(3) Talent and Ecosystem Synergy

ICL's talent pipeline combines elite recruitment and industry integration. Its 67 AI professors (including 9 Royal Society Fellows) mentor 312 doctoral students, who average 3.2 papers/year. The MSc AI program admits only 8.7% of applicants, yielding graduates with £68,000 starting salaries. Industry partnerships drive commercialization: collaborations with 86 firms (Google, Siemens Healthineers) and 37 spin-offs (£1.2B total valuation) bridge research and market needs. In 2023, AI patents (58 filings) and licensing revenue (£18.6M, +22% YoY) demonstrated scalable impact, such as a 98.2%-accurate ECG anomaly detector.

(4) Policy and Interdisciplinary Advantage

London's status as Europe's AI hub amplifies ICL's reach. The city hosts 1,200 AI firms (43% of UK total), with 240 near campus, while government policies like the Global Talent Visa recruited 73 AI experts in 2023. Tax incentives (230% R&D deductions) lower corporate R&D costs by 40%. Cross-disciplinary centers like the Hamlyn Centre (£47M for surgical robotics) and Energy Futures Lab (98% renewable grid efficiency) exemplify ICL's fusion of AI with medicine, climate science, and engineering. For instance, AI-optimized climate models cut simulation time by 85%, cited over 4,200 times.

II. Global AI Patent Research

(1) Global AI Patent Distribution

To define what qualifies as an AI patent, this study considers all invention patents related to machine learning, deep learning, supervised learning, reinforcement learning, and other AI-driven technologies (see Appendix 1 for detailed keyword sets), not only patents that use AI to create a novel effect but also inventions generated by AI. However, based on our preliminary research, Europe's AI patent standards differ from those of other economies as the European Patent Office does not consider mathematics, algorithms or AI per se patentable, but only applications that use those methodologies to create a novel effect, which may lead to significant discrepancies between Europe's patent data and its AI paper rankings. In this chapter, we focus on a head-to-head comparative study between China and the United States. Using the International Patent Classification (IPC) system from WIPO (World Intellectual Property Organization), AI-related patents are categorized under G06N (all AI-related patents) and specific sections of G06K (image and character recognition technologies).

A patent search and deduplication process was conducted using Web of Science, Patsnap, and Incopat databases. As of February 14, 2025, a total of 1.484 million AI-related patents have been identified.

From the above data, we can observe the following:

(1) China and the United States are the two largest AI patent-producing countries, significantly outpacing all other nations. Japan and South Korea form the second tier. European countries such as Germany, the United Kingdom, and France have similar AI patent numbers but lag far behind China, the U.S., and even Japan and South Korea.

(2) In terms of AI patents per million people, South Korea leads the world, with over 2,000 AI patents per million people, far surpassing other countries. Japan, the U.S., Israel, and Switzerland also have over 1,000 AI patents per million people, placing them among the global leaders.

Table 7 – Top 30 Countries/Regions in AI Patents

Rank	Country/Region	AI Patent Count	Patents per Million People
1	Mainland, China	529,591	367.8
2	United States	465,684	1,365.2
3	Japan	218,057	1,751.2
4	South Korea	118,207	2,317.9
5	Germany	29,926	360.6
6	United Kingdom	15,636	228.6
7	France	14,905	218.26
8	Canada	12,944	338.8
9	Netherlands	12,558	701.6
10	Israel	10,926	1,114.9
11	Switzerland	9,390	1,055.1
12	Sweden	7,012	667.8
13	Taiwan, China	5,545	232.0
14	Australia	5,346	200.2
15	India	4,460	3.1
16	Finland	4,193	762.4
17	Ireland	3,725	726.1
18	Italy	3,327	56.5
19	Singapore	3,114	552.1
20	Denmark	2,768	474.0
21	Belgium	2,304	197.4
22	Austria	1,824	200.2
23	Spain	1,455	30.6
24	Saudi Arabia	1,189	35.0
25	Russia	936	6.4
26	Norway	800	145.5
27	Luxembourg	706	1,103.1
28	Hong Kong ,China	683	91.1
29	New Zealand	666	129.8
30	Cyprus	403	330.3

(2) Global Distribution of AI Patent Institutions

Table 8 – Top 15 AI Patent Holders Globally

Rank	Institution/Organization	AI Patent Count	Country
1	IBM	17,702	United States
2	Tencent	12,380	China
3	Samsung Electronics	11,434	Korea
4	Google	8,176	United States
5	Canon Inc.	7,521	Japan
6	Baidu	7,316	China
7	Microsoft	6,523	United States
8	Huawei	6,470	China
9	Intel	6,279	United States
10	Mitsubishi Electronics	5,842	Japan
11	Apple	5,534	United States
12	Qualcomm	5,462	United States
13	Sony	5,451	Japan
14	Hitachi	5,124	Japan
15	Zhejiang University	4,786	China

IBM, as one of the world's oldest technology companies and also has been working on AI research for a very long time, currently holds the largest number of AI-related patents globally. In addition, China's Tencent and South Korea's Samsung rank second and third, respectively. Among U.S. companies, Google, Microsoft, Intel, Apple, and Qualcomm all appear in the top 15.

Notably, Zhejiang University is the only university among the global top 15 AI patent holders, demonstrating its outstanding achievements in AI technology commercialization.

As the highest-ranked Chinese company, this study conducts a case analysis on Tencent.

As one of China's highest-valued tech companies, Tencent benefits from long-term strategic investment, strong business integration, and an open ecosystem that fosters synergy.

1. R&D Investment: Billions in Funding and a Top Talent Pool

- Tencent ranks among the world's leading AI R&D investors. According to its latest financial report, annual R&D spending reached ¥61.4 billion ($8.6 billion), accounting for 11% of total revenue—a higher ratio than Alibaba (8.7%) and Meta (10%). As of June 2023, 74% of Tencent's workforce consisted of R&D personnel, with over 10,000 employees in AI-related teams, including its three core research divisions: Tencent AI Lab, YouTu Lab, and WeChat AI Team.

- Tencent's talent strategy follows a "world-class scientists + engineering teams" model. Leading AI figures include Dr. Zhang Zhengyou, Tencent's Chief Scientist and Director of AI Lab and Robotics X Lab (IEEE Fellow), and Jia Jiaya, former professor at The Chinese University of Hong Kong and head of YouTu Lab. Tencent's research teams have published over 900 papers at major AI conferences such as NeurIPS and CVPR and have won multiple top-tier AI competitions (e.g., ICDAR, VCR).

2. Broad Patent Portfolio with Strong Commercialization

Tencent's computer vision patents account for over 35% of its portfolio, covering image recognition and video analysis, supporting features like WeChat facial recognition payment and video processing. About 28% of its patents are related to natural language processing (NLP), powering applications such as WeChat Translation. Additionally, 18% of patents focus on voice interaction, integrated into Tencent Meeting and AI-powered customer service systems.

Tencent also leads in patent quality metrics. According to the World Intellectual Property Organization (WIPO) 2022 report, Tencent filed over 4,200 international PCT patents, with an approval rate of 72%—significantly above the industry average of 55%. One of its core patents, the "Multimodal Human-Computer Interaction System" (Patent No. CN113742016A), is under review in 20+ countries, including the U.S., Europe, and Japan.

3. Open Ecosystem: Investments and Academic Collaboration

Investment and Acquisitions: Between 2020 and 2023, Tencent invested in 67 AI companies, covering key sectors such as chips (Enflame Technology), autonomous driving (Momenta), and robotics (Dreame Technology). These investments have resulted in 1,200+ joint patents. Industry-Academia Partnerships: Tencent has joint research labs with Tsinghua University and Hong Kong University of Science and Technology, with over 180 collaborative projects, generating 430 patents. Developer Ecosystem: Tencent Cloud's TI AI platform provides access to 300+ AI models, attracting 1.6 million developers. The platform has facilitated patent generation for AI tools, including the Codis automated code generation system.

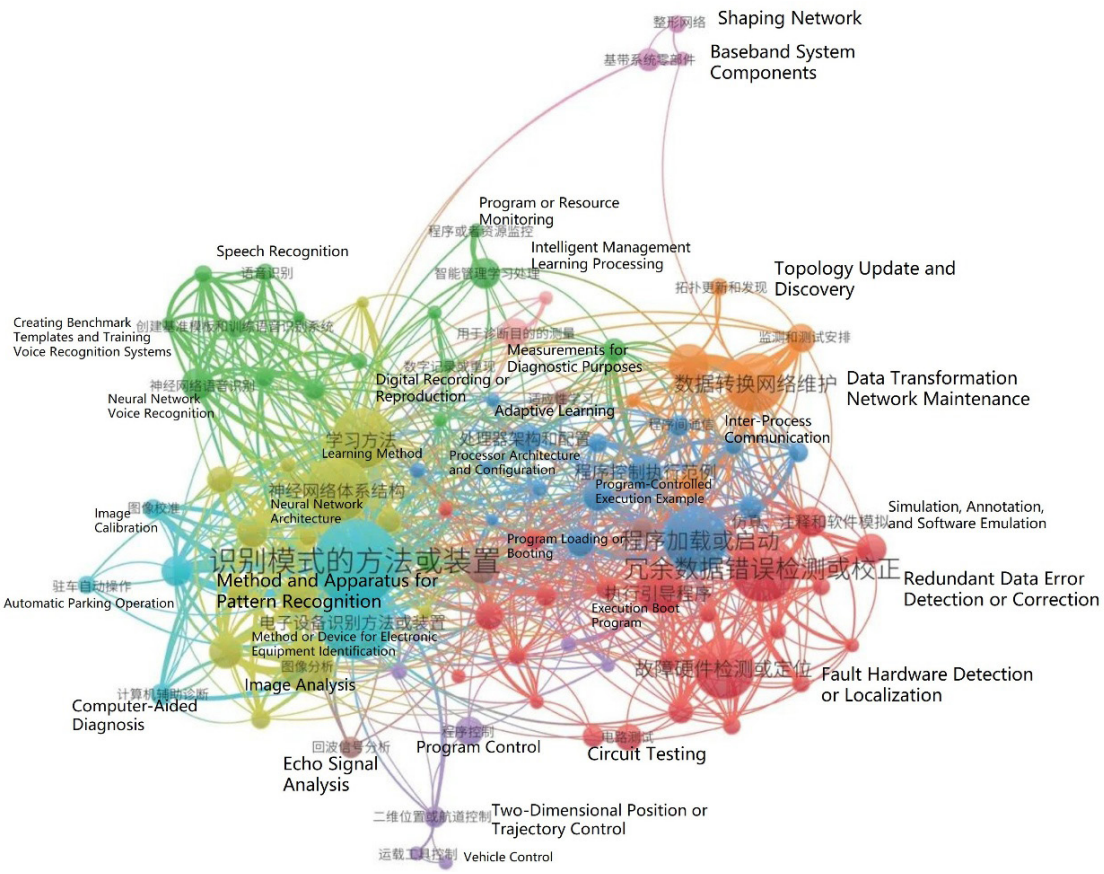
4. Policy Incentives: National AI Strategy Accelerates R&D

China's "New Generation Artificial Intelligence Development Plan" aims for global AI leadership by 2030. Tencent plays a key role, leading 16 national AI research projects, including the Ministry of Industry and Information Technology's (MIIT) Smart Voice Interaction System initiative. The company has received over ¥2.5 billion ($350 million) in government R&D subsidies. Tencent's AI technology is also widely adopted in government projects, such as Shenzhen's smart city infrastructure (optimizing traffic for 14 million residents) and Shanghai's digital governance system, further expanding Tencent's AI patent portfolio.

(3) AI Patent Co-Occurrence Analysis: China vs. the U.S.

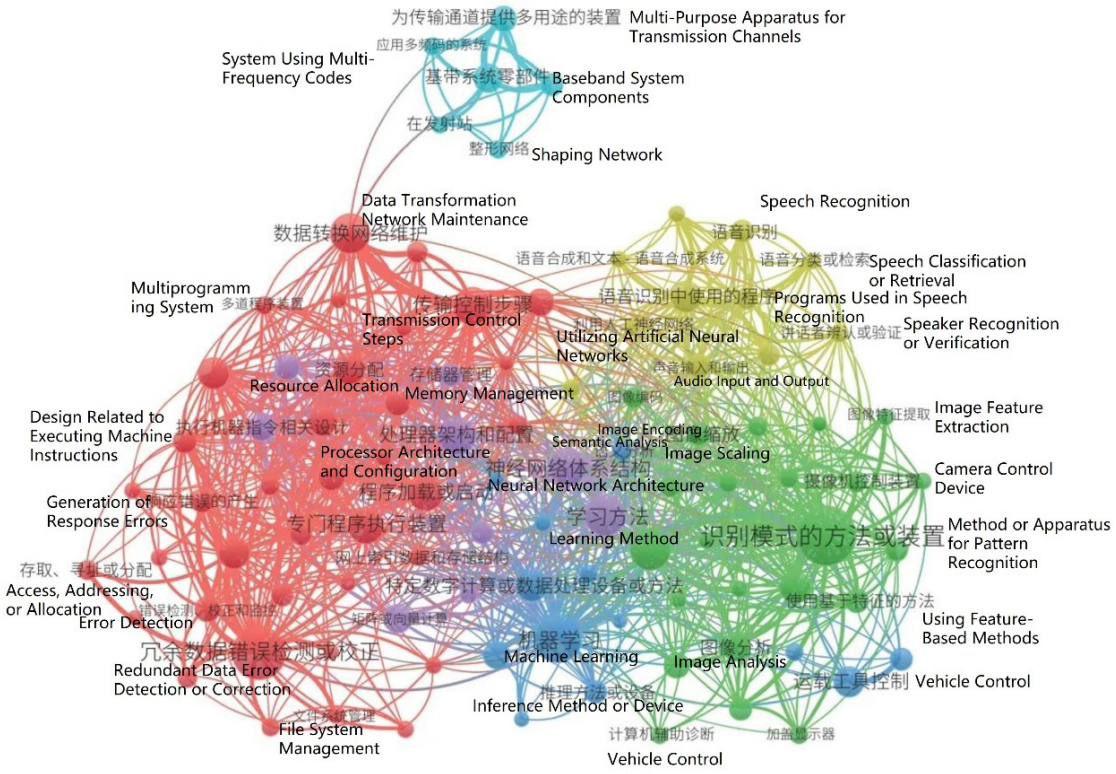
Through the above analysis, it is evident that China and the U.S. dominate the AI patent landscape. To further explore the differences in patent strategies between top AI enterprises in both countries, this study conducted a co-occurrence analysis of the 100 most frequently cited AI patents from leading Chinese AI firms. The results indicate that China's major AI companies have structured their patent portfolios into eight distinct technology clusters. The most prominent clusters focus on recognition methods and devices, speech recognition, hardware failure detection, and data error detection.

Figure 6 – Co-Occurrence Analysis of the Top 100 AI Patent Technologies from Leading Chinese AI Enterprises



The co-occurrence relationships among the top 100 most frequently cited AI patent technologies from leading U.S. AI enterprises reveal six distinct technology clusters. Compared to Chinese enterprises, which focus heavily on recognition methods, speech recognition, and data error detection, U.S. companies have a broader patent distribution across foundational and intermediate AI technologies. These include processor architecture and configuration, baseband system components, and machine learning.

Figure 7 – Co-Occurrence Analysis of the Top 100 AI Patent Technologies from Leading U.S. AI Enterprises



References

[1] Definition of AI Research Papers/Patents – The following keyword groups were used to define AI-related research:

Technical Topics:

Machine Learning, Deep Learning, Supervised Learning, Unsupervised Learning, Semi-supervised Learning, Reinforcement Learning, Policy Gradient, Q-learning, Deep RL;

Neural Networks:

Neural Network, Convolutional Neural Network (CNN), Recurrent Neural Network (RNN), Generative Adversarial Network (GAN), Variational Autoencoder (VAE), Diffusion Model, Long Short-Term Memory (LSTM), Transformer, Self-attention;

Natural Language Processing (NLP):

Text Classification, Sentiment Analysis, Machine Translation, QA System, Dialogue System;

Computer Vision:

Image Recognition, Object Detection, Image Segmentation, Video Analysis;

Speech Recognition & Synthesis:

Text-to-Speech, Voice Recognition;

Tools and Frameworks:

AI Frameworks: TensorFlow, PyTorch, Keras, MXNet

Deep Learning Tools: Neural Architectural Search, Model Compression, Quantization;

Data Processing: Data Augmentation, Feature Extraction, Data Preprocessing;

AI Chips & Hardware: GPU, TPU, Neuromorphic Computing;

This keyword list does not cover all AI-related research papers and patents exhaustively. However, for this study, it serves as a baseline for identifying AI-related publications and patents.

[2] The co-occurrence analysis in this paper references: Comparative Analysis of AI R&D and Innovation Between China and the U.S., authored by Yang Xiyi et al., published in Bulletin of the Chinese Academy of Sciences (BCAS), Issue 6, 2024, under the section "Science and Society."

[3] WIPO. (2023). Global AI Patent Landscape Report 2022. World Intellectual Property Organization.

[4] Lee, K., & Wong, C. Y. (2023). AI Industrial Policies and Global Power Dynamics. Nature Machine Intelligence, 5(4), 287-299.

[5] Zhang, W., et al. (2022). China vs. the U.S.: A Bibliometric Analysis of AI Research Outputs. Proceedings of the National Academy of Sciences, 119(12).

[6] European Commission. (2023). AI Watch: Benchmarking AI Development in the EU. Publications Office of the EU.

[7] Cockburn, I., et al. (2022). The Global AI Talent Tracker. MIT Sloan School Working Paper.

[8] Floridi, L., et al. (2023). Ethical AI Governance and National Competitiveness. Science, 379(6638), 1108-1111.

[9] Allen, G., & Husain, A. (2021). AI and the Future of Warfare. Center for Security and Emerging Technology.

[10] Howell, A., et al. (2023). AI Chip Dominance: A Geopolitical Analysis. IEEE Micro, 43(3).

[11] UNCTAD. (2022). AI Readiness in Developing Countries. United Nations Conference on Trade and Development.

[12] McKinsey Global Institute. (2023). The State of AI in 2023: Adoption and Competitive Advantage. McKinsey & Company.

[13] Zhou, Y., et al. (2022). Open Source AI and National Competitiveness. NeurIPS 2022 Workshop on AI & Society.

[14] Preskill, J. (2023). Quantum Machine Learning and National Security Priorities. PRX Quantum, 4(2).

[15] Wägner, C. S., et al. (2022). Global AI Research Collaboration Patterns. Scientometrics, 127(9).

[16] OECD. (2023). SMEs in the AI Ecosystem: A Cross-Country Analysis. OECD Digital Economy Papers.

[17] Hintze, M., & Schwarz, P. M. (2021). Data Localization Laws and AI Development. Harvard Journal of Law & Technology, 35(1).

[18] Jin, D., & Lee, H. (2023). AI Competition in East Asia: South Korea, Japan, and China. Asian Journal of Innovation and Policy, 12(1).

[19] CB Insights. (2023). Global AI Investment Report 2023.

[20] Jobin, A., & Vayena, E. (2022). Divergence in AI Ethics Standards: Implications for Global Competition. AI & Society, 38(2).

[21] Topol, E. J., et al. (2023). National Healthcare AI Capacity Index. The Lancet Digital Health, 5(4).

[22] Cath, C., et al. (2022). AI Policy Toolkit for National Competitiveness. Stanford HAI White Paper.

International Finance Forum（IFF）

The IFF is an international, independent, non-profit, non-governmental organization. It was founded in October 2003 by G20 countries and international organizations such as the United Nations, the World Bank, and the International Monetary Fund, and is a high-level permanent institution for dialog and multilateral cooperation in the field of global finance. The IFF is also known as the 'F20 (Finance 20)'.

The IFF's goal is to establish a platform for strategic dialogue, exchange and cooperation, practical innovation, academic research, and talent cultivation in fields such as the global economy, finance, and public policy through an international, market-oriented, and professional operating mechanism, as well as to promote the world of financial services along with comprehensive and sustainable development.

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