Global Innovation Hubs Index 2025

清华大学产业发展与环境治理研究中心
CIDEG
Center for Industrial Development and Environmental Governance, Tsinghua University

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Executive Summary

In 2025, artificial intelligence (AI) investment and applications have gained strong momentum against the backdrop of a slowdown in global investment and talent flow, highlighting further polarization of the global innovation landscape. Trade conflicts, fragmented investment flows and geopolitical uncertainties have driven supply chain regionalization and heightened global technological race. Amid these shifts, scientific and technological innovation continue to provide new drivers for global development. The Global Innovation Hubs Index (GIHI) — developed by the Center for Industrial Development and Environmental Governance (CIDEG) at Tsinghua University, with data services and translation support from Nature Research Intelligence, has been tracking and analysing year-on-year changes and the latest trends in global innovation since 2020. The GIHI2025 continues to apply scientific, objective, independent and impartial principles to evaluate global innovation hubs (GIHs) using three indicators — research innovation, innovation economy and innovation ecosystem — providing a reference for policymakers, entrepreneurs and practitioners.

The GIHI2025 top 20 cities/metropolitan areas overall are San Francisco-San Jose, New York MA, Beijing, Guangdong-Hong Kong-Macao Greater Bay Area, London MA, Boston MA, Tokyo MA, Paris MA, Baltimore-Washington, Shanghai, Seoul MA, Singapore, Seattle-Tacoma-Bellevue, Munich, Los Angeles-Long Beach-Anaheim, San Diego MA, Chapel Hill-Durham-Raleigh, Chicago-Naperville-Elgin, Dallas-Fort Worth and Amsterdam MA.

The following conclusions have been made in the GIHI2025:
First, the global innovation landscape is becoming increasingly multi-polarized, with leading cities/metropolitan areas gaining more competitive edge. The GIHs are mainly located along the east and west coasts of North America, the 'Blue Banana' zone in Europe, China, Japan and South Korea.(1) The strengths of the leading cities/metropolitan areas are becoming even more prominent. For example, San Francisco-San Jose has ranked first for six consecutive years, with New York MA and Beijing ranking second and third, respectively, for four consecutive years. Guangdong-Hong Kong-Macao Greater Bay Area has risen to the fourth spot. (2) North American cities/metropolitan areas are leading among the first-tier GIHs and are moving up the rank in general. Among them, Denver MA and Phoenix MA are rising rapidly, driven by AI industrialization and a resurgence of semiconductor investment returning to the United States. (3) European cities/metropolitan areas continue to take the lead in innovation ecosystem, with ten cities/metropolitan areas gaining higher rankings. (4) Asian cities/metropolitan areas benefit from progress in research innovation and innovation economy, showing the strongest development momentum, with 20 cities/metropolitan areas catching up in the rank. (5) A total of 13 Primary Hotspots — which are leading urban innovation clusters — is identified worldwide, which are highly overlapped geographically with global megaregions. The Primary Hotspots spread in a gradient way, which gather innovation elements, such as world-class universities and innovative enterprises, locally while radiating influence to neighboring cities. For example, the United States is led by the California megaregion on the west coast and the megaregion on the northeast coast, empowering both Cascadia Megaregion and Texas Triangle Megaregion. The 'Blue Banana' megaregion in Europe, which spans from northern Italy to the northwest of England, encompasses densely populated and industrialized areas. This megaregion is closely integrated with surrounding functional corridors to form a highly connected transnational network. In Asia, east Asia is leading the innovation landscape, extending influence to secondary hotspots in southeast Asia.

Second, the development patterns of cities/metropolitan areas in the United States, Europe and China show differentiated advantages, and mini-hubs have carved out unique and specialized development paths despite their relatively small scale. (1) The United States maintains a comprehensive lead thanks to its full-chain innovation pattern. It shows a balanced development across all dimensions and ranks highest on average, which reflects its systematic strength from knowledge sourcing to industrial application. Europe leverages its mature innovation ecosystem to drive simultaneous and steady progress in both research and industry. China has established strong sourcing capability for science to drive industrial upgrading and ecological refinement. Beijing, Guangdong-Hong Kong-Macao Greater Bay Area and Shanghai continue to lead in development, while second-tier cities, such as Nanjing, Hangzhou and Wuhan, are catching up rapidly. With sustained investment in public science by the central and local governments, China is transitioning from 'scale expansion' to 'quality enhancement'. (2) Cambridge, Basel and Geneva are the top three mini-hubs. Cambridge, Basel and Oslo continue to rank top in research innovation, innovation economy and innovation ecosystem, respectively. Through focused functionality and embedded networks, these small-scale mini-hubs leverage their unique functional spaces — such as university towns, specialized industrial clusters and international gateways — to deliver distinctive innovation advantages.

Third, in research innovation, cities/metropolitan areas in Europe and the United States continue to dominate with profound research legacy, while Asian cities/metropolitan areas, especially those in China, demonstrate strong growth momentum in science and technology human resources, as well as in knowledge creation. It forms a dual-track pattern that features the lead of Europe and the United States, and the rise of Asia. Cities/metropolitan areas in the United States have significant advantages in top talent retention, high-performance computing and sourcing capability for original innovation. For example, Boston MA, San Francisco-San Jose and New York MA have gathered far more winners of top scientific awards than European and Asian cities/metropolitan areas combined. The overall ranking in research innovation for Chinese cities/metropolitan areas has improved, thanks to the expansion of research labour force and the increasing influence of scientific papers in societies and industries. Beijing comes first in research innovation globally, leading in the number of active researchers (per million people) and the total citations from patents, policy reports and clinical trials. Meanwhile, for Nanjing, Wuhan, Chengdu and Hangzhou, the total citations from patents, policy reports and clinical trials are growing rapidly, and the impact of basic research on technological innovation, policy making and medical practice continues to increase.

Fourth, in innovation economy, competition between regions is becoming increasingly fierce, presenting a trend of leading by top performers and competing on multiple fronts. AI has become an important engine for global economic recovery. In terms of highlighted cities/metropolitan areas, San Francisco-San Jose has a huge lead with its comprehensive strengths as a dominant global innovation hub. Guangdong-Hong Kong-Macao Greater Bay Area has shown strong growth and jumped to the second place this year thanks to its AI technology. The area leads the world with 9,535 AI PCT patent applications. Hangzhou enters the global top 20 for the first time and is among the top three in China in the total number of valid patents. Its leading enterprises help drive the agglomeration of AI industry, demonstrating a typical development path for emerging innovation cities. In terms of regional competition, North America is taking the lead, driven by its innovative enterprises and rich experience in high-end manufacturing. Asia, supported by strong capability in science and technology, active patent output and a booming new economy, is rising more rapidly. It boasts the largest number of cities/metropolitan areas on the list, with leading cities/metropolitan areas showing prominent global competitiveness and other cities/metropolitan areas catching up quickly.

Fifth, in innovation ecosystem, cities/metropolitan areas in the United States are leveraging a vibrant AI industry to attract more venture capital. Leading Asian cities/metropolitan areas stand out in openness and collaboration, and European cities/metropolitan areas excel in profound innovation culture and increasingly optimized public service. Meanwhile, global capital investment and talent flow are slowing down. San Francisco-San Jose has seen a 111% increase in venture capital driven by the AI industry, and has enhanced its strength in support for start-ups together with New York MA and Denver MA. Among Asian cities/metropolitan areas, Singapore and Tokyo MA have performed well in attracting foreign investment, while Beijing and Guangdong-Hong Kong-Macao Greater Bay Area are among the top in the world in paper co-authorship network centrality. Europe demonstrates accumulated strength in public services and innovation culture, with London MA and Amsterdam MA maintaining leading positions in digital governance and cultural resources. Foreign direct investment (FDI) rebounds slightly globally, with the United States and Asia experiencing particularly strong growth. However, Europe has declined slightly due to geopolitical uncertainty. Venture capital remains cautious, and the AI industry has become the main destination of venture capital inflow. Investors prefer mature projects with better prospect, and start-ups are under mounting pressure of financing. Faced with global uncertainties, the UAE, India and some cities/metropolitan areas in the United States bucked the trend to attract professional talent. The number of international flights has recovered significantly compared with the pre-COVID level. Cities/metropolitan areas in Europe and the Middle East have relatively higher flight density, and the Asia-Pacific region shows noticeable recovery.

Finally, the GIHI2025 also features two special focus sections, focusing on two cutting-edge fields. The following insights have been drawn:
In the field of quantum science and technology, global competition in theoretical innovation and technological exploration has deepened. In terms of theoretical innovation, the global quantum field is currently dominated by China, the United States, and the European Union. China leads in the total number of research papers and the size of talent pool, with Beijing and Hefei becoming important hubs for high-quality output. Boston MA and New York MA in the United States play a key role in theoretical breakthroughs and frontier exploration. In terms of technological innovation, quantum computing has become a key technology area in patent landscapes. Cities/metropolitan areas such as New York MA, San Francisco-San Jose, Beijing and Hefei are very active performers and have built up a diverse ecosystem that includes both government-led and enterprise-driven innovation. The future market is expected to see explosive growth, but it also faces profound challenges in theory and engineering. Geopolitical factors are increasing the barriers to equipment and standards in quantum technology, leading to fragmented cross-border research and industrial cooperation, thereby constraining overall development.

Executive Summary

In the field of controlled nuclear fusion, it has entered a phase of rapid development for technological innovation and commercialization. The number of new patent applications between 2020 and 2024 is more than doubled compared with the previous number combined. Chinese GIHs are leading in patent portfolio, while the United States has a first-mover advantage in commercialization. By development paths, China relies both on national strategic forces in science and technology and on new national systems to drive synergy in research and development (R&D). The United States follows a diversified technology path that is driven by active innovation capital. Europe gathers global resources through big science programs. In the future, AI is expected to speed up breakthroughs in plasma confinement and high-performance material selection, significantly improving R&D efficiency. Given increasingly fierce competition, promoting complementarity and open cooperation among GIHs is still a vital path to accelerate the commercialization of controlled nuclear fusion and achieve energy independence.

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Research Team

Principal Investigator

Chen Ling	Professor, School of Public Policy and Management, Tsinghua University; Director, Center for Industrial Development and Environmental Governance (CIDEG), Tsinghua University; Member of Directors, Chinese Association of Science of Science and Science & Technology Policy Research

Team Members

Sun Xiaopeng	Center for Industrial Development and Environmental Governance, Tsinghua University
Wang Tianxiang	Center for Industrial Development and Environmental Governance, Tsinghua University
Li Junchao	Center for Industrial Development and Environmental Governance, Tsinghua University
Lai Liqin	School of Public Policy and Management, Tsinghua University
Huang Zhanglong	School of Public Policy and Management, Tsinghua University
Zhang Mizhi	Shanghai Institute for Science of Science
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Project Coordinators

Pan Shali	Center for Industrial Development and Environmental Governance, Tsinghua University
Li Fangfang	Center for Industrial Development and Environmental Governance, Tsinghua University
Miao Xinzhu	Center for Industrial Development and Environmental Governance, Tsinghua University
Cen Lichao	Springer Nature
Yan Zijun	Springer Nature
Wang Xiaoxia	Springer Nature
Ding Sijia	Springer Nature

Layout & Design

Zhao Xinwu	Springer Nature
Sou Nakamura	Springer Nature

Translation Services

Jolie Wu	Springer Nature
Amanda Rider	Springer Nature
John Pickrell	Springer Nature

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Introduction

In 2025, scientific and technological innovation remains closely related to productivity improvement, institutional reconstruction and global competition. Generative AI is increasingly embedded into scientific research, industry and public services, driving knowledge creation, industrial upgrading and the reshaping of governance models. Scientific and technological innovation is critical for competitiveness and new momentum. The Global Innovation Hubs Index (GIHI) uses objective data to trace the overall performance and rankings of leading global innovation hubs (GIHs) in areas such as scientific research, technological innovation and support for start-ups. It explores the key drivers behind innovative transformation, revealing key elements and pathways for cities to deliver valuable innovation, while offering reference for policymakers about the development of GIHs.

In line with the tradition established in the GIHI2020 report, for the GIHI2025 we have continued to apply scientific, objective, independent and impartial principles in evaluating 113 GIHs and 12 mini-hubs, including newly added cities such as Riyadh, Cairo, Shenyang, Nanchang and Kunming compared with the GIHI2024 (see Appendix IV for the GIH selection process). While adhering to the selection principles, the GIHI2025 adapts to the current scientific development and takes into account input from industry experts, media figures and the public. Some adjustments have been made to the assessment metrics and focus sections as follows.

First, to improve its scientific rigour and forward-looking perspective, the index system has been optimized for GIHI2025. For three of the patent-related level-3 indicators, quantum information and controlled nuclear fusion have been added to the previous four areas, and the search strategy defined in the patent field is disclosed in the appendix. For the level-3 indicator of 'number of patent cooperation treaty (PCT) patents', the statistical period has been extended from one year to five years to avoid fluctuations caused by single-year data and present the cyclicality and accumulation of R&D activities more accurately. These changes are intended to further ensure the authority, objectivity, comprehensiveness and immediacy of the indicators. See Appendix I for a more detailed explanation of these adjustments.

Second, we focus on two frontier fields with transformative potential and strategic significance: quantum science and technology, and controlled nuclear fusion. For quantum science and technology, the GIHI2025 analyses the progress of basic research and technology development, reveals the capital investment and talent reserve in different regions, and identifies the risks and challenges in this field. For controlled nuclear fusion, the GIHI2025 reveals the geographic distribution of technology patents, the key role of large scientific facilities in regional technology development, the latest trends and key players in China, the United States, Europe and Japan, as well as the technological progress and characteristics of key regions and institutions. It also analyses the investment, financing, risks and challenges in the field.

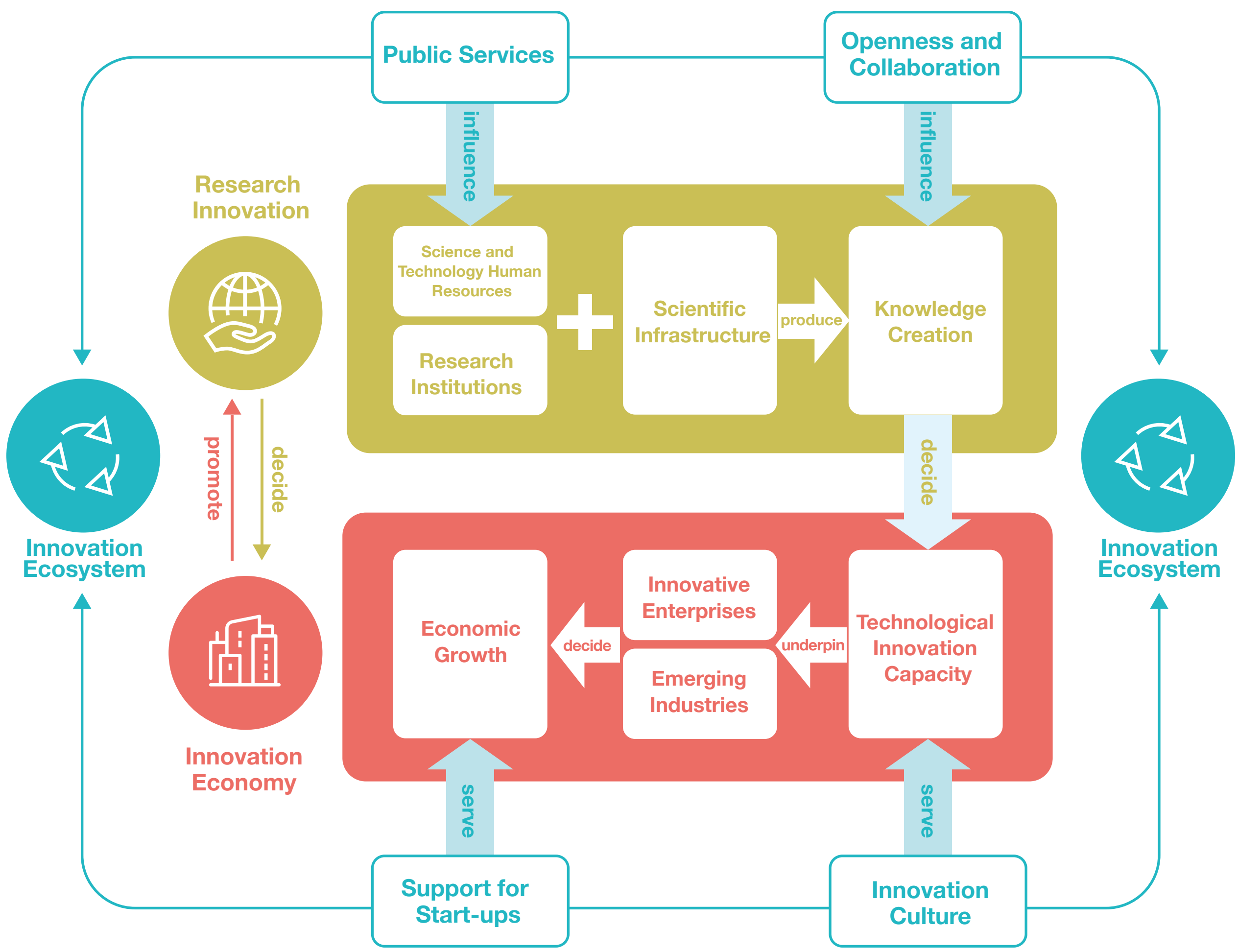
1. The Global Innovation Hubs Index system

1.1 A conceptual model for GIHI

Global innovation hubs (GIHs) are defined as cities or metropolitan areas that lead the flow of global innovation elements and influence the efficiency of resource allocation, drawing on their unique advantages in science and technology innovation. With advanced technological and innovative resources, GIHs are also hubs of scientific activity, and play an important role in the global innovation landscape. The GIHI assesses the development of GIHs in three dimensions — research innovation, innovation economy and innovation ecosystem. The conceptual model for GIH assessment is shown in Figure 1.

FIGURE 1

A conceptual model for GIH assessment



1.The Global Innovation Hubs Index system

1.2
The index system

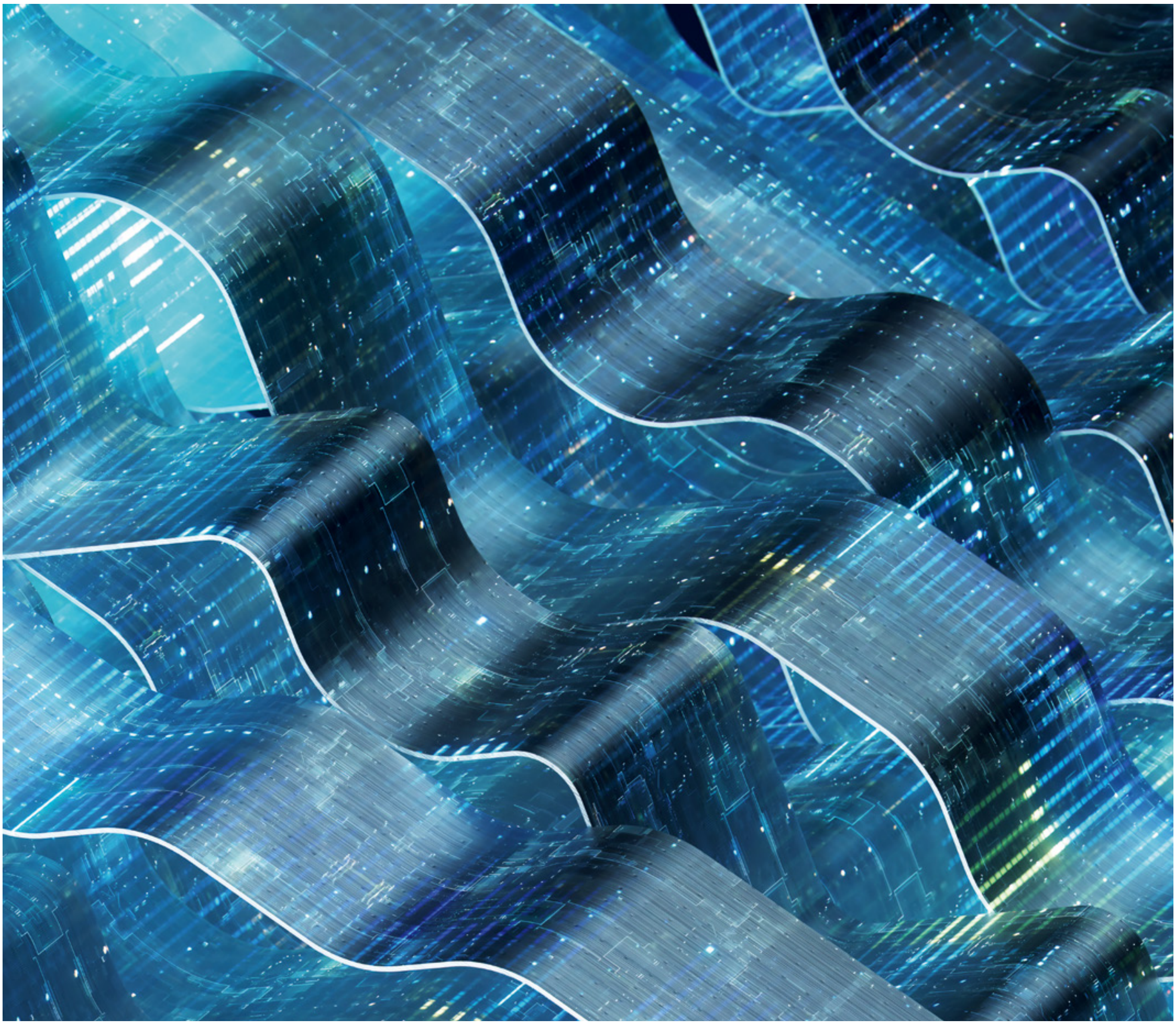
The GIHI system is shown in Table 1.

TABLE 1

Global Innovation Hubs Index (GIHI) system

Level-1 indicator	Level-1 indicator weight	Level-2 indicator	Level-2 indicator weight	Level-3 indicator
A Research Innovation	30%	A1. Science and Technology Human Resources	30%	01. Number of active researchers (per million people)
				02. Number of winners of top scientific awards
		A2. Research Institutions	30%	03. Number of world-leading universities
				04. Number of top 200 world-class research institutions
		A3. Scientific Infrastructure	10%	05. Number of large scientific facilities
				06. Number of top 500 supercomputers
		A4. Knowledge Creation	30%	07. Number of highly cited papers
				08. Total citations from patents, policy reports and clinical trials
B Innovation Economy	30%	B1. Technological Innovation Capacity	25%	09. Total number of valid patents (per million people)
				10. Number of patent cooperation treaty (PCT) patents
		B2. Innovative Enterprises	25%	11. Number of leading innovative companies
				12. Number of unicorn companies
		B3. Emerging Industries	25%	13. Market value of high-tech manufacturing companies
				14. Revenue of listed companies in new economy industries
		B4. Economic Growth	25%	15. GDP growth rate
				16. Labour productivity
C Innovation Ecosystem	40%	C1. Openness and Collaboration	25%	17. Paper co-authorship network centrality
				18. Patent collaboration network centrality
				19. Foreign direct investment (FDI)
				20. Outward foreign direct investment (OFDI)
		C2. Support for Start-ups	25%	21. Venture capital investment (VC)
				22. Private equity (PE)
				23. Number of registered lawyers (per million people)
		C3. Public Services	25%	24. Number of data centres (public clouds)
				25. Broadband connection speed
				26. Number of international flights (per million people)
				27. E-governance level
		C4. Innovation Culture	25%	28. Professional talent inflow (per million people)
				29. Residents' average years of schooling
				30. Number of public libraries and museums (per million people)

The GIHI index system is shown in Table 1. Research innovation, innovation economy and innovation ecosystem constitute level-1 indicators and the key elements of each area make up level-2 indicators of the GIHI system. The weight of GIHI is allocated as follows: the total weight for level-1 indicators is 100%, with 30% for research innovation, 30% for innovation economy and 40% for innovation ecosystem, respectively. The linear-weighted-sum method is used to calculate the overall scores. See Appendix II for the definitions and data sources of GIHI indicators and Appendix III for information about data standardization.



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1.3 Subjects of evaluation

This report uses three international city rankings — the Nature Index 2024 Science Cities, the 2024 Global Cities Index by Kearney, and the Global Innovation Index 2024 by WIPO. Cities/metropolitan areas with strong innovation capabilities were evaluated, which totaled 125 cities/metropolitan areas. Among these, 12 cities/metropolitan areas with a population of less than one million were evaluated separately as mini-hubs. The remaining 113 cities/metropolitan areas are included in the main assessment and the report presents evaluation results for the top 100 ones (see Appendix IV for the GIH selection process).

These 125 cities/metropolitan areas are from 40 countries/regions in six continents, covering 380 major administrative divisions. Among them, there are 48 Asian cities, 38 European cities, 31 North American cities, four Oceanian cities, two South American cities and two African cities. These cities/metropolitan areas are home to the top innovation resources and output in the world, and they stand out in the research innovation, innovation economy and innovation ecosystem indicators. Accounting for only 11.9% of the world's total population, these cities/metropolitan areas boast 139 world-leading universities, 164 of the top 200 world-class research institutions, 1,503 leading innovative companies, and 1,523 unicorn companies valued at more than US$1 billion. They have attracted 277 winners of top scientific awards, such as Nobel Prizes, the Turing Award and the Fields Medal.

2. The GIHI ranking

2.1 Ranking results

The GIHI2025 ranking is shown in Table 2.

TABLE 2

Overall ranking of the top 100 Global Innovation Hubs (GIHs)

City/metropolitan area	Overall		Research Innovation		Innovation Economy		Innovation Ecosystem	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank
San Francisco-San Jose	**100.00**	1	92.14	4	100.00	1	100.00	1
New York MA	**87.10**	2	96.46	2	73.62	5	90.99	3
Beijing	**85.19**	3	100.00	1	76.45	4	77.04	12
Guangdong-Hong Kong-Macao Greater Bay Area	**82.62**	4	89.64	5	79.02	2	76.56	16
London MA	**81.43**	5	83.35	7	67.78	14	95.40	2
Boston MA	**81.08**	6	92.71	3	71.03	7	79.49	6
Tokyo MA	**77.16**	7	74.24	12	77.10	3	78.69	7
Paris MA	**75.74**	8	79.35	8	68.60	13	80.48	5
Baltimore-Washington	**75.22**	9	84.75	6	65.22	23	77.62	10
Shanghai	**74.64**	10	78.72	9	70.25	9	75.33	25
Seoul MA	**73.96**	11	71.13	17	73.16	6	77.38	11
Singapore	**72.76**	12	69.49	20	66.78	18	84.29	4
Seattle-Tacoma-Bellevue	**71.49**	13	68.23	30	71.02	8	75.66	23
Munich	**71.15**	14	71.01	18	66.47	19	77.89	9
Los Angeles-Long Beach-Anaheim	**70.72**	15	74.49	11	64.34	32	75.70	22
San Diego MA	**69.88**	16	68.21	32	67.01	17	76.16	19
Chapel Hill-Durham-Raleigh	**69.68**	17	73.40	13	64.75	27	72.98	33
Chicago-Naperville-Elgin	**69.62**	18	72.24	14	64.81	26	74.01	30
Dallas-Fort Worth	**69.25**	19	64.70	60	68.69	12	75.63	24
Amsterdam MA	**69.14**	20	68.02	33	64.16	34	77.98	8
Zurich	**68.98**	21	71.76	15	63.11	58	74.86	27
Dublin	**68.76**	22	63.79	66	69.51	10	73.91	31
Kyoto-Osaka-Kobe	**68.43**	23	67.96	34	68.86	11	69.19	55
Austin	**68.19**	24	65.07	57	66.28	20	75.22	26
Toronto MA	**68.10**	25	67.85	35	62.76	74	76.80	15
Nanjing	**67.92**	26	74.73	10	64.56	31	66.17	80
Copenhagen	**67.72**	27	68.89	24	63.86	42	72.92	34
Stockholm	**67.71**	28	68.50	27	64.64	29	72.21	38
Madrid	**67.42**	29	65.90	49	63.35	50	75.94	20
Denver MA	**67.37**	30	63.58	69	64.29	33	77.01	13

City/metropolitan area	Overall		Research Innovation		Innovation Economy		Innovation Ecosystem	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Houston MA	67.14	31	68.72	26	64.06	35	70.98	45
Philadelphia MA	67.02	32	68.73	25	63.58	45	71.24	43
Atlanta MA	67.00	33	69.15	22	63.32	54	71.10	44
Hangzhou	66.98	34	68.38	29	67.53	15	65.98	82
Phoenix MA	66.94	35	63.32	76	64.01	36	76.34	18
Rome	66.94	36	68.41	28	62.57	82	72.75	36
Helsinki	66.76	37	65.10	56	63.32	53	74.78	28
Milan	66.71	38	66.65	45	65.14	24	70.34	51
Taipei	66.48	39	66.22	48	66.06	21	68.81	59
Daejeon	66.48	40	67.29	38	67.05	16	66.22	78
Berlin MA	66.22	41	66.79	43	62.55	83	72.27	37
Wuhan	66.14	42	71.61	16	63.93	37	64.79	85
Frankfurt	66.13	43	62.95	81	62.85	69	75.76	21
Sydney	66.09	44	69.45	21	60.69	109	71.53	40
Melbourne	65.86	45	70.58	19	60.54	110	69.76	53
Pittsburgh	65.82	46	68.21	31	62.79	72	69.10	56
Vancouver MA	65.81	47	66.39	46	62.48	85	71.48	42
Hamburg	65.80	48	63.52	71	63.32	52	73.42	32
Barcelona MA	65.76	49	66.97	41	62.54	84	70.62	48
Dubai	65.68	50	60.00	113	63.33	51	76.87	14
Manchester	65.64	51	65.56	52	62.74	76	71.49	41
Montreal MA	65.61	52	67.36	37	62.07	97	70.36	50
Moscow	65.60	53	67.06	40	63.90	40	68.10	62
Minneapolis-Saint Paul	65.57	54	64.84	59	63.90	39	70.43	49
Miami MA	65.52	55	61.84	96	63.54	47	74.07	29
Nagoya MA	65.48	56	65.29	55	65.52	22	67.38	69
Abu Dhabi	65.28	57	60.92	108	61.96	98	76.52	17
Lyon-Grenoble	65.20	58	65.62	51	63.26	56	69.28	54
Vienna	64.69	59	65.63	50	62.95	66	68.09	63
Dusseldorf	64.66	60	61.12	104	63.07	62	72.77	35
Xi'an	64.64	61	69.13	23	62.57	81	64.61	86
St. Louis	64.47	62	65.01	58	62.94	67	68.07	64
Brisbane	64.45	63	66.23	47	60.00	113	70.79	46
Sao Paulo	64.43	64	64.25	64	61.51	105	70.77	47
Doha	64.32	65	62.17	89	62.13	92	71.83	39

2.The GIHI ranking

City/metropolitan area	Overall		Research Innovation		Innovation Economy		Innovation Ecosystem	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Chengdu	**64.27**	66	67.46	36	63.56	46	63.85	93
Hefei	**64.12**	67	66.75	44	63.61	44	64.10	90
Rotterdam	**64.02**	68	63.33	75	63.27	55	68.02	65
Cologne	**63.93**	69	63.17	79	62.58	80	68.86	58
Tel Aviv	**63.89**	70	62.76	83	62.09	95	69.87	52
Lisbon	**63.81**	71	63.29	77	62.12	94	69.00	57
Riyadh	**63.74**	72	62.26	87	65.13	25	65.69	83
Brussels	**63.67**	73	63.19	78	62.72	77	67.82	67
Warsaw	**63.65**	74	62.54	84	62.97	65	68.10	61
Gothenburg	**63.55**	75	63.50	72	62.99	64	66.72	75
Changsha	**63.54**	76	67.26	39	62.44	86	63.33	98
Tianjin	**63.51**	77	66.95	42	62.09	96	64.07	91
Perth	**63.46**	78	64.05	65	62.17	91	66.98	71
Bangkok	**63.45**	79	61.86	95	63.93	38	66.87	72
Changchun	**63.39**	80	65.35	54	64.63	30	61.86	108
Portland	**63.34**	81	61.79	98	62.63	78	68.44	60
Cincinnati	**63.34**	82	61.98	91	62.84	70	67.92	66
Jinan	**63.15**	83	64.59	61	63.83	43	63.08	100
Prague	**63.07**	84	63.58	70	62.32	90	66.03	81
Stuttgart	**63.06**	85	61.53	101	63.37	48	66.76	74
Qingdao	**62.96**	86	64.42	62	63.25	57	63.44	96
Suzhou	**62.89**	87	62.81	82	63.88	41	64.11	89
Budapest	**62.79**	88	61.89	94	62.89	68	66.18	79
Zhengzhou	**62.72**	89	63.49	73	63.07	61	63.94	92
Detroit MA	**62.61**	90	61.31	102	62.75	75	66.44	77
Buenos Aires	**62.51**	91	62.23	88	61.09	107	67.43	68
Chongqing	**62.50**	92	64.28	63	62.43	88	63.30	99
Las Vegas	**62.50**	93	60.08	112	62.82	71	67.35	70
Ankara	**62.45**	94	61.82	97	64.74	28	62.57	101
Mexico City	**62.44**	95	61.58	100	61.87	100	66.85	73
Bengaluru	**62.09**	96	60.80	109	63.00	63	64.98	84
Fuzhou	**62.00**	97	63.05	80	63.10	59	62.09	107
Kuala Lumpur	**61.97**	98	62.39	86	61.77	101	64.58	87
Harbin	**61.92**	99	65.37	53	60.77	108	62.56	102
Xiamen	**61.91**	100	63.41	74	62.43	87	62.35	103

2.2
Overall analysis

San Francisco-San Jose has been named the top ranked GIH for the sixth consecutive year, scoring much higher than other GIHs; New York MA ranks second again with a score of 87.10; Beijing comes in third with a score of 85.19; Guangdong-Hong Kong-Macao Greater Bay Area, and London MA rank fourth and fifth, respectively. The remaining top 20 cities/metropolitan areas are Boston MA, Tokyo MA, Paris MA, Baltimore-Washington, Shanghai, Seoul MA, Singapore, Seattle-Tacoma-Bellevue, Munich, Los Angeles-Long Beach-Anaheim, San Diego MA, Chapel Hill-Durham-Raleigh, Chicago-Naperville-Elgin, Dallas-Fort Worth and Amsterdam MA.

The top 20 spots in the overall ranking remain largely unchanged. San Francisco-San Jose, New York MA and Beijing have ranked in the top three for three consecutive years, and the rankings of leading cities are relatively stable with their excellent innovation systems and accumulation. Among them, Guangdong-Hong Kong-Macao Greater Bay Area has risen from the 6th in 2024 to the 4th in 2025, becoming a top GIH with significant upward momentum.

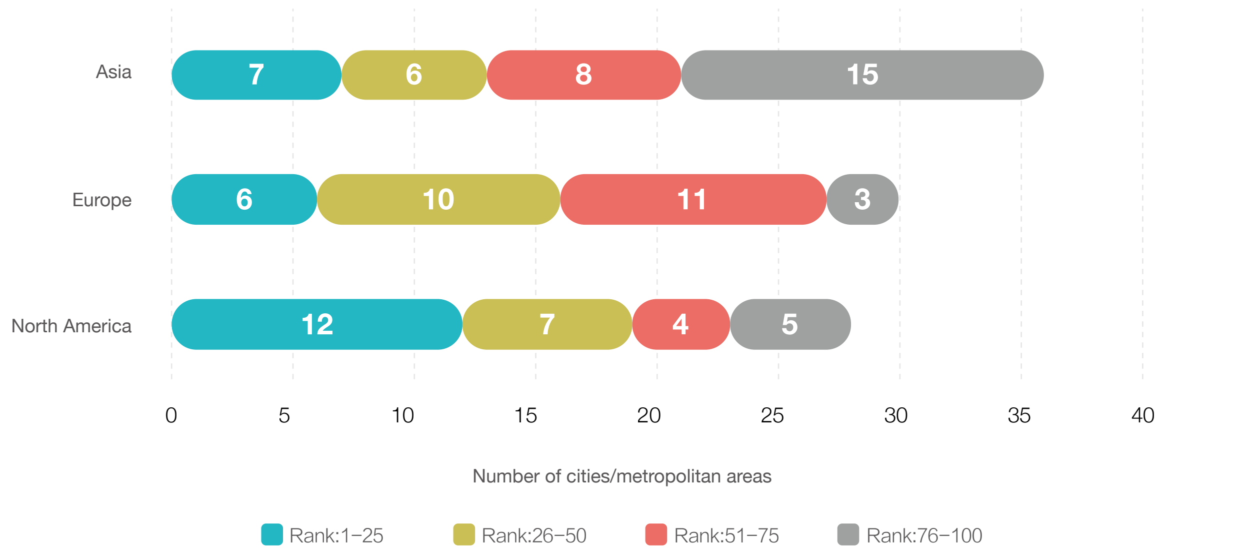
TABLE 3 **A comparison of the top 20 GIHs in overall ranking between 2023-2025**

City/metropolitan area	Rank 2025	Rank 2024	Rank 2023
San Francisco-San Jose	1	1	1
New York MA	2	2	2
Beijing	3	3	3
Guangdong-Hong Kong-Macao Greater Bay Area	4	6	6
London MA	5	5	4
Boston MA	6	4	5
Tokyo MA	7	9	7
Paris MA	8	8	9
Baltimore-Washington	9	10	8
Shanghai	10	7	10
Seoul MA	11	11	11
Singapore	12	12	12
Seattle-Tacoma-Bellevue	13	15	15
Munich	14	14	17
Los Angeles-Long Beach-Anaheim	15	13	13
San Diego MA	16	18	18
Chapel Hill-Durham-Raleigh	17	17	19
Chicago-Naperville-Elgin	18	16	14
Dallas-Fort Worth	19	22	16
Amsterdam MA	20	19	23

2.The GIHI ranking

FIGURE 2

Quartile graph of overall ranking for cities/ metropolitan areas in Asia, Europe and North America



A multi-polarized innovation landscape

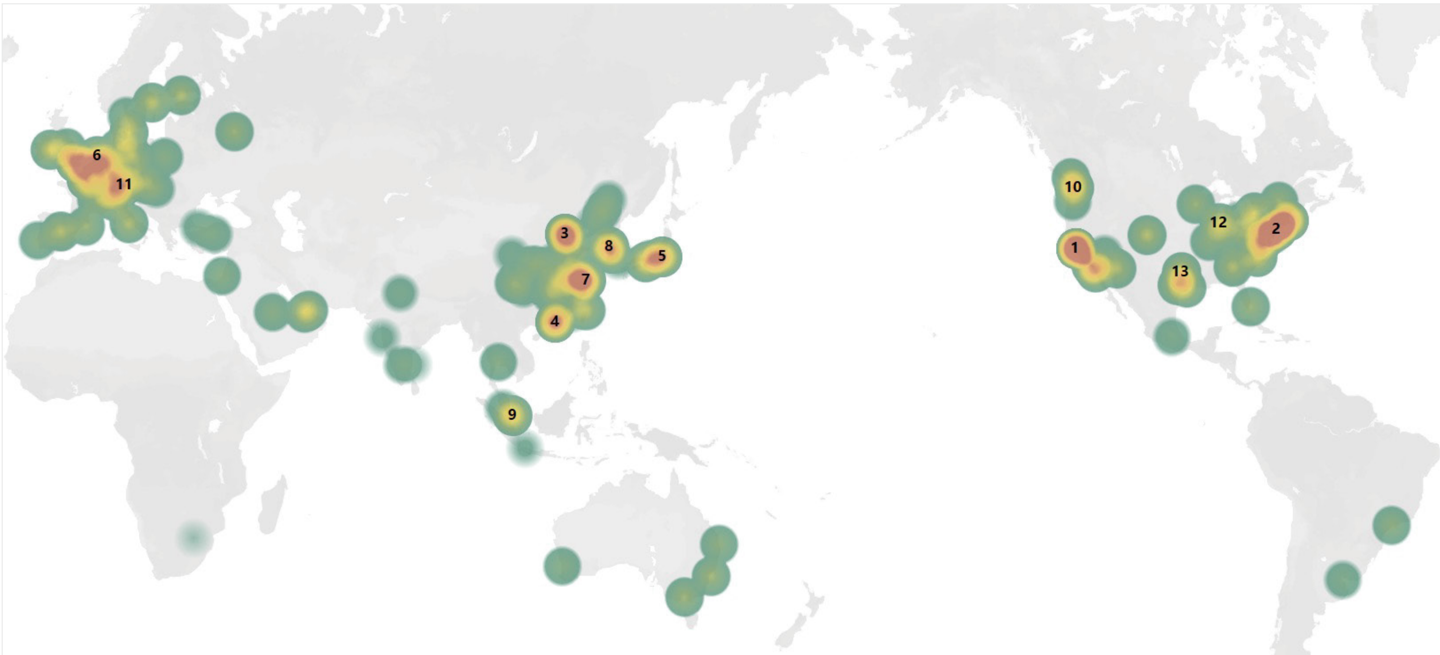
As shown in Figure 2, Europe and North America maintain an overall lead in the global innovation landscape, while Asian cities show strong growth momentum. North American cities/metropolitan areas dominate the top tier by taking 12 of the top 25 seats, showing significant advantage in quantity and outstanding innovation capability. Eleven North American cities/ metropolitan areas have risen in the overall ranking, with Denver MA (↑16) and Phoenix MA (↑13) making notable progress. These cities have benefited from improved innovation economy, a booming AI industry, and 64 new unicorn companies, which have led to rapid agglomeration of capital and talent, as well as growth in the market value of high-tech manufacturing companies. In addition, due to factors in geopolitics and industrial security, FDI reorientation, capacity reshoring and domestic reinvestment have helped to reshape the landscape of semiconductor, clean energy and high-end manufacturing industries across North America.

Europe has a robust middle tier, with nearly two-thirds of European cities/ metropolitan areas in the second and third tiers. The core functions of original innovation are mainly attributed to leading cities such as London MA, Paris MA, Zurich and Munich, which anchor and radiate influence with their mature regional collaborative systems. At the same time, the density of leading innovative companies and the relatively high labour productivity translate into sustained competitiveness for the core force. Overall, Europe has remained stable and progressive, with 10 European cities rising in the rankings, mainly due to their improved innovation ecosystem. For example, private equity (PE) investment in Rome and Dublin has increased significantly driven by improved expectations on M&As/exits.

Asian cities/metropolitan areas comprise the majority of the top 100 rankings, with top cities leading the way with the followers catching up with strong growth momentum. A total of seven Asian cities/metropolitan areas, including Beijing, Guangdong-Hong Kong-Macao Greater Bay Area, Tokyo MA, Shanghai, Seoul MA, Singapore and Kyoto-Osaka-Kobe, rank among the top 25, making Asia the most vibrant regions for innovation. Many Asian cities are led by these top ones, resulting in accelerated rise and the release of strong potential. 20 Asian cities rank higher compared with last year, and their overall performance is strongly supported by advances in both research innovation and innovation economy.

China's innovation hubs have strengthened their advantages, with 21 cities/metropolitan areas featured in the top 100 overall rankings, marking an increase of two cities. In terms of top performers, Beijing (3rd), Guangdong-Hong Kong-Macao Greater Bay Area (4th) and Shanghai (10th) continue to lead as high-level innovation hubs, ranking among the top 10 GIHs. Guangdong-Hong Kong-Macao Greater Bay Area has risen by two places compared with 2024. In addition, the overall innovation capabilities for Chinese cities continue to strengthen, with 14 cities ranking higher than the previous year. Among China's second-tier cities, Nanjing (↑6), Hangzhou (↑8) and Wuhan (↑5) have improved upon their 2024 positions, solidifying the core strength of this group.

FIGURE 3 Global hotspots of innovation



No.	Core city/metropolitan area
1	San Francisco-San Jose, Los Angeles-Long Beach-Anaheim, San Diego MA
2	New York MA, Boston MA, Baltimore-Washington, Chapel Hill-Durham-Raleigh
3	Beijing
4	Guangdong-Hong Kong-Macao Greater Bay Area
5	Tokyo MA, Kyoto-Osaka-Kobe
6	London MA, Paris MA, Amsterdam MA, Dublin
7	Shanghai

No.	Core city/metropolitan area
8	Seoul MA
9	Singapore
10	Seattle-Tacoma-Bellevue
11	Munich, Zurich
12	Chicago-Naperville-Elgin
13	Dallas-Fort Worth, Austin, Houston MA

Note: The numbering is irrelevant to the rankings of the cities/metropolitan areas.

2.The GIHI ranking

Analysis of global primary hotspots of innovation:

As shown in Figure 3, the GIHI2025 has identified 13 primary hotspots — which are leading urban innovation clusters — with high heat values globally through spatial clustering analysis. Higher heat values indicate stronger innovation capability of the core cities/metropolitan areas, which are surrounded by more well-performed innovation cities. Below the heat map, the table shows the leading innovation cities/metropolitan areas in each primary hotspot.

These primary hotspots are highly overlapping with the global megaregions spatially, such as the Californian megaregion on the west coast and the Boston-Washington corridor on the northeast coast of the United States, and the 'Blue Banana' zone in Western Europe. The megaregions are super urban networks composed of multiple metropolitan areas, which are highly integrated in economy, society, infrastructure and ecology. This regional synergy and integration lay a solid foundation for scientific and technological innovation. The red spots represent primary hotspots with the highest heat value and the strongest sourcing capability for innovation, as well as close and efficient cross-city collaboration networks. Spatially, the distribution of hotspots features a 'red core - yellow periphery' gradient. Leading cities/metropolitan areas aggregate innovation elements in the core areas, and have spillover and synergy effects on surrounding cities, such as China's Yangtze River Delta region.

Specifically, the red primary hotspots are spread across the United States, Europe, China, Japan and South Korea.

North America: Megaregions in east coast and west coast take the lead while the North and South boast multiple growth drivers.

North America is led by the California megaregion and the northeast megaregion. Inland areas are also trending up. On the one hand, the California megaregion has become a source of innovation in AI, semiconductors and biomedicine. They also boast top universities and venture capital ecosystems, which greatly facilitate the development of start-ups established by scientists and the translation of research. The northeast megaregion is also among the top measured by heat value of innovation, with the Boston-Washington corridor as the core, supported by many federal agencies, research resources and defence contractors. They outperform in the biomedicine and defense sectors. On the other hand, innovation of many hotspots in the north and south of the United States is driven by specialized industries and getting increasingly stronger. There has been a spillover of innovation into the Texas Triangle megaregion from the east and west coasts, where the University of Texas system provides solid support for basic research, and the new energy vehicles, chip manufacturing and autonomous driving sectors are growing rapidly. The Cascadia megaregion in the United States and Canada have become a new growth pole fueled by cloud computing, AI and aerospace. The Great Lakes megaregion, located on the United States-Canada border, has an automobile manufacturing base and benefits from the accelerated development of the electric vehicle and battery industries in North America, as well as the nearshoring of supply chains.

Europe: The 'Blue Banana' megaregion in Western Europe is highly integrated with the outer functional corridor.

The red high heat zone in Europe is dominated by the arc-shaped 'Blue Banana'[1] megaregion in Western Europe, which forms a transnational innovation collaborative hot zone with multiple secondary functional corridors. The 'Golden Triangle' in the UK is not only a powerhouse for basic research and technology transfer, but also a hub for venture capital allocation. The Benelux-Rhine corridor is well positioned to expand with semiconductors and sophisticated equipment. The DACH countries (Germany, Austria and Switzerland) stand out in deep technology and industrial software. The Alpes-Rhone Belt brings together life science giants and large facilities. Meanwhile, Northern Europe is leading the way in digital and climate technology. Thanks to a mature system that consists of evolved and unified rules, dense carriers and flexible factors, Europe has formed a transnational collaborative innovation hotspot structured around a 'principal axis + corridor' model.

Asia: East Asia takes centre stage while Southeast Asia is growing more rapidly.

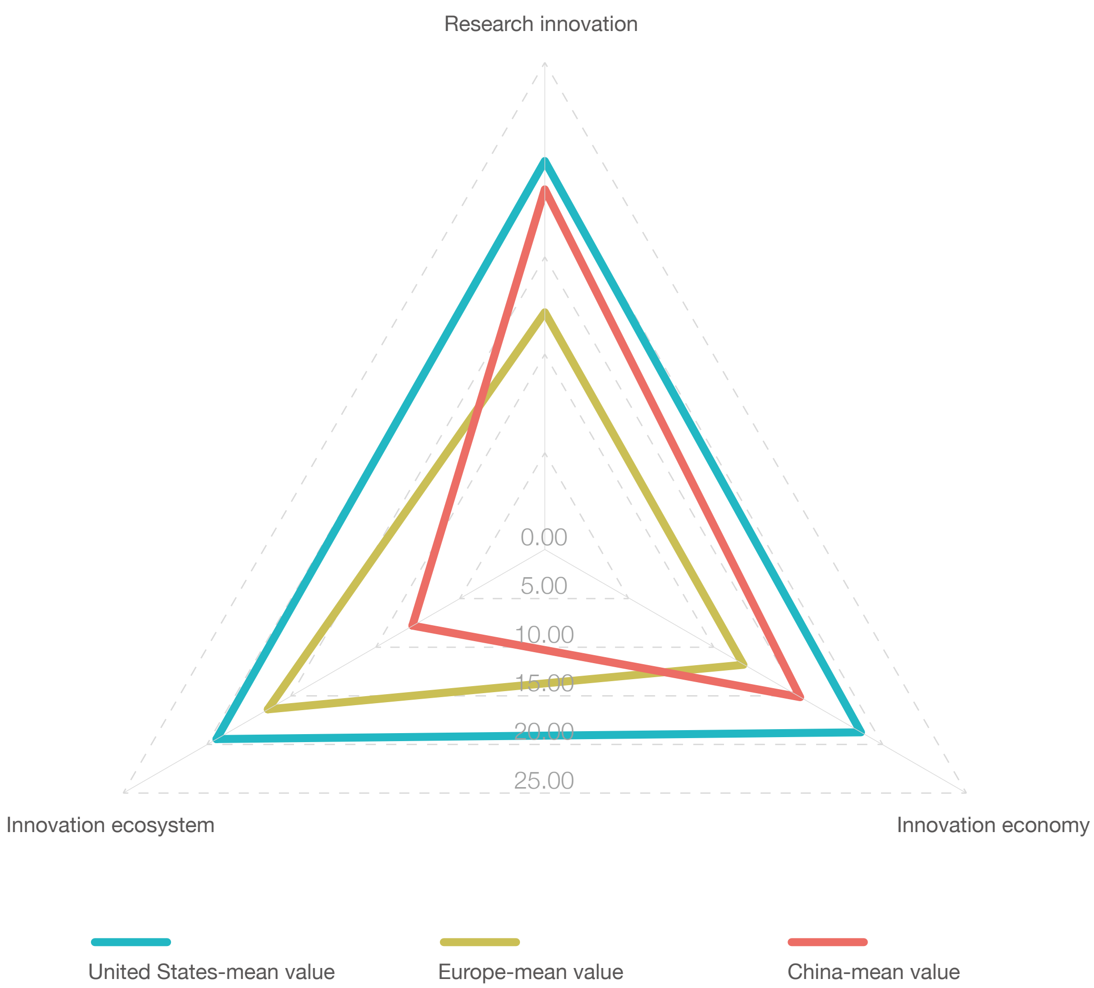
The primary hotspots of innovation in Asia are mainly in China, Japan and South Korea, and the secondary hotspots in Southeast Asia are rising rapidly. China has three super-hotspots from north to south: Beijing-Tianjin-Hebei, Yangtze River Delta and Guangdong-Hong Kong-Macao Greater Bay Area. Beijing-Tianjin-Hebei, with Beijing as its core, spills over to surrounding cities with strong research knowledge creation. The Yangtze River Delta is characterized by a 'red core and yellow circle' gradient. To be specific, Shanghai brings together R&D resources, capital and headquarters, fosters synergy among Jiangsu, Zhejiang and Anhui provinces, and strengthens the chain of 'research-translation-commercialization'. Guangdong-Hong Kong-Macao Greater Bay Area, supported by its deep integration of advanced manufacturing and digital economy, is developing rapidly through cross-border collaboration and global market channels. The Taiheiyo Belt in Japan and the Seoul National Capital Area in South Korea remain robust. Meanwhile, secondary hotspots are taking shape in the Singapore-Malaysia-Indonesia corridor, among which Singapore, as a digital and technology service hub in Southeast Asia, continues to connect the Global South and the global industrial chain.

1. The 'Blue Banana' is a concept introduced by French geographer Roger Brunet in 2002, describing a densely populated, highly industrialized corridor extending from north Italy to the northwest of England.

The development patterns of the GIHs in the United States, Europe and China: The global innovation hotspots are mainly located in the United States, Europe and China, and demonstrate differentiated development patterns (see Appendix VI for the measurement method). The United States has established an integrated full-chain pattern. Its cities/metropolitan areas rank the highest on average, and perform equally well by each indicator, reflecting the comprehensive advantages of knowledge sourcing, industrial transformation and ecosystem support. Supported by a profound innovation ecosystem, European cities/metropolitan areas have established steady innovation forces, fueling scientific research and industries in tandem. Chinese cities/metropolitan areas have gained initial advantages in research innovation and innovation ecosystem. Thanks to the investment and support for public science from the central and local governments, China's basic research is evolving from 'scale expansion' to 'quality enhancement'. Its innovation ecosystem is also improving rapidly. Chinese cities/metropolitan areas as a whole exhibit dual characteristics of catching up and leapfrogging.

FIGURE 4

The development patterns of the GIHs in the United States, Europe and China



2.The GIHI ranking

2.3 Mini-hubs

In the GIHI2025, we continue to evaluate 12 mini-hubs. According to the GIHI indicator system, we assessed the innovation of cities primarily on scale indicators, the population size of these cities (less than one million) makes them unsuitable to be included in the overall ranking. Mini-hubs feature small populations but strong innovation momentum. All mini-hubs, except for Jerusalem, are in Europe and the United States. Specifically, they are in the United States, Switzerland, Germany, the Netherlands, the United Kingdom and Norway.

Cambridge, Basel and Geneva are the top three mini-hubs overall due to their strong innovation capability. Cambridge remains top-ranked thanks to its excellent research innovation and innovation ecosystem. Owing to its high-quality basic research output rooted in its historic research resources, the city has attracted more foreign investment and venture capital than any other mini-hubs. Basel ranks second overall for its performance in innovation economy. Geneva ranks third, equally strong in innovation economy and innovation ecosystem. Table 4 shows their rankings and scores.

Cambridge, Basel and Oslo steadily dominate and rank first in research innovation, innovation economy and innovation ecosystem, respectively. Specifically, in research innovation, Cambridge, Oxford and Ithaca take the top three spots, highlighting the sourcing capability for innovation of world-class universities and research institutions such as the University of Cambridge, the University of Oxford, and Cornell University. In innovation economy, the top three cities are Basel, Eindhoven and Geneva, which pursue industrialization in biomedical clusters, semiconductors and high-end manufacturing chains, and international organizations and financial services, respectively. In innovation ecosystem, Oslo, Cambridge and Geneva are at the forefront, leveraging their strength

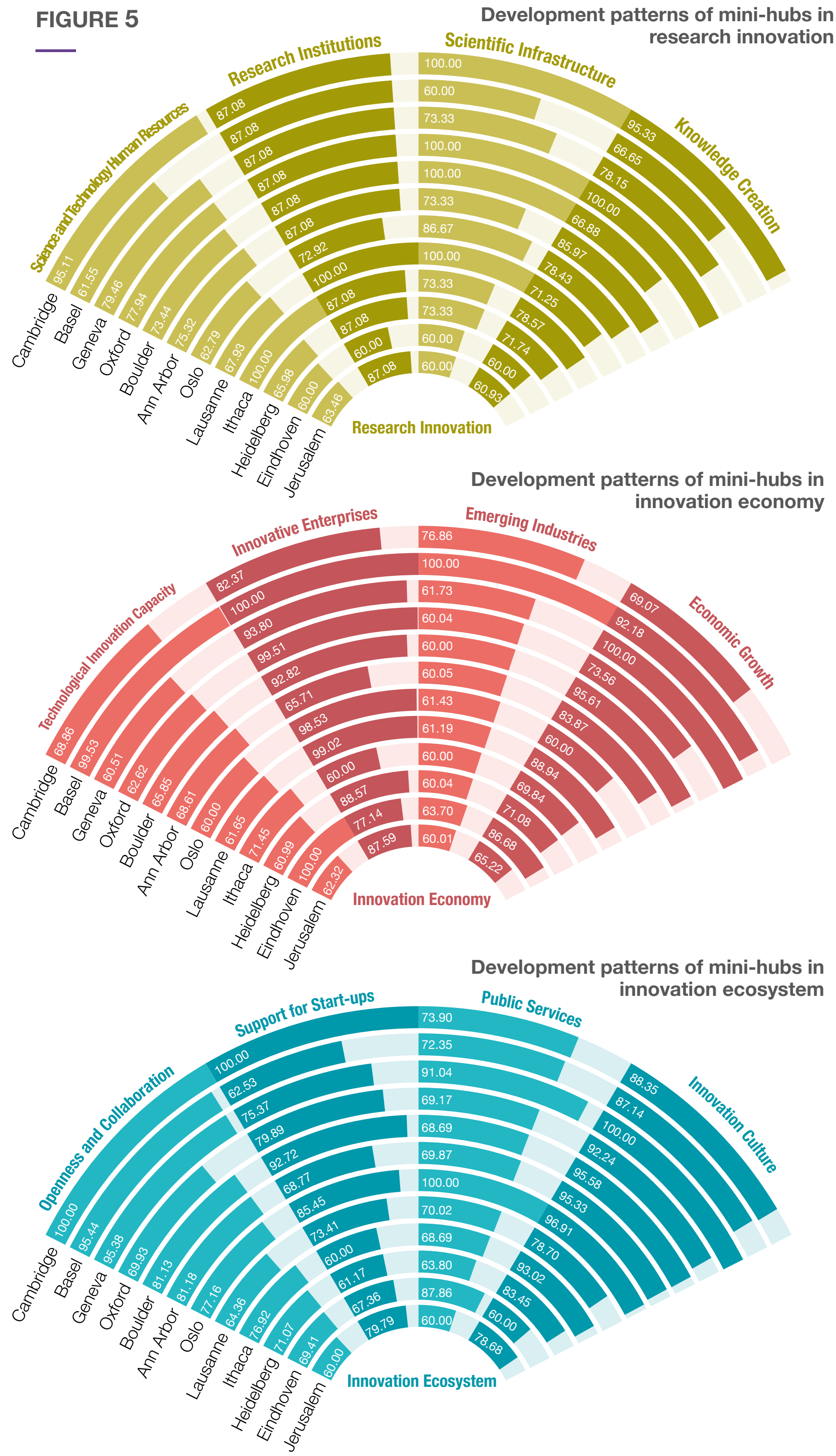
TABLE 4 The GIHI2025 ranking of mini-hubs

City/metropolitan area	Overall		Research Innovation		Innovation Economy		Innovation Ecosystem	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Cambridge	100.00	1	100.00	1	70.32	5	99.47	2
Basel	91.40	2	75.75	10	100.00	1	76.25	7
Geneva	91.10	3	86.67	6	71.66	3	99.01	3
Oxford	85.37	4	96.53	2	65.72	7	76.90	6
Boulder	83.81	5	82.10	7	71.39	4	89.67	4
Ann Arbor	78.66	6	88.47	4	63.92	8	77.30	5
Oslo	77.59	7	75.88	9	61.61	10	100.00	1
Lausanne	76.79	8	88.15	5	69.89	6	64.39	9
Ithaca	76.24	9	93.19	3	60.00	12	69.14	8
Heidelberg	64.50	10	79.98	8	62.38	9	60.00	12
Eindhoven	61.17	11	60.00	12	79.06	2	61.60	10
Jerusalem	60.00	12	74.09	11	61.06	11	61.29	11

in digital infrastructure, support for start-ups and international open cooperation to create an ecosystem for scientific and technological innovation. Cambridge and Geneva rank second and third in innovation ecosystem, respectively, which match their leadership in scientific research and industry. The remaining five cities excel in single indicators.

Despite small scale, the 'straight-A' mini-hubs, supported by functional focus and network embedding, continue to display distinct strengths brought by different functional spaces, such as university towns, specialized industry clusters, and international exchange portals. For example, Cambridge, Oxford and London MA work closely in the Golden Triangle in the UK. Cambridge is known for its strong research and vibrant entrepreneurial ecosystem, attracting more foreign capital and venture capital than any other mini-hubs. Oxford continues to facilitate basic research with the help of its prestigious universities and research institutions, and sound scientific infrastructures. Basel and Geneva constitute the 'dual engines' of the northern Alps. Basel, home to global pharmaceutical and life sciences clusters, has been a leader in innovation economy for a long time. It has seven leading innovative companies and records top revenue of listed companies in the new economy. Geneva, known for international organizations and financial services, has maintained balanced advantages in both industrialization and innovation ecosystem. Eindhoven outperforms by the PCT patent indicator on the back of the heritage system of high-tech parks and multinational corporations. Oslo has deployed low-carbon data centres with the help of clean electricity and cold climate. It also features high-coverage optical fibre and 5G, as well as thorough public services and flight networks, which has resulted in its continued high ranking in innovation ecosystem.

FIGURE 5



3. Research innovation

In research innovation, a dual-track landscape has emerged with Europe and the United States taking the lead while Asia rapidly ascends. Beijing holds the top spot for the first time. Europe and the United States maintain their overall advantages due to solid foundations. The United States stands out for top talent, high-performance computing and original innovation, with Boston MA, San Francisco-San Jose and New York MA boasting more winners of top scientific awards than those in Europe and Asia combined. Chinese cities have generally ranked higher than the previous year, supported by steady expansion of research forces and growing influence of scientific papers in society and industry. In particular, Beijing has surpassed New York MA for the first time to rank first in research innovation in the world.

YUICHIRO CHINO/MOMENT/GETTY

3.1

A comprehensive analysis of research innovation

The GIHI2025 ranking in research innovation is shown in Table 5.

TABLE 5

Ranking and scores of the top 100 GIHs in research innovation

Rank	City/metropolitan area	Research Innovation	Science and Technology Human Resources	Research Institutions	Scientific Infrastructure	Knowledge Creation
1	Beijing	**100.00**	86.02	92.60	90.62	100.00
2	New York MA	**96.46**	88.33	89.09	76.59	96.52
3	Boston MA	**92.71**	100.00	74.94	65.72	93.67
4	San Francisco-San Jose	**92.14**	92.89	74.16	100.00	87.76
5	Guangdong-Hong Kong-Macao Greater Bay Area	**89.64**	69.63	100.00	73.50	85.09
6	Baltimore-Washington	**84.75**	85.86	70.00	66.74	90.61
7	London MA	**83.35**	76.28	77.40	67.78	87.77
8	Paris MA	**79.35**	73.83	74.94	84.40	75.55
9	Shanghai	**78.72**	70.29	80.91	70.36	75.79
10	Nanjing	**74.73**	75.08	73.38	60.00	71.69
11	Los Angeles-Long Beach-Anaheim	**74.49**	69.63	74.94	61.55	74.28
12	Tokyo MA	**74.24**	67.03	70.00	92.17	70.65
13	Chapel Hill-Durham-Raleigh	**73.40**	78.41	68.31	60.00	70.14
14	Chicago-Naperville-Elgin	**72.24**	70.01	68.31	68.82	72.25
15	Zurich	**71.76**	76.15	68.31	61.55	67.22
16	Wuhan	**71.61**	67.61	71.69	66.21	70.06
17	Seoul MA	**71.13**	64.55	70.00	70.41	72.24
18	Munich	**71.01**	71.66	70.00	64.68	66.66
19	Melbourne	**70.58**	67.97	68.31	64.15	71.32
20	Singapore	**69.49**	66.25	68.31	65.72	69.39
21	Sydney	**69.45**	66.02	68.31	63.11	70.46
22	Atlanta MA	**69.15**	65.04	68.31	63.11	70.60
23	Xi'an	**69.13**	67.20	70.00	60.00	67.56
24	Copenhagen	**68.89**	70.26	66.62	61.04	67.16
25	Philadelphia MA	**68.73**	68.53	64.16	60.00	71.62
26	Houston MA	**68.72**	65.08	70.00	63.12	67.44
27	Stockholm	**68.50**	67.54	66.62	66.74	66.76
28	Rome	**68.41**	68.55	65.84	66.21	66.54
29	Hangzhou	**68.38**	66.94	67.53	61.55	67.88
30	Seattle-Tacoma-Bellevue	**68.23**	67.97	64.16	61.04	70.38

3.Research innovation

Rank	City/metropolitan area	Research Innovation	Science and Technology Human Resources	Research Institutions	Scientific Infrastructure	Knowledge Creation
31	Pittsburgh	68.21	69.83	66.62	60.00	66.03
32	San Diego MA	68.21	69.41	64.16	64.15	67.72
33	Amsterdam MA	68.02	66.31	66.62	65.20	67.21
34	Kyoto-Osaka-Kobe	67.96	67.92	65.84	70.38	64.36
35	Toronto MA	67.85	66.79	64.16	62.08	70.15
36	Chengdu	67.46	63.49	68.31	63.11	67.38
37	Montreal MA	67.36	66.36	66.62	62.59	66.20
38	Daejeon	67.29	74.05	61.69	65.19	62.72
39	Changsha	67.26	65.72	68.31	61.04	65.25
40	Moscow	67.06	67.32	64.16	74.01	63.00
41	Barcelona MA	66.97	66.19	62.47	67.78	68.05
42	Tianjin	66.95	64.61	68.31	62.59	64.94
43	Berlin MA	66.79	65.33	63.38	65.70	68.17
44	Hefei	66.75	65.45	65.84	67.77	64.40
45	Milan	66.65	67.00	62.47	64.15	67.64
46	Vancouver MA	66.39	66.72	64.16	63.63	65.47
47	Brisbane	66.23	66.94	64.16	61.55	65.55
48	Taipei	66.22	73.21	60.00	63.12	63.16
49	Madrid	65.90	67.27	61.69	61.55	67.04
50	Vienna	65.63	66.98	62.47	63.12	65.11
51	Lyon-Grenoble	65.62	65.98	62.47	69.85	63.66
52	Manchester	65.56	66.39	64.16	61.55	64.19
53	Harbin	65.37	65.15	64.16	64.66	63.79
54	Changchun	65.35	63.78	67.53	61.55	62.49
55	Nagoya MA	65.29	65.39	64.16	69.34	61.61
56	Helsinki	65.10	67.27	62.47	61.04	64.06
57	Austin	65.07	64.26	64.16	66.76	63.06
58	St. Louis	65.01	65.56	64.16	60.00	64.04
59	Minneapolis-Saint Paul	64.84	64.46	64.16	60.00	64.66
60	Dallas-Fort Worth	64.70	64.18	64.16	60.00	64.55
61	Jinan	64.59	64.76	64.16	61.04	63.28
62	Qingdao	64.42	63.82	65.06	60.00	63.10
63	Chongqing	64.28	61.36	65.84	61.55	63.79
64	Sao Paulo	64.25	65.09	62.47	62.59	63.31
65	Perth	64.05	64.97	62.47	61.55	63.23

Rank	City/metropolitan area	Research Innovation	Science and Technology Human Resources	Research Institutions	Scientific Infrastructure	Knowledge Creation
66	Dublin	63.79	67.09	60.00	60.00	63.65
67	Lanzhou	63.79	66.89	61.69	61.55	61.39
68	Dalian	63.71	63.65	63.38	61.55	62.59
69	Denver MA	63.58	65.09	60.00	63.12	63.97
70	Prague	63.58	65.08	61.69	63.11	62.08
71	Hamburg	63.52	63.76	60.00	69.85	62.72
72	Gothenburg	63.50	64.26	62.47	61.04	62.57
73	Zhengzhou	63.49	62.73	64.16	60.00	62.59
74	Xiamen	63.41	63.48	64.16	60.00	61.58
75	Rotterdam	63.33	63.76	62.47	60.00	62.96
76	Phoenix MA	63.32	62.63	62.47	63.12	62.96
77	Lisbon	63.29	66.18	60.00	61.55	62.59
78	Brussels	63.19	63.05	62.47	60.00	63.30
79	Cologne	63.17	64.50	62.47	60.00	61.75
80	Fuzhou	63.05	63.19	63.38	60.00	61.72
81	Frankfurt	62.95	62.72	62.47	63.12	61.81
82	Suzhou	62.81	61.57	64.16	60.00	61.84
83	Tel Aviv	62.76	62.59	61.69	62.59	62.49
84	Warsaw	62.54	65.10	60.00	60.00	62.10
85	Nanchang	62.44	63.84	61.69	60.00	61.21
86	Kuala Lumpur	62.39	64.20	60.00	60.00	62.61
87	Riyadh	62.26	61.93	62.47	60.00	61.79
88	Buenos Aires	62.23	65.01	60.00	61.04	60.92
89	Doha	62.17	65.22	60.00	60.00	60.94
90	Shenyang	62.15	63.91	60.00	60.00	62.23
91	Cincinnati	61.98	63.77	60.00	60.00	61.86
92	Chennai MA	61.98	64.16	60.00	60.00	61.46
93	Central National Capital Region Delhi MA	61.93	61.13	60.00	62.08	63.70
94	Budapest	61.89	63.42	60.00	61.55	61.40
95	Bangkok	61.86	63.40	60.00	61.04	61.52
96	Miami MA	61.84	62.59	60.00	60.00	62.70
97	Ankara	61.82	62.68	60.00	63.63	61.22
98	Portland	61.79	63.01	60.00	60.00	62.11
99	Kunming	61.75	62.79	60.00	63.11	61.11
100	Mexico City	61.58	63.03	60.00	60.00	61.51

3.Research innovation

FIGURE 6

Quartile graph of ranking in research innovation for cities/ metropolitan areas in Asia, Europe and North America

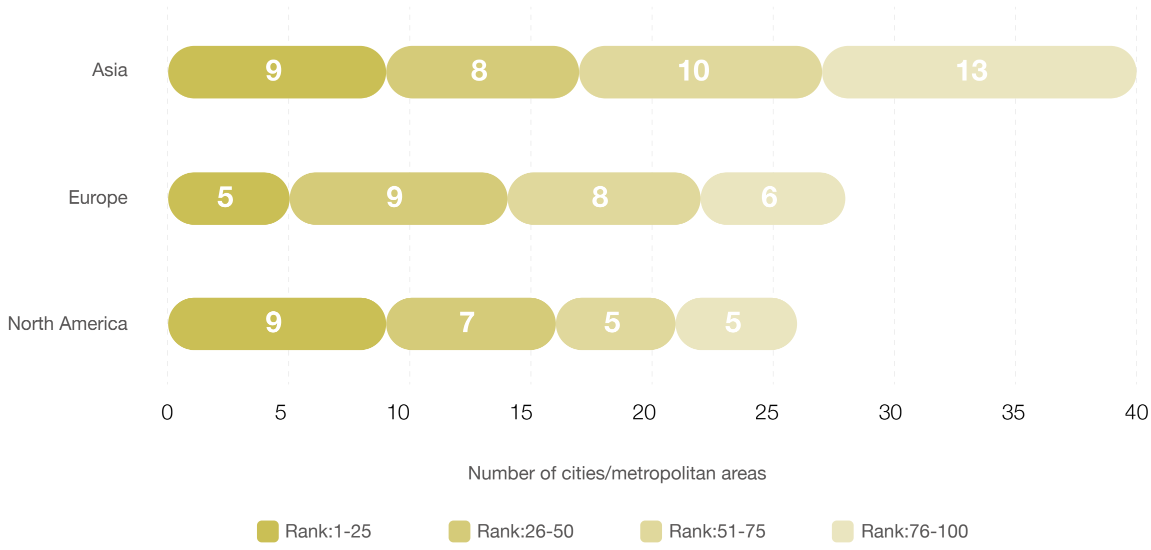


TABLE 6

A comparison of the top 20 GIHs in research innovation between 2023-2025

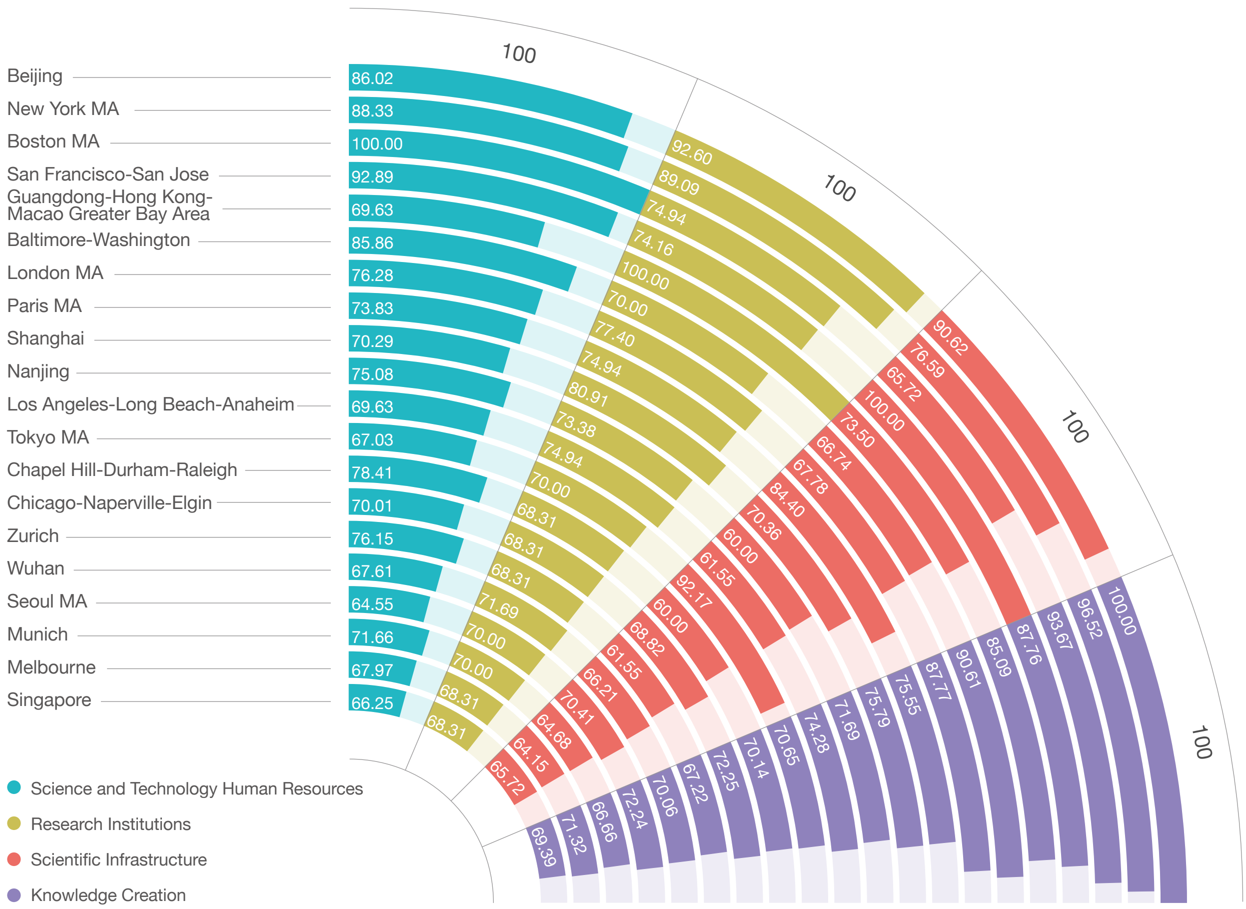
City/metropolitan area	Rank 2025	Rank 2024	Rank 2023
Beijing	1	2	2
New York MA	2	1	1
Boston MA	3	3	3
San Francisco-San Jose	4	4	4
Guangdong-Hong Kong-Macao Greater Bay Area	5	5	7
Baltimore-Washington	6	6	5
London MA	7	7	6
Paris MA	8	8	8
Shanghai	9	9	9
Nanjing	10	15	15
Los Angeles-Long Beach-Anaheim	11	10	10
Tokyo MA	12	12	12
Chapel Hill-Durham-Raleigh	13	11	11
Chicago-Naperville-Elgin	14	13	13
Zurich	15	14	14
Wuhan	16	18	25
Seoul MA	17	17	17
Munich	18	19	18
Melbourne	19	16	16
Singapore	20	21	21

The United States maintains a strong lead in research innovation, while China continues to make impressive strides in narrowing the gap. Specifically, the United States takes up seven spots in the top 20 list. New York MA, Boston MA, and San Francisco-San Jose have been among the top five for five consecutive years, ranking second, third and fourth, respectively in the GIHI2025, highlighting their robust research competitiveness. Chinese cities/ metropolitan areas demonstrate remarkable performance in research innovation. Beijing has topped the list for the first time, while Guangdong-Hong Kong-Macao Greater Bay Area and Shanghai rank fifth and ninth, respectively. Nanjing enters top 10 for the first time. They are the core forces of China's research innovation. Moreover, Singapore has ascended to the ranks of the top 20 in research innovation, marking a notable improvement in research strength of Southeast Asia.

From a geographical perspective, North American cities/metropolitan areas rank prominently as a whole, with a majority of top cities in research innovation concentrating along the US east coast. Asian cities/ metropolitan areas are distributed in gradient, and the main hubs are concentrated in East Asia. In particular, Beijing, the Yangtze River Delta region and Guangdong-Hong Kong-Macao Greater Bay Area have led other cities to catch up gradually. European cities/ metropolitan areas show relatively balanced distribution, primarily occupying the middle range (26th-75th).

FIGURE 7

Development of the top 20 GIHs in research innovation



3.Research innovation

The rankings of the top 20 cities/metropolitan areas in research innovation have remained relatively stable over time. However, Chinese cities/metropolitan areas have shown a notable upward trend this year. Among them, Beijing, leveraging its strength in research institutions, has made significant progress in science and technology, human resources development, and knowledge creation. It now ranks first globally in the number of active researchers (per million people), the number of top 200 world-class research institutions, and the total citations from patents, policy reports and clinical trials — surpassing New York MA to claim the top spot in overall research innovation. Nanjing has also demonstrated strong performance, particularly in science and technology human resources and knowledge creation. Its number of active researchers (per million people) and the total citations from patents, policy reports and clinical trials have increased rapidly, propelling the city to move up by five places in the overall ranking. Wuhan continues its upward trajectory for the third consecutive year, driven by consistent gains in science and technology human resources and knowledge creation.

The GIHI top 20 cities/metropolitan areas in research innovation exhibit distinct performance across each sub-indicator. Beijing leads the list with its outstanding capacity for knowledge creation. New York MA and London MA excel in knowledge creation, driven by strong development of science and technology human resources and research institutions. Boston MA and Baltimore-Washington emphasize the synergistic development of science and technology human resources and knowledge creation. San Francisco-San Jose and Tokyo MA leverage their solid scientific infrastructure to foster the concentration and development of innovation elements. Guangdong-Hong Kong-Macao Greater Bay Area and Shanghai stand out in research institutions.

3.2 Science and technology human resources

Scientific and technological talent is the fundamental driving force behind innovation. Based on key factors such as the distribution and mobility of scientific talent as well as the transformation cycles of research outputs, the GIHI2025 uses two indicators — the number of active researchers (per million people) and the number of winners of top scientific awards — to measure a GIH's talent pool. Figures 8 and 9 show the number of active researchers (per million people) and the number of winners of top scientific awards for the top 20 cities/metropolitan areas in science and technology human resources, respectively.

North American cities/metropolitan areas have significant advantages in science and technology human resources. Among the top five, four are from North America, which are Boston MA, San Francisco-San Jose, New York MA and Baltimore-Washington, while Beijing holds the fourth position. Among the top 20, North American cities/metropolitan areas take up nine spots, while Asian cities/metropolitan areas occupy six spots. Nanjing ranks among the top ten and Guangdong-Hong Kong-Macao Greater Bay Area ranks among the top 20 for the first time. European cities/metropolitan areas occupy five spots in the top 20, including London MA, Zurich, Paris MA, Munich and Copenhagen.

FIGURE 8

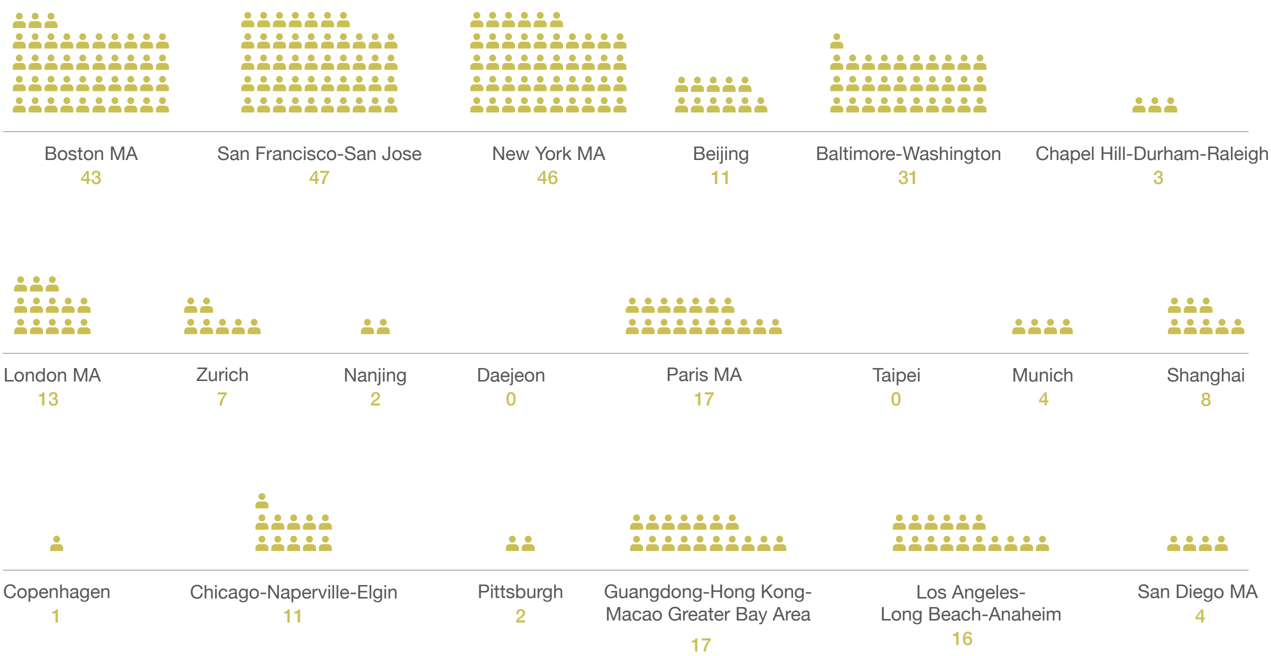
Number of active researchers (per million people) for the top 20 GIHs in science and technology human resources

In terms of the number of active researchers per million people, Beijing, Boston MA and Chapel Hill-Durham-Raleigh stand out, with significantly higher figures than other cities/metropolitan areas. Beijing leads globally, benefiting from a dual advantage of innovation resources and policies. It has demonstrated strong performance in attracting and training high-level scientific talent, ranking first with 52,102.75 active researchers per million people. Boston MA, supported by top universities, such as Harvard University, Massachusetts Institute of Technology, Tufts University, and many research institutions, shows strong innovation capacity across various frontier fields such as biomedicine, AI, clean energy and fin-tech. With 50,824.33 active researchers per million, it ranks second globally by a narrow margin. Chapel Hill-Durham-Raleigh is third with 42,617.71 active researchers per million people. In addition, global research output is growing steadily, and most evaluated cities/metropolitan areas have shown varying degrees of expansion in scientific and technological talent numbers. New York MA has seen a 15.88% increase in the number of active researchers per million people compared to the previous period — the highest growth among the top 20 cities/metropolitan areas in science and technology human resources. China has also expanded significantly in scientific talent tool. Among the top 20, Beijing, Shanghai, Nanjing and Guangdong-Hong Kong-Macao Greater Bay Area all achieved growth rates of more than 10%.

The distribution of top science and technology human resources shows a clear pattern of geological concentration. More than half of the winners of top scientific awards gather in the top 20 GIHs ranked by this indicator. Specifically, North American cities/metropolitan areas have 203 winners, with Boston MA, San Francisco-San Jose and New York MA contributing 136, which is far ahead of Europe (42) and Asia (38). This underscores the strong scientific research foundation and exceptional innovation capacity of North American cities/metropolitan areas, giving them a clear edge in both the scale and quality of science and technology human resources. European and Asian cities/metropolitan areas still have potential to attract and cultivate top scientific talent.

FIGURE 9

Number of winners of top scientific awards for the top 20 GIHs in science and technology human resources



3.Research innovation

3.3 Research institutions

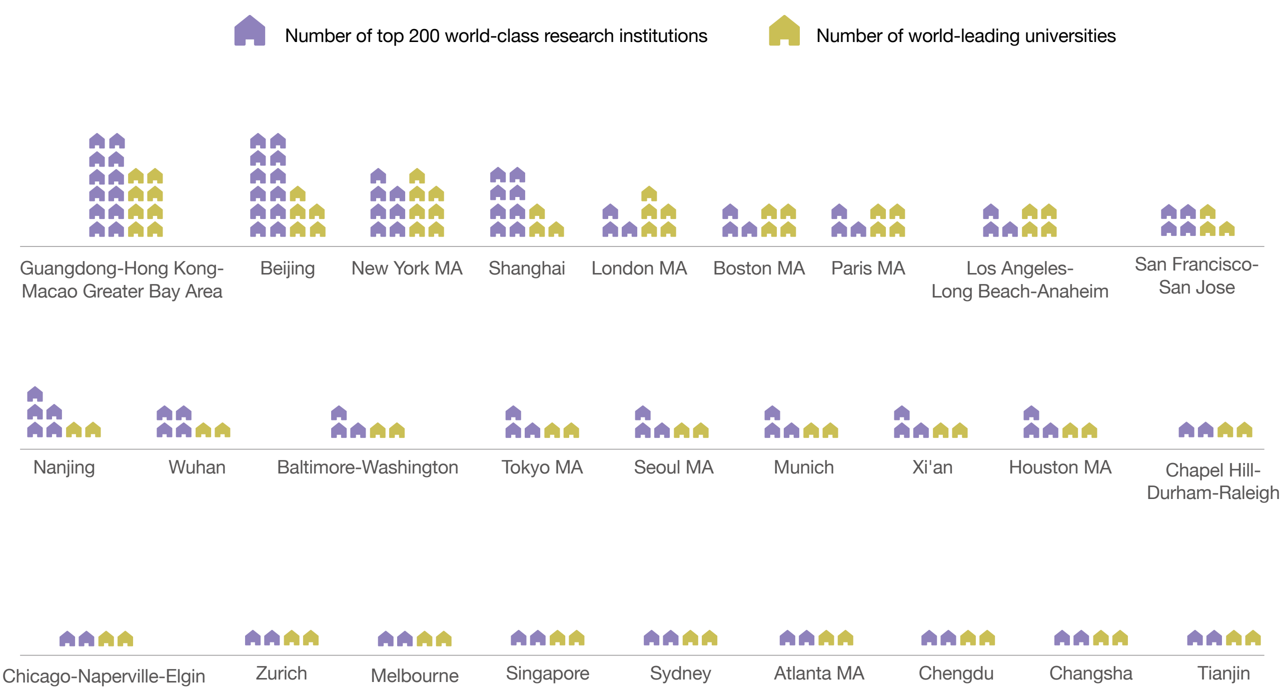
Research institutions are the core actors of innovation. This report evaluates the strength of cities and metropolitan areas in this domain by examining two key indicators: the number of top 200 world-class research institutions, as measured by publications tracked in the Nature Index, and the number of world-leading universities. The competitiveness of research institutions in basic research, technology application and cutting-edge innovation is shaped not only by long-term knowledge accumulation, but also by strategic planning, resource allocation and policies. To foster original innovation and drive disruptive technological breakthroughs, research institutions need to dynamically optimize their strategic priorities, resource allocation, and policy frameworks. Therefore, the overall rankings of research institutions remain stable with localized fluctuations. Figure 10 shows the number of top 200 world-class research institutions and the number of world-leading universities for the top 20 GIHs in research institutions.

Asian cities/metropolitan areas are leading in research institutions. For the top 20 GIHs, Asia, North America, Europe and Oceania occupy 12, 9, 4 and 2 spots, respectively.

China stands out by taking up three spots in top five. Globally, Guangdong-Hong Kong-Macao Greater Bay Area ranks first with 12 world-class 200 research institutions and eight world-leading universities. Beijing ranks second with 12 world-class 200 research institutions and five world-leading universities. Shanghai ranks fourth again with eight world-class 200 research institutions and three world-leading universities. Nanjing has two more top 200 research institutions this year, rising to the tenth place. Wuhan, Xi'an, Chengdu, Changsha and Tianjin are also among the top 20.

FIGURE 10

Number of world-leading universities and top 200 world-class research institutions for the top 20 GIHs in research institutions



3.4
Scientific infrastructure

Scientific infrastructure is the platform and catalyst for innovation. Large-scale sophisticated scientific facilities or systems are essential for discovery of fundamental laws, major evolution of knowledge, and updates of key technology. The GIHI2025 measures the development of scientific infrastructure by the numbers of top 500 supercomputers and large scientific facilities in a city/metropolitan area. Figure 11 shows the number of large scientific facilities and the number of top 500 supercomputers for the top 20 GIHs in scientific infrastructure.

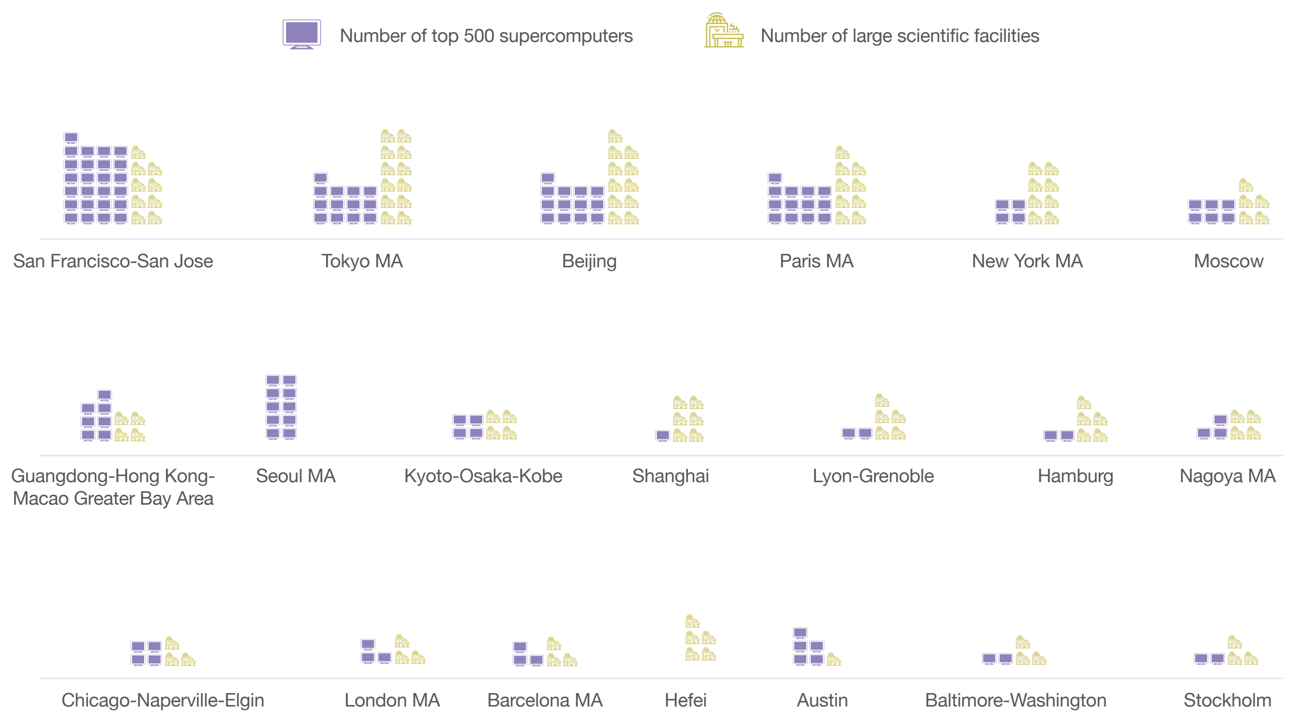
The top five cities/metropolitan areas in scientific infrastructure are San Francisco-San Jose, Tokyo MA, Beijing, Paris MA and New York MA. In particular, San Francisco-San Jose, Tokyo MA and Beijing remain leaders in scientific infrastructure, far ahead of other cities/metropolitan areas. Among the top 20, Asian cities occupy eight spots, European cities take seven and North American cities hold five.

San Francisco-San Jose, Tokyo MA, Beijing, Paris MA and Seoul MA are the top five by the number of top 500 supercomputers. On the country level, the United States and China are the top two in the number of top 500 supercomputers. The United States dominates in the field of high-performance computing, leading the world with 174 top 500 supercomputers. In terms of performance, the top four supercomputers all belong to the United States. Among them, El Capitan, Frontier and Aurora — deployed by laboratories under the U.S. Department of Energy — are the only three exascale systems on the list. Their computing capabilities far exceed the fourth-ranked Eagle, which has a peak performance of 561.2 petaflops per second.

Large scientific facilities are investment-intensive and interdisciplinary, which makes them incubators for technological breakthroughs. Globally, more than half are located in the top 20 GIHs ranked for scientific infrastructure, with Tokyo MA leading the world with 12 large scientific facilities.

FIGURE 11

Number of top 500 supercomputers and large scientific facilities for the top 20 GIHs in scientific infrastructure



3.Research innovation

3.5
Knowledge creation

Knowledge is the driving force of innovation. This report uses the number of highly cited papers published by a city/metropolitan area to measure its original innovation capability and academic influence. It uses total external citations to measure the impact of research papers on society and industry. Figure 12 shows the number of highly cited papers and total citations from patents, policy reports and clinical trials for the top 20 GIHs ranked for knowledge creation.

The top five cities/metropolitan areas in knowledge creation are Beijing, New York MA, Boston MA, Baltimore-Washington and London MA. North America takes up ten spots in the top 20 and nine are from the United States. New York MA, Boston MA and Baltimore-Washington have remained in the top five over the years. Asia takes up six spots, which are Beijing, Tokyo MA, Seoul MA, Guangdong-Hong Kong-Macao Greater Bay Area, Shanghai and Nanjing. Europe takes up two spots, which are London MA and Paris MA. Oceania also comes with two, namely Melbourne and Sydney.

The strong innovation capability of North American cities/metropolitan areas is evidenced by the number of highly cited papers. A total of ten cities/metropolitan areas in the United States are in the top 20. New York MA, Boston MA, San Francisco-San Jose and Baltimore-Washington are in the top four. Asian cities/metropolitan areas occupy five spots in the top 20. Among them, Beijing, Guangdong-Hong Kong-Macao Greater Bay Area and Shanghai in China rank 5th, 7th and 12th, respectively. Other Asian cities/metropolitan areas on the list include Singapore and Tokyo MA. London MA and Paris MA in Europe rank 6th and 9th, respectively. Melbourne and Sydney in Oceania rank 14th and 18th respectively.

The evaluated cities/metropolitan areas show a close correlation between the total citations from patents, policy reports, and clinical trials, and the number of highly cited papers. This indicates that cites with strong original innovation capabilities are able to effectively translate academic strengths into social and industrial applications, a sign of positive alignment of value between theories and applications. For Asian cities/metropolitan areas, the impact of scientific papers on society and industry is prominent. Asia takes up nine spots in the top 20 by total citations from patents, policy reports and clinical trials, which are all Chinese cities/metropolitan areas except for Tokyo MA and Seoul MA. Beijing ranks first for the first time, while Nanjing, Wuhan, Chengdu and Hangzhou have seen rapid growth in citation frequency compared with the previous period. This is directly related to China's large investment in patents and a significant increase in the number of patent applications in recent years. North American cities also make significant contributions to society and industry through scientific research, with seven cities in the top 20 for total citation frequency. New York MA, Baltimore–Washington, and Boston MA rank second, third, and fifth respectively.

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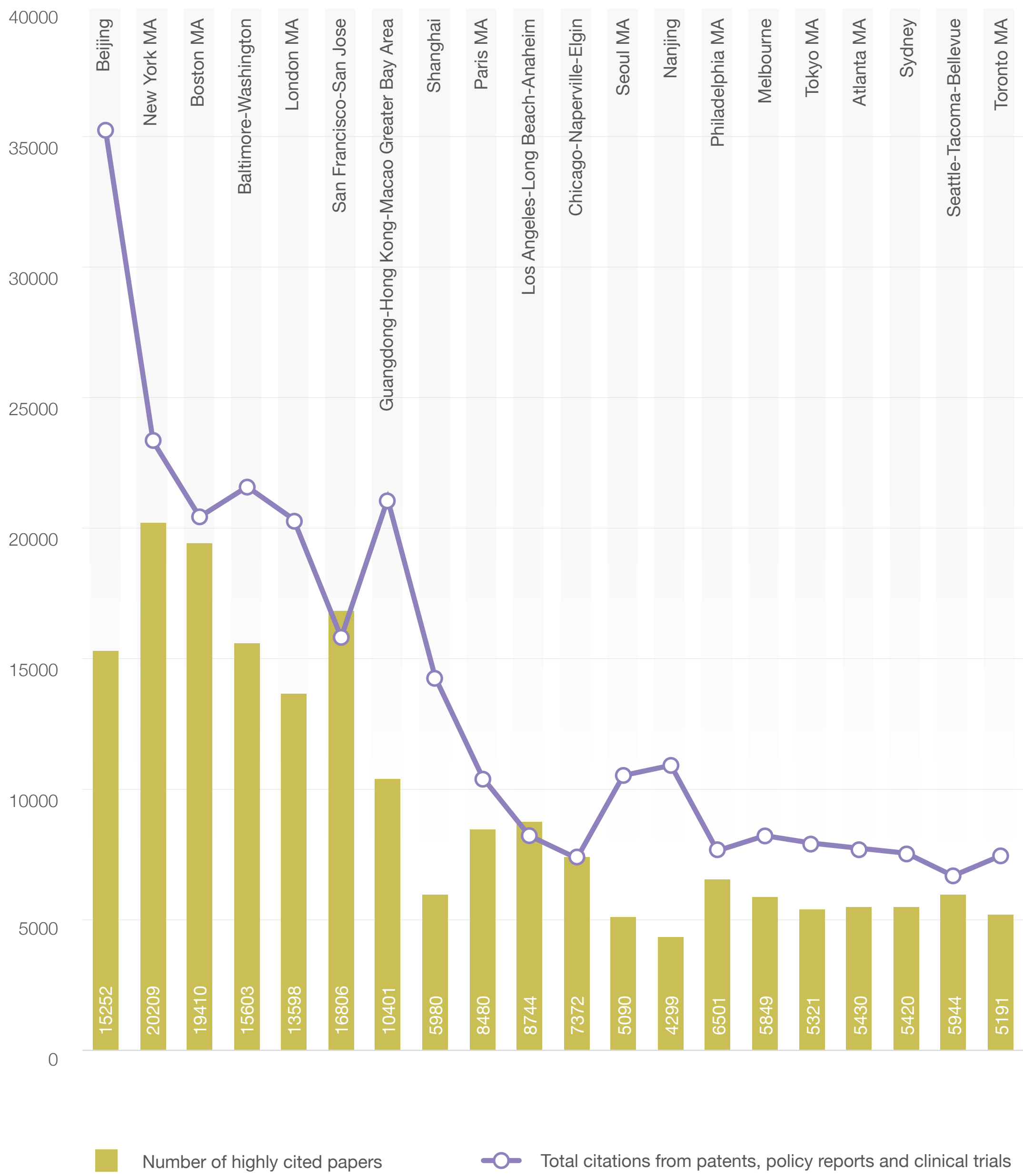
FIGURE 12

Number of highly cited papers and total citations from patents, policy reports and clinical trials for the top 20 GIHs in knowledge creation



FOCUS
Quantum science and technology

The year 2025 marks the 100th anniversary of the birth of quantum mechanics. To commemorate this milestone, UNESCO has proposed the designation of the year 2025 as the International Year of Quantum Science and Technology (IYQ). As one of the two cornerstones of modern physics, quantum mechanics has not only profoundly reshaped our understanding of the physical world, but also given birth to a series of technological breakthroughs. For example, in the first quantum revolution, semiconductor technology — based on quantum band theory — led to the invention of integrated circuits, while laser technology — based on the principle of excited radiation — gave birth to lasers, which together laid the foundation for modern information technology.

Since the 1990s, major breakthroughs in quantum regulation technology ushered the world into the 'second quantum revolution', which features active and precise manipulation of the quantum state of microscopic particles. This revolution was led by quantum information technology. By leveraging the unique physical phenomena such as quantum superposition, entanglement and interference, it has brought about fundamental changes to the fields of information processing, communication transmission and precision measurement. Now, the pursuit of supremacy in quantum computing — aiming for 'explosive' growth in computing power and the creation of an absolutely secure communication system — has become a strategic frontier and a major development opportunity.

By analysing papers in 'quantum physics' and patents in 'quantum information', this report evaluates the capabilities of theoretical and technological innovation of major GIHs in quantum science and technology. It further reveals each GIH's development potential, as well as the risks and challenges they face in advancing this frontier field.

Theoretical innovation capability

According to Dimensions database (Figure 13), the number of global 'quantum physics' papers is on steady rise: up from 10,996 in 2000 to 46,440 in 2024, with a compound annual growth rate (CAGR) of 6.09%. As shown in Figure 14, about 80% of the total publications in this field come from the top 20 countries and regions over the past 25 years, and this proportion has remained stable for a long time. Among them, China stands out with a rapid rise in publication volume, achieving a CAGR of 12.59%. In 2020, it surpassed the United States to become the world's leading country in quantum physics publications.

Quantum physics research is dominated by three powerhouses, namely China, the United States and the European Union. Benefiting from the world's top universities and research institutions, China — represented by GIHs such as Beijing — has demonstrated robust research vitality and is leading in total publications. The United States, represented by Boston MA, on the other hand, has a clear edge with regard to original innovation.

FIGURE 13

The global trend of publications in quantum physics (2000-2024)

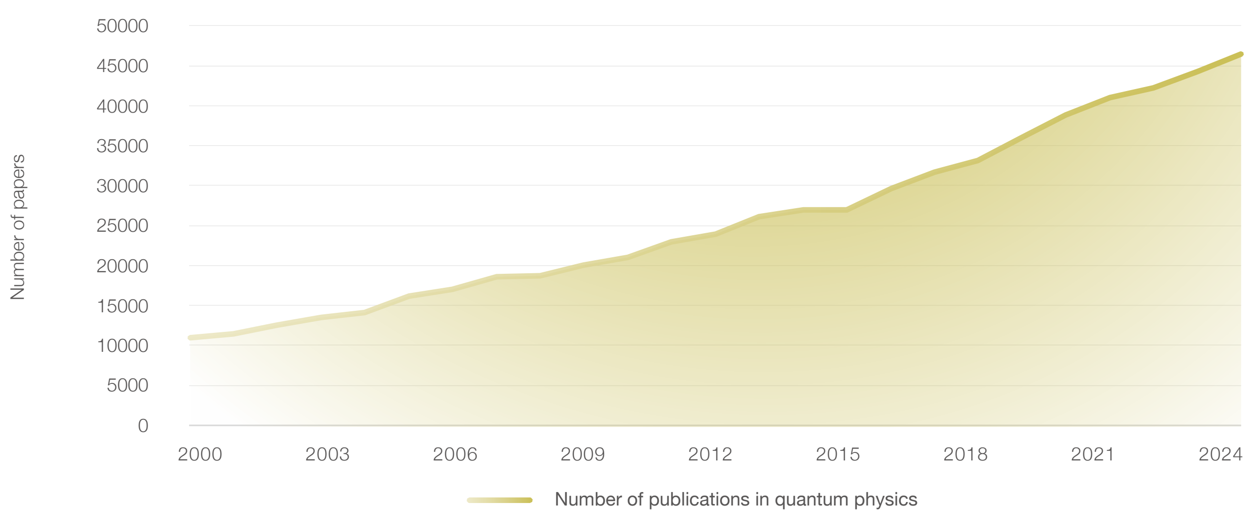
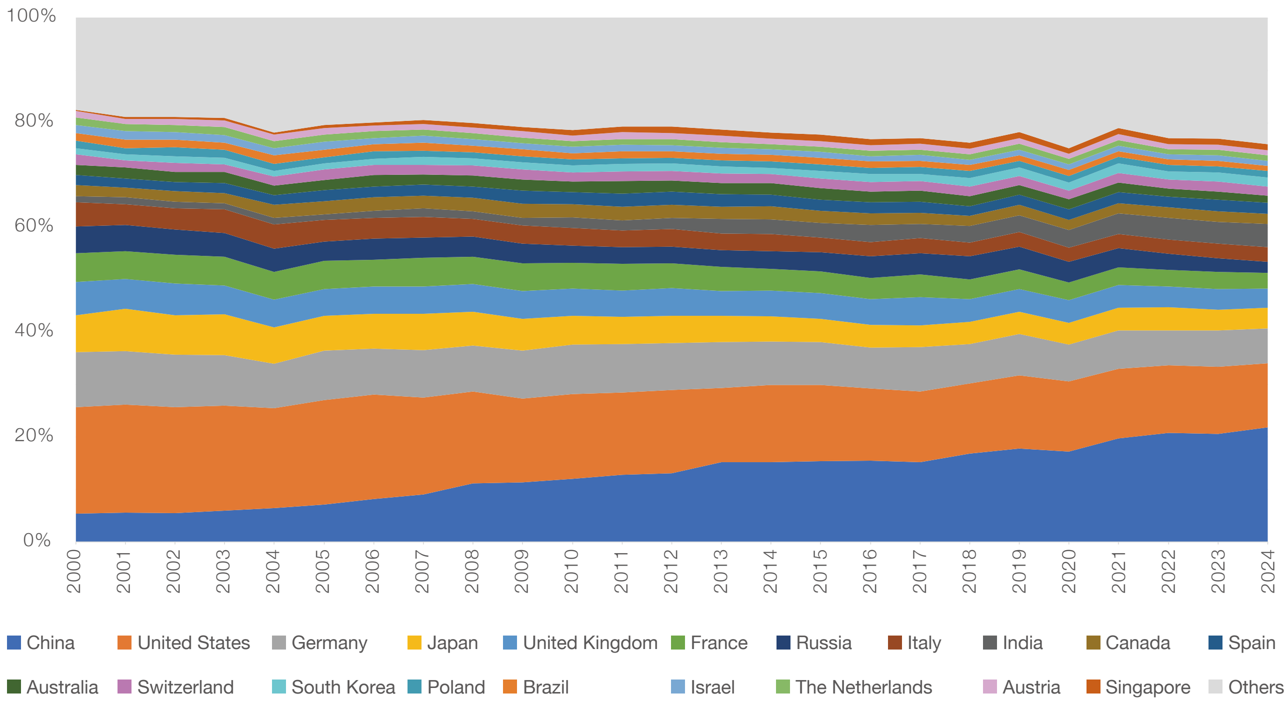


FIGURE 14

The global trend of shares of the top 20 countries in the number of publications in quantum physics (2000-2024)



In 2024, China's annual publications in quantum physics exceeded 10,000, accounting for 21.48% of the global total. The United States ranked second, accounting for 12.27%. The top 20 EU countries as a whole contributed 17.76%. The combined share of China, the United States and EU exceeded 50% of the global total, highlighting a landscape dominated by the three powerhouses. Among the top 20 countries, Singapore and India also maintained strong growth, with a CAGR of 13.61% and 12.26%, respectively, in the same period. In 2024, India ranked fourth in the world in quantum physics publications, just behind Germany, the leader in EU.

As shown in Figure 15, the top 10 cities/metropolitan areas measured by the accumulated publications in quantum physics over the past 25 years are Beijing, Tokyo MA, Paris MA, Guangdong-Hong Kong-Macao Greater Bay Area, New York MA, Boston MA, Shanghai, Moscow, Baltimore-Washington and San Francisco-San Jose. In the overall assessment of GIHs in research innovation, except for Tokyo MA at 12th and Moscow at 38th, the rest of the above cities rank in the top 10, revealing the important roles they play in facilitating research and exploration of frontier theories in quantum physics.

From a developmental perspective, Chinese cities demonstrate particularly strong research vitality in the field of quantum physics, with the number of publications maintaining rapid growth. In 2024, the top ten cities/metropolitan areas in publications in quantum physics are Beijing, Guangdong-Hong Kong-Macao Greater Bay Area, Shanghai, Tokyo MA, Hefei, Nanjing, Paris MA, New York MA, Hangzhou and San Francisco-San Jose — with six of them located in China. Beijing, Guangdong-Hong Kong-Macao Greater Bay Area and Shanghai firmly held the top three positions in the world, demonstrating a strong lead. Hefei records a strong growth and is poised to surpass Tokyo MA to become a fourth-ranked city.

From the perspective of original innovation capacity, cities/metropolitan areas in the United States still take the lead in original innovation capability with their solid foundation. The top 10 cities/metropolitan areas with the highest number of highly cited papers between 2014 and 2023 are: Boston MA, New York MA, San Francisco-San Jose, Beijing, Guangdong-Hong Kong-Macao Greater Bay Area, Baltimore-Washington, Los Angeles-Long Beach-Anaheim, Tokyo MA, Singapore and Seattle-Tacoma-Bellevue. Among them, cities in the United States account for more than half of the list. The top three — Boston MA, New York MA and San Francisco-San Jose — each has produced more than 100 highly cited papers, highlighting their notable lead.

[Focus] Quantum science and technology

FIGURE 15

Top 20 cities/metropolitan areas by the number of publications in quantum physics (2000-2024)

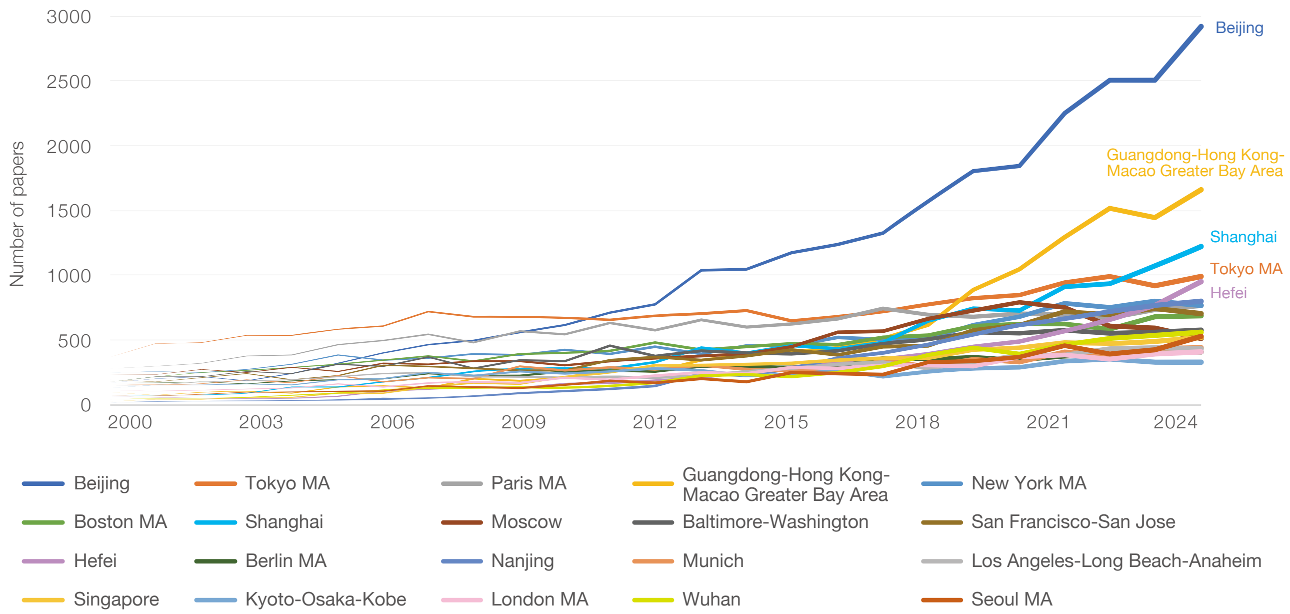
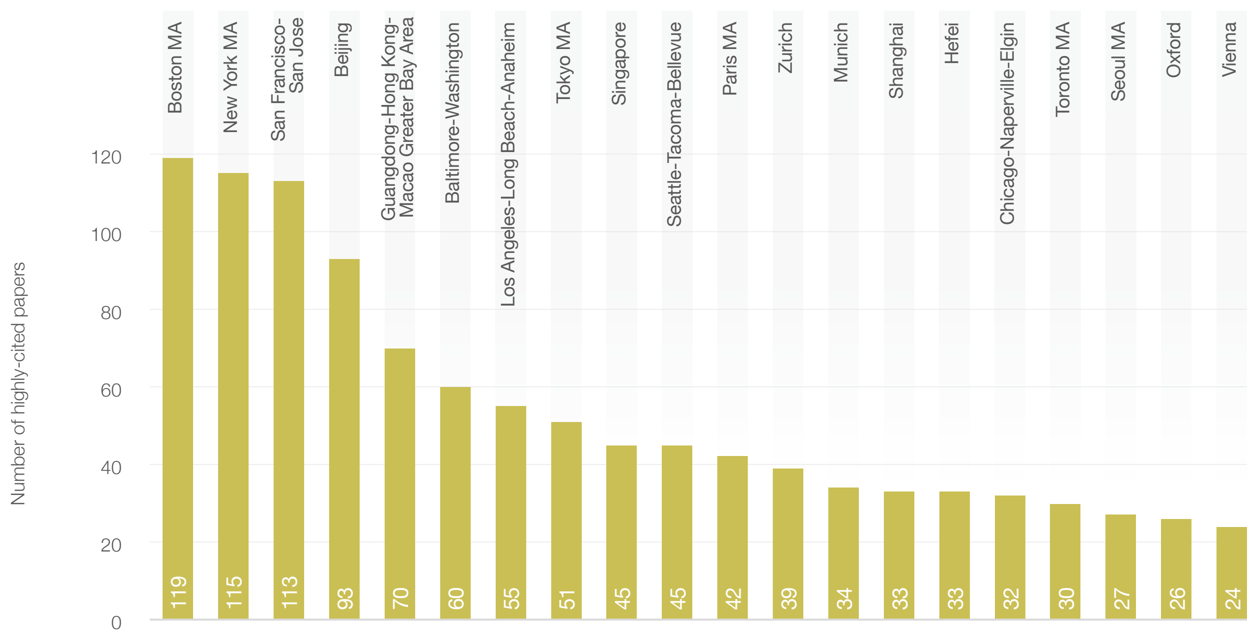


FIGURE 16

Top 20 cities/metropolitan areas by the number of highly cited papers in quantum physics (2014-2023)



From the perspective of research institutions (Figure 17), the top five research institutions by the number of publications in quantum physics from 2000 to 2024 are University of Tokyo, University of Science and Technology of China, University of Chinese Academy of Sciences, Massachusetts Institute of Technology and ETH Zurich. The top 20 are all world-leading universities or research institutions, located in the United States (7), China (5), the United Kingdom (2), Singapore (2), Japan and Switzerland (1). These universities or institutions serve as 'research anchors' for their respective cities and even countries, playing a pivotal role in building theoretical innovation capabilities and core competitiveness in the field of quantum physics.

FIGURE 17

Top 20 institutions by the number of publications in quantum physics (2000-2024)

[Focus] Quantum science and technology

Technological innovation capacity

According to Derwent Innovation (Figure 18), the number of 'quantum information' patent family disclosures in the world has been trending up from 89 in 2000 to 6,625 in 2024. Since 2015, the growth rate has been extraordinary, with a CAGR of 23.83%. By application, quantum computing (IPC code G06N, referring to computing devices based on specific computing models) has become the most popular technological innovation hotspot, with a CAGR up to 52.10% between 2015 and 2024, much higher than the overall level. In 2024, the patent families in quantum computing accounted for 41.43% of the total in quantum information in the same period, highlighting the increasingly fierce competition for intellectual property rights in the field.

The top 10 cities by the number of valid patent families in quantum information (Figure 19) are Beijing, Seoul MA, Guangdong-Hong Kong-Macao Greater Bay Area, Tokyo MA, San Francisco-San Jose, Hefei, New York MA, Shanghai, Nanjing and Hangzhou. Chinese cities take up 11 spots in the top 20, holding a dominant position.

FIGURE 18 Number of invention patents in quantum information published globally (2000-2024)

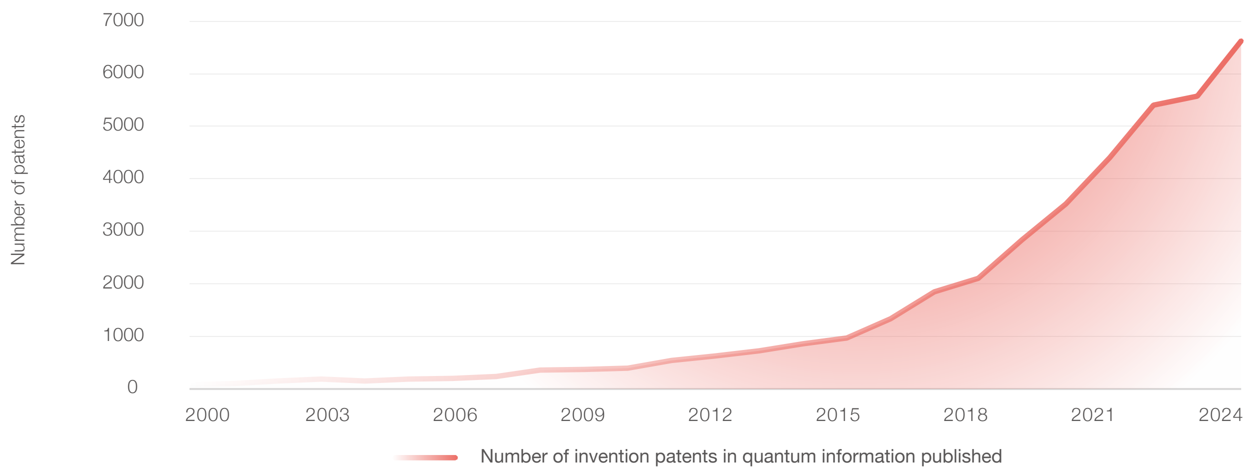
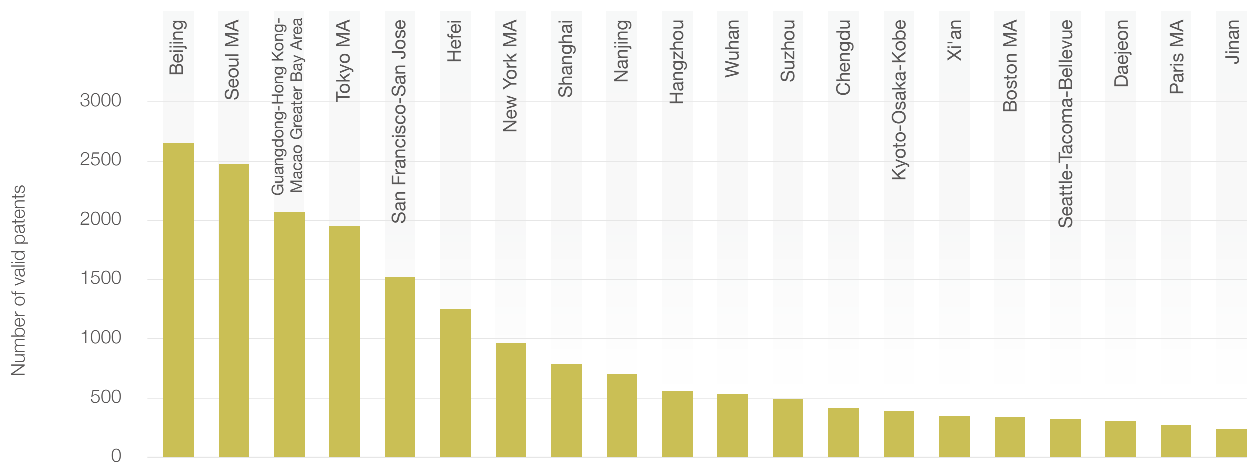


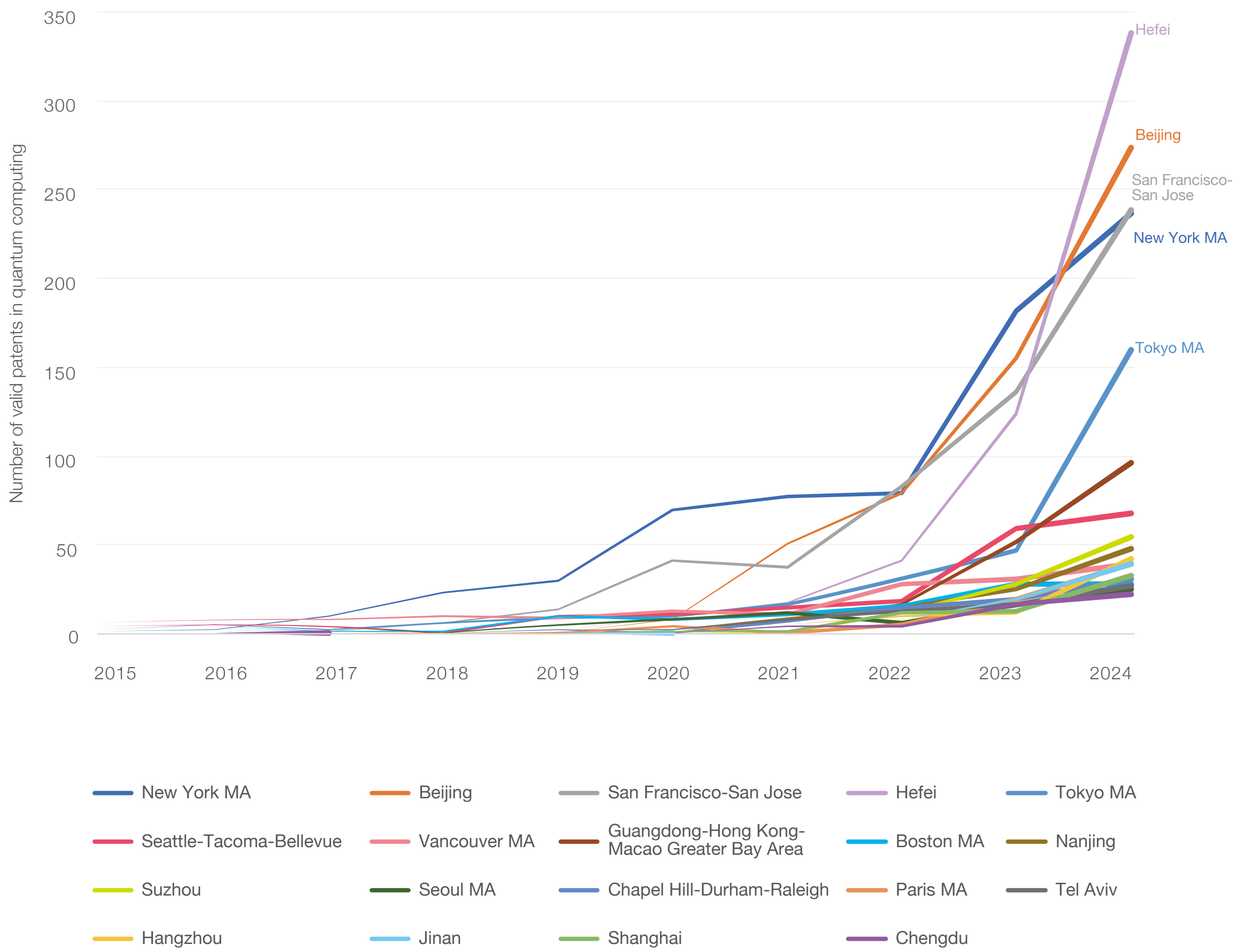
FIGURE 19 Top 20 cities/metropolitan areas by the number of valid patents in quantum information



The top 10 cities by the number of valid patent families in 'quantum computing' are New York MA, Beijing, San Francisco-San Jose, Hefei, Tokyo MA, Seattle-Tacoma-Bellevue, Vancouver MA, Guangdong-Hong Kong-Macao Greater Bay Area, Boston MA and Nanjing. Since Google announced 'quantum supremacy' in 2019, countries around the world have accelerated their strategic planning and intellectual property competitions in quantum computing. As shown in Figure 20, the leading cities in theoretical innovation are rapidly advancing patent protection, with Beijing, New York MA, San Francisco-San Jose and Hefei standing out. Tokyo MA, Guangdong-Hong Kong-Macao Greater Bay Area and Seattle-Tacoma-Bellevue also demonstrate strong competitiveness.

FIGURE 20

The annual trends of the top 20 cities/metropolitan areas in the number of valid patents in quantum computing (2015-2024)



[Focus] Quantum science and technology

Global quantum information patents are experiencing explosive growth, with quantum computing technology becoming the focus of competition with a CAGR of more than 50%. At the city level, innovation leaders are highly concentrated. Beijing, New York MA, San Francisco-San Jose, and Hefei stand out in the core field of quantum computing. Leading cities in technological innovation also feature differentiated innovation models: New York MA is driven by large enterprises, Chinese cities such as Hefei and Beijing are by public research institutions, while Vancouver and San Francisco are led by start-ups or diversified hybrid ecosystems.

Based on the analysis of the institutions with 25 or more patents in the top 20 cities/metropolitan areas by the number of valid patent families in quantum computing (Figure 21), the cutting-edge innovation capability and cities' competitiveness in this field are mainly driven by three types of entities — namely large multinational companies in information technology, small companies and unicorns in the subsectors of quantum computing, and universities and public research institutions. Different resource endowments of the cities have resulted in diversified innovation models:

- Driven by large multinational companies: represented by New York MA, this model is characterized by sustained investment from major global companies. IBM, for example, has been investing in quantum computing R&D since the 1970s, and holds the world's largest number of valid patent families, making New York MA a technology hub in the field. Similar cities include Tokyo MA and Seattle-Tacoma-Bellevue.
- Driven by small companies and unicorns: This model is represented by Vancouver MA. D-Wave, the world's first company to commercialize quantum computing, has its quantum annealing machine well applied to solve combinatorial optimization problems. The company also incubated 1Qbit, the world's first quantum computing software company. Both are listed on Nasdaq and are promoting technology R&D and market expansion by integrating local innovation resources with external capital. Similar cities include Tel Aviv.
- Driven by universities and public research institutions: supported by strong theoretical research capabilities of the University of Science and Technology of China, Hefei has successfully incubated Origin Quantum, which holds the second largest number of patents in the world. The city has become a global innovation hub of quantum computing. Similar cities include Boston MA, Paris MA and Beijing. In early 2024, Baidu and Alibaba withdrew from quantum computing R&D and donated their laboratories to the Beijing Academy of Quantum Information Sciences and Zhejiang University, further strengthening the dominance of China's public research institutions.
- Hybrid innovation ecosystems: San Francisco-San Jose has diversified drivers. In addition to technology giants such as Google and Intel, the good innovation ecosystem in Silicon Valley has also cultivated a number of small innovative enterprises focusing on different technology routes, such as Rigetti Computing and PsiQuantum. Wells Fargo Bank and other other industrial players are actively exploring application scenarios of quantum computing, providing important support for developing and deploying the technology.

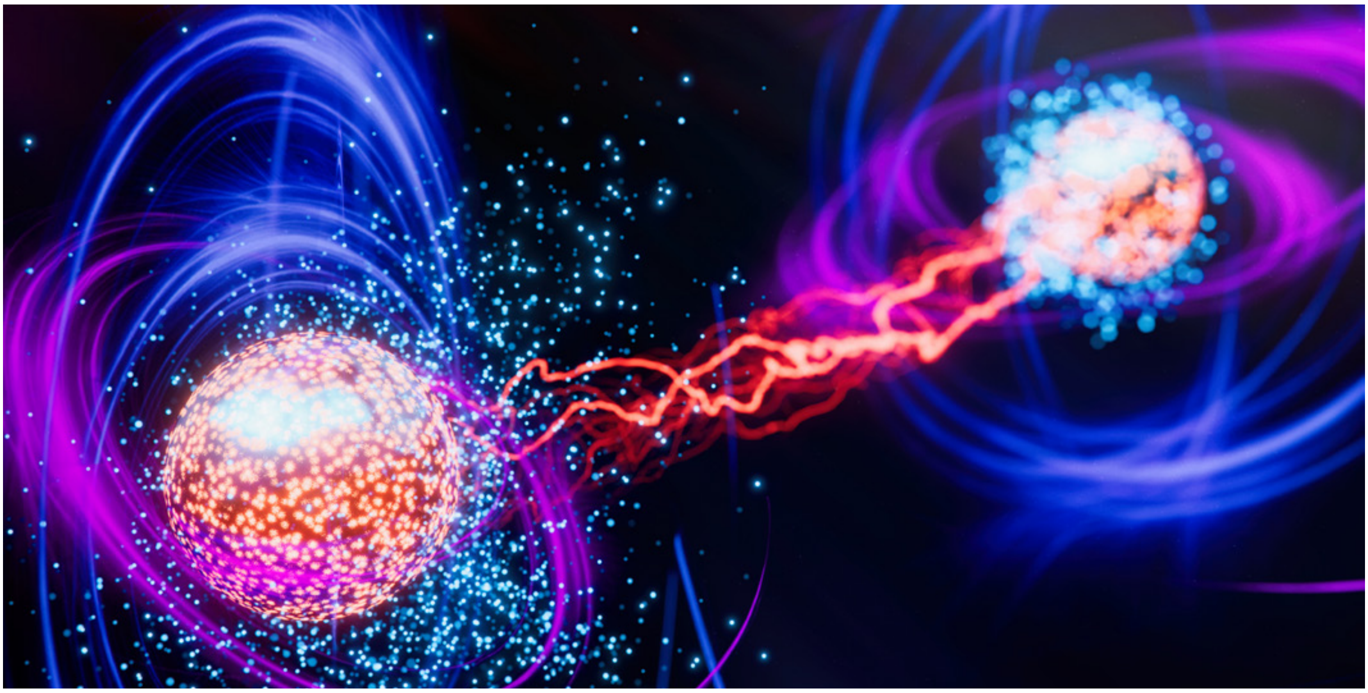


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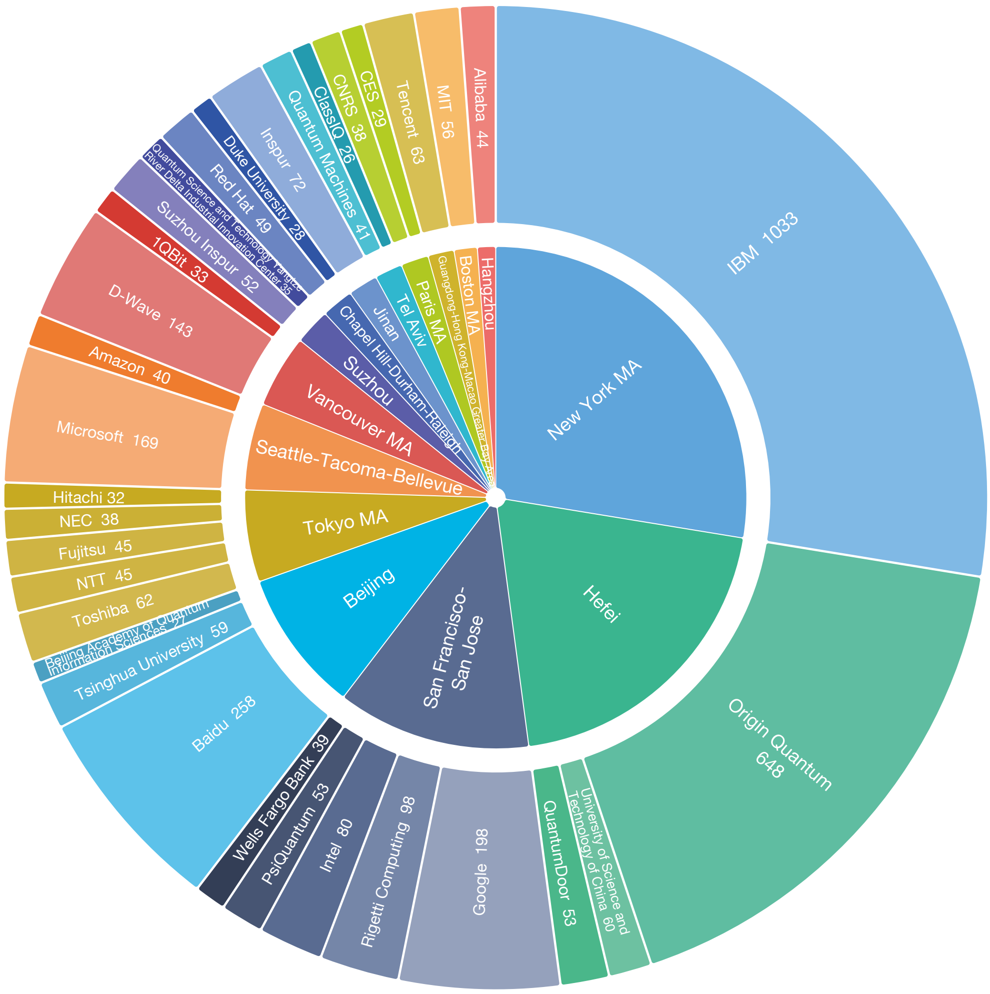
FIGURE 21

The main innovation entities among the top 20 cities/metropolitan areas in the number of valid patents in quantum computing



[Focus] Quantum science and technology

Development potential

Overall, the theoretical and technological innovation in quantum technology keeps accelerating. However, the journey from theoretical breakthroughs to practical applications remains a long and challenging marathon. To transform disruptive technologies into mature industrial ecosystems, still requires large-scale capital investment and continuous support from high-level human resources.

The market of quantum technology is expected to maintain rapid growth in the next 15 years, with quantum computing growing most significantly. But the whole industry is still in the early stage of investment-driven development. In order to seize the development opportunity, countries have increased capital investment strategically and promoted technology R&D and output transformation by strengthening business incubation and mobilizing national strategic scientific and technological forces. In terms of talent pool, China and the United States have shown prominent strengths. Europe and the rest of the Asia-Pacific region have also demonstrated competitiveness. Overall, it features a multipolar development pattern.

According to McKinsey's *Quantum Technology Monitor 2025*, the market of quantum technology is expected to grow at an annual rate of 11-14% in the next 15 years. Optimistically, the total market size is expected to reach US$97 billion in 2035 and exceed US$198 billion in 2040. The growth rate in quantum computing is notable, with an expected annual growth rate of 40%. By corporate revenue, the total revenue growth of global quantum computing companies has accelerated significantly: up from about US$200 ~ 254 million in 2021 to US$650 ~ 750 million in 2024, and is expected to exceed US$1 billion in 2025. This growth is mainly attributed to the gradual introduction of quantum computing technology and the accelerating hardware deployment by countries, as well as the implementation of quantum solutions driven by investment from the governments and defense sectors.

- In terms of financing, the total funding raised by global quantum technology start-ups totalled US$1.3 billion in 2023 and rose to US$2 billion in 2024, with quantum computing accounting for 80%. Start-ups in the United Stated received the most investment. Currently, the annual revenue of global quantum computing companies remains significantly lower than their funding scale, indicating that the industry is still in its infancy with growth primarily driven by investment rather than commercial returns.

- Strategically at the national level, in order to safeguard national security and maintain competitiveness in the global science and technology economy, leading countries in innovation have committed a total investment of more than US$54 billion in quantum information — a figure that continues to grow rapidly. Here is a breakdown of country-level investment


MF3D/E+/GETTY

commitments: US$15.3 billion (to be confirmed) for China, US$9.2 billion for Japan, US$6 billion for the United States, US$5.2 billion for Germany, US$4.6 billion for the United Kingdom, US$2.4 billion for South Korea, US$2.2 billion for France, US$1.7 billion for India, and US$1 billion each for the Netherlands and Spain.

- Countries are seizing development opportunities by strengthening business incubation and mobilizing national strategic scientific and technological forces to drive R&D and research transformation. In 2024, 34% of venture capital in quantum technology came from the public sector (including governments, sovereign funds and universities), an increase of 19% from 2023. Take the United States as an example, after the National Quantum Initiative Act was passed in 2018, five National Quantum Information Science Research Centers (NQISRCs) were established in 2020, which were supported by five national laboratories of the U.S. Department of Energy. They have integrated national laboratories, top universities, large enterprises and other leading innovation institutions to jointly facilitate interdisciplinary R&D of quantum information. They would be applied to energy, medicine, finance and national security, ensuring the United States' leadership in global quantum competition.

Talent is the core resource for quantum science and technology innovation and industrial development. The volume and quality of talent in quantum technology determine future competitiveness and development potential of a country or a city. Based on data from Dimensions over the past decade, two indicators — the number of active scientists and the number of highly cited scientists — could be used to assess major cities/metropolitan areas' strength in human resources in quantum science and technology, especially the reserve of high-end talent.

As shown in Figure 22, in the past decade, active scientists who have engaged in quantum physics research and published papers around the world were mainly from cities/metropolitan areas in China and the United States. China and the United States occupy ten and four spots in the top 20, respectively, showing that China is significantly leading in the talent pool. In terms of distribution of highly cited scientists (Figure 23), China and the United States also dominated the list. In the top 20 cities/metropolitan areas, these countries occupy six spots each. By proportion, they had nearly the same number of high-impact scientists, together accounting for about two-thirds of the total, far above other countries. Overall, China has notable advantages in the scale of talent. With equally strong high-end talent pools, China and the United States are considered the dual cores for global quantum technology development. In addition, some cities in Europe and other parts of the Asia-Pacific region are also competitive, reflecting the multipolar development pattern on a global scale.

Risks and challenges

Quantum science and technology is promising given the booming theoretical and application innovation. Moreover, several quantum computing technology roadmaps point out that next five years will be a critical window period for the development of the industry. However, it still faces theoretical and engineering challenges that need to be addressed before further development. Take quantum computing as an example: from proof-of-concept, specialized quantum computing to the final construction of a general-purpose quantum computing system, long-term technology accumulation is indispensable. Currently, a variety of technology roadmaps such as superconductivity, ion traps, light quantum, neutral atoms, silicon spin, and topology are progressing in parallel, each featuring unique advantages. A clear mainstream path has not yet been formed amid a multitude of competing alternatives. In terms of hardware, there are still major technical bottlenecks in large-scale preparation, error correction and operational stability of quantum qubits. Meanwhile, the software ecosystem — encompassing new quantum algorithms and applications, computational method interoperability, user-friendly software stacks, development tools, and cloud platform construction — remains in an early exploratory and developmental phase.

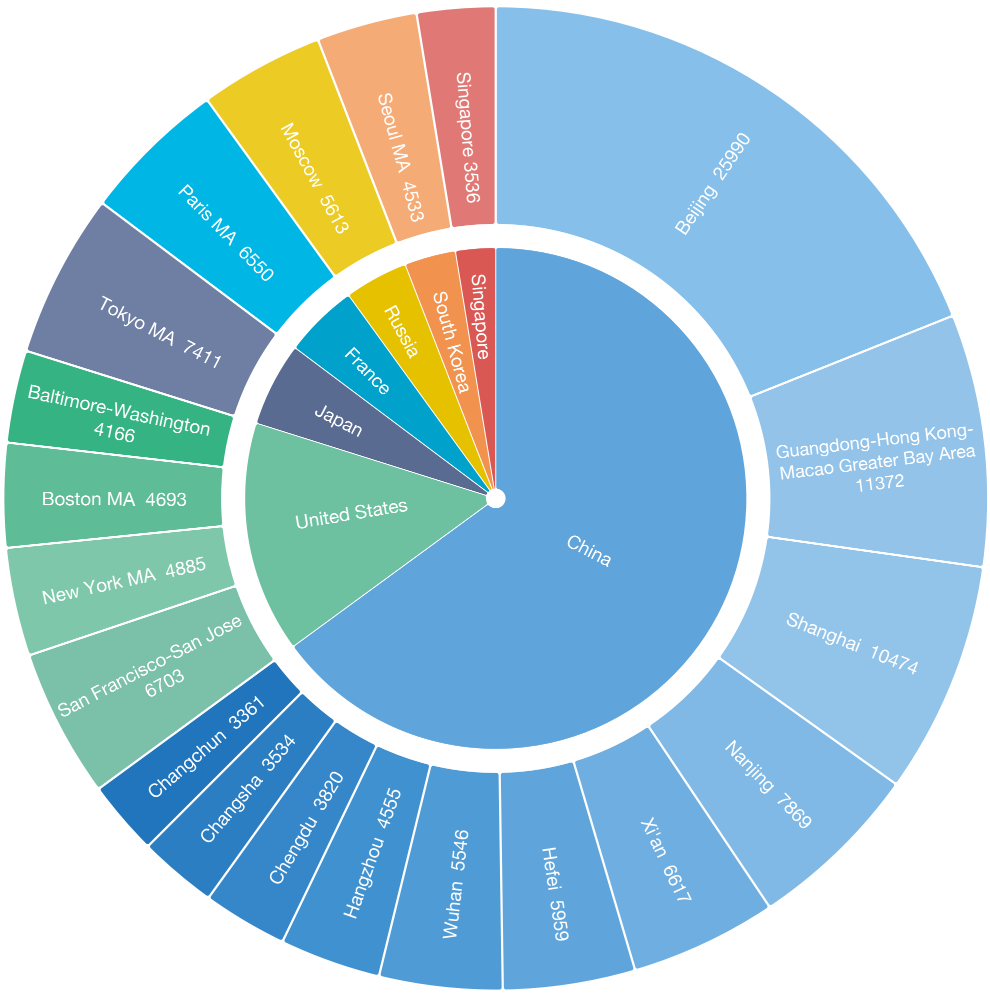
Given the rising geopolitical risks, quantum science and technology is facing multiple disruptions and challenges. Quantum information has gradually become a key battlefield where national security, economic competition and political maneuvering intersect. Most countries tend to prioritize domestic development by allocating government funding and technological infrastructure internally, rather than engaging in international cooperation — further deepening the fragmentation of the global science and technology ecosystem. For example, the United States has added a number of China's core quantum research institutions and enterprises to its export control 'Entity List', aiming to hinder China's progress in quantum computing, communications and other fields through technology blockades. However, this move effectively drives China to accelerate the optimization of its scientific and technological innovation system, increase

> **Quantum technology, especially quantum computing, holds immense promise, but its development still faces significant challenges. Technically, a mainstream technical route has not yet been formed amid a multitude of competing alternatives. There are also bottlenecks in the hardware and software ecosystems. Due to geopolitical risks, global technology competition and barriers have intensified, leading to the fragmentation of technological ecosystems and the potential division of technical standards. Looking ahead, the key issues to promote global governance and cooperation, and to close the technology gaps will be a key topic in the field.**

resource investment and organizational coordination, and demonstrate a deeper commitment to development. Domestic industry and supply chain enterprises are seizing this opportunity to gradually achieve technological independent control over key technologies. In addition, competing interests between countries may also bring about the risk of fragmentation of technical standards. If major countries fail to reach agreement over standards, it may lead to the fragmentation of the global quantum market in the future, increasing R&D costs, reducing system interoperability, and ultimately delaying technology iteration and application

FIGURE 22

Top 20 cities/metropolitan areas by the number of active scientists in quantum physics (2015-2024)

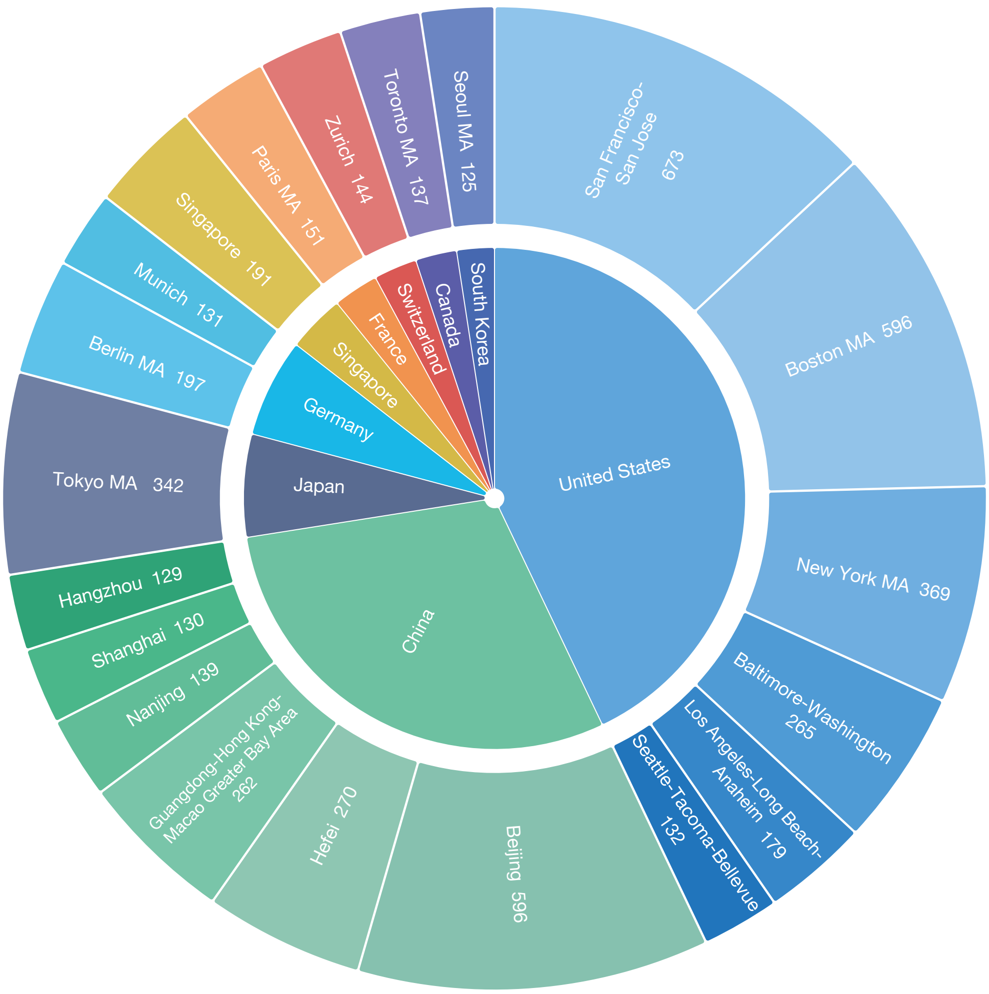


for the entire field.

Quantum science and technology, with its disruptive potential, is becoming a crucial driving force for the evolution of the technology ecosystem. Going forward, key topics for the international community would include how to further promote global quantum technology governance, narrow the technology gap between the north and the south, and strengthen international cooperation, thereby achieving sustainable development of the field. This is the deeper mission behind the IYQ, which goes beyond mere commemoration to actively promote these transformative goals.

FIGURE 23

Top 20 cities/metropolitan areas by the number of highly cited scientists in quantum physics (2015-2024)



4. Innovation economy

The global economy is undergoing a transformation, with scientific and technological innovation emerging as the primary engine of growth. Leading cities in innovation economy continue to dominate, with San Francisco-San Jose boasting stronger edges, and Guangdong-Hong Kong-Macao Greater Bay Area rising to second place globally. North America has significant advantages in innovative enterprises and high-end manufacturing. Nearly 60% of the North American cities in the top 100 enter the global top 50. Asia is catching up quickly on technology patents and revenue of the new economy. A large number of Asian cities are in the lead, and several rank among the top 100. Overall, Asian cities are concentrated at both ends of the list.

4.1
A comprehensive analysis of innovation economy

The GIHI2025 innovation economy ranking is shown in Table 7.

TABLE 7

Ranking and scores of the top 100 GIHs in innovation economy

Rank	City/metropolitan area	Innovation Economy	Technological Innovation Capacity	Innovative Enterprises	Emerging Industries	Economic Growth
1	San Francisco-San Jose	**100.00**	100.00	100.00	100.00	88.49
2	Guangdong-Hong Kong-Macao Greater Bay Area	**79.02**	89.28	74.94	77.64	73.14
3	Tokyo MA	**77.10**	97.35	71.99	70.68	72.15
4	Beijing	**76.45**	84.89	77.90	69.46	73.44
5	New York MA	**73.62**	68.18	76.80	69.10	79.57
6	Seoul MA	**73.16**	95.45	64.69	69.37	68.70
7	Boston MA	**71.03**	76.48	70.88	62.31	80.17
8	Seattle-Tacoma-Bellevue	**71.02**	74.34	62.78	67.65	88.61
9	Shanghai	**70.25**	72.39	70.95	64.89	75.02
10	Dublin	**69.51**	64.99	62.26	63.65	100.00
11	Kyoto-Osaka-Kobe	**68.86**	84.29	63.48	62.76	72.27
12	Dallas-Fort Worth	**68.69**	63.85	61.80	73.69	77.11
13	Paris MA	**68.60**	67.77	65.46	64.91	82.06
14	London MA	**67.78**	63.45	66.40	63.58	83.04
15	Hangzhou	**67.53**	69.41	64.83	61.28	82.32
16	Daejeon	**67.05**	87.14	60.09	60.07	70.49
17	San Diego MA	**67.01**	73.66	63.30	62.01	75.84
18	Singapore	**66.78**	64.96	62.23	61.25	88.63
19	Munich	**66.47**	72.61	61.86	60.15	80.59
20	Austin	**66.28**	66.70	62.43	62.66	80.29
21	Taipei	**66.06**	68.74	61.28	66.13	71.92
22	Nagoya MA	**65.52**	71.07	61.28	60.80	76.62
23	Baltimore-Washington	**65.22**	62.85	62.60	62.04	79.47
24	Milan	**65.14**	61.46	60.74	60.53	87.53
25	Riyadh	**65.13**	60.13	60.16	61.19	88.97
26	Chicago-Naperville-Elgin	**64.81**	62.18	63.21	62.50	75.60
27	Chapel Hill-Durham-Raleigh	**64.75**	65.73	60.56	60.58	80.39
28	Ankara	**64.74**	60.22	60.09	60.12	88.80
29	Stockholm	**64.64**	63.06	62.07	61.14	78.66
30	Changchun	**64.63**	61.62	60.25	60.06	86.30

4.Innovation economy

Rank	City/metropolitan area	Innovation Economy	Technological Innovation Capacity	Innovative Enterprises	Emerging Industries	Economic Growth
31	Nanjing	64.56	72.21	60.86	60.53	70.98
32	Los Angeles-Long Beach-Anaheim	64.34	62.63	64.94	60.57	72.61
33	Denver MA	64.29	61.48	60.98	61.91	79.13
34	Amsterdam MA	64.16	61.08	61.63	60.85	79.66
35	Houston MA	64.06	63.56	60.93	60.51	78.25
36	Phoenix MA	64.01	62.76	60.90	61.88	76.17
37	Wuhan	63.93	65.55	61.12	60.92	73.88
38	Bangkok	63.93	60.08	60.29	60.64	82.69
39	Minneapolis-Saint Paul	63.90	63.83	61.28	60.23	76.81
40	Moscow	63.90	61.80	60.16	60.53	80.94
41	Suzhou	63.88	67.49	61.77	60.52	70.71
42	Copenhagen	63.86	61.38	60.98	60.23	80.10
43	Jinan	63.83	64.56	60.43	60.42	76.86
44	Hefei	63.61	64.98	61.34	60.21	73.61
45	Philadelphia MA	63.58	62.15	61.97	60.22	75.48
46	Chengdu	63.56	64.13	61.25	60.59	73.78
47	Miami MA	63.54	61.03	60.89	60.12	79.02
48	Stuttgart	63.37	65.09	60.46	60.03	74.24
49	Mumbai MA	63.35	60.77	61.95	62.18	71.85
50	Madrid	63.35	61.05	60.77	61.51	75.31
51	Dubai	63.33	60.05	60.45	60.09	79.95
52	Hamburg	63.32	61.20	60.68	60.03	78.15
53	Helsinki	63.32	64.75	61.02	60.84	71.53
54	Atlanta MA	63.32	61.92	61.12	60.41	75.56
55	Rotterdam	63.27	60.72	60.09	60.16	79.38
56	Lyon-Grenoble	63.26	61.56	60.00	60.00	78.82
57	Qingdao	63.25	63.24	60.78	60.07	75.00
58	Zurich	63.11	64.53	60.51	60.03	73.27
59	Fuzhou	63.10	61.80	60.37	60.13	76.54
60	Jakarta	63.09	60.00	60.48	60.69	77.27
61	Zhengzhou	63.07	61.27	60.25	60.04	77.44
62	Dusseldorf	63.07	61.04	60.37	60.19	77.16
63	Bengaluru	63.00	60.51	62.61	61.09	70.95
64	Gothenburg	62.99	61.59	60.37	60.11	76.18
65	Warsaw	62.97	60.75	60.09	60.16	77.55

Rank	City/metropolitan area	Innovation Economy	Technological Innovation Capacity	Innovative Enterprises	Emerging Industries	Economic Growth
66	Vienna	**62.95**	61.58	60.29	60.15	76.02
67	St. Louis	**62.94**	62.10	60.18	60.22	75.40
68	Budapest	**62.89**	60.39	60.09	60.17	77.48
69	Frankfurt	**62.85**	61.14	60.82	60.02	75.13
70	Cincinnati	**62.84**	61.82	60.16	60.10	75.48
71	Las Vegas	**62.82**	60.63	60.16	60.02	76.92
72	Pittsburgh	**62.79**	62.34	60.50	60.26	73.51
73	Chennai MA	**62.78**	60.23	60.06	60.34	76.70
74	Toronto MA	**62.76**	61.87	61.61	61.71	68.65
75	Detroit MA	**62.75**	61.12	60.43	60.00	75.40
76	Manchester	**62.74**	60.46	60.19	60.01	76.57
77	Brussels	**62.72**	60.94	60.43	60.50	74.40
78	Portland	**62.63**	61.12	60.31	60.01	74.88
79	Istanbul	**62.62**	60.86	60.19	60.22	75.01
80	Cologne	**62.58**	60.57	60.43	60.02	74.99
81	Xi'an	**62.57**	64.16	60.37	60.38	70.06
82	Rome	**62.57**	60.69	60.37	60.12	74.74
83	Berlin MA	**62.55**	61.73	61.63	60.09	70.79
84	Barcelona MA	**62.54**	61.23	60.31	60.08	74.10
85	Vancouver MA	**62.48**	62.12	60.82	60.69	70.39
86	Changsha	**62.44**	63.06	60.78	60.51	69.48
87	Xiamen	**62.43**	63.02	60.68	60.26	70.19
88	Chongqing	**62.43**	61.23	60.47	60.18	72.93
89	Central National Capital Region Delhi MA	**62.35**	60.51	61.06	61.01	70.40
90	Prague	**62.32**	60.49	60.06	60.00	74.33
91	Perth	**62.17**	60.12	60.00	60.03	73.99
92	Doha	**62.13**	60.14	60.00	60.21	73.35
93	Nanchang	**62.13**	61.42	60.09	60.07	71.88
94	Lisbon	**62.12**	60.12	60.09	60.07	73.40
95	Tel Aviv	**62.09**	61.58	62.15	60.77	65.82
96	Tianjin	**62.09**	62.85	60.72	60.34	68.12
97	Montreal MA	**62.07**	61.01	60.78	60.90	68.94
98	Abu Dhabi	**61.96**	60.09	60.16	61.01	70.46
99	Shenyang	**61.95**	61.80	60.37	60.08	69.77
100	Mexico City	**61.87**	60.18	60.39	61.18	68.95

4.Innovation economy

FIGURE 24

Quartile graph of ranking in innovation economy for cities/metropolitan areas in Asia, Europe and North America

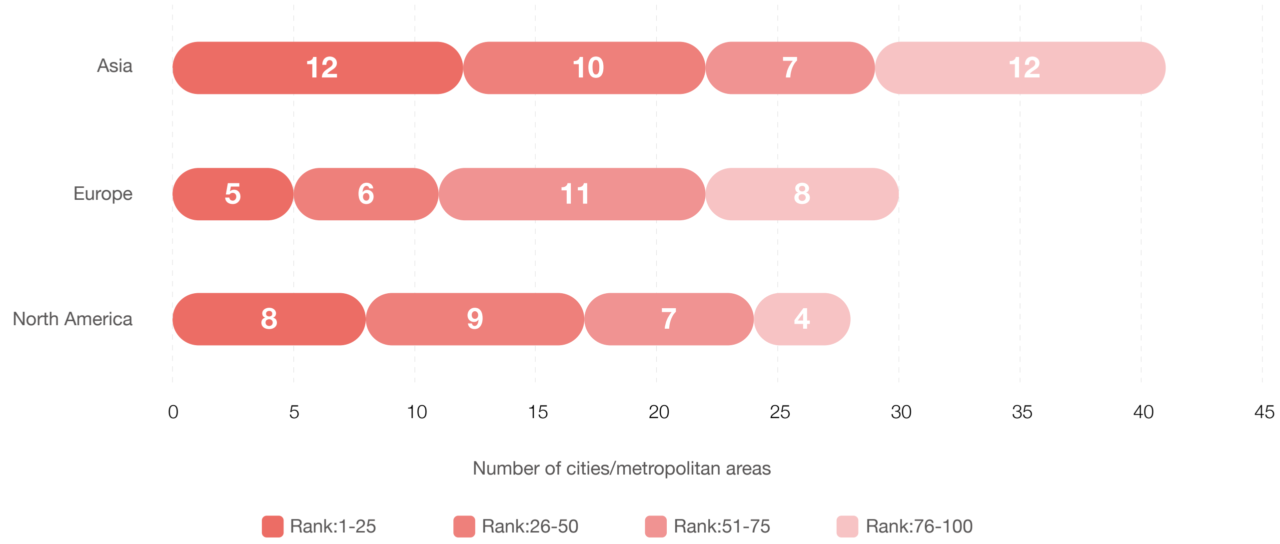


TABLE 8

A comparison of the top 20 GIHs in innovation economy between 2023-2025

City/metropolitan area	Rank 2025	Rank 2024	Rank 2023
San Francisco-San Jose	1	1	1
Guangdong-Hong Kong-Macao Greater Bay Area	2	5	5
Tokyo MA	3	4	2
Beijing	4	2	4
New York MA	5	3	3
Seoul MA	6	6	6
Boston MA	7	8	7
Seattle-Tacoma-Bellevue	8	9	11
Shanghai	9	10	15
Dublin	10	7	10
Kyoto-Osaka-Kobe	11	16	13
Dallas-Fort Worth	12	17	8
Paris MA	13	11	14
London MA	14	13	17
Hangzhou	15	24	23
Daejeon	16	12	35
San Diego MA	17	14	16
Singapore	18	15	12
Munich	19	19	21
Austin	20	21	18

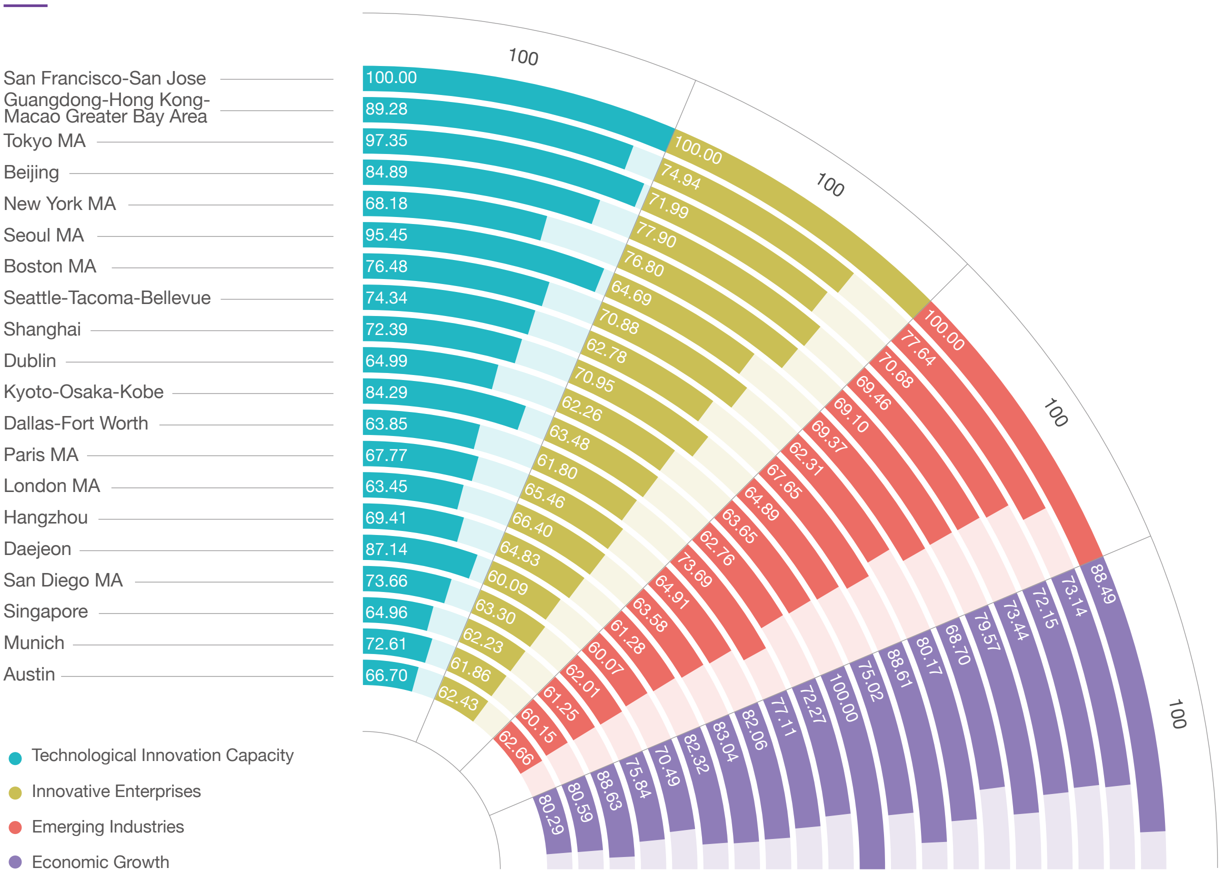
According to the assessment of innovation economy (see Table 7), top GIHs show a pattern characterized by 'one dominant leader followed by multiple strong contenders with clearly defined tiers'. San Francisco-San Jose ranks first by a significant margin. The relative scores show that San Francisco-San Jose continues to broaden its advantage in innovative enterprises and emerging industries. Its incremental performance is particularly remarkable. Guangdong-Hong Kong-Macao Greater Bay Area, Tokyo MA and Beijing rank second, third and fourth, respectively, forming a fiercely competitive second tier. New York MA and Seoul MA follow closely with adjacent positions and comparable scores, forming the third tier featuring great potential.

Geographically (see Figure 24), the innovation economy is more developed in North America, Asia and Europe, and the listed cities from these regions demonstrate unique characteristics. Among the top 20, there are nine cities in Asia, seven in North America and four in Europe. Among the top 100, Asia leads the world with a total of 41 spots. The leading cities are strongly competitive. However, regional development remains uneven, displaying a distribution pattern of 'large at both ends and small in the middle'. North America, while having a slightly smaller total count in the ranking, maintains a relatively leading position with highly concentrated distribution. Nearly 60% of North American cities/metropolitan areas are among the top 50, ranking 26th to 50th in the middle range. Europe ranks second with a total of 30 spots, but few cities are at the top and most are at the middle/lower ends, indicating a spindle-shaped pattern, which swells in the middle and tapers at both ends.

As shown by the trends (see Table 8), a few top cities/metropolitan areas lead by a large margin, while the rest are competing to catch up. San Francisco-San Jose has ranked first for six consecutive years thanks to its efficient allocation and continuous iteration of innovative elements such as talent, technology and capital. Guangdong-Hong Kong-Macao Greater Bay Area, with strong growth momentum, moves up from fifth place to second place this year, making it one of the most dynamically ascending cities/metropolitan areas. Tokyo MA and

FIGURE 25

Development of the top 20 GIHs in innovation economy



Beijing rank third and fourth owing to their outstanding technological innovation capabilities and innovative enterprises. New York MA ranks fifth for its ability in attracting high-tech manufacturing enterprises and incubating unicorns.

Many of the top 20 GIHs in innovation economy have shown strong upward momentum. Compared with last year, cities/metropolitan areas such as Guangdong-Hong Kong-Macao Greater Bay Area, Seattle-Tacoma-Bellevue, Shanghai and Hangzhou have made significant progress. Guangdong-Hong Kong-Macao Greater Bay Area has risen to the second place, mainly due to its outstanding technological innovation capabilities and engagement in the competition of AI technology globally. It takes the lead in the world with 9,535 AI PCT patent applications in recent years. Seattle-Tacoma-Bellevue brings together information technology companies, and its flagship enterprise, Microsoft, drives rapid development of local innovation economy through cloud services and AI. Given strengths in biomedicine, new energy vehicles, integrated circuits and digital economy, Shanghai has risen to the tenth place in innovation economy as the market value of its high-tech manufacturing enterprises and the revenue of new economy companies have increased significantly. Hangzhou has entered among the top 20 globally for the first time as a representative of the emerging innovation cities. Led by Alibaba and DeepSeek among other top enterprises in the AI sector, Hangzhou boasts 13,508 AI patents. This places the city eighth in the world and third among Chinese cities/metropolitan areas, trailing only Beijing and Guangdong-Hong Kong-Macao Greater Bay Area.

According to the sub-indicators (see Figure 25), San Francisco-San Jose leads the world in three sub-indicators: technological innovation capacity, innovative enterprises and emerging industries. It also outperforms in economic growth and ranks among the top, building up solid and comprehensive advantages. Asian cities/metropolitan areas, such as Tokyo MA, Seoul MA, Guangdong-Hong Kong-Macao Greater Bay Area, Daejeon, Beijing and Kyoto-Osaka-Kobe, also have strong technological innovation capacity. Beijing ranks first in the world with 53,327 AI patents, demonstrating its strong technical strength and continuous R&D investment in this field. Guangdong-Hong Kong-Macao Greater Bay Area leads with 9,535 AI PCT patent applications in the past five years, highlighting its leading edge in the international patent layout and global technology competition. In terms of economic growth, Dublin, Singapore, Seattle-Tacoma-Bellevue, London MA, Hangzhou, Paris MA, Munich, Austin and Boston MA are in the forefront, demonstrating their high economic vitality.

4.2 Technological innovation capacity

The number of technology patents reflects the level of technology accumulation and innovation activity in a specific region. This report evaluates technological innovation capacity using the number of valid patents (per million people) and PCT patents over the past five years in six fields, including AI, smart chips, renewable energy, biomedicine, quantum information and controlled nuclear fusion. The top five cities/metropolitan areas in technological innovation capacity are San Francisco-San Jose, Tokyo MA, Seoul MA, Guangdong-Hong Kong-Macao Greater Bay Area and Daejeon (see Figure 26). Asian cities/metropolitan areas stand out by taking up 12 spots in the top 20, followed by North America and Europe with six and two spots respectively.

Top 20 cities/metropolitan areas by the number of valid patents (per million people) are concentrated in a few regions. In particular, Asian cities/metropolitan areas stand out in the field of AI. North America and Asia dominate the top 20 list, with China and the United States occupying seven and six spots respectively. There are six cities/metropolitan areas that have more than 5,000 valid patents per million people, namely San Francisco-San Jose, Daejeon, Beijing, Seoul MA, Kyoto-Osaka-Kobe and Tokyo MA. San Francisco-San Jose tops the list with 11,159 valid patents per million people. It is home to a large number of world-leading high-tech companies and top research institutions, and has continued to lead technological transformation in AI, smart chips and other fields, therefore fostering a highly vibrant innovation ecosystem. Daejeon ranks second with 10,620 valid patents per million people. It's an important life science R&D highland in Asia for technological innovation in biomedicine. Beijing ranks third with 6,233 valid patents per million people. Supported by national innovation platforms like Zhongguancun Science City, as well as many universities, research institutions and innovative enterprises, Beijing continues to produce output in AI, quantum information and aerospace. The quality and technical influence of its patents keep improving. Asian cities/metropolitan areas are strong at AI-related R&D and have made significant technological progress. Four Asian cities are in the top five, with Beijing ranking first while Guangdong-Hong Kong-Macao Greater Bay Area, Tokyo MA and Seoul MA taking third to fifth place, respectively.

Based on the number of PCT patents over the past five years, Asian cities/metropolitan areas lead the world by occupying the top three places. Guangdong-Hong Kong-Macao Greater Bay Area ranks first with 21,363 PCT patent applications, followed by Tokyo MA and Seoul MA with 20,881 and 17,832, respectively. Data of PCT patents by field shows that in recent years, Asian cities/metropolitan areas have maintained intense R&D activities in strategic emerging industries such as AI and smart chips. They have actively advanced the global deployment of technological achievements and engaged deeply in global technological competition. In terms of AI- related PCT patents, Guangdong-Hong Kong-Macao Greater Bay Area tops the list with the most applications (9,535), followed by Seoul MA (8,563). In PCT patents of smart chips, Guangdong-Hong Kong-Macao Greater Bay Area also takes the lead with 4,724 applications, followed by Tokyo MA (1,914). Among the top 20 cities/metropolitan areas by the number of PCT patents, Asia took 12 spots, making up 60% of the list. This underscores Asia's growing role as the centre of global scientific and technological innovation and an important force in promoting industrial transformation.

Based on the standardized scores of the number of valid patents by field (see Figure 27), cities/metropolitan areas in North America and Asia stand out. San Francisco-San Jose, Beijing and Tokyo MA have the largest number of valid patents across fields. North America and Asia dominate in the fields of AI and smart chips. For AI, Beijing, San Francisco-San Jose and Guangdong-Hong Kong-Macao Greater Bay Area are the top three cities, holding 53,327, 47,831 and 45,555 valid patents, respectively. For smart chips, San Francisco-San Jose leads the world with 16,336 valid patents, followed by Tokyo MA (15,809) and Seoul MA (13,608). Asian cities/metropolitan areas also dominate in biomedicine, renewable energy, and quantum information. For biomedicine, Tokyo MA, Seoul MA and Guangdong-Hong Kong-Macao Greater Bay Area are the top three, each holding more than 20,000 valid patents. For renewable energy, Tokyo MA leads with 71,179 valid patents, far ahead of Beijing and Guangdong-Hong Kong-Macao Greater Bay Area, which rank second and third with 51,081 and 41,868 valid patents, respectively. For quantum information, Beijing, Seoul MA and Guangdong-Hong Kong-Macao Greater Bay Area are in the first tier, each holding more than 2,000 valid patents. For controlled nuclear fusion, Beijing ranks first with 253 valid patents, followed by Paris MA (100) and Tokyo MA (93).

FIGURE 26

Total number of valid patents (per million people) and number of PCT patents for the top 20 cities/metropolitan areas in technological innovation capacity

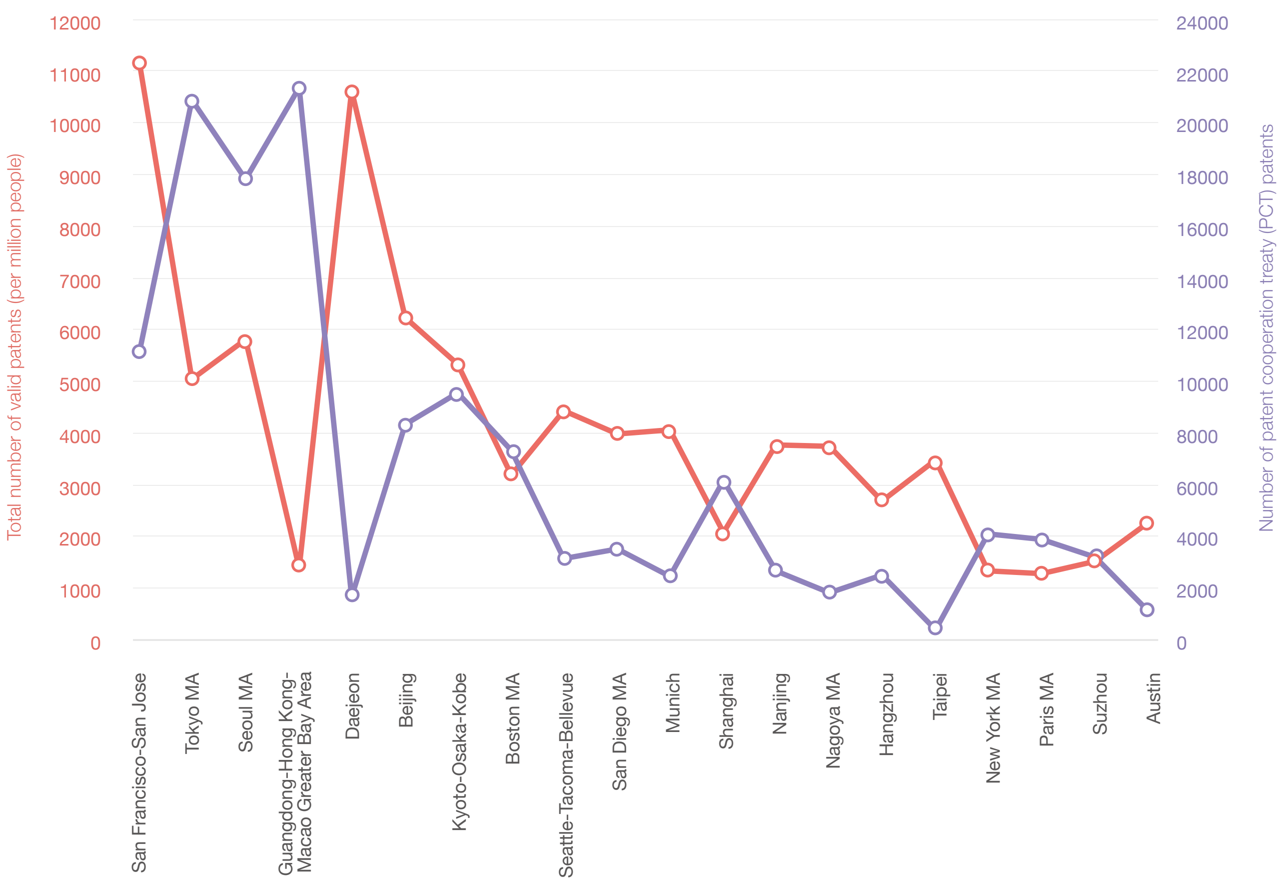
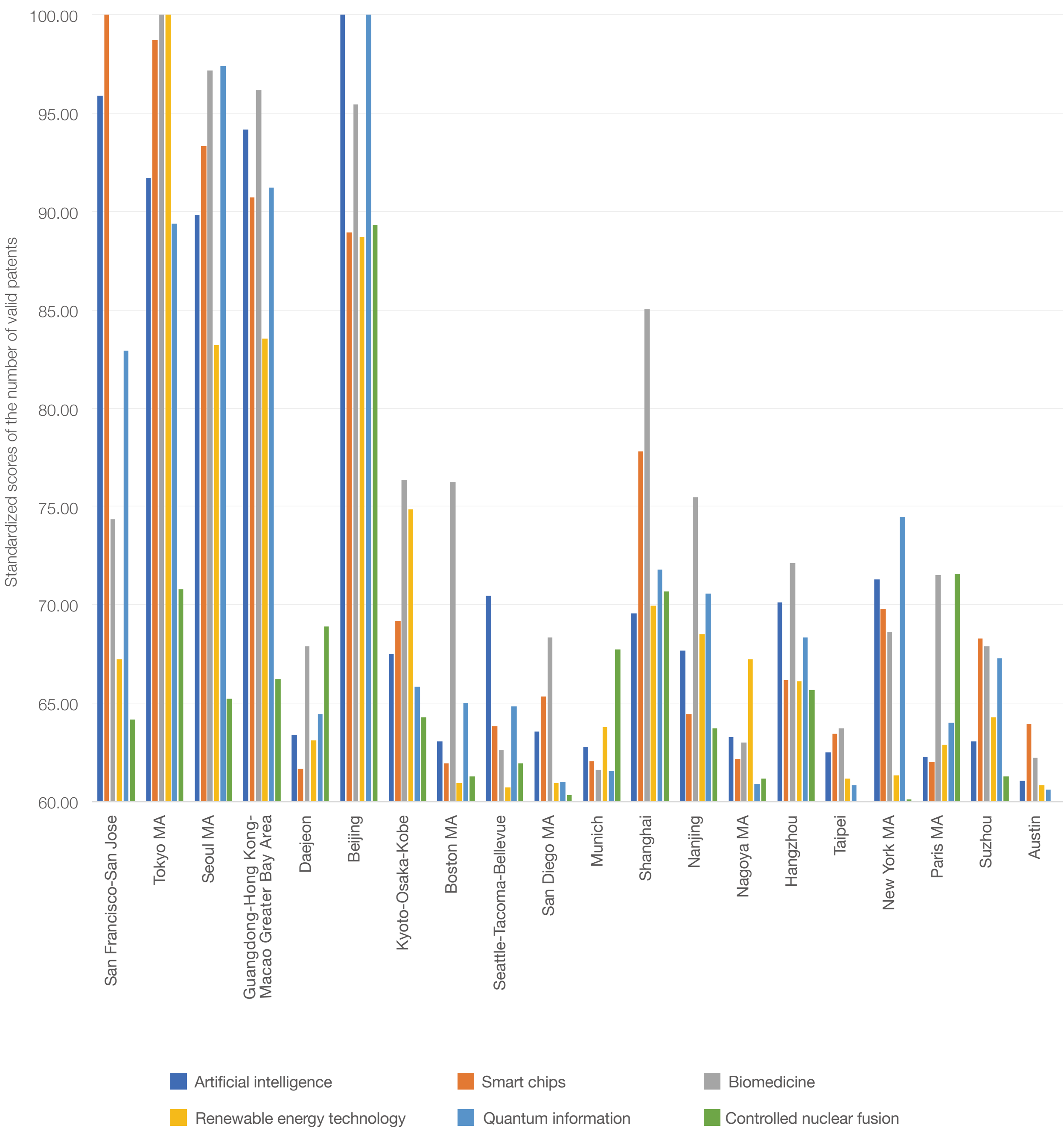


FIGURE 27

Standardized scores of the number of valid patents by field for the top 20 cities/ metropolitan areas in technological innovation capacity



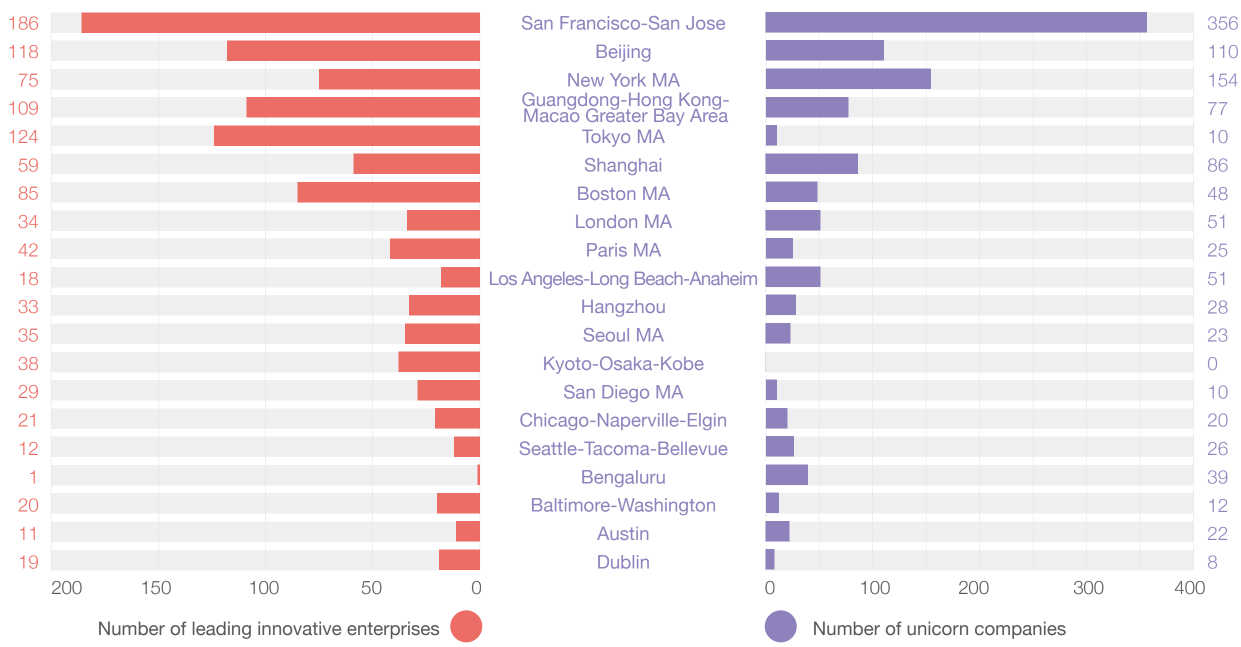
4.3 Innovative enterprises

Enterprises are important carriers of technological innovation and industrial transformation, acting as the major players in regional innovation systems. This report uses the number of leading innovative companies and the number of unicorn companies to measure the scale and vitality of innovative companies. The top five cities/metropolitan areas by the number of innovative enterprises are San Francisco-San Jose, Beijing, New York MA, Guangdong-Hong Kong-Macao Greater Bay Area and Tokyo MA (see Figure 28). In the top 20, North America, Asia and Europe take up nine, eight and three spots, respectively.

Data shows that leading innovative companies are highly concentrated in a few top cities/metropolitan areas in North America and Asia. Four cities/metropolitan areas have more than 100 leading innovative companies, namely San Francisco-San Jose, Tokyo MA, Beijing and Guangdong-Hong Kong-Macao Greater Bay Area. San Francisco-San Jose ranks first with 186 leading innovative companies, benefiting from its solid technology industry foundation, a vibrant venture capital ecosystem and an open innovation culture in Silicon Valley. It keeps nurturing high-growth technology companies and has become a global innovation hub of great influence. Asian cities/metropolitan areas also perform well. Tokyo MA, Beijing and Guangdong-Hong Kong-Macao Greater Bay Area rank second to fourth globally with 124, 118 and 109 leading innovative companies, respectively. Despite the rapid rise of Asian cities/metropolitan areas, the United States remains the innovation leader as 10 of the top 20 cities/metropolitan areas come from the country, demonstrating its accumulation in frontier industries and cutting-edge technologies.

Data shows that GIHs have proven to be fertile ground for nurturing unicorn companies. San Francisco-San Jose in the United States holds an absolute lead in both total number and relative growth. China's three major cities/metropolitan areas have formed distinctive clusters in key fields. San Francisco-San Jose leads the way with 356 unicorns and sees high-valued companies emerging constantly in AI, big data, cloud computing, blockchain and fin-tech, highlighting strong original innovation capabilities and an appeal for the capital. New York MA and Beijing have 154 and 110 unicorns, respectively, forming the second tier in unicorn companies. In terms of unicorn growth, San Francisco-San Jose and New York MA rank the top two, with an increase of 32 and 11 unicorns compared to last year. China's major innovation cities have performed well in nurturing unicorns in distinct ways. Beijing has gathered a large number of high-growth enterprises in AI, chip design and new retail, leading frontier technological innovation and development of new economy. Shanghai ranks fourth with 86 unicorns, showing strong innovation strength in biomedicine, integrated circuits and software services. Guangdong-Hong Kong-Macao Greater Bay Area rank fifth with 77 unicorns by focusing on fin-tech, new energy vehicles and new retail to continuously unleash innovation potential.

FIGURE 28 **Number of leading innovative companies and unicorn companies for the top 20 cities/metropolitan areas in innovative enterprises**



4.Innovation economy

4.4 Emerging industries

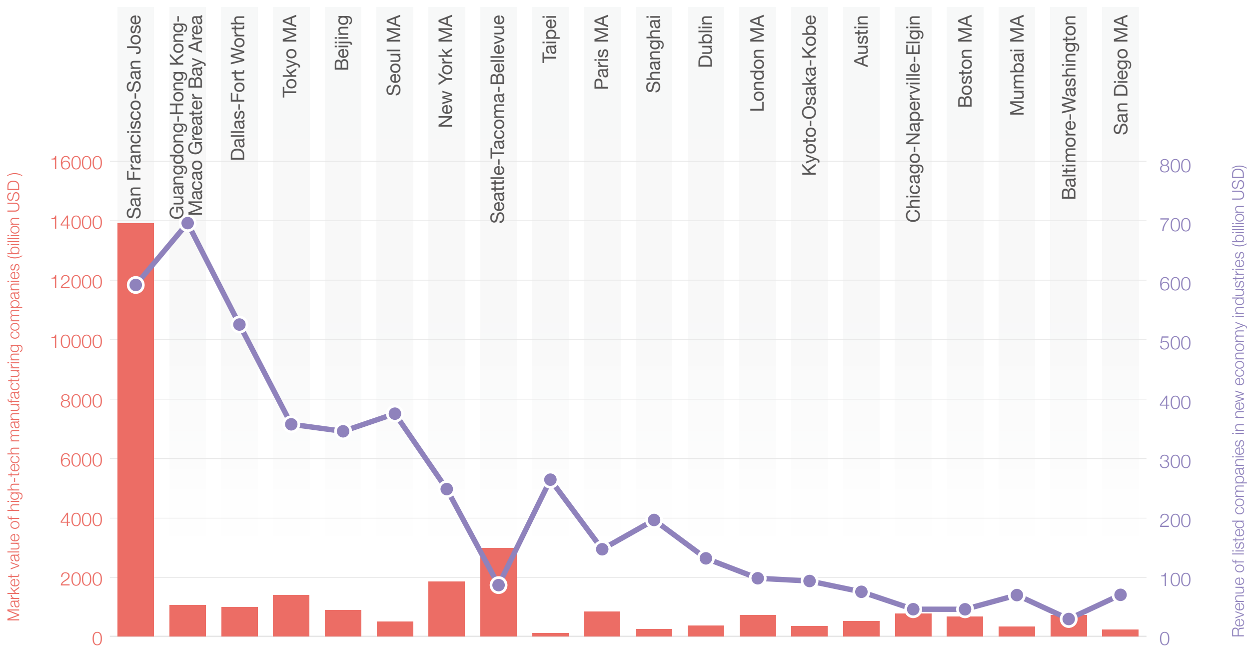
Emerging industries in this report refer to high-tech manufacturing and new economy industries that help sustain the competitive edge of the economy, such as biomedicine, high-end equipment manufacturing and next-generation information technology. This report uses the market value of high-tech manufacturing companies and the revenue of listed companies in new economy industries to measure the activity of emerging industries. The top five cities/metropolitan areas in emerging industries are San Francisco-San Jose, Guangdong-Hong Kong-Macao Greater Bay Area, Dallas-Fort Worth, Tokyo MA and Beijing (see Figure 29). In the top 20 list, North America takes up nine spots, Asia has eight and Europe holds three.

As shown by the market value of high-tech manufacturing companies, the global high-tech manufacturing industry continues to concentrate in top cities, with cities/metropolitan areas in the United States leading the way. San Francisco-San Jose, Seattle-Tacoma-Bellevue and New York MA maintain their positions as the world's top three. San Francisco-San Jose tops the list with a market capitalization of US$13,896.140 billion, mainly benefiting from the explosive growth of tech giants such as Nvidia, Apple and Meta in AI, cloud computing and chip design. Among the top 20 by market capitalization of high-tech manufacturing companies, the United States stands out with nine spots, highlighting its dominant position in the global high-end manufacturing value chain. Compared with last year, cities/metropolitan areas in the United States and China have grown significantly, sweeping the top four spots. San Francisco-San Jose leads with an incremental value of US$809.250 billion. Beijing ranks second with US$322.480 billion, Denver MA third with US$231.870 billion, and Guangdong-Hong Kong-Macao Greater Bay Area follows with US$104.390 billion.

When looking at the revenue of listed companies in new-economy industries, North American and Asian cities/metropolitan areas are on a par, each securing eight spots in the top 20. The top five cities/metropolitan areas are Guangdong-Hong Kong-Macao Greater Bay Area, San Francisco-San Jose, Dallas-Fort Worth, Seoul MA and Tokyo MA. Asian cities/metropolitan areas account for three in the top five as they remain forward-looking and could empower industries rapidly. Guangdong-Hong Kong-Macao Greater Bay Area ranks first, highlighting the scale effect and advantages of industrial clusters of China's digital economy. San Francisco-San Jose follows closely, maintaining significant global influence through robust corporate profitability, active technological innovation, and high recognition from the capital markets. Dallas-Fort Worth, Seoul MA and Tokyo MA rank third to fifth, reflecting the key roles that North America and East Asia play in the global new economy.

FIGURE 29

The market value of high-tech manufacturing companies and the revenue of listed companies in the new-economy sector for the top 20 cities/metropolitan areas in emerging industries



4.5
Economic growth

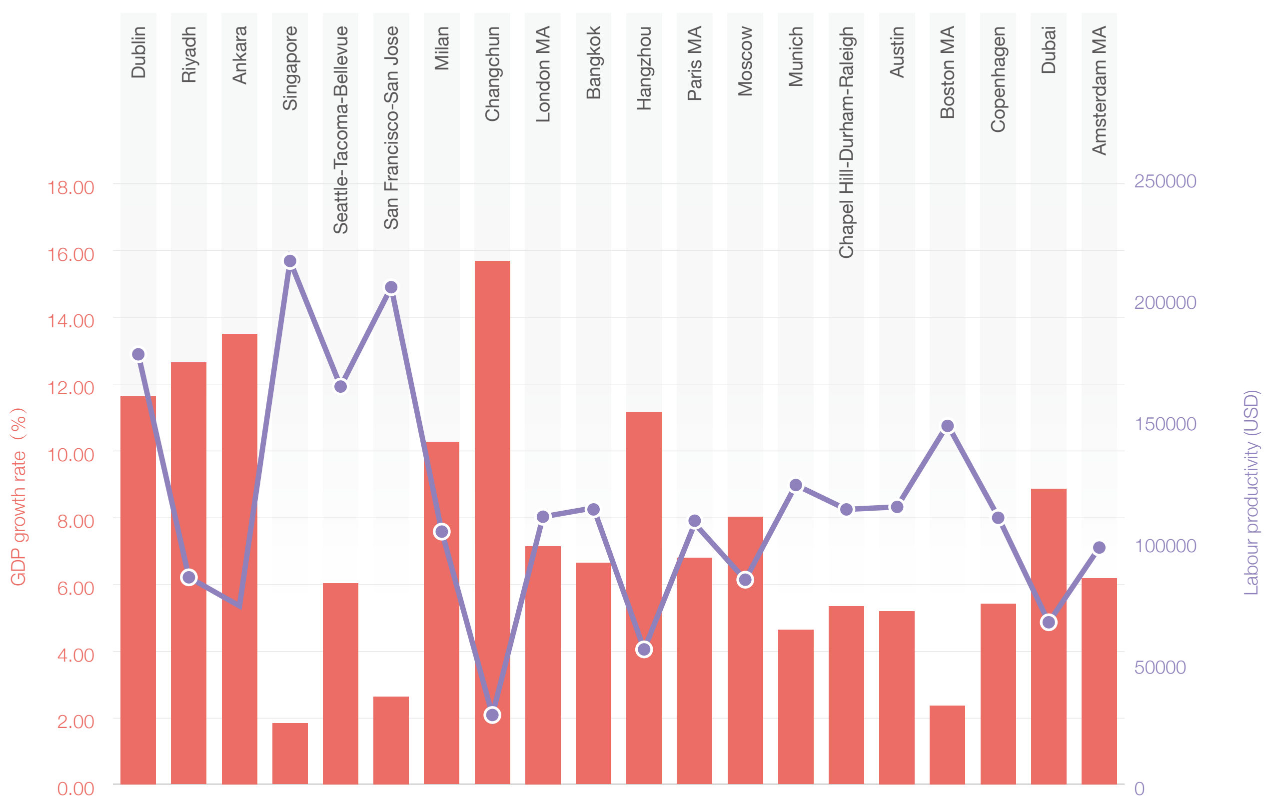
Innovation is the core engine driving high-quality economic development. Therefore, economic growth not only reflects regional dynamics, but also acts as a key indicator for measuring innovation performance. This report uses the GDP growth rate in 2023, adjusted by purchasing power parity (PPP) to measure a city's overall economic growth and living standards. Labour productivity in 2023 is used to measure social productivity. The top five cities/metropolitan areas in economic growth are Dublin, Riyadh, Ankara, Singapore and Seattle-Tacoma-Bellevue (see Figure 30). Among the top 20 cities/metropolitan areas, Europe occupies eight spots, Asia holds seven spots, and North America takes five spots. Europe tops the list, demonstrating its sustained competitiveness in the global innovation economy.

According to GDP growth rate, the global economy has entered a transitional phase, maintaining slow but positive growth under heavy downward pressure. Some cities of emerging economies have shown strong growth momentum. Among the evaluated cities/metropolitan areas, Changchun, Ankara, Riyadh, Dublin and Hangzhou rank in the top five globally in GDP growth rate, all above 11%. In addition, 95% of the evaluated cities/metropolitan areas achieve positive GDP growth rate, indicating that the global economy is on a fast track to normality.

Labour productivity of major GIHs has been trending up steadily. Singapore has once again taken the lead while Europe and the United States still have significant edges. Singapore tops the list by an absolute margin, followed by San Francisco-San Jose, Dublin, Seattle-Tacoma-Bellevue and Boston MA to form the first tier. As a global trade hub with highly specialized service industry systems, Singapore continues to see increasing value of unit labour in the fields of finance, logistics and high-end manufacturing. Benefiting from the strong technology spillover effect of Silicon Valley and the high value-added output of tech giants, San Francisco–San Jose has gained superior productivity in software R&D, cloud computing and AI sectors that is difficult to be replicated by others. The top 20 cities/metropolitan areas are mainly located in North America and Europe, which take up 16 spots collectively.

FIGURE 30

The GDP growth rate and labour productivity for the top 20 cities/metropolitan areas in economic growth



[Focus] Controlled nuclear fusion

FOCUS
Controlled nuclear fusion

Controlled nuclear fusion is regarded as the 'ultimate solution' for humanity's future clean energy needs. Its significance goes far beyond energy itself given its potential impact on the future of human civilization. In recent years, the world's major innovative countries have accelerated their deployment of controlled nuclear fusion, ushering in a booming period of technological innovation and commercialization in the field.

Technological innovation in controlled nuclear fusion has witnessed explosive growth in recent years. Cities/metropolitan areas such as Hefei have taken the advantage by harnessing its large scientific facilities and accumulated technology expertise. Chinese cities are important players and drivers of technological innovation. Cities/metropolitan areas in Europe and the United States are leading in the global industrial technology landscape. The ITER programme could have a profound impact on technological innovation and the commercialization of controlled nuclear fusion.

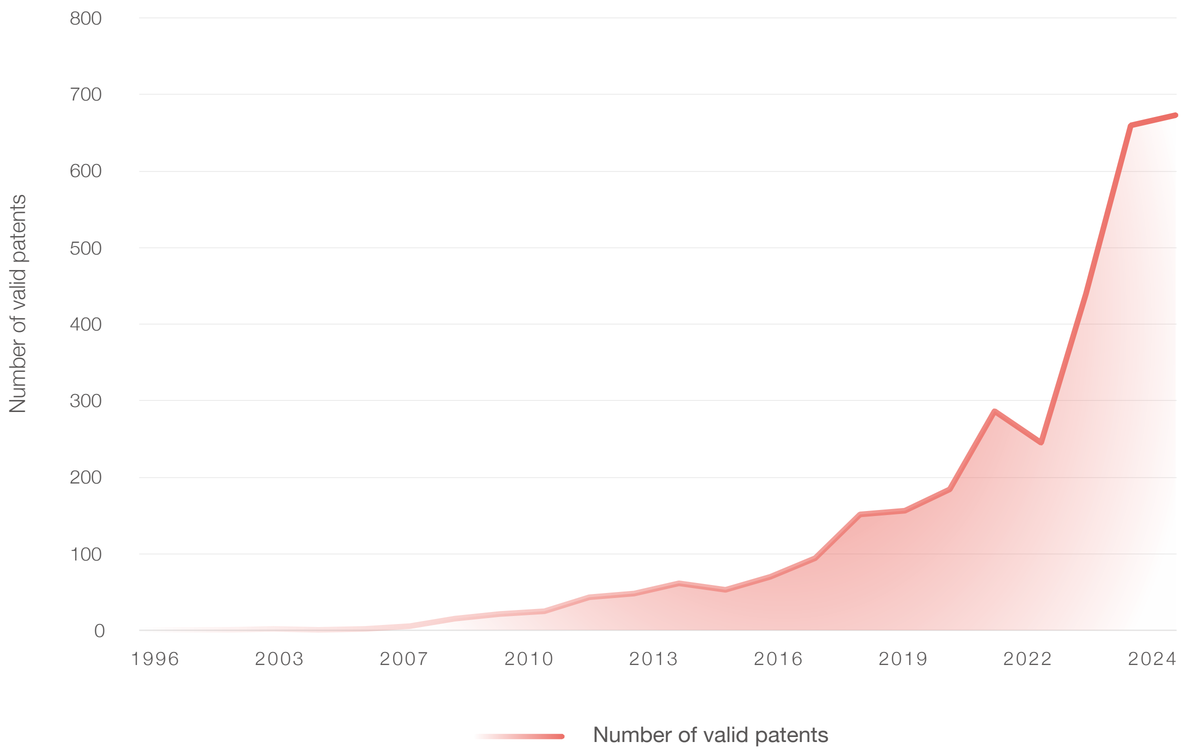
By analysing the patents and corporate investment & financing in the field, this report evaluates the technological innovation capabilities, development characteristics, commercialization potential, opportunities and challenges faced by major GIHs.

Fundamental trends

Global patents for controlled nuclear fusion technology are experiencing a period of explosive growth. As of the end of 2024, there were 3,245 valid patents in controlled nuclear fusion globally, more than

FIGURE 31

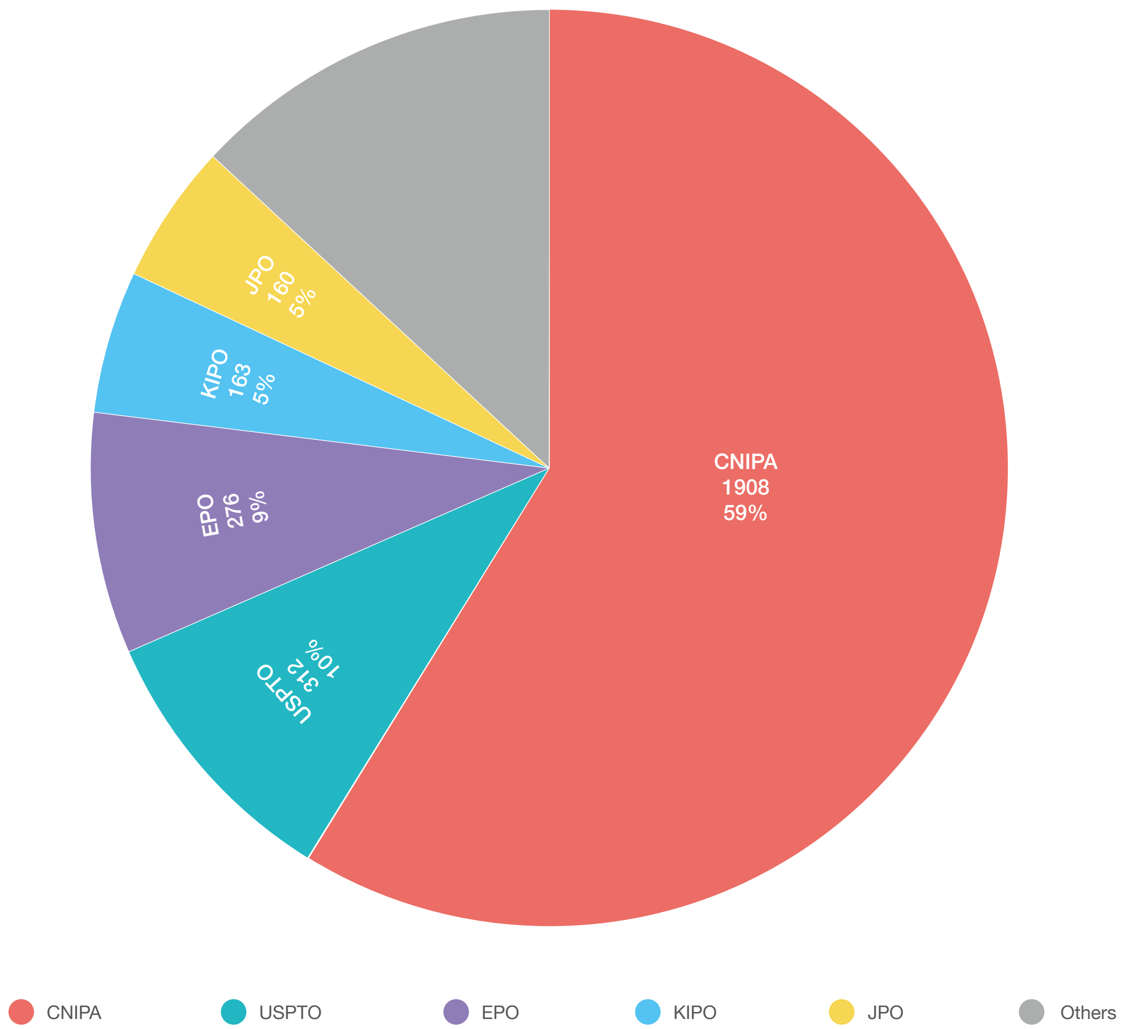
Annual trends of the number of valid patents in the field of controlled nuclear fusion



half (54.64%) of which were contributed in the past three years, highlighting the key breakthroughs and technological progress made in the field recently. Many universities, research institutions and even enterprises have invested various resources in engineering and commercialization of controlled nuclear fusion. There are 2,819 patents from the world's five major intellectual property offices, namely the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), China National Intellectual Property Administration (CNIPA) and the United States Patent and Trademark Office (USPTO), accounting for nearly 90% (86.87%) of those in the field of controlled nuclear fusion. This indicates that the competition in controlled nuclear fusion is primarily centred among China, the United States, Europe, Japan and South Korea. The CNIPA has contributed 1,908, or nearly 60% (58.80%) of the patents for controlled nuclear fusion, demonstrating China's unprecedented scale of deployment in the industry and its continuously enhanced competitiveness.

FIGURE 32

Valid patents in the field of controlled nuclear fusion by country/region



[Focus] Controlled nuclear fusion

Large scientific facilities are essential for GIHs to gain a competitive edge in controlled nuclear fusion arena. As shown in Figure 33, patent data published since 1996 are used in the analysis of valid patents. These patents cover 380 cities, 124 of which are in the evaluated cities/metropolitan areas of GIHI. Hefei ranks first with 345 valid patents, followed by Chengdu, Beijing, Xi'an and Paris MA, with 293, 253, 127 and 100, respectively. For the top 20 cities/metropolitan areas by country/region, 12 are in China, Japan and South Korea each hold two, while the United States, Germany, France and Russia each hold one. Hefei has produced considerable output by leveraging its major scientific facilities such as the Experimental Advanced Superconducting Tokamak (EAST) and the Comprehensive Research Facility for Fusion Technology (CRAFT), as well as the Institute of Plasma Physics, Chinese Academy of Sciences among other national research resources of strategic significance. Chengdu has gained the advantage in controlled nuclear fusion after years of development of nuclear technology. Paris MA has produced many international scientific results relying on the ITER facility and the French Alternative Energies and Atomic Energy Commission. Tokyo MA has investigated magnetic confinement fusion with tokamaks by using the world's largest nuclear fusion reactor JT-60SA, jointly built by Japan and Europe.

The United States and Europe are pioneering in exploring the application of controlled nuclear fusion in industry. As shown in Figure 34, by the number of PCT patents, Paris MA (89), San Francisco-San Jose (48), Tokyo MA (41), Munich (38) and Boston MA (31) are the top five in the world. Guangdong-Hong Kong-Macao Greater Bay Area, Beijing, Hefei and Shanghai in China make it to the top 20 with 26, 23, 11 and 9 PCT patent applications. For the top 20 cities/metropolitan areas by country/region, seven are in the United States, six in Europe, four in China, and three in Japan. Cities/metropolitan areas in the United States and Europe lead by a large margin, showing that they are much ahead in global cooperation and commercialization of controlled nuclear fusion.

FIGURE 33 Top 20 cities/metropolitan areas by the number of valid patents in controlled nuclear fusion

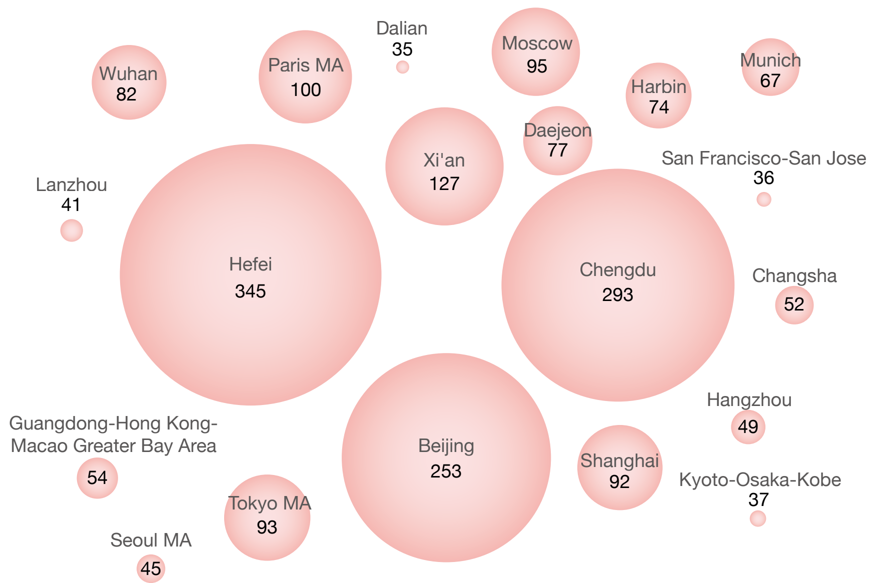


FIGURE 34 Top 20 cities/metropolitan areas by the number of PCT patents in controlled nuclear fusion

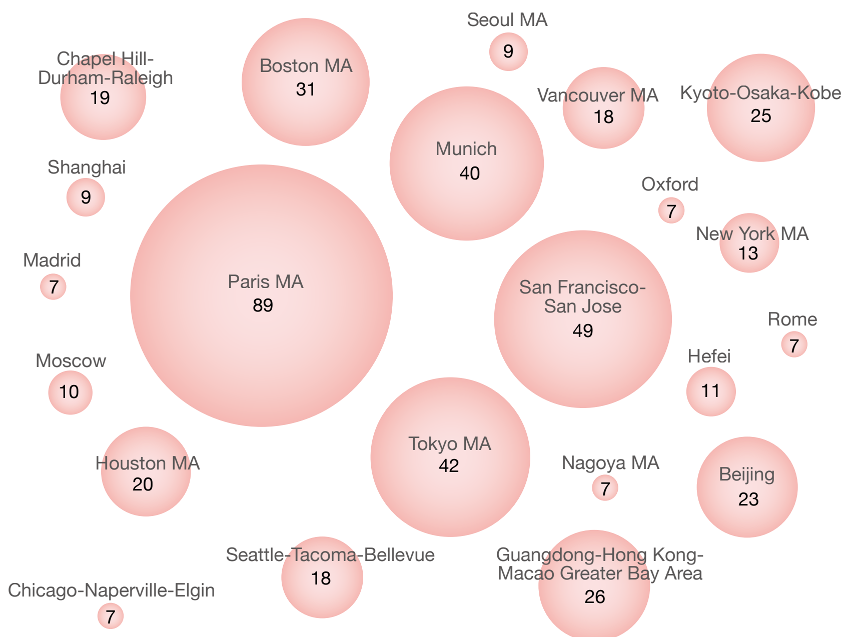


FIGURE 35

Annual trends of the top 10 cities/ metropolitan areas in the number of valid patents in controlled nuclear fusion

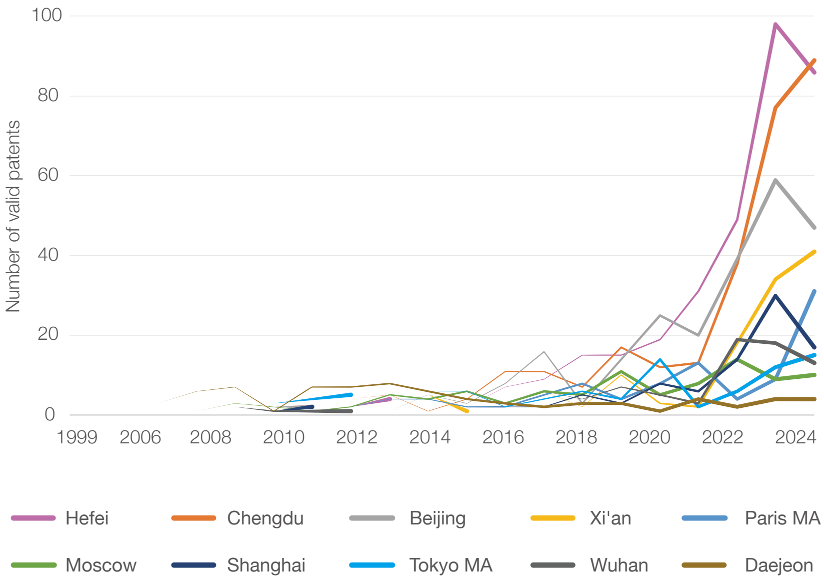
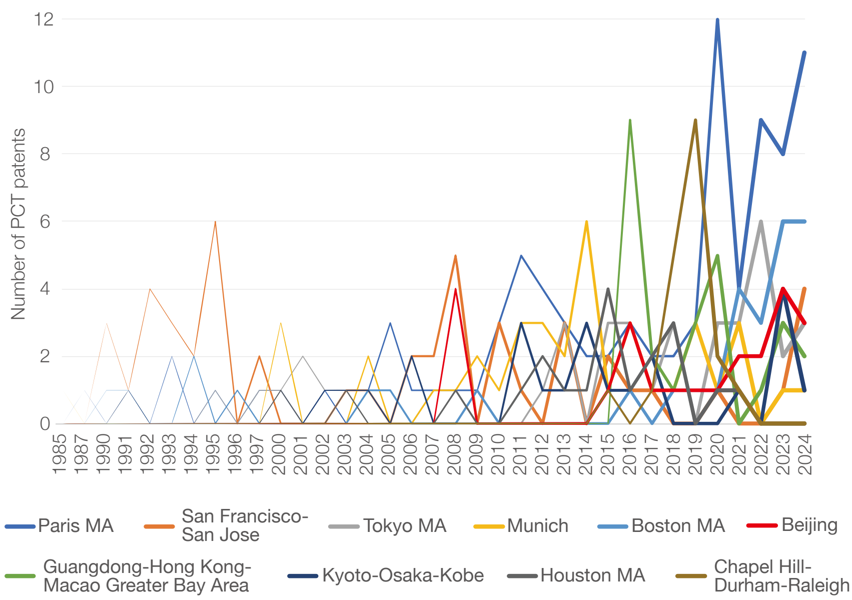


FIGURE 36

Annual trends of the top 10 cities/ metropolitan areas in the number of PCT patents in controlled nuclear fusion



China is an important driving force for the development of controlled nuclear fusion technology. As shown in Figure 35, for the top 10 cities/metropolitan areas measured by the number of valid patents, the patents in controlled nuclear fusion have experienced three stages. The first phase, spanning from 1999 to 2010, saw a gradual increase in patents within this field, with an annual average of 6.17 valid patents. The second phase, spanning from 2011 to 2021, witnessed rapid development, with an annual average of 54.64 valid patents. The third phase, commencing in 2022, has seen fast growth, with an annual average of 306.33 valid patents. Over three years, this phase has accumulated 919 patents, accounting for nearly 60% (59.02%) of the total. By the average annual growth rate of valid patents in the past three years, the top five cities are Xi'an (141.01%), Chengdu (85.25%), Tokyo MA (71.00%), Wuhan (63.03%) and Shanghai (41.50%), driven by major growth from major players. In terms of PCT patents, as shown in Figure 36, since the launch of the ITER programme in 1985 — one of the world's largest and most influential international research cooperation projects — patents for controlled nuclear fusion have trended up amid fluctuations until 2010. Then technological breakthroughs and engineering verification have made progress. Multiple technological pathways have advanced simultaneously, and commercialization has sped up. PCT patents of the top 10 cities/ metropolitan areas from 2011 to 2024 account for more than 70% (73.08%) of the total over years. Paris MA, San Francisco-San Jose, Tokyo MA, Munich and Boston MA all have more than 30 PCT patents, and act as key growth hubs in controlled nuclear fusion.

[Focus] Controlled nuclear fusion

Characterization of innovation entities

This report identifies the top 100 institutions with the highest number of patents based on the number of valid patents and PCT patents in the field of controlled nuclear fusion. Each of these institutions has more than ten patents. The latest developments and distribution of innovation entities in controlled nuclear fusion in China, the United States and Europe are analysed by country/region, city/metropolitan area and type of institutions. **Overall, China, the United States and Europe — supported by national research resources of strategic significance, commercial companies and big science programmes respectively — are the top powerhouses in controlled nuclear fusion.**

KOTO_FEJA/E+/GETTY

China's innovation entities are mainly located in Beijing, Chengdu and Hefei, led by national research resources of strategic significance. A total of 37 entities in China is shortlisted for the top 100 institutions by the number of controlled nuclear fusion patents, 31 of which are in the evaluated cities/metropolitan areas of the GIHI2025. Beijing, Chengdu, Hefei, Xi'an, Shanghai and Hangzhou each have six, five, five, four, two and two entities shortlisted, featuring 149, 259, 302, 65, 41 and 31 patents, respectively. Hefei and Chengdu stand out with the highest number of patents. By types of entity, the Hefei Institutes of Physical Sciences of the Chinese Academy of Sciences, the Southwestern Institute of Physics in Chengdu, and the Laser Fusion Research Center in Mianyang are the top three institutions in China, with 248, 203 and 90 patents, respectively. They are affiliated with the Chinese Academy of Sciences, China National Nuclear Corporation and China Academy of Engineering Physics, respectively. As national-level research institutions, they are at the forefront of China's controlled nuclear fusion development. Harbin Institute of Technology, Huazhong University of Science and Technology, Tsinghua University, National University of Defense Technology, Hefei University of Technology, and Xi'an Jiaotong University each have more than 30 patents, and keep developing nuclear energy by leveraging their strengths in disciplines including physics, materials, mechanical engineering, electrical and electronics.

The innovation entities in the United States are mainly located in the northeast and the west, giving rise to a multitude of companies. A total of 31 entities in the United States is shortlisted for the top 100 institutions by the number of controlled nuclear fusion patents, 10 of which are in the assessed cities/metropolitan areas of the GIHI2025 and located in the northeast and the west coast. Houston MA, Boston MA, Chapel Hill-Durham-Raleigh, San Francisco-San Jose, New York MA and Chicago-Naperville-Elgin each have two, two, two, one, one and one entity shortlisted, featuring 34, 33, 33, 33 and 18 patents, respectively. For example, the University of California in San Francisco-San Jose has 33 patents, the Massachusetts Institute of Technology in Boston MA has 22 patents, and Halliburton Energy Services Group in Houston MA has 19 patents. Among the 31 entities, more than 80% are key enterprises in controlled nuclear fusion. For example, TAE Technologies, General Electric, Brilliant Light Power, Honeywell and Lockheed Martin have 39, 34, 32, 26 and 24 patents, respectively. These companies have adopted different technological routes to

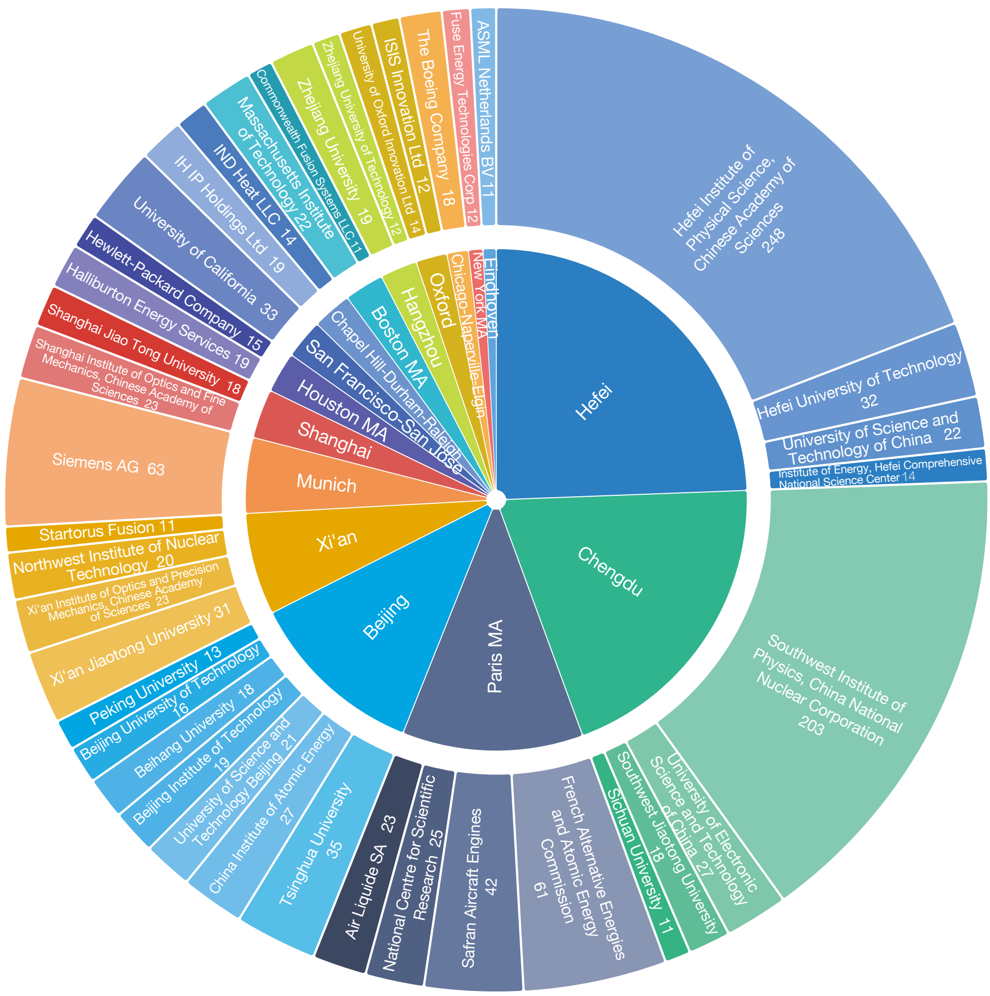
> **China and the United States are the most active innovation entities and have more top institutions than any other countries. Cities in China, the United States and Europe have promoted controlled nuclear fusion in distinct ways: Chinese cities mainly rely on national research resources of strategic significance; cities in the United States are driven by commercial companies; European cities benefit from international big science programmes.**

facilitate the commercialization of controlled nuclear fusion.

European innovation entities are mostly in Paris MA, Oxford and Munich and supported by big science programmes. Controlled nuclear fusion in Europe is mainly developed in France, the United Kingdom, Germany, the Netherlands and Austria. A total of 19 entities is shortlisted for the top 100 institutions by the number of controlled nuclear fusion patents, and 12 of which are in the assessed cities/metropolitan areas of the report. Paris MA, Oxford, Munich and Eindhoven each have four, two, one and one entity shortlisted, featuring 151, 26, 63 and 11 patents, respectively. A majority of the 19 entities are enterprises and research institutions, such as Tokamak Energy, in the United Kingdom, with 106 patents, Siemens AG, in Germany, with 63 patents, the French Alternative Energies and Atomic Energy Commission with 61 patents, Safran Aircraft Engines (a subsidiary of Psiphon Group) in France with 42 patents, and the French National Center for Scientific Research with 25 patents. Europe started early in the field of controlled nuclear fusion and has initiated the world's largest International Thermonuclear Fusion Experimental Reactor (ITER) project.

FIGURE 37

Distribution of major innovation entities from China, the United States and Europe in the field of controlled nuclear fusion among the assessed GIHs



[Focus] Controlled nuclear fusion

Investment and financing

By analysing the financing data of global controlled nuclear fusion start-ups, the FIA (Futures Industry Association) 2024 Annual Report provides an overview of the start-ups by region/metropolitan area, technical route, financing growth and funding source. It shows that both the innovation entities and the investment are booming in the field.

As commercialization speeds up, China and the United States have witnessed a growing number of start-ups in controlled nuclear fusion, which have become the sought-after targets of capital investment. As shown in Figure 38, in terms of the geographic distribution of funded companies, the top five countries are the United States (31), China (11), Japan (5), the United Kingdom (3) and Germany (2), which have covered the facilities and key technology segments of different routes.

By financing scale, China and the United States are at the forefront for the commercialization of controlled nuclear fusion. Since 2020, the financing scale of global commercial controlled nuclear fusion enterprises has been expanding. As of August 2025, 65 companies had raised a total of US$14.2 billion, of which US$9.7 billion or 69% came from private equity, and US$4.5 billion or 31% from public capital. In terms of funding, companies in the United States and China lead the way by receiving US$6.9 billion and US$5.2 billion, respectively, collectively accounting for 85% of the global total. Cities/metropolitan areas in the United States that have attracted the most funds are Boston MA (US$2 billion), Seattle-Tacoma-Bellevue (US$1.4 billion),

FIGURE 38

Funded companies in the field of controlled nuclear fusion by country

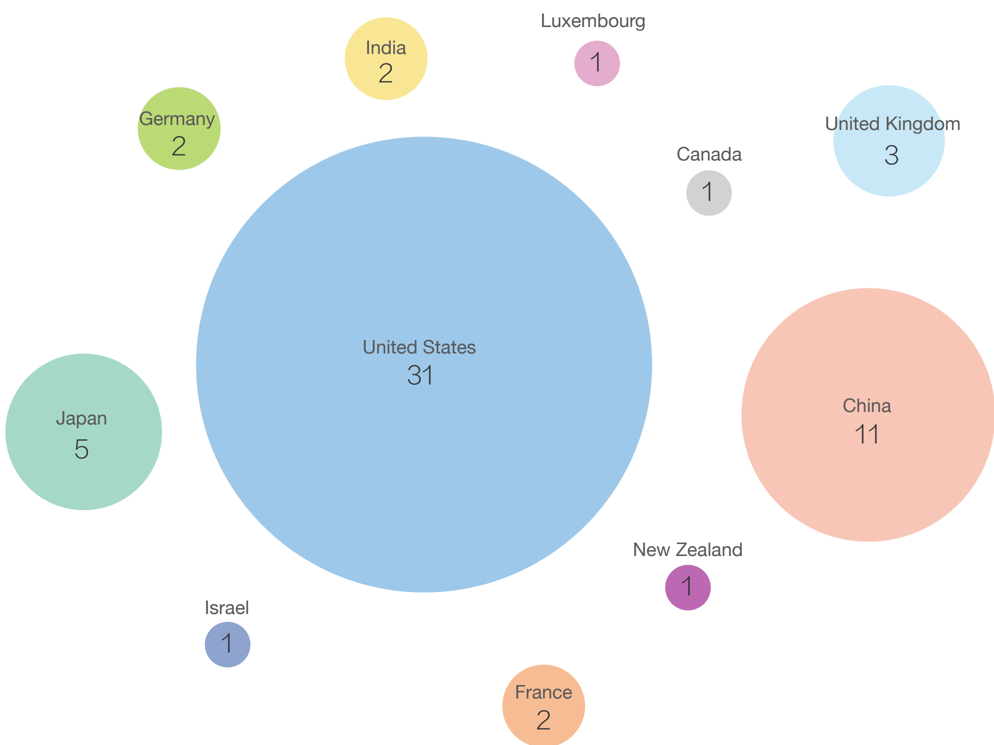
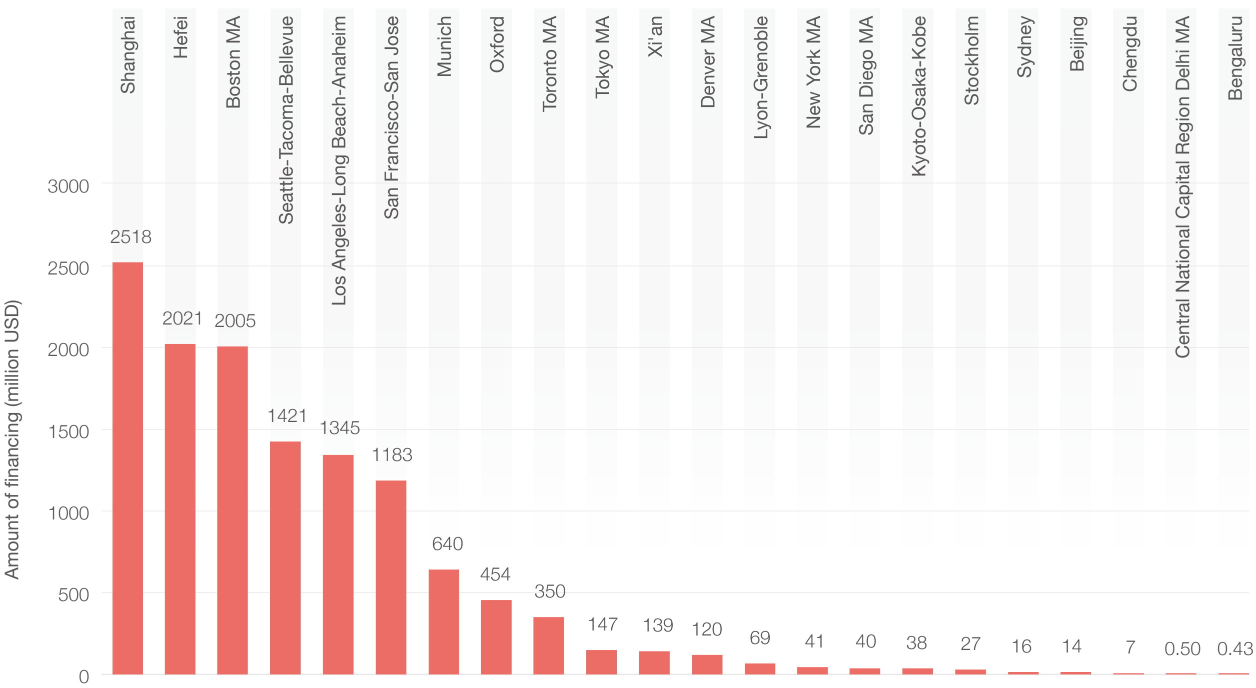


FIGURE 39

Total amount of financing received by city/ metropolitan area in the field of controlled nuclear fusion



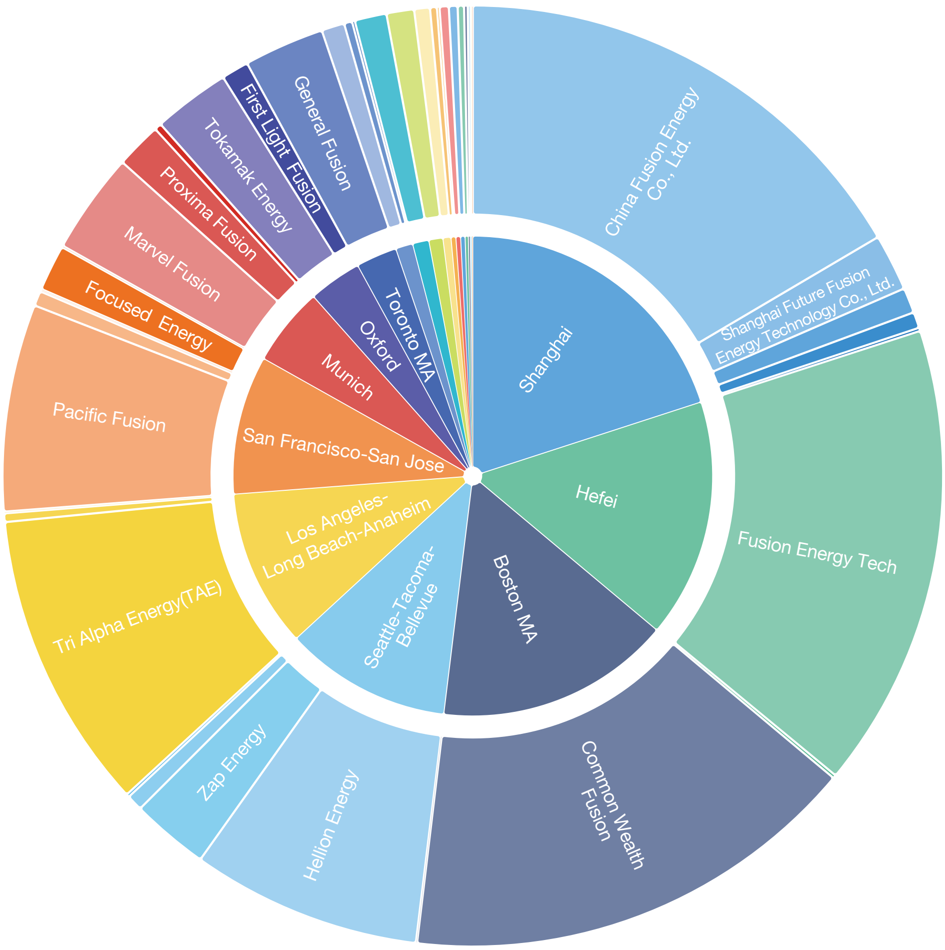
In terms of investment and financing, companies in the United States are the most active. Top companies in China and the United States are at the forefront of global competition for the commercialization of controlled nuclear fusion. San Francisco-San Jose ranks first by the number of funded companies — owing to its vibrant innovation ecosystem — and covers various technical routes. Shanghai and Hefei top the list with the largest financing scale worldwide. They are the peak cities leading the commercialization of controlled nuclear fusion in China. Magnetic confinement fusion is the main focus of current commercial investment.

Los Angeles-Long Beach-Anaheim (US$1.3 billion) and San Francisco-San Jose (US$11). It indicates that the funds mainly flowed to top companies, such as Commonwealth Fusion Systems, Helion Energy, TAE and Pacific Fusion, which received US$2 billion, US$1 billion, US$1.3 billion and US$900 million, respectively. Supported by a vibrant investment ecosystem, San Francisco-San Jose ranks first by the number of funded companies in the assessed GIHs, covering multiple technical routes of controlled nuclear fusion. In China, Shanghai and Hefei have raised the most funds, securing US$2.5 billion and US$2 billion, respectively, leading the commercialization of controlled nuclear fusion in the country. Shanghai ranks second only to San Francisco-San Jose by the number of funded companies, and first by financing scale in the assessed GIHs. China Fusion Energy Co., Ltd. and Shanghai Future Fusion Energy Technology Co., Ltd. received state capital injections of US$2 billion and US$200 million, respectively. As the core players in the commercialization of controlled nuclear fusion in Shanghai, they are part of the most active development ecosystem in China, together with Energy Singularity, Nova Fusion and Shanghai Yixi Technology Development, Fusion New Energy, a start-up in Hefei incubated by the Hefei Institutes of Physical Sciences of the Chinese Academy of Sciences, received US$2 billion in financing.

[Focus] Controlled nuclear fusion

FIGURE 40

Funded companies in the field of controlled nuclear fusion by city/metropolitan area



Based on financing, magnetic confinement fusion still represents the mainstream of commercial investment among various technical routes. Overall, global capital prefers magnetic confinement fusion, which comes with the longest horizon and an accumulated investment of US$9.2 billion or 65%, This involves 31 companies, with tokamaks leading with US$5.2 billion, stellarators US$400 million, and field-reversed configurations US$1.8 billion (represented by TAE). It is followed by inertial confinement fusion and magnetic inertial confinement, which have attracted an accumulated investment of US$1.8 billion or 12%, and involve 13 and 10 companies, respectively. By region, the companies in the United States focusing on magnetic confinement have raised a total of US$4 billion, and those focusing on the other two routes have raised more than US$1 billion, respectively, highlighting relatively balanced investment. China has put most of its investment in magnetic confinement fusion, with companies raising a total of US$4.9 billion. In Europe, companies taking on inertial confinement fusion and magnetic confinement fusion have raised nearly US$800 million and US$700 million, respectively.

FIGURE 41

The amount (million USD) and proportion of financing for different technology routes in the field of controlled nuclear fusion in the United States

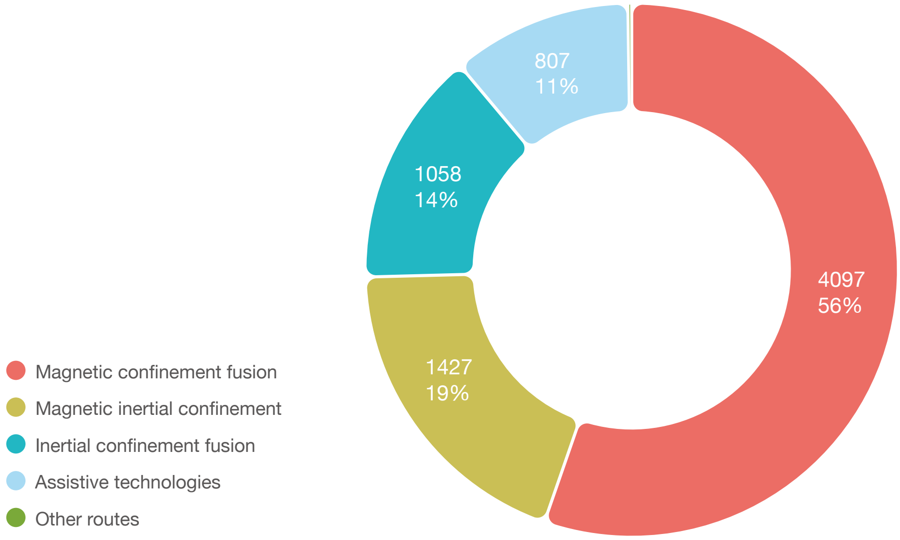


FIGURE 42

The amount (million USD) and proportion of financing for different technology routes in the field of controlled nuclear fusion in China

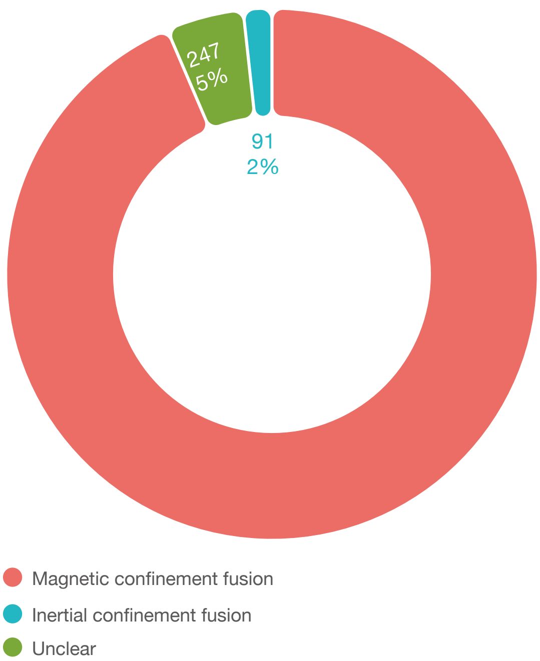
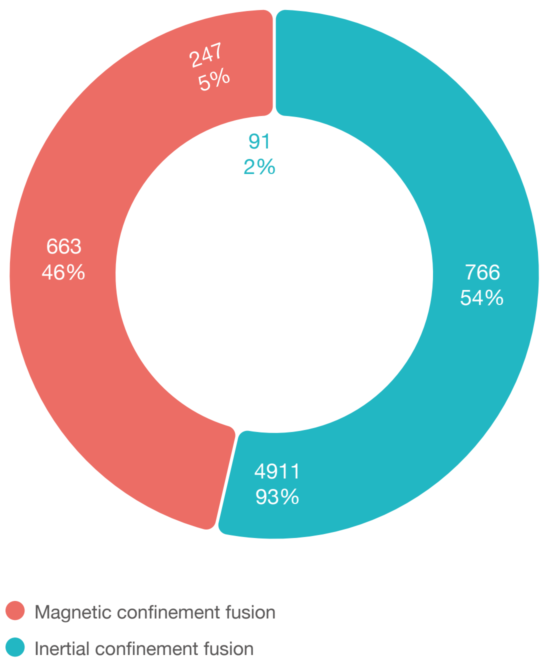


FIGURE 43

The amount (million USD) and proportion of financing for different technology routes in the field of controlled nuclear fusion in Europe



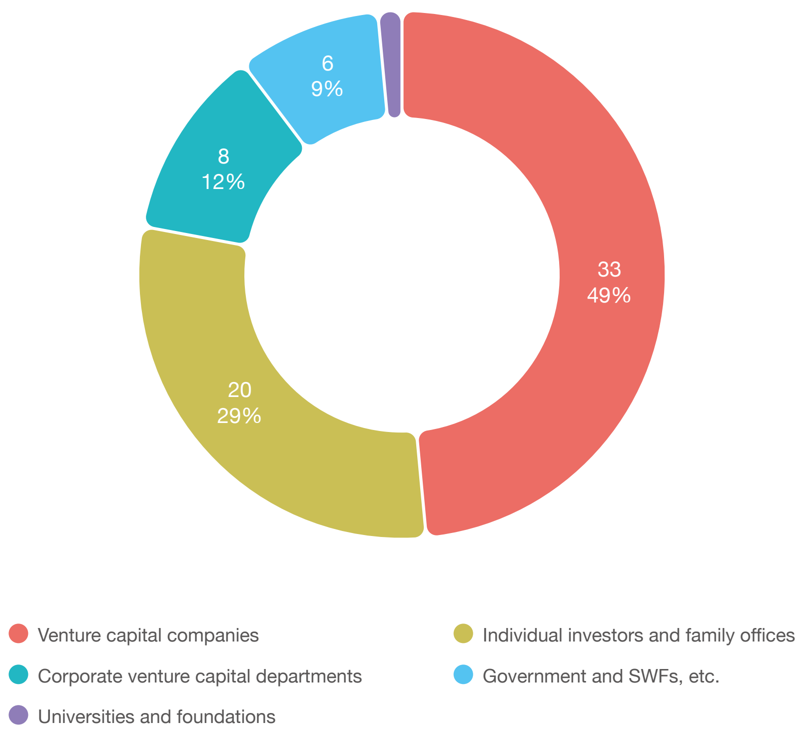
[Focus] Controlled nuclear fusion

The application of AI would speed up breakthroughs in controlled nuclear fusion. Amid increasingly fierce competition, complementary and open cooperation among GIHs is still crucial to accelerate the commercialization of controlled nuclear.

Large enterprises and governments are increasingly leading the way by actively investing in controlled nuclear fusion. In the past five years, the investment entities have become more diversified, mainly including venture capital companies (VC), individual investors, corporate venture capital (CVC), governments and sovereign funds, university-backed investment and technology transfer institutions, and innovation ecosystem institutions. **Until 2022, the investment entities were mainly venture capital companies such as Addition (formerly Tiger Fund) and DFJ Growth, and individual investors such as Bill Gates and Jeff Bezos, accounting for 49% and 29%, respectively. Since 2023, corporate venture capital and governments (including sovereign funds) have entered the market,** accounting for 20% and 10%, respectively. For example, Google, Shell and Siemens carried out integrated investment-based empowerment strategies in response to their business needs. Google cooperated with TAE to develop the 'Optometrist Algorithm', which shortened the time required for performance tuning tasks from two months to a few hours and helped achieve an ultra-high plasma temperature of 75 million °C. Siemens supplied Marvel Fusion with thermal energy conversion systems and power generation systems. In addition, university-backed investment and technology transfer institutions, and innovation ecosystems among other public organizations, such as the European

FIGURE 44

Proportion of different types of investors in the field of controlled nuclear fusion (as of 2022)



Institute of Innovation and Technology, the Oxford Cluster, and the Wisconsin Alumni Research Foundation, are also important promoters.

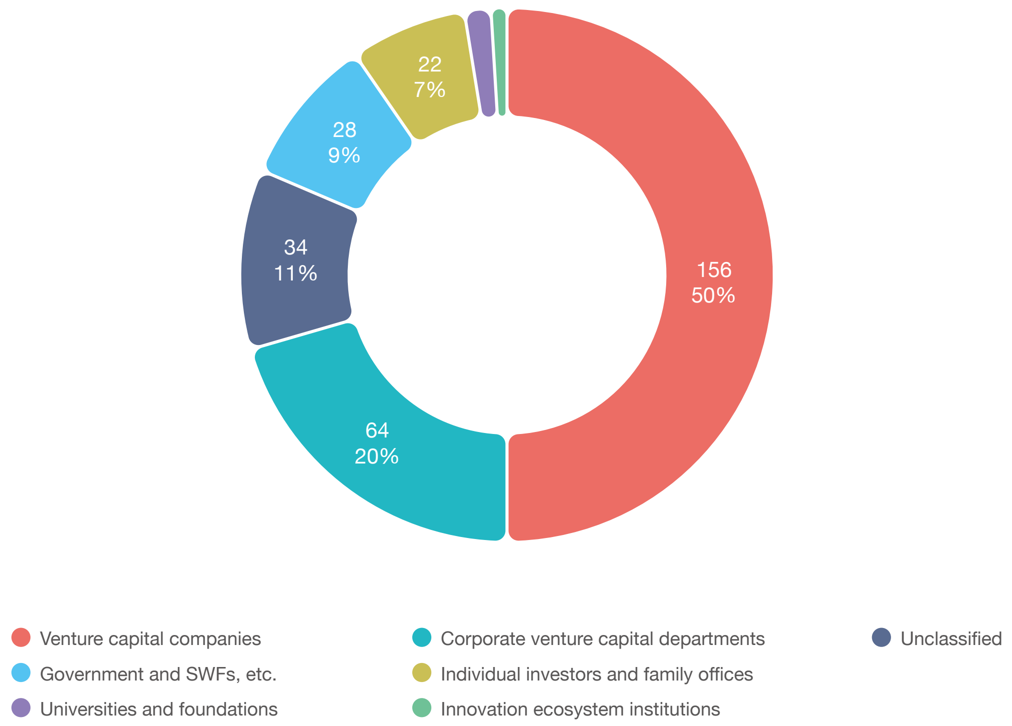
Future opportunities and challenges

For a long time, the development of controlled nuclear fusion has been hindered by challenges in high-power plasma control and large-scale engineering technology. AI technologies, such as machine learning, have been increasingly applied to accelerate breakthroughs in key areas of controlled nuclear fusion. These technologies have shown unprecedented advantages in plasma control and advanced material development, and have significantly sped up the commercialization of controlled nuclear fusion. Meanwhile, the rapid development of 3D printing has greatly simplified the designing and manufacturing of stellarators and other complex devices. Unprecedented opportunities have emerged in the field of controlled nuclear fusion.

With increasing investment of technological resources, the feasibility threshold for fusion power projects achieving Q>10 may be overcome in the next few years. The ITER, SPARC, Burning Plasma Experimental Superconducting Tokamak (BEST) and HH170 are all aiming for this goal. However, we must recognize that it will take a long time to solve the technical problems in manufacturing and production of controlled nuclear fusion devices. To make it happen earlier, cooperation between global scientific forces is essential. The industrialization of fusion requires not only technological innovation but also the corresponding mechanisms and cooperation models, to ensure that basic research and engineering technology could empower and facilitate industrialization. It will also benefit the development of interdisciplinary subjects and play a key role in fusion development.

FIGURE 45

Proportion of different types of investors in the field of controlled nuclear fusion (starting from 2023)



5. Innovation ecosystem

Investment in AI-related industries has been increasing despite a slowdown in global capital flows, reduced talent mobility and diminished vitality of traditional venture capital, injecting fresh dynamism into global innovation activities. The global innovation ecosystem features distinct regional patterns, with Europe and the United States maintaining overall leadership while leading Asian cities demonstrate strong growth momentum. Singapore and Tokyo MA are the global leaders in attracting foreign investment, while Guangdong-Hong Kong-Macao Greater Bay Area and Beijing outperform in paper co-authorship.

YUICHIRO CHINO/MOMENT/GETTY

5.1
A comprehensive analysis of innovation ecosystem

The GIHI2025 ranking for innovation ecosystem is shown in Table 9.

TABLE 9

Ranking and scores of the top 100 GIHs in innovation ecosystem

Rank	City/metropolitan area	Innovation Ecosystem	Openness and Collaboration	Support for Start-ups	Public Services	Innovation Culture
1	San Francisco-San Jose	**100.00**	90.08	100.00	88.52	89.11
2	London MA	**95.40**	95.01	77.94	98.98	100.00
3	New York MA	**90.99**	90.08	83.63	90.81	84.66
4	Singapore	**84.29**	100.00	66.17	95.64	78.63
5	Paris MA	**80.48**	89.99	66.91	88.90	79.38
6	Boston MA	**79.49**	85.20	69.44	80.30	84.04
7	Tokyo MA	**78.69**	97.69	63.28	84.54	76.24
8	Amsterdam MA	**77.98**	67.62	63.43	100.00	88.44
9	Munich	**77.89**	73.48	68.64	83.95	87.79
10	Baltimore-Washington	**77.62**	79.55	67.25	86.29	80.93
11	Seoul MA	**77.38**	90.36	63.99	85.67	76.09
12	Beijing	**77.04**	92.18	67.47	83.03	68.58
13	Denver MA	**77.01**	65.71	72.94	81.61	86.02
14	Dubai	**76.87**	69.65	60.85	95.72	91.56
15	Toronto MA	**76.80**	75.88	64.82	84.10	88.63
16	Guangdong-Hong Kong-Macao Greater Bay Area	**76.56**	94.09	62.45	90.02	67.76
17	Abu Dhabi	**76.52**	75.17	60.00	91.92	90.06
18	Phoenix MA	**76.34**	87.08	62.10	82.81	82.10
19	San Diego MA	**76.16**	73.75	67.62	78.80	88.00
20	Madrid	**75.94**	71.04	67.35	85.45	83.75
21	Frankfurt	**75.76**	66.58	67.21	93.29	80.05
22	Los Angeles-Long Beach-Anaheim	**75.70**	74.22	66.39	88.11	78.80
23	Seattle-Tacoma-Bellevue	**75.66**	76.16	64.03	83.09	86.48
24	Dallas-Fort Worth	**75.63**	71.78	64.86	88.19	84.06
25	Shanghai	**75.33**	85.77	67.94	85.37	65.16
26	Austin	**75.22**	71.53	65.97	79.07	89.68
27	Zurich	**74.86**	65.12	62.88	90.83	89.20
28	Helsinki	**74.78**	62.89	61.51	85.61	99.20
29	Miami MA	**74.07**	66.53	66.29	85.07	83.65
30	Chicago-Naperville-Elgin	**74.01**	72.33	64.27	87.07	79.50

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Rank	City/metropolitan area	Innovation Ecosystem	Openness and Collaboration	Support for Start-ups	Public Services	Innovation Culture
31	Dublin	**73.91**	68.89	65.10	86.31	81.75
32	Hamburg	**73.42**	63.83	63.71	79.82	94.36
33	Chapel Hill-Durham-Raleigh	**72.98**	69.66	63.45	78.45	88.58
34	Copenhagen	**72.92**	65.01	62.20	93.83	80.13
35	Dusseldorf	**72.77**	60.46	68.49	83.19	82.29
36	Rome	**72.75**	66.19	68.60	76.61	82.73
37	Berlin MA	**72.27**	67.63	64.44	79.08	85.28
38	Stockholm	**72.21**	65.35	61.56	88.48	83.69
39	Doha	**71.83**	64.41	60.11	97.36	77.15
40	Sydney	**71.53**	68.61	65.38	82.63	75.91
41	Manchester	**71.49**	62.73	63.51	83.84	84.34
42	Vancouver MA	**71.48**	69.27	62.65	77.05	86.16
43	Philadelphia MA	**71.24**	71.19	64.02	79.49	78.05
44	Atlanta MA	**71.10**	68.18	63.30	83.83	77.64
45	Houston MA	**70.98**	72.96	63.01	80.84	75.87
46	Brisbane	**70.79**	62.27	62.75	77.39	90.12
47	Sao Paulo	**70.77**	62.38	69.83	79.48	73.56
48	Barcelona MA	**70.62**	67.54	63.62	83.55	76.07
49	Minneapolis-Saint Paul	**70.43**	65.75	63.38	80.00	81.25
50	Montreal MA	**70.36**	66.46	64.30	77.70	80.72
51	Milan	**70.34**	65.72	65.59	81.03	75.45
52	Tel Aviv	**69.87**	62.77	69.95	76.57	72.37
53	Melbourne	**69.76**	68.37	63.71	78.90	76.39
54	Lyon-Grenoble	**69.28**	63.78	61.56	81.66	80.80
55	Kyoto-Osaka-Kobe	**69.19**	70.97	60.46	78.86	78.07
56	Pittsburgh	**69.10**	65.61	62.80	78.70	78.68
57	Lisbon	**69.00**	63.63	64.45	80.09	75.61
58	Cologne	**68.86**	60.37	66.81	76.55	77.21
59	Taipei	**68.81**	66.44	63.34	82.93	71.35
60	Portland	**68.44**	61.94	62.15	79.60	80.28
61	Warsaw	**68.10**	62.10	61.92	80.82	78.02
62	Moscow	**68.10**	65.04	60.75	77.36	80.85
63	Vienna	**68.09**	63.45	61.36	83.08	75.44
64	St. Louis	**68.07**	65.03	62.34	78.33	76.57
65	Rotterdam	**68.02**	60.85	61.15	82.06	79.28

Rank	City/metropolitan area	Innovation Ecosystem	Openness and Collaboration	Support for Start-ups	Public Services	Innovation Culture
66	Cincinnati	67.92	63.11	61.70	77.96	79.62
67	Brussels	67.82	63.71	61.45	76.27	80.83
68	Buenos Aires	67.43	60.37	63.43	75.18	79.82
69	Nagoya MA	67.38	67.45	60.15	76.66	77.49
70	Las Vegas	67.35	60.00	62.40	79.95	77.16
71	Perth	66.98	61.52	62.58	78.02	75.73
72	Bangkok	66.87	62.33	61.31	82.22	72.79
73	Mexico City	66.85	62.20	68.56	69.03	71.61
74	Stuttgart	66.76	62.17	62.75	76.54	75.39
75	Gothenburg	66.72	61.01	60.15	80.78	77.37
76	Busan	66.51	60.87	60.35	80.36	76.74
77	Detroit MA	66.44	62.24	62.21	79.01	72.67
78	Daejeon	66.22	63.01	60.60	81.83	71.40
79	Budapest	66.18	60.99	61.17	72.82	81.23
80	Nanjing	66.17	73.88	61.64	75.79	64.04
81	Prague	66.03	61.96	63.53	73.42	74.33
82	Hangzhou	65.98	72.61	61.70	75.67	64.62
83	Riyadh	65.69	62.97	60.46	81.31	70.17
84	Bengaluru	64.98	66.91	65.03	62.25	73.39
85	Wuhan	64.79	71.28	60.88	75.74	62.92
86	Xi'an	64.61	70.05	60.99	75.01	63.98
87	Kuala Lumpur	64.58	62.65	60.64	75.01	72.19
88	Istanbul	64.29	64.48	64.53	74.64	61.73
89	Suzhou	64.11	68.51	61.34	75.02	62.92
90	Hefei	64.10	67.84	62.47	75.25	61.08
91	Tianjin	64.07	67.83	60.93	75.33	63.98
92	Zhengzhou	63.94	68.62	61.36	74.99	62.13
93	Chengdu	63.85	69.00	61.17	75.76	61.02
94	Central National Capital Region Delhi MA	63.68	65.47	65.75	63.78	66.81
95	Johannesburg	63.59	60.77	60.07	72.63	73.82
96	Qingdao	63.44	66.44	60.78	75.12	63.47
97	Shenyang	63.40	67.43	60.84	75.02	62.27
98	Changsha	63.33	66.59	61.21	75.27	61.86
99	Chongqing	63.30	66.51	61.80	75.32	60.58
100	Jinan	63.08	66.40	60.94	75.27	61.63

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FIGURE 46

Quartile graph of ranking in innovation ecosystem for cities/ metropolitan areas in Asia, Europe and North America

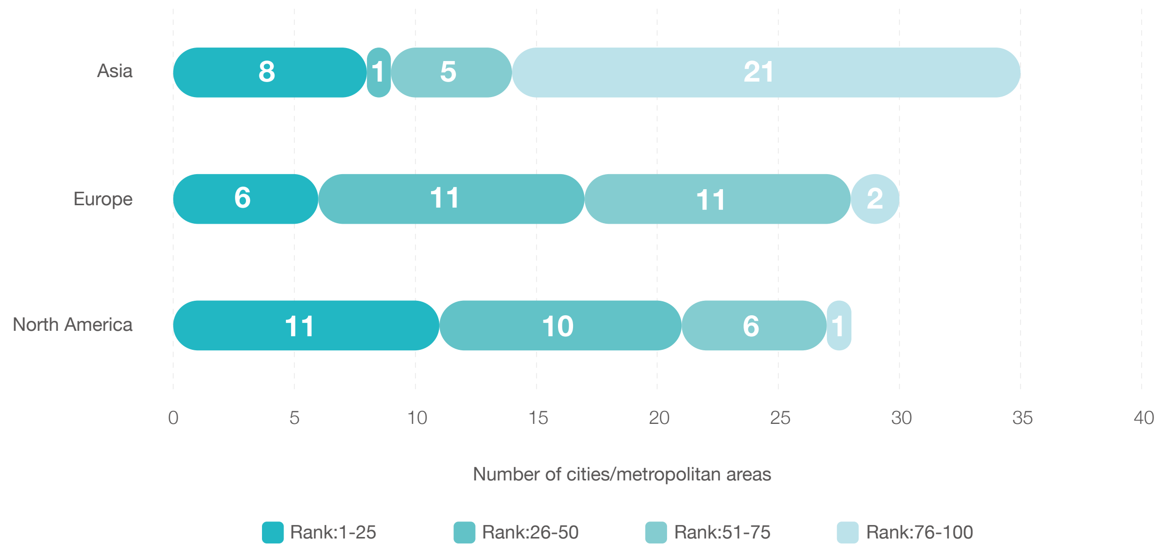


TABLE 10

A comparison of the top 20 GIHs in innovation ecosystem between 2023-2025

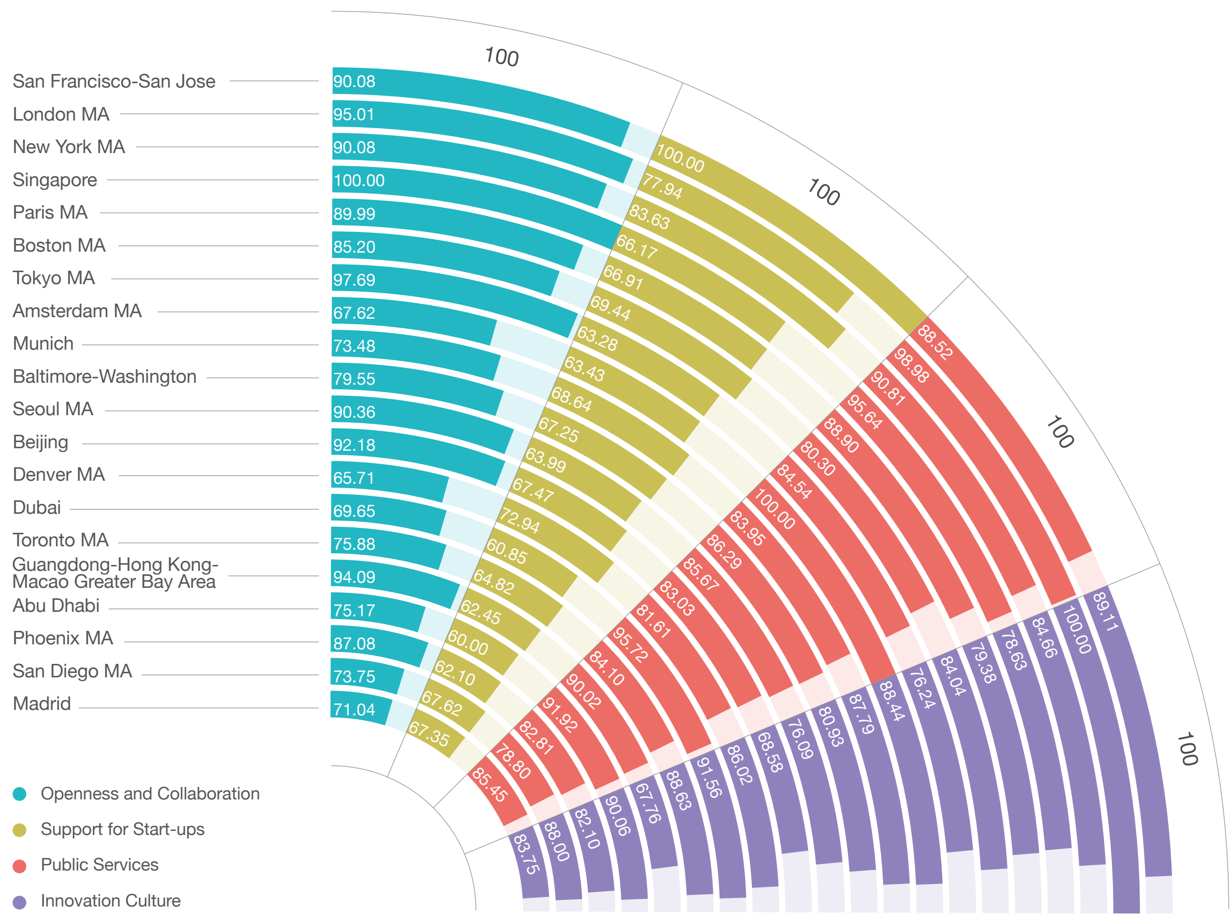
City/metropolitan area	Rank 2025	Rank 2024	Rank 2023
San Francisco-San Jose	1	2	1
London MA	2	1	2
New York MA	3	3	3
Singapore	4	5	7
Paris MA	5	8	4
Boston MA	6	7	8
Tokyo MA	7	14	24
Amsterdam MA	8	10	14
Munich	9	15	17
Baltimore-Washington	10	11	15
Seoul MA	11	17	5
Beijing	12	9	11
Denver MA	13	33	26
Dubai	14	13	9
Toronto MA	15	12	12
Guangdong-Hong Kong-Macao Greater Bay Area	16	6	6
Abu Dhabi	17	19	43
Phoenix MA	18	40	10
San Diego MA	19	22	28
Madrid	20	20	21

Globally, San Francisco-San Jose returns to the top in innovation ecosystem, followed by London MA and New York MA. Among the top 20 cities/metropolitan areas, North America occupies eight spots, Asia takes seven and Europe holds five.

As shown in Figure 46, North American cities/metropolitan areas stand out, occupying 11 spots in the top 25. A majority of them rank in the first and second tiers. Most European cities are in the second and third tiers. Certain Asian cities excel in innovation ecosystem, but more than half of them still have considerable room to catch up.

FIGURE 47

Development of the top 20 GIHs in innovation ecosystem



5.Innovation ecosystem

As the trends indicate, top cities/metropolitan areas remain stable amid regional diversification, and new forces are on the rise (Table 10). Among the top 20 cities/metropolitan areas, San Francisco-San Jose, London MA and New York MA have occupied the top three places for three consecutive years. San Francisco-San Jose has attracted substantial venture capital, with total funding up by 111%. By region, the innovation ecosystem in North America continues to inject vitality into innovation. San Francisco-San Jose and New York MA remain in the top three. Meanwhile, thanks to the strong ability to attract foreign investment and support for start-ups, Boston MA, Baltimore-Washington, Denver MA and Phoenix MA also stand out, with Denver MA and Phoenix MA ranking much higher than the previous year. Europe sees improved public services on the back of a mature and resilient ecosystem. Munich and Amsterdam MA move up steadily. Among Asian cities, Tokyo MA and Singapore perform well. Tokyo MA, in particular, has made significant progress, rising from 24th in the GIHI2023 to 7th this year. Singapore, Tokyo MA and Seoul MA have improved by four, five and five places, respectively, benefiting from enhanced openness and collaboration. Moreover, the rise of some emerging cities is reshaping the global innovation ecosystem. For example, Abu Dhabi in the Middle East has climbed from 43rd to 17th over three years.

Figure 47 shows the performance of the top 20 GIHs in innovation ecosystem across each sub-indicator, revealing the strengths and characteristics of different regions.

Asian cities/metropolitan areas are better positioned in openness and cooperation, with Singapore and Tokyo MA ranking in the top two driven by foreign direct investment (FDI). Guangdong-Hong Kong-Macao Greater Bay Area and Beijing rank fourth and fifth, standing out in paper co-authorship. Singapore, Dubai and Abu Dhabi have improved significantly in public services, demonstrating the rapid enhancement in e-governance and infrastructure connectivity in emerging economies in Asia and the Middle East.

Cities/metropolitan areas in the United States perform well in support for start-ups. Driven by the AI industry, San Francisco-San Jose, New York MA and Denver MA rank first, second and fourth, respectively, with London MA coming at the third place. They also rank among the top five in venture capital (VC), private equity (PE) and the number of registered lawyers (per million people), highlighting the complete ecosystems of established GIHs.

European cities/metropolitan areas have solid advantages in public services and innovative cultures. Thanks to the unified digital transformation policies at the EU level, European cities/metropolitan areas have gained more edges in e-governance, with Amsterdam MA and London MA ranking in the top two. Owing to rich cultural heritage, London MA, Helsinki and Hamburg are among the top three in innovative culture. They are also leading in the number of public libraries and museums, and residents' average years of education.

5.2
Openness and collaboration

Openness and collaboration are key drivers in an innovation ecosystem, as they help enhance knowledge flow across organizations, facilitate integration and allocation of innovation resources, and accelerate interdisciplinary collaboration to improve the value co-creation capabilities and sustainable competitiveness of the GIHs. The GIHI2025 evaluates a city's level of openness and collaboration using sub-indicators such as paper co-authorship network centrality, patent collaboration network centrality, FDI and OFDI.

The top five cities/metropolitan areas in openness and collaboration are Singapore, Tokyo MA, London MA, Guangdong-Hong Kong-Macao Greater Bay Area and Beijing. By region, among the top 20 cities/metropolitan areas, nine of them are in North America, eight in Asia and three in Europe. Singapore, Tokyo MA and Seoul MA in Asia, and Phoenix MA, Seattle-Tacoma-Bellevue and San Diego MA in the United States have improved their rankings significantly.

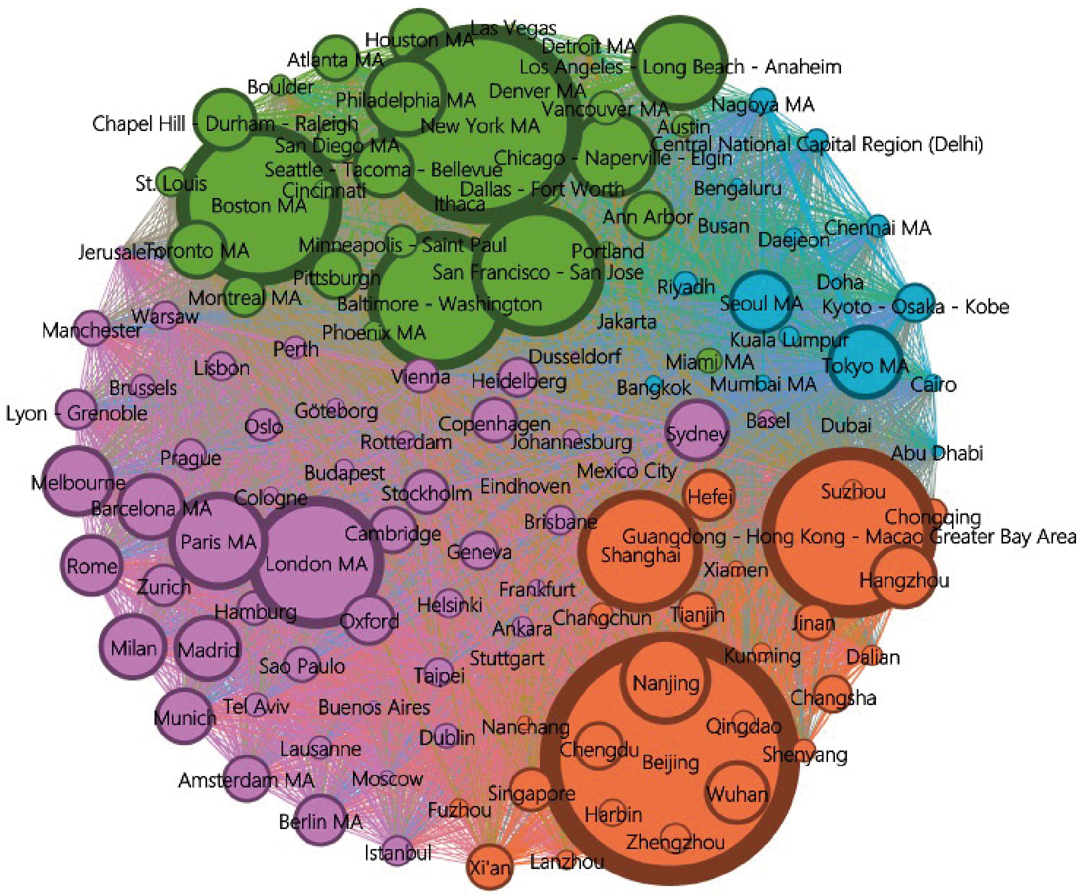
Based on data from 2024, this report analyses the paper co-authorship between cities across disciplines, and the patent collaboration in AI, smart chips, biomedicine, renewable energy, quantum information and controlled nuclear fusion, depicting the paper co-authorship network and patent collaboration network for the GIHs. A node represents a city/metropolitan area. The node size indicates the importance and impact of a city/metropolitan area in the network, while the colours reflect the sub-networks. The thickness of the connecting lines measures the intensity of bilateral cooperation.

As shown in Figure 48, there are four sub-networks of paper co-authorship among GIHs: the first centres on Chinese cities/metropolitan areas, such as Beijing, Guangdong-Hong Kong-Macao Greater Bay Area and Shanghai; the second centres on North American metropolitan areas, such as New York MA, Boston MA and Baltimore-Washington; the third centres on European metropolitan areas, such as London MA, Paris MA and Barcelona MA; the fourth centres on certain Asian metropolitan areas, such as Tokyo MA, Seoul MA and Kyoto-Osaka-Kobe.

Specifically, the paper co-authorship network has following characteristics: North American and Chinese cities constitute the two largest sub-networks of paper co-authorship, both showing a significant tendency to conduct domestic cooperation. The North American co-authorship network has New York MA at the core, whose top ten partners are all from the United States except for London MA. The Chinese co-authorship network has Beijing at the core, which mainly cooperates with domestic peers. Cities/metropolitan areas in the European and Asian sub-networks are more prominent in cross-border cooperation. Some play a key role in cross-board paper co-authorship. For example, Singapore is deeply embedded in China's innovation network on one hand, while establishing close cooperation with London MA, New York MA and Seoul MA. Sydney has built a bridge for knowledge flow across the Pacific Ocean by establishing multi-dimensional academic connections with London MA, Guangdong-Hong Kong-Macao Greater Bay Area, Beijing, New York MA and other GIHs.

FIGURE 48

The GIHs paper co-authorship network (2024)



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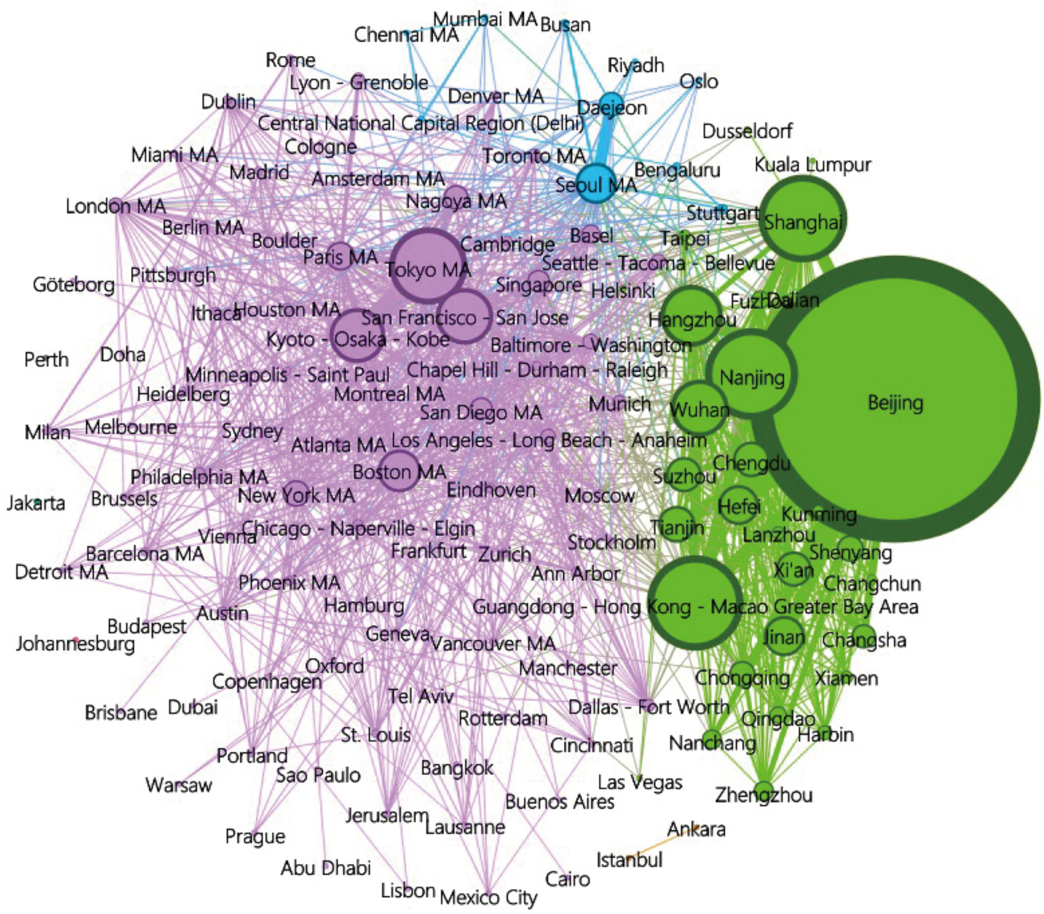
As shown in Figure 49, there are three sub-networks of patent collaboration among GIHs: the first is the Europe-the United States-Japan sub-network with San Francisco-San Jose, Tokyo MA and Paris MA at the core. It is characterized by extensive and diversified patent technology flow and cooperation, as well as a high level of international cooperation. This sub-network is key to global technological innovation and cooperation. San Francisco-San Jose continues to serve as the engine in frontier fields, and has established close cooperation ties with many GIHs. Tokyo MA maintains active technical exchanges with Asian cities such as Kyoto-Osaka-Kobe and Seoul MA, as well as cities in Europe and the United States such as Paris MA and Boston MA. The second is the China sub-network with Beijing, Guangdong-Hong Kong-Macao Greater Bay Area and Shanghai at the core. Beijing, as a key force of technological innovation, boasts the largest scale of patent collaboration. The city has formed a close domestic technical cooperation system with cities including Guangdong-Hong Kong-Macao Greater Bay Area, Shanghai, Hangzhou, Nanjing, Wuhan, demonstrating strong capabilities of collaborative innovation. The third sub-network features a combined and diversified combination of regions. It centres on some metropolitan areas in Japan, South Korea and India, and also covers European cities such as Oslo and Stuttgart, resulting in an emerging cross-regional technology innovation platform.

Foreign direct investment (FDI) in the assessed GIHs showed signs of recovery in 2024. More than half of the cities/metropolitan areas achieved growth in total investment. Due to geopolitical turmoil and the restructuring of industrial and supply chains, the attraction of foreign investment

FIGURE 49

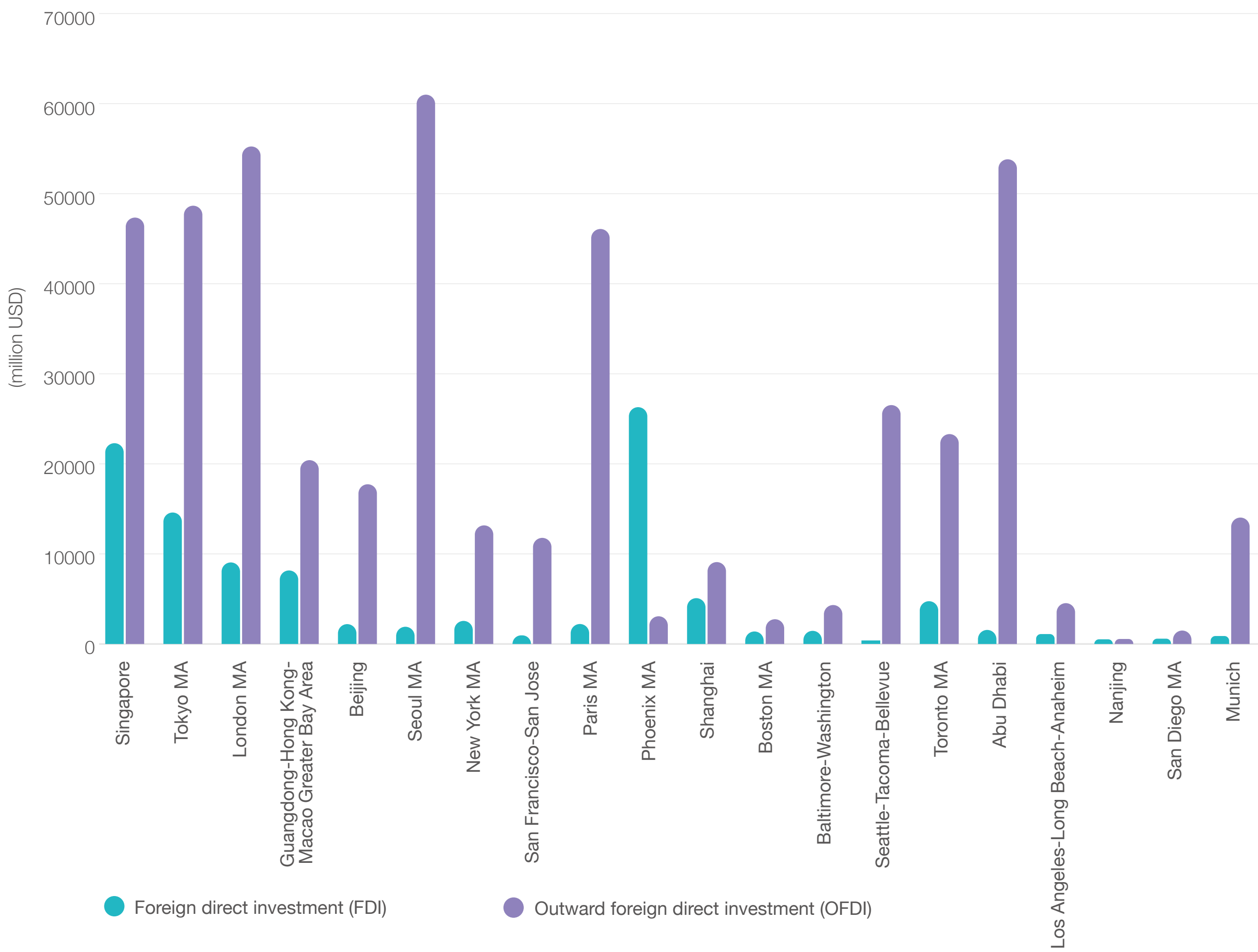
The GIHs patent collaboration network (2024)



differed significantly by region. Global FDI inflows to North America and certain Asian cities have accelerated, while nearly 60% of European cities/metropolitan areas have experienced a decline in total FDI. North American cities/metropolitan areas have become important destinations for FDI, with nearly 75% of all the assessed cities/metropolitan areas in the United States recording increases in total FDI. Phoenix MA ranks first in the world with US$26.297 billion. This 26-fold increase in total FDI over last year is attributed to the announcement of additional investment for building new semiconductor factories by the global semiconductor foundry giant, TSMC. Asian cities are still the hotspots for FDI, accounting for ten of the top 20 cities/metropolitan areas in total FDI. Singapore and Tokyo MA have maintained steady growth, ranking second and third, respectively. Four emerging cities in India, namely Bangaluru, Chennai MA, the Central National Capital Region (Delhi) and Mumbai are among the top 20 as well.

On outward foreign direct investment, driven by Samsung Group, outward foreign direct investment (OFDI) of Seoul MA increased by 74% year-on-year, jumping to the top with US$60.996 billion. London MA and Abu Dhabi are in the top three. In 2024, Asian countries continued to lead global export of capital, with the number of cities in the top 20 increasing from nine to ten, and most of them maintained steady growth. OFDI of Seattle-Tacoma-Bellevue has grown significantly, driven by technology giants such as Microsoft. And the investment is significantly tilted towards AI infrastructure. In addition, a majority of the top 20 cities/metropolitan areas in openness and collaboration (Figure 50) registered much higher OFDI than FDI, highlighting their capability of exporting capital and guiding industrial investment.

FIGURE 50 **Foreign direct investment (FDI) and outward foreign direct investment (OFDI) in the top 20 cities/metropolitan areas in openness and collaboration**



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5.3
Support for start-ups

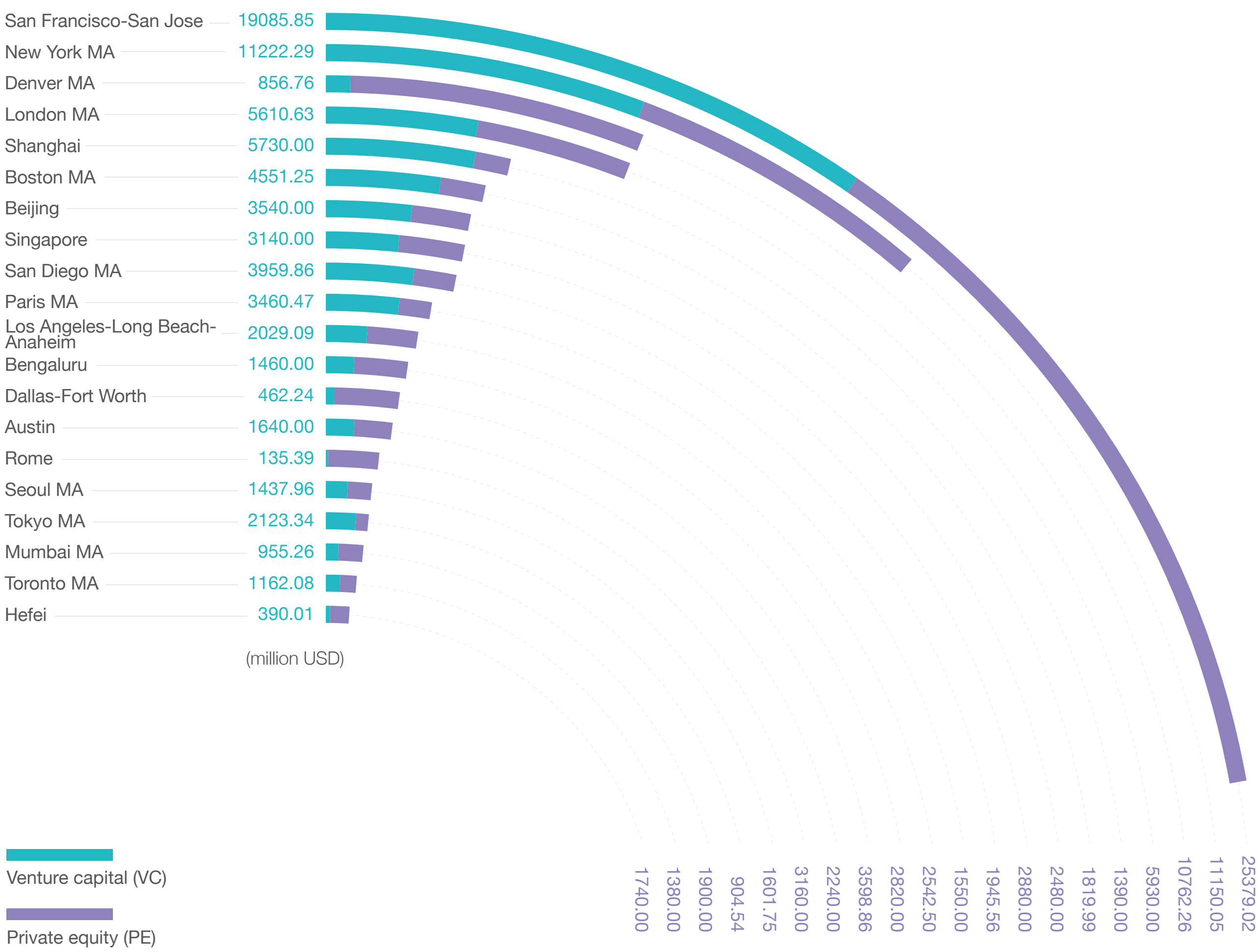
In this report, we conducted a comprehensive evaluation of support for start-ups by measuring the amount of venture capital (VC) and private equity (PE) investment and the number of registered lawyers (per million people). These indicators reflect the cities/metropolitan areas' financing support for start-ups and the optimization of its business environment.

The top five cities/metropolitan areas in support for start-ups are San Francisco-San Jose, New York MA, London MA, Denver MA and Tel Aviv. Among the top 20 cities/metropolitan areas, eight are in Europe, eight in North America, and three in Asia. With the planning of public legal service systems in place, Chinese cities/metropolitan areas have seen an overall increase in the number of registered lawyers, providing a foundation for the continuous optimization of the business environment.

Regarding the overall trend and the performance of top cities, as shown in Figure 51, San Francisco-San Jose, driven

FIGURE 51

Top 20 cities/metropolitan areas by total venture capital (VC) and private equity (PE) investment



by AI, maintained the first place in VC and PE investment, with the scale of venture capital investment increasing significantly to US$44.465 billion. As funds move toward high-quality assets, the Bay Area is in a better position to absorb capital inflows on the back of top AI enterprises and project pools. As the second largest destination of venture capital, New York MA leads third- and fourth-ranked Denver MA and London MA by more than US$10 billion in total investment, demonstrating its advantages in capital allocation as both a global financial centre and a global innovation hub. Denver's outstanding performance this year was largely attributed to the city's unicorn and a large-scale data centre provider, Vantage, which received US$9.2 billion in private equity to accelerate the construction of new data centres around the world.

On capital allocation, the transaction volume of venture capital in each round has declined and the investment amount has kept flat. The transaction volume of private equity funds has remained stable, while the investment amount has increased significantly. These funds are more inclined to the mid-to-late stage and mature projects. Geopolitical and supply chain uncertainties combined with high interest rates have led to weakening risk appetite and difficult early-stage financing. China and European countries, represented by Germany, have been more affected by uncertainties. In contrast, cities/metropolitan areas in Japan, India and South Korea have recovered and demonstrated strong resilience.

From an industry perspective, in 2024, 33% of international venture capital flowed to the AI industry. Nearly 74% of the global AI investment transactions concentrated in the early rounds, namely the seed round to the C+ round, with an outstanding valuation premium. Investors have shown special confidence and expectations in AI that are rare in the general technology sectors. Overall, while investment in other technology sectors is largely stable and conservative, the development of AI has stimulated global venture capital activity significantly and directly pushed up the scale and growth rate of investment in AI hubs such as the Bay Area.

YUICHIRO CHINO/MOMENT/GETTY

5.4 Public services

Urban public services provide infrastructure support for technology companies and innovators, which help stabilize the innovation environment. The GIHI2025 uses the number of data centres (public clouds), broadband connection speed, the number of international flights (per million people) and the level of e-governance to assess the cities/metropolitan areas comprehensively by examining their capacity of hosting digital infrastructure, efficiency of information transmission and interaction, access to global resources, and the digitalization and convenience of government services.

The top five cities/metropolitan areas in public services are Amsterdam, London MA, Doha, Dubai and Singapore. Among the top 20 cities/metropolitan areas, eight are in Europe, six are in Asia and six are in North America, which remains largely the same as the previous year. Doha and Dubai in the Middle East stand out, while North American cities/metropolitan areas rank in the tenth to the twentieth range.

The construction of data centres is mainly dominated by Europe and North America. London MA ranks first with 218 data centres (Figure 52). The UK will receive £8 billion investment from Amazon from 2024 to 2028, which will be used to build, operate and maintain data centres. This will further strengthen the digital and AI infrastructure of the country and support the transformation of the UK's digital economy. The United States is also actively investing in construction of data centres. Compared with 2024, seven of the 10 fastest risers are located in the United States. Notably, despite the booming construction of global data centres, most of the new ones are located outside the cities/metropolitan areas covered in this report, so the number of data centres (public clouds) in most assessed cities/metropolitan areas remains stable.

In addition, global air travel continues

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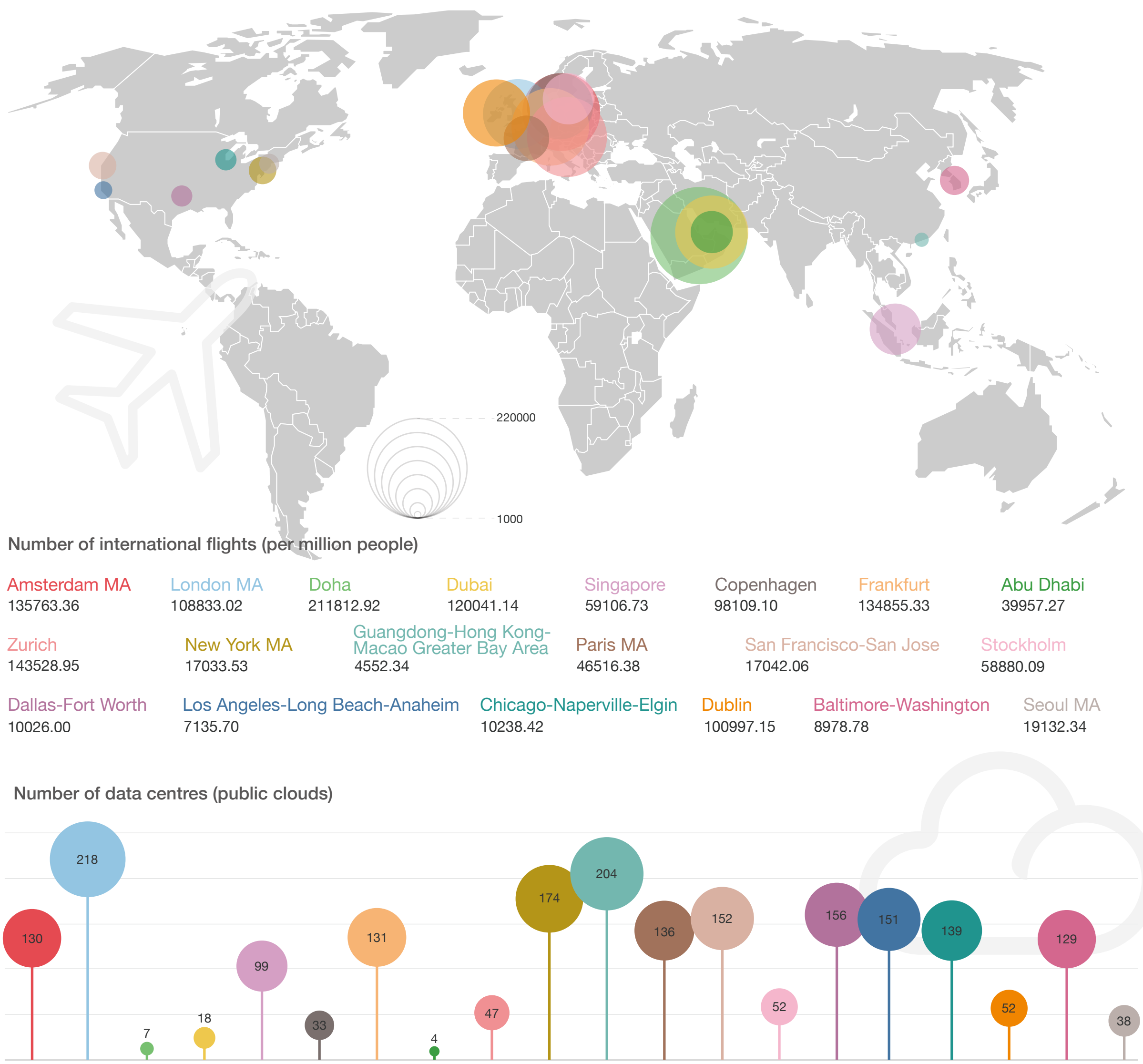
to recover as the impact of the COVID-19 pandemic recedes. The number of international flights (per million people) from the assessed cities increased by 8% on average in 2024 compared to 2023. In particular, the aviation market in the Asia-Pacific region has been on a significant recovery trajectory. Europe is in a leading position in the number of international flights (per million people), with most cities ranking high, occupying seven spots of the top ten. In contrast, North American cities/metropolitan areas are largely in the middle and lower ends of the overall ranking, witnessing relatively slow growth in the number of flights due to weak demand and fierce competition from low-budget airlines.

In terms of broadband connection speed, Europe and Asia are distributed at two extremes, while North America is at an intermediate level. The Middle East is particularly strong in mobile internet speed, with cities from the United Arab Emirates and Qatar ranking among the top

FIGURE 52

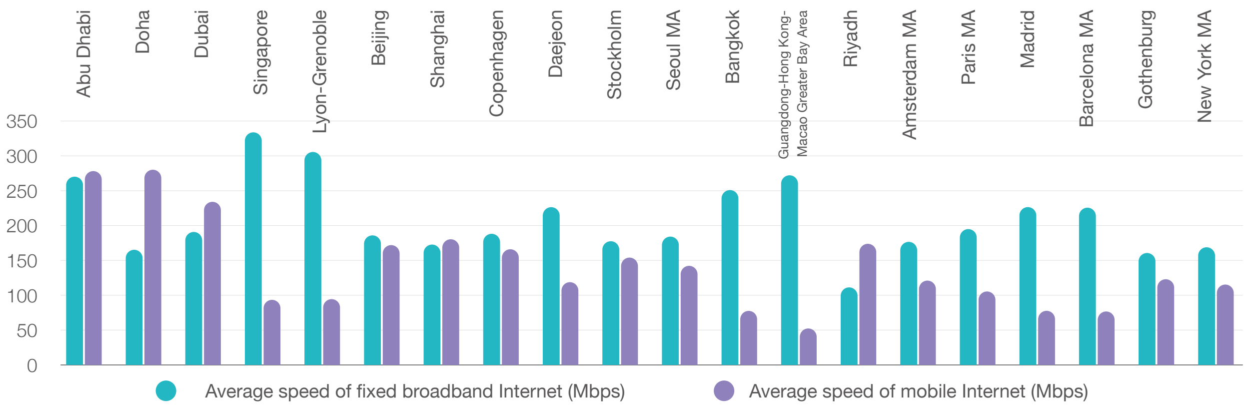
Numbers of international flights (per million people) and that of data centres (public clouds) for the top 20 GIHs in public services



three in the world. This demonstrates the widespread application of cloud services and the world-leading digital infrastructure construction in the region, supported by large-scale government-led investment in telecommunications infrastructure. Meanwhile, Singapore ranks first with an average fixed broadband speed of 333.79 Mbps. The East Asian metropolitan areas, represented by Daejeon and Guangdong-Hong Kong-Macao Greater Bay Area, have made considerable progress in recent years. China Telecom Guangdong and Huawei have jointly built the first 400G all-optical transmission network in Guangdong-Hong Kong-Macao Greater Bay Area, supporting the development of digital economy in the Greater Bay Area by enabling ultra-low latency, ultra-high bandwidth, and ultra-high reliability. Europe occupies ten spots of the top 25 by improving fixed broadband infrastructure, with France, Denmark and Sweden performing particularly well.

FIGURE 53

Average speed of fixed broadband Internet and that of mobile Internet for the top 20 GIHs in broadband connection speed



5.5
Innovation culture

Innovation culture is a key element of a city's sustained competitiveness as it helps stimulate inherent innovation vitality by shaping an open and vibrant social environment. High-quality innovation culture attracts diverse talents, promotes knowledge exchange and collision of ideas, which help facilitate the transformation of innovation outcomes and the development of emerging industries. The GIHI2025 measures a city/metropolitan area's innovation culture through three sub-indictors: professional talent inflow (per million people), residents' average years of education, and number of public libraries and museums (per million people).

The top five cities/metropolitan areas in innovation culture are London MA, Helsinki, Hamburg, Dubai and Brisbane. Among the top 20 cities, only Dubai and Abu Dhabi in the United Arab Emirates are Asian cities, the rest are either from Europe (eight spots) or the United States (nine spots). Europe ranks third on the back of the systemic advantages in developing innovation culture infrastructure. European cities/metropolitan areas account for more than half of the top 20 in residents' average years of schooling and the number of public libraries and museums (per million people). European cities have effectively enhanced the vitality of urban innovation and the accessibility of cultural resources by transforming historical industrial spaces into important public cultural venues, such as the Tate Modern in London, while promoting digital transformation of cultural spaces.

In terms of professional talent inflow (per million people), the overall talent mobility has weakened due to the uncertainty of the global economy. Compared with 2023, less than 50% of the assessed GIHs saw an increase in inflow of specialized talent. However, the top cities/metropolitan areas maintain a strong talent inflow with their supportive policies, industries and location. Abu Dhabi and Dubai are at the top of the list, which is attributed not only to their talent-friendly policies introduced by the UAE government but also the region's employment structure dependent on foreign labour imports. Austin ranks third as company relocations and the improved technology ecosystem have boosted the local talent market, making the city an important destination of overflow in specialized and technical talents from the east and west coasts of the United States. As the capital of the United Kingdom and a global innovation hub, London MA ranks fourth and is particularly attractive to talent in finance, information technology and professional services. Bangaluru, an emerging city and known as the Silicon Valley of India, is of great importance to the IT industry in the country and brings together domestically trained talent in information technology. It has entered the top five in the GIHI2025 for the first time.

6. Summary

The GIHI2025 is based on three dimensions: research innovation, innovation economy and innovation ecosystem. During the selection of indicators, we take into account a variety of factors, such as a balance of tradition and future prospects, scientific and technological advancement, economic and social progress, and performance and environment. The goal is to identify crucial factors that affect the performance of GIHs and explore the elements that contribute to successful innovation.

Overall, competition among GIHs is becoming increasingly fierce and multi-polarization gains traction across the global innovation landscape. The booming AI industry has become a key engine to promote innovation, while uncertainty is affecting the global innovation ecosystem. Supported by the highly integrated synergetic network of megaregions, leading cities in the primary hotspots of innovation have gathered innovation elements and driven the development of surrounding areas. The mini-hubs continuously strengthen their expertise benefiting from differentiated spatial function forms by taking on characteristic development paths. North American cities/metropolitan areas are still the innovation leaders. European cities/metropolitan areas remain robust thanks to profound cultural and institutional foundations, while Asian cities/metropolitan areas are catching up quickly led by top cities.

In research innovation, Europe and the United States maintain leadership, while Asia is rising rapidly. Beijing rises to the top of the list. Cities/metropolitan areas in the United States stand out in top talent training and high-performance computing infrastructure. Chinese cities/metropolitan areas adopt a development path centred on research innovation, with first-class research institutions and researchers providing solid support for enhancing the quality of knowledge creation. In innovation economy, the global economy is well on the way to recovery. North American cities/metropolitan areas boast deep-rooted strengths in innovative enterprises, venture capital and high-end manufacturing. Asian cities/metropolitan areas are rising rapidly with technology accumulation and emerging industries. San Francisco-San Jose is far ahead, while Guangdong-Hong Kong-Macao Greater Bay Area has climbed to the second place in the world with strong growth momentum. In innovation ecosystem, Europe and the United States continue to take the lead, boasting world-leading public services and supportive business environment for start-ups, respectively. Leading cities/metropolitan areas in Asia outperform in openness and collaboration. Although the overall liquidity of capital and talent has slowed down due to geopolitical uncertainty, the global international flight capacity has recovered to the pre-COVID levels. Amid the rapid development of AI, global investment is showing signs of recovery in top cities.

The second quantum revolution is accelerating and is reconstructing the technical paradigm of information computing, communication and measurement. Quantum technology is dominated by three powerhouses: China, the United States and the European Union. Quantum computing has become a hotspot for patents, where New York MA, San Francisco-San Jose, Beijing and Hefei are particularly active. Quantum technology is expected to see explosive growth in future despite theoretical and engineering challenges. Meanwhile, cross-border research and industrial cooperation in quantum technology are constrained by geopolitical factors.

In the field of controlled nuclear fusion, technological breakthroughs are growing as the number of new patents from 2020 to 2024 has exceeded the sum of previous years. As a key driver, China relies on national research resources to promote innovation. The United States pioneers commercialization through multiple capital-driven paths. Europe develops by virtue of big science programmes. AI technology is expected to accelerate the research and development process in areas such as plasma confinement and high-performance material selection. Given fierce competition, complementary and open cooperation between GIHs is still a key approach to speeding up commercialization of controlled nuclear fusion.

The world is looking for a new balance amid high interest rates, geopolitical tensions, climate risks and technological alterations. As crucial hubs that connect knowledge, capital and industry, GIHs lead technological breakthroughs and contribute to new growth drivers, especially generative AI, high-end manufacturing, clean energy and biomedicine. Networking megaregions and cross-border corridors help accelerate the flow of key elements, but regional collaboration requires superior technical standards, data security and supply chain resilience. Looking forward, GIHs still need to embrace open collaboration, application-oriented development and institutional innovation to strengthen original innovation and adjust to various scenarios, thus injecting solid momentum into global recovery and long-term growth.

The global innovation network is dynamic and evolving and the index system needs to be further improved. We invite evaluators, practitioners and policymakers across the world who have read this report to make comments and suggestions.

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Appendix

Appendix I: Adjustments to the GIHI Indicators

GIHI2025	Adjustments	Details
09. Total number of valid patents (per million people)	Statistical connotation	Adjustment of patent search strategy: after the adjustment, patent data was collected from the six fields of artificial intelligence, smart chips, biomedicine, renewable energy technology, quantum information and controlled nuclear fusion, with reference to the classification systems defined in the 'Key Digital Technology Patent Classification System (2023)' and the 'Classification of Strategic Emerging Industries and International Patent Classification Cross-Reference Table (2021)'.
10. Number of PCT patents	Statistical connotation	Adjustment of patent search strategy: after the adjustment, patent data was collected from the six fields of artificial intelligence, smart chips, biomedicine, renewable energy technology, quantum information, and controlled nuclear fusion, with reference to the classification systems defined in the 'Key Digital Technology Patent Classification System (2023)' and the 'Classification of Strategic Emerging Industries and International Patent Classification Cross-Reference Table (2021)'. The statistical period has been changed to a 5-year basis.
11. Number of leading innovative companies	Data source	As the 2024 EU Industrial R&D Investment Scoreboard has revised the global corporate R&D expenditure rankings from the previous year's Top 2,500 to the Top 2,000, this study has accordingly adjusted its statistics for the number of enterprises included in this metric.
18. Patent collaboration network centrality	Statistical connotation	Adjustment of patent search strategy: after the adjustment, patent data was collected from the six fields of artificial intelligence, smart chips, biomedicine, renewable energy technology, quantum information, and controlled nuclear fusion, with reference to the classification systems defined in the 'Key Digital Technology Patent Classification System (2023)' and the 'Classification of Strategic Emerging Industries and International Patent Classification Cross-Reference Table (2021)'.
25. Broadband connection speed	Data source	Transfer the data resource of fixed broadband connection speed from Testmy.net into Speedtest to keep alignment with that of mobile Internet.

Appendix II: GIHI indicator definitions and data sources

A.Research innovation

01. Number of active researchers (per million people)

Definition: The number of researchers who had publications between 2020 and 2024 per million people in the assessed city. If a researcher had more than one publication during this period, he/she will be counted only once.
Data sources: Digital Science – Dimensions

02. Number of winners of top scientific awards

Definition: The top scientific awards refer to Nobel prizes (excluding the prizes for literature and peace), the Fields Medal and the Turing Award. The winners are calculated according to the city where they currently work or live. About statistics: (1) the winners are identified on the official websites; (2) the city is determined by their current workplace or institution by using "biography" and "institution" in Wikipedia, combined with Google search results to confirm the information is up to date. And further verify position details through the workplace or institution's official website, the recipient's personal homepage, and their most recently posted CV, and then sum up. Cities in which the winner works part time are all included.
Data sources: Turing Award website (https://amturing.acm.org/byyear.cfm); Nobel Prize website (https://www.nobelprize.org/); Fields Prize website (https://www.mathunion.org/imu-awards/fields-medal). Data as of 10 July 2025.

03. Number of world-leading universities
Definition: This study uses the number of top 200 universities in the Shanghai Ranking's Academic Ranking of World Universities (ARWU) 2024 to characterize a city's leading universities.
Data sources: Shanghai Ranking's Academic Ranking of World Universities (ARWU) 2024 (https://www.shanghairanking.cn/rankings/arwu/2024)

04. Number of top 200 world-class research institutions
Definition: The number of top 200 scientific institutions in scientific publications according to the Nature Index 2024. For affiliated institutions located in different cities, we use Nature Index's signature metric, Share, to measure if the affiliated institution has met the criteria of being the top 200 scientific institutions. With a Share higher than the 200th institution, the affiliated institution is counted, otherwise not. A description of how the Share is calculated is available here: https://www.nature.com/articles/d41586-020-02580-2.
Data sources: Nature Index

05. Number of large scientific facilities
Definition: The number of large scientific facilities in the assessed city. The large scientific facilities counted in this report include two major categories: dedicated research installations, including research installations built for major science and technology goals in specific disciplinary fields; and public experimental platforms, including large public experimental installations with strong support capabilities for basic, applied basic research and applied research in multidisciplinary fields. Those fields include energy, materials, geography, astronomy, biology, environment, nuclear physics, and high-energy physics. To ensure the independence of indicators, the large scientific facilities do not include supercomputers or scientific installations with supercomputer characteristics.
Data sources: Data are collected from various plans of large scientific facilities in different countries, the official websites of the main management agencies of the facilities and relevant literature, which are then confirmed and supplemented by experts from various departments organized by Tsinghua University.

06. Number of top 500 supercomputers
Definition: A supercomputer is a computer consisting of hundreds or more processors that can process large and complex tasks that cannot be performed using ordinary PCs and servers. This study assesses the level of development of IT science facilities in each city by measuring the number of the world's top 500 supercomputers. As China no longer reports its supercomputer list to the Global Top 500 Supercomputers, the GIHI 2025 also includes the data from the 2024 China High-Performance Computer Performance TOP100 list.
Data sources: Global Top 500 Supercomputers, data as of November 2024 (https://www.top500.org/statistics/sublist/); 2024 China High-Performance Computer Performance TOP100 list. (https://www.csiam.org.cn/1003/202411/2246.html)

07. Number of highly cited papers
Definition: The number of the top 1% of highly cited papers of each discipline between 2000 and 2023. If a paper is in the top 1% of highly cited papers in several disciplines, it is counted only once.
Data sources: Digital Science – Dimensions

08. Total citations from patents, policy reports and clinical trials
Definition: Total citations of scientific papers published in the city between 2020 and 2024 from patents, policy reports and clinical trials, an indicator that looks at the impact of scientific papers outside the academic community and the level of knowledge transfer.
Data sources: Digital Science – Dimensions

B.Innovation economy

09. Total number of valid patents (per million people)
Definition: This indicator focuses on the stock of valid patents, which are those still in force after an application has been granted (the patent is still within the legal term of protection and the patentee is required to have paid the required annual fee). This year's research is based on the 'Classification of Strategic Emerging Industries and International Patent Classification Cross-Reference Table (2021)' and the 'Key Digital Technology Patent Classification System (2023)', which respectively count the number of patents in the six technology fields of artificial intelligence (AI), smart chips, biomedicine, renewable energy, quantum information and controlled nuclear fusion that are valid on December 31, 2024. Among them, artificial intelligence, biomedicine and renewable energy refer to the 'Classification of Strategic Emerging Industries and International Patent Classification Cross-Reference Table (2021)', smart chips and quantum information refer to the 'Key Digital Technology Patent Classification System (2023)', and controlled nuclear fusion refer to the IPC, CPC category and keywords to form a search strategy. Artificial intelligence mainly includes fields of AI hardware platforms, general AI technology, and key AI technology; intelligent chips mainly include fields of GPUs, FPGAs, ASICs, brain-inspired chips, and NPUs; biomedicine mainly includes fields of biopharmaceutical manufacturing, genetic engineering drug and vaccine manufacturing, chemical drug raw materials, and preparation manufacturing; renewable energy mainly includes fields of nuclear power, wind energy, solar energy, smart grids, biomass energy, and other new energy industries. Quantum information mainly includes fields of quantum measurement, quantum computing, and quantum communication; controlled nuclear fusion mainly includes fields of fusion reactor fuels, methods for manufacturing fusion fuel targets, and nuclear fusion reactors. After data search, consolidation according to the Derwent patent family, data cleaning and processing, 433,398 patents in AI, 130,613 patents in smart chips, 272,010 patents in biomedicine, 420,410 patents in renewable energy technology, 22,226 patents in quantum information, and 2,359 patents in controlled nuclear fusion have been obtained.
Data sources: Derwent Innovation patent database

Appendix

10. Number of PCT patents

Definition: The report focuses on patent filing internationally published under the Patent Cooperation Treaty (PCT). This year's study statistically analyses PCT patent data published in 2020-2024 in the six technology fields of AI, smart chips, biomedicine renewable energy, quantum information, and controlled nuclear fusion.

This study relies on the Derwent Innovation patent data platform and refers to the patent classification systems in the 'Classification of Strategic Emerging Industries and International Patent Classification Cross-Reference Table (2021)' and the 'Key Digital Technology Patent Classification System (2023) to statistically analyse the patent performance of the four technology fields of AI, smart chips, biomedicine, renewable energy, quantum information and controlled nuclear fusion. AI mainly includes fields of AI hardware platforms, general AI technology, and key AI technology; intelligent chips mainly include fields of GPUs, FPGAs, ASICs, brain-inspired chips, and NPUs; biomedicine mainly includes fields of biopharmaceutical manufacturing, genetic engineering drug and vaccine manufacturing, chemical drug raw materials, and preparation manufacturing; renewable energy mainly includes fields of nuclear power, wind energy, solar energy, smart grids, biomass energy, and other new energy industries. Quantum information mainly includes fields of quantum measurement, quantum computing, and quantum communication; controlled nuclear fusion mainly includes fields of fusion reactor fuels, methods for manufacturing fusion fuel targets, and nuclear fusion reactors. 57,286 PCT patents in the field of AI, 15,142 PCT patents in the field of smart chips, 64,996 PCT patents in the field of biomedicine, 33,405 PCT patents in the field of renewable energy, 4,648 patents in quantum information, and 228 patents in controlled nuclear fusion have been obtained.

11. Number of leading innovative companies

Definition: This study combined the top 2,000 companies in R&D investment in 2023 published by the EU Industrial R&D Investment Scoreboard 2024, Derwent Top 100 Global Innovators 2024, and 2024 Fortune Global 500 (only science and technology enterprises are included) to rank enterprises in evaluated cities, as an indicator of the enterprises' ability to drive innovation and spillover effect to surrounding regions.

Data sources: EU Industrial R&D Investment Scoreboard, 2024; Top 100 Global Innovators 2024 by Clarivate; Fortune Global 500, 2024

12. Number of unicorn companies

Definition: Unicorn is the term used to refer to start-ups that are valued at $1 billion or more, which have existed for a relatively short period of time (typically within a decade) and have not been listed. This study combined the Complete List of Unicorn Companies 2024 released by CB Insights and the 2024 Hurun Global Unicorn List. By removing duplicated companies, 1,705 unicorn companies in the assessed cities have been included in the scope of this report.

Data sources: Complete List of Unicorn Companies published by CB Insights(https://www.cbinsights.com/research-unicorn-companies, data as of July, 2025; 2024 Hurun Global Unicorn List (https://www.hurun.cn/zh-CN/Rank/HsRankDetails?pagetype=unicorn&num=E9W1YX99)

13. Market value of high-tech manufacturing companies

Definition: This study evaluates innovative companies by calculating the market capitalization of high-tech manufacturing companies in the 2025 Forbes Global 2000 list by cities/metropolitan areas. The Forbes 2000 list is based on four indicators: sales, profit, assets and market value. This report classifies high-tech manufacturing enterprises according to the secondary industries of the Global Industry Classification Standard (GICS), divided into three categories: pharmaceutical and chemical enterprises, electronic information enterprises and high-end manufacturing enterprises, of which pharmaceutical and chemical enterprises include chemistry, biomedicine, and health care equipment and services enterprises, electronic information enterprises include companies engaged in IT software and services, semiconductors, technology hardware and equipment and telecommunications; and high-end manufacturing companies including those engaged in aerospace and defence, materials and transportations.

Data sources: Forbes Website (https://www.forbes.com/lists/global2000)

14. Revenue of listed companies in new economy industries

Definition: The new economy industry is a forward-looking industry that has high human capital investment, high-tech investment, light assets, and sustainable and rapid growth. In this report, new economy industries refer to information technology, communication services and health care industries. The specific industry codes and sub-industries are shown in the table below. The measurement indicator is 2024 operating incomes of the listed companies in new economy industries of the cities. For missing values, apply the value of 'latest available operating incomes'.

Definition of new economy industries (GICS classification standard)

45 Information technology	4510 Software and services	451020	IT services
		451030	Software
	4520 Technical hardware and equipment	452010	Communications equipment
		452020	Technical hardware, storage and peripherals
		452030	Electronic equipment, instruments and parts
	4530 Semiconductors and semiconductor equipment	453010	Semiconductors and semiconductor equipment

50 Communication services	5010 Telecommunications services	501010	Diversified information services
		501020	Radio telecommunication services
35 Health care	3510 Health care equipment and services	351010	Health care equipment and supplies
		351020	Health care providers and services
		351030	Health care technology
	3520 Pharmaceuticals, biotechnology and life sciences	352010	Biotechnology
		352020	Pharmaceuticals
		352030	Life science tools and services

Data sources: Osiris, an online database of publicly listed companies worldwide

15. GDP growth rate

Definition: This study uses the GDP growth rate in 2023 calculated from the purchasing power parity of 2015 for each city (using 2015 as the real GDP base). To eliminate the effect of differences in prices among countries on the purchasing power of different currencies and the effect of price changes on GDP, this study uses the GDP deflator of each country to convert nominal GDP into real GDP that takes 2015 as the base year. The GDP growth rate is then calculated using GDP time series data in US dollars that are generated based on the constant prices and purchasing power in 2015. Due to lack of data, the GDP growth rate for 2021 are used for Montreal MA, Toronto MA, Vancouver MA, Mexico City, Vienna, Helsinki, Lyon-Grenoble, Paris MA, Berlin MA, Cologne, Dusseldorf, Frankfurt, Hamburg, Heidelberg, Munich, Stuttgart, Dublin, Milan, Rome, Amsterdam MA, Eindhoven, Rotterdam, Oslo, Warsaw, Barcelona MA, Madrid, Gothenburg, Stockholm, Basel, Geneva, Lausanne, Zurich, Kyoto-Osaka-Kobe, and Cairo; the GDP growth rates for 2022 are used for Brussels, Prague, Copenhagen, Budapest, Lisbon, Cambridge, London MA, Manchester, Oxford, Nagoya MA, Tokyo MA, Kuala Lumpur, and Riyadh.
Data sources: GDP data are from statistics offices of countries and cities, such as the National Bureau of Statistics of China, the United States Bureau of Economic Analysis, Eurostat, and Organisation for Economic Co-operation and Development (OECD); purchasing power parities (PPP) index and GDP deflator are from the World Bank.

16. Labour productivity

Definition: The output per unit of labour, calculated as gross regional product (GRP) divided by the working age population in each city aged from (15 to 64). The GDP used in this study is the GDP-PPP data for 2023 (based on 2015). When no data is directly available, estimations are made based on the demographic structure of the country or state/province containing the city, and the city's total population.
Data sources: workforce data collected from departments of statistics of each country and city.

C. Innovation ecosystem

17. Paper co-authorship network centrality

Definition: Co-authorship of a paper means two or more researchers work together to write and publish a scientific paper. The paper co-authorship network centrality reflects the openness and internationalization of a city's scientific research and this study calculates the eigenvector centrality of each city to measure the importance of a node in the paper co-authorship network based on the 2024 intercity paper publication collaboration matrix of the 125 evaluated cities. The importance of a node in the eigenvector centrality depends on the number of neighbouring nodes (the degree of the node) and the importance of the neighbouring nodes, which provides a more accurate representation of the node's position in the network. The eigenvector centrality calculates the centrality of a node based on the centrality of neighboring nodes and the eigenvector centrality of node i is Ax = λx where A is the adjacency matrix of a graph G with the eigenvalue λ. For information about the calculation of the eigenvector centrality, see the following link: https://networkx.github.io/documentation/stable/reference/algorithms/generated/networkx.algorithms.centrality.eigenvector_centrality_numpy.html?highlight=eigenvector_centrality_numpy
Data sources: Digital Science – Dimensions

18. Patent collaboration network centrality

Definition: Patent collaboration is the joint filing of patent applications by two or more researchers or organizations. This study is based on the combination and deduplication of data of stock valid patents (2024) and PCT public patents. It has constructed the technology collaboration network of an assessed city on the basis of joint filing on artificial intelligence, intelligent chips, biomedicine, renewable energy, quantum technology and controlled nuclear fusion to examine the patent cooperation network centrality of metropolitan areas, and to reflect the range of cooperation of each GIH. It is calculated as shown below:

$$C_i = \sum_{j=1}^{n} D_{ij}\,, D_{ij} = 0 \text{ or } 1$$

Data sources: Derwent Innovation patent database.

19. Foreign direct investment (FDI)

Definition: This study measures a city's attraction by its foreign direct investment (FDI) in greenfield projects in 2024. Greenfield investment refers to enterprises in which part or all of their assets are owned by foreign investors in accordance with the laws of the host country.
Data sources: fDi markets, an online database of cross-border greenfield investments (https://www.fdimarkets.com/)

Appendix

20. Outward foreign direct investment (OFDI)
Definition: The total amount of Outward Foreign Direct Investment (OFDI) made by companies located in the assessed city in 2024, which measures the spillover effects of a city's capital.
Data sources: fDi markets, an online database of cross-border greenfield investments (https://www.fdimarkets.com/).

21. Venture capital investment (VC)
Definition: This study measures the venture capital (VC) activities by measuring the amount of venture capital investment received in 2024, defined as the total financing amount in seed, angel, series A and series B rounds in the early stages of a company's development.
Data sources: CB Insights (https://www.cbinsights.com/)

22. Private Equity (PE)
Definition: Private Equity (PE) refers to the growth capital received during the pre-initial public offering (IPO) period of a proposed public company. In this study, the investment activity is measured by the total amount of private equity investment in 2024. PE investment is calculated as the total of financing rounds from series C, series D, series E+, growth equity and private equity.
Data sources: CB Insights (https://www.cbinsights.com/)

23. Number of registered lawyers (per million people)
Definition: The number of registered lawyers per million people in an assessed city in 2023. In this study, the number of registered lawyers is used to evaluate a city's entrepreneurial ecosystem. When data is not directly available, we use data from the state or province where the city belongs. For Budapest, Jakarta, Jerusalem, Tel Aviv, Kuala Lumpur, Bangkok, Doha, Cairo and Riyadh, the country/region-level data are used instead; for Toronto MA, Vancouver MA, Heidelberg, Eindhoven, Bengaluru, Central National Capital Region (Delhi), Chennai MA, Mumbai MA, Kyoto-Osaka-Kobe, Nagoya MA, Tokyo MA, Brisbane, Melbourne, Perth, Sydney, Buenos Aires, and Sao Paulo, data from the state or province are used instead.
Data sources: lawyer associations in countries and cities; ministries of justice in countries.

24. Number of data centres (public clouds)
Definition: Data centre hosting is an outsourced data centre solution where small and medium-sized companies with limited corporate IT resources often choose to host data centres to expand their data centre capacity rather than build their own data centres to save costs. In this study, the number of colocation data centres in the city is used to measure the city's digital economy growth.
Data sources: Cloudscene (https://cloudscene.com) data as of 8 May 2025.

25. Broadband connection speed
Definition: Broadband connection speed refers to the maximum theoretical rate that can be achieved by a network broadband technology which uses the 'fixed broadband internet speed' and 'mobile internet speed' to measure the broadband transmission service capacity of a city. This study uses the average upload and download rates (Mbps).
Data sources: Speedtest (https://www.speedtest.net) on 27 May 2025.

26. Number of international flights (per million people)
Definition: The number of all direct international flights departing from and arriving at the city in 2024.
Data sources: Official Aviation Guide, an aviation intelligence provider (https://www.oag.com/)

27. E-governance level
Definition: This study uses the E-Government Development Index (EGDI) published by the Department of Economic and Social Affairs at the United Nations to examine global development of e-government and to reflect the status of data governance. EGDI is based on a survey, which examines official websites in countries, including national portals, online service portals and e-participation portals. The 2024 Online Services Questionnaire consists of 180 yes/no questions about institutional framework, service provision, content provision, technology and e-participation.
Data sources: E-Government Development Index (EGDI) 2024 from the United Nations (https://publicadministration.un.org/egovkb/en-us/Reports/ UN-E-Government-Survey-2024)

28. Professional talent inflow (per million people)
Definition: In this study, the professional talent inflow into the assessed city, as recorded on LinkedIn Talent Insights between July 2024 and June 2025 is used to measure the attraction of the city/metropolitan areas to talents. For Dublin, Moscow, Busan, Daejeon, Seoul MA, Dubai, Abu Dhabi, Doha, Cairo and Riyadh, as the data is unavailable at the city level, the indicator is estimated using the proportion of citizens in the country/region and the talent inflow into that country/region. As LinkedIn shut down its China platform in October 2021, the data for mainland Chinese cities in 2024 is collected from Zhaopin.com.
Data sources: Zhaopin.com; LinkedIn Talent Insights (https://business.linkedin.com/talent-solutions/talent-insights), a dataset that is based on the integrated information submitted by LinkedIn members voluntarily, and the accuracy of data is not committed by LinkedIn. Data as of 30 June 2025.

29. Residents' average years of schooling
Definition: The average years of schooling for people aged over 25 in an assessed city. The average years of schooling in 2022 from the Subnational Human Development Index (HDI) published by the United Nations Development Programme are used to measure a city's education quality and human resources.
Data sources: Global Data Lab

30. Number of public museums and libraries (per million people)
Definition: In this study, the number of public museums and libraries in a city/metropolitan area that were open in 2024 is used to measure the public service environment for arts and culture in a city. Data sources: public museums: official museum directories, official tourism welcome pages, platforms for museum-goers and web maps; and public libraries: official statistical yearbooks or bulletins, official library websites, government websites, official tourism welcome pages and web maps (including the number of libraries open to the public excluding university libraries).

Appendix III: Data standardization method

There are differences in the data dimensions of the GIHI indicators, so we need to standardize the raw data of all the indicators first. This report uses the Z-Score, with the formula shown as below:

$$y_{ij}^{s} = \frac{x_{ij} - \bar{x}_i}{Std(x_i)}$$

y_{ij}^{s} is the standardized value of the Z-Score for the i-th level-3 indicator for city j. x_{ij} is the raw data for the i-th level-3 indicator for city j. $\bar{x}_i$ is the mean of the raw data for the i-th level-3 indicator for all cities and $Std(x_i)$ is the standard deviation of the raw data for the i-th level-3 indicator for all cities. All indicators are turned dimensionless. The mean value of the treated indicators is 0 and the standard deviation is 1.

The Z-score for each of the three levels of indicators are linearly weighted by the indicator weights to calculate the Z-score for their level-1 indicators and the GIHI index z-scores. Since there are zero and negative values in the Z-score, to make the final score clearer and more intuitive, this report uses min-max normalization on the basis of the Z-score to map the evaluated cities' scores to the [0,1] range.

$$Y_{aj}^{n} = \frac{X_{aj} - X_{min}}{X_{max} - X_{min}}$$

Y_{aj}^{n} is the min-max normalized value of the Z-Score for the a-th level-1 indicator for city j. X_{aj} is the Z-Score for the a-th level-1 indicator for city j. X_{min} is the minimum Z-Score for the a-th level-1 indicator for all cities. X_{max} is the maximum Z-Score for the a-th level-1 indicator for all cities.

Based on this, this report sets the base score of the evaluated cities to 60 so that the combined score of the level-1 indicators and GIHI indicators is [60,100] i.e. the first-ranked city scores 100 points and the last-ranked city scores 60 points.

The scores for level-1 indicators are shown in the following formula and the final scores for the three level-1 indicators for city j (A, B and C) are as follows Y_{Aj}, Y_{Bj}, Y_{Cj}.

$$Y_{Aj} = 60 + Y_{Aj}^{n} * 40$$

$$Y_{Bj} = 60 + Y_{Bj}^{n} * 40$$

$$Y_{Cj} = 60 + Y_{Cj}^{n} * 40$$

The GIHI composite score is Y_j, which is the result of the min-max normalization of city j based on the weighted Z-Score of all level-3 indicators and mapped to [60,100]. The formula of Y_j is as follows:

$$Y_j^{s} = \sum_{i=1}^{n} w_i y_{ij}^{s}$$

$$Y_j = 60 + \left(\frac{Y_j^{s} - Y_{min}}{Y_{max} - Y_{min}}\right) * 40$$

Y_j^{s} is the GIHI Z-Score for the sum of city j's level-3 indicators. w_i is the weight of the i-th level-3 indicator. y_{ij}^{s} is the standardized value of the Z-Score for the i-th level-3 indicator of city j, where n=30, indicating the number of level-3 indicators; i=1 means starting from the first level-3 indicator.

Appendix IV: The GIH selection process

In this report, cities/metropolitan areas were selected via the following steps: first we counted the cities in the science cities in the Nature Index - Science Cities 2024, the 2024 Global Cities Index by Kearney, and the 'top innovation clusters world-wide', by size and intensity, reported by WIPO Global Innovation Index 2024. We then selected the top 50 cities/metropolitan areas and those that rank below 50 but feature in at least two of the three lists. Supplement these with the cities (metropolitan areas) of Shenyang and Riyadh, as the final 125 cities/metropolitan areas to be assessed. Among them, there were 12 cities/metropolitan areas with a population of less than 1 million and these were evaluated separately as mini-hubs. The remaining 113 cities/metropolitan areas were included in the main list for assessment.

These 125 cities/metropolitan areas are from 40 countries/regions in six continents, covering 380 major administrative cities. Among them, there are 48 Asian cities, 38 European cities, 31 North American cities, four Oceanian cities, two South American cities and two African cities.

Appendix

Appendix V: Scope of administrative divisions of GIHs

No.	City/metropolitan area	Administrative division	Country/region
1	Montreal MA	Montreal	Canada
		Laval	Canada
		Longueuil	Canada
2	Toronto MA	Toronto	Canada
		Oshawa	Canada
		Vaughan	Canada
		Richmond Hill	Canada
		Burlington	Canada
		Markham	Canada
		Brampton	Canada
		Mississauga	Canada
		Oakville	Canada
		Milton	Canada
3	Vancouver MA	Vancouver	Canada
		Surrey	Canada
		Burnaby	Canada
		Richmond	Canada
		Delta	Canada
4	Mexico City	Mexico City	Mexico
5	Ann Arbor	Ann Arbor	United States
6	Atlanta MA	Sandy Springs	United States
		Atlanta	United States
		Athens	United States
7	Austin	Austin	United States
8	Baltimore - Washington	Baltimore	United States
		Washington, D.C.	United States
		Arlington	United States
		Alexandria	United States
9	Boston MA	Lowell	United States
		Cambridge	United States
		Boston	United States
10	Boulder	Boulder	United States
11	Chapel Hill - Durham - Raleigh	Chapel Hill	United States
		Durham	United States
		Raleigh	United States
12	Chicago - Naperville - Elgin	Naperville	United States
		Chicago	United States
		Aurora	United States
		Joliet	United States
13	Cincinnati	Cincinnati	United States
14	Dallas - Fort Worth	Plano	United States
		Frisco	United States
		Irving	United States
		Arlington	United States
		Richardson	United States
		Fort Worth	United States
		Dallas	United States
		Denton	United States
		Lewisville	United States
		Carrollton	United States
		Mesquite	United States
15	Denver MA	Denver	United States
		Aurora	United States
		Lakewood	United States
		Arvada	United States
		Westminster	United States
		Centennial	United States
16	Detroit MA	Detroit	United States
		Warren	United States

17	Houston MA	Houston	United States
		Pearland	United States
		Pasadena	United States
18	Ithaca	Ithaca	United States
19	Las Vegas	Las Vegas	United States
20	Los Angeles - Long Beach - Anaheim	Torrance	United States
		Santa Ana	United States
		Rancho Cucamonga	United States
		Pomona	United States
		Pasadena	United States
		Orange	United States
		Los Angeles	United States
		Long Beach	United States
		Huntington Beach	United States
		Glendale	United States
		Fullerton	United States
		El Monte	United States
		Downey	United States
		Costa Mesa	United States
		Anaheim	United States
		Garden Grove	United States
		Ontario	United States
		Inglewood	United States
		Burbank	United States
21	Miami MA	Miami	United States
		Fort Lauderdale	United States
		Hollywood	United States
		Miramar	United States
		Pompano Beach	United States
		West Palm Beach	United States
		Davie	United States
		Pembroke Pines	United States
22	Minneapolis - Saint Paul	Minneapolis	United States
		Saint Paul	United States
23	New York MA	New York City	United States
		Staten Island	United States
		Paterson	United States
		Bridgeport	United States
		Edison	United States
		New Haven	United States
		Stamford	United States
		Brooklyn	United States
		The Bronx	United States
		Queens	United States
		Newark	United States
		Jersey City	United States
		Yonkers	United States
24	Philadelphia MA	Philadelphia	United States
25	Phoenix MA	Phoenix	United States
		Mesa	United States
		Chandler	United States
		Gilbert	United States
		Glendale	United States
		Scottsdale	United States
		Tempe	United States
26	Pittsburgh	Pittsburgh	United States

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27	Portland	Portland	United States
		Vancouver	United States
		Hillsboro	United States
28	San Diego MA	Vista	United States
		San Diego	United States
		Escondido	United States
		El Cajon	United States
		Chula Vista	United States
		Carlsbad	United States
29	San Francisco - San Jose	Berkeley	United States
		Concord	United States
		Antioch	United States
		San Jose	United States
		Fremont	United States
		Richmond	United States
		Santa Rosa	United States
		Oakland	United States
		Hayward	United States
		San Mateo	United States
		Vallejo	United States
		Santa Clara	United States
		San Francisco	United States
		Sunnyvale	United States
30	Seattle - Tacoma - Bellevue	Tacoma	United States
		Seattle	United States
		Renton	United States
		Kent	United States
		Everett	United States
		Bellevue	United States
31	St. Louis	St. Louis	United States
32	Vienna	Vienna	Austria
33	Brussels	Brussels	Belgium
34	Prague	Prague	Czech Republic
35	Copenhagen	Copenhagen	Denmark
36	Helsinki	Helsinki	Finland
		Espoo	Finland
		Vantaa	Finland
37	Lyon - Grenoble	Lyon	France
		Grenoble	France
		Villeurbanne	France
38	Paris MA	Paris	France
		Cergy-Pontoise	France
		Boulogne-Billancourt	France
		Saint-Quentin-en-Yvelines	France
39	Berlin MA	Berlin	Germany
		Potsdam	Germany
40	Cologne	Cologne	Germany
41	Dusseldorf	Dusseldorf	Germany
42	Frankfurt	Frankfurt	Germany
		Offenbach	Germany
43	Hamburg	Hamburg	Germany
44	Heidelberg	Heidelberg	Germany
45	Munich	Munich	Germany
46	Stuttgart	Stuttgart	Germany
47	Budapest	Budapest	Hungary
48	Dublin	Dublin	Ireland
49	Milan	Milan	Italy
		Monza	Italy
50	Rome	Rome	Italy

51	Amsterdam MA	Amsterdam	The Netherlands
		Hoofddorp	The Netherlands
		Haarlem	The Netherlands
		Almere Stad	The Netherlands
52	Eindhoven	Eindhoven	The Netherlands
53	Rotterdam	Rotterdam	The Netherlands
54	Oslo	Oslo	Norway
55	Warsaw	Warsaw	Poland
56	Lisbon	Lisbon	Portugal
		Amadora	Portugal
57	Moscow	Moscow	Russia
		Balashikha	Russia
		Korolev	Russia
58	Barcelona MA	Barcelona	Spain
		Badalona	Spain
59	Madrid	Madrid	Spain
		Mostoles	Spain
		Alcala de Henares	Spain
		Fuenlabrada	Spain
		Leganes	Spain
		Getafe	Spain
		Alcobendas	Spain
60	Göteborg	Gothenburg	Sweden
61	Stockholm	Stockholm	Sweden
		Sollentuna	Sweden
62	Basel	Basel	Sweden
63	Geneva	Geneva	Switzerland
64	Lausanne	Lausanne	Switzerland
65	Zurich	Zurich	Switzerland
66	Cambridge	Cambridge	United Kingdom
67	London MA	London	United Kingdom
		Watford	United Kingdom
		Croydon	United Kingdom
		Enfield Town	United Kingdom
		Sutton	United Kingdom
68	Manchester	Manchester	United Kingdom
		Bolton	United Kingdom
		Stockport	United Kingdom
		Oldham	United Kingdom
69	Oxford	Oxford	United Kingdom
70	Beijing	Beijing	China
71	Changchun	Changchun	China
72	Changsha	Changsha	China
73	Chengdu	Chengdu	China
74	Chongqing	Chongqing	China
75	Dalian	Dalian	China
76	Fuzhou	Fuzhou	China
77	Guangdong - Hong Kong - Macao Greater Bay Area	Shenzhen	China
		Guangzhou	China
		Hong Kong	China
		Macao	China
		Zhuhai	China
		Foshan	China
		Huizhou	China
		Dongguan	China
		Zhongshan	China
		Jiangmen	China
		Zhaoqing	China
78	Hangzhou	Hangzhou	China
79	Harbin	Harbin	China

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80	Hefei	Hefei	China
81	Jinan	Jinan	China
82	Kunming	Kunming	China
83	Lanzhou	Lanzhou	China
84	Nanchang	Nanchang	China
85	Nanjing	Nanjing	China
86	Qingdao	Qingdao	China
87	Shanghai	Shanghai	China
88	Shenyang	Shenyang	China
89	Suzhou	Suzhou	China
90	Taipei	Taipei	China
91	Tianjin	Tianjin	China
92	Wuhan	Wuhan	China
93	Xiamen	Xiamen	China
94	Xi'an	Xi'an	China
95	Zhengzhou	Zhengzhou	China
96	Bengaluru	Bengaluru	India
97	Central National Capital Region Delhi MA	Delhi	India
		Faridabad	India
		Ghaziabad	India
		New Delhi	India
		Noida	India
		Greater Noida	India
		Gurgaon	India
98	Chennai MA	Chennai	India
99	Mumbai MA	Mumbai	India
		Navi Mumbai	India
		Kalyān	India
		Ulhasnagar	India
		Panvel	India
100	Jakarta	Jakarta	Indonesia
101	Jerusalem	Jerusalem	Israel
102	Tel Aviv	Tel Aviv	Israel
		Bnei Brak	Israel
		Holon	Israel
		Ramat Gan	Israel
103	Kyoto - Osaka - Kobe	Kyoto	Japan
		Osaka	Japan
		Kobe	Japan
		Sakai	Japan
		Hirakata	Japan
		Toyonaka	Japan
		Takatsuki	Japan
		Suita	Japan
		Ibaraki	Japan
		Neyagawa	Japan
		Uji	Japan
		Izumi	Japan
		Moriguchi	Japan
		Matsubara	Japan

104	Nagoya MA	Nagoya	Japan
		Okazaki	Japan
		Inazawa	Japan
		Ichinomiya	Japan
		Anjo	Japan
		Kakamigahara	Japan
		Kasugai	Japan
		Komaki	Japan
		Gifu-shi	Japan
		Ogaki	Japan
		Seto	Japan
		Toyota	Japan
		Kariya	Japan
105	Tokyo MA	Tokyo	Japan
		Asaka	Japan
		Zama	Japan
		Kamakura	Japan
		Chigasaki	Japan
		Hino	Japan
		Atsugi	Japan
		Fujisawa	Japan
		Noda	Japan
		Yokosuka	Japan
		Ichihara	Japan
		Kashiwa	Japan
		Chiba	Japan
		Soka	Japan
		Saitama	Japan
		Koshigaya	Japan
		Abiko	Japan
		Ageoshimo	Japan
		Tokorozawa	Japan
		Kawasaki	Japan
		Matsudo	Japan
		Higashimurayama	Japan
		Musashino	Japan
		Sayama	Japan
		Yokohama	Japan
		Nagareyama	Japan
		Kawagoe	Japan
		Sakura	Japan
		Chofu	Japan
		Machida	Japan
		Kawaguchi	Japan
		Isehara	Japan
		Kisarazu	Japan
		Hiratsuka	Japan
		Hachioji	Japan
		Honcho	Japan
		Tama	Japan
106	Kuala Lumpur	Kuala Lumpur	Malaysia
		Klang	Malaysia
		Subang Jaya	Malaysia
		Petaling Jaya	Malaysia
		Shah Alam	Malaysia
		Sepang	Malaysia
107	Singapore	Singapore	Singapore
108	Busan	Busan	South Korea
109	Daejeon	Daejeon	South Korea

110	Seoul MA	Seoul	South Korea
		Osan	South Korea
		Seongnam-si	South Korea
		Guri-si	South Korea
		Goyang-si	South Korea
		Ansan-si	South Korea
		Suwon	South Korea
		Incheon	South Korea
		Hwaseong-si	South Korea
		Bucheon-si	South Korea
		Uijeongbu-si	South Korea
		Anyang-si	South Korea
		Hanam	South Korea
111	Bangkok	Bangkok	Thailand
112	Ankara	Ankara	Turkey
113	Istanbul	Istanbul	Turkey
		Turkey	South Korea
114	Abu Dhabi	Abu Dhabi	United Arab Emirates
115	Dubai	Dubai	United Arab Emirates
116	Riyadh	Riyadh	Saudi Arabia
117	Doha	Doha	State of Qatar
118	Brisbane	Brisbane	Australia
119	Melbourne	Melbourne	Australia
120	Perth	Perth	Australia
121	Sydney	Sydney	Australia
122	Buenos Aires	Buenos Aires	Argentina
123	Sao Paulo	Sao Paulo	Brazil
		Sao Bernardo do Campo	Brazil
		Santo Andre	Brazil
		Diadema	Brazil
		Barueri	Brazil
		Sao Caetano do Sul	Brazil
124	Cairo	Cairo	Egypt
		Giza	Egypt
125	Johannesburg	Johannesburg	South Africa
		Soweto	South Africa
		Randburg	South Africa

Note: The 125 cities/metropolitan areas listed above are the major administrative cities in the geographic range which do not exactly overlap with the actual range of metropolitan areas. The GIHI generally adopts the same boundaries of metropolitan areas as the Nature Index.

Appendix VI: Measurement of development models

In order to reveal the characteristics of development patterns in different regions, and to comprehensively compare and evaluate the three level-1 indicators of cities/metropolitan areas this report measures development patterns. First, the Z-score is used to standardize the raw data of the level-3 indicators and then the Z-score of the level-1 indicators is obtained via linear weighting (see Appendix III for details). Second, to make comparable the scores of the three level-1 indicators — research innovation, innovation economy and innovation ecosystem — the Z-scores of the three level-1 indicators of the 113 evaluated cities were uniformly min-max normalized so that the scores of the evaluated cities were mapped to the [0,1] range. Finally, the score range of the level-1 indicators is set to [0,100] to calculate the scores of level-1 indicators for each evaluated city by taking the development patterns into consideration.

Appendix VII: Patent classification and search strategy

1. Patent classification of AI technology

Field of technology	International patent classification	Description
Artificial intelligence	G06F40*, A61B5/0476, A61B5/0478	
	G05B15/02, G06K9/66, G07C9/00, G08B19/00, G08B25/10	Information system integration services, such as AI systems for production areas and smart home systems
	G05D1/02, G05D1/08, G05D1/10, G05D1/12, G06F1/16	Wearable smart device manufacturing; intelligent unmanned aerial vehicle manufacturing; digital home intelligent terminal equipment, intelligent sensing and control equipment and other smart consumer device manufacturing; financial electronic application products
	G06F3/01	Wearable smart device manufacturing; intelligent unmanned aerial vehicle manufacturing; digital home intelligent terminal equipment, intelligent sensing and control equipment and other smart consumer device manufacturing; financial electronic application products; information system integration services such as AI systems for production areas and smart home systems; AI for operation system, artificial intelligence middleware, artificial function library; development of application as computer vision and audition software, biometrics software
	G06F9/44, G06F9/455, G06N3/00, G06N3/04, G06N3/06, G06N3/063, G06N3/067, G06N3/10, G06N3/12, G06N5/00, G06N5/02, G06N5/04	AI for operating system, AI middleware, AI function library, development of application as computer vision and audition software, biometrics software
	G06K9/00, G06K9/62, G06N3/02, G06N3/08	Information system integration services, such as AI systems for production areas and smart home systems, AI for operation system, AI middleware, AI function library, development of applications such as computer vision and audition software, biometrics software
	A61B5*(excluding A61B5/0476, A61B5/0478), G16H	Keywords of brain structures and brain diseases, such as the human brain, amygdala and epilepsy

Source: China National Intellectual Property Administration, Classification of Strategic Emerging Industries and International Patent Classification Cross-Reference Table (2021)

Derwent Innovation search strategy

(IC=(G06F40 or A61B5/0476 or A61B5/0478 or G05B15/02 or G06K9/66 or G07C9/00 or G08B19/00 or G08B25/10 or G05D1/02 or G05D1/08 or G05D1/10 or G05D1/12 or G06F1/16 or G06F3/01 or G06F9/44 or G06F9/455 or G06N3/00 or G06N3/04 or G06N3/06 or G06N3/063 or G06N3/067 or G06N3/10 or G06N3/12 or G06N5/00 or G06N5/02 or G06N5/04 or G06K9/00 or G06K9/62 or G06N3/02 or G06N3/08 or A61B5 not (A61B5/0476 or A61B5/0478) or G16H)) and PY<=(2024)

Appendix

2. Patent classification of smart chip technology

Field of technology		International patent classification	Description
Smart chip		G06F3*, G06F8*, G06F9*, G06F11*, G06F12*, G06F13*, G06F15*, G06F16*, G06F17*, G06F21*, G06F30*, G06F40*, G06K7*, G06K9*, G06K17*, G06K19*, G06N*, G06T1*, G06T3*, G06T5*, G06T7*, G06T11*, G06T15*, G06V*, G16B*, G16C*, G16H*, H01L21*, H01L23*, H01L25*, H01L27*, H05K1*, H05K3*	Graphic processing units (GPUs), field programmable gate arrays (FPGAs), application-specific integrated circuits (ASIC), security operations centres (SOCs), complex programmable logic devices (CPLDs), smart integrated circuits, smart chips, AI chips, smart single-chip computers, GPUs, FPGAs, ASICs, SOC chips, neuro-inspired computing chips, etc.
	GPU	G06F9*, G06N3* , G06T1* , G06T3* , G06T5*, G06T7*, G06T11*, G06T15*	GPU, image processor, visual processor, display card chip, display chip, etc.
	FPGA	G05B19*, G06F7*, G06F9*, G06F11*, G06F40*, G06F13*, G06F15*, G06F17*, G06F30*, H03K19*	FPGAs, Field-programmable logic device, field-programmable logic gate array, etc.
	ASIC	G06F*, H01L21*, H01L23*, H01L25*, H01L27*, H03K*, H05K1*, H05K3*	ASIC, application-specific integrated circuit, application-specific large-scale integrated circuit, application-specific integrated chip, application-specific chip, etc.
	Brain-inspired chips	G06N3*, G06F9*, G06F15*, G11C13*	Brain-inspired chips, brain-inspired computers, neural chips, neuromorphic computing, resistive RAM, etc.
	NPU	G06N3*, G06F9*, G06F15*	NPU, neural processing unit, etc.

Source: China National Intellectual Property Administration, Key Digital Technology Patent Classification System (2023)

Derwent Innovation search strategy

(IC=(G06F3 or G06F8 or G06F9 or G06F11 or G06F12 or G06F13 or G06F15 or G06F16 or G06F17 or G06F21 or G06F30 or G06F40 or G06K7 or G06K9 or G06K17 or G06K19 or G06N or G06T1 or G06T3 or G06T5 or G06T7 or G06T11 or G06T15 or G06V or G16B or G16C or G16H or H01L21 or H01L23 or H01L25 or H01L27 or H05K1 or H05K3 or G06F9 or G06N3 or G06T1 or G06T3 or G06T5 or G06T7 or G06T11 or G06T15 or G05B19 or G06F7 or G06F9 or G06F11 or G06F40 or G06F13 or G06F15 or G06F17 or G06F30 or H03K19 or G06F or H01L21 or H01L23 or H01L25 or H01L27 or H03K or H05K1 or H05K3 or G06N3 or G06F9 or G06F15 or G11C13 or G06N3 or G06F9 or G06F15) And CTB=(chip or chips or "integrated circuit" or "Smart Microcontroller Unit" or "Smart integrated circuit" or "Graphics Processing Unit" or gpu or "Field Programmable Gate Array" or fpga or "Application Specific Integrated Circuit" or asic or "Complex Programmable Logic Device" or CPLD or "Image Processing Unit" or ipu or "Visual Processing Unit" or vpu or "Field Programmable Logic Device" or FPLD or "Field Programmable Gate Array" or FPGA or "Field Programmable Logic Gate Array" or ASLSIC or Brain adj inspired adj computer* or Neuromorphic or Memristor or "Neural Processing Unit" or NPU or Neural adj network adj processor*)) and PY<=(2024)

3. Patent classification of renewable energy

Field of technology	International patent classification	Description
Nuclear power industry	G21C5*, G21C17/013, G21C17/017, G21C19*, G21C21*, G21C23*, G21D3	
	E04G21*, E04H5*	Nuclear power transmission equipment engineering; nuclear power plant construction.
	G21C1*, G21C9*, G21C11*, G21C13*, G21C15*, G21C17*(excluding G21C17/013, G21C17/017), G21D1*, G21D5*	Complete sets of equipment for advanced pressurized water reactor nuclear power plants with million-kilowatt capacity, fast neutron reactor and high temperature gas-cooled reactor nuclear power plants etc., nuclear power boilers and auxiliary equipment, emergency protection arrangements structurally associated with the reactor
	G21C3*, G21C7*, G21G1*	Processing of nuclear fuel, manufacturing of special equipment for uranium purification and conversion, uranium enrichment, etc.
Wind energy industry	F03D1*, F03D3*, F03D5*, F03D7*, F03D17*	
	E02D27*, F03D13*	Offshore wind turbine construction; offshore wind power equipment installation, wind farm construction.
	F03D9*, F03D15*, F03D80*	Manufacturing of wind energy prime movers; manufacturing of generators and generator sets, such as onshore and offshore wind turbines
	H02J3/38, H02J3/44, H02J3/46, H02J3/48, H02J3/50	Wind Power
Solar energy industry	F03G6*(Excluding F03G6/00, F03G6/04, F03G6/06), F24S10*, F24S25*(Excluding F24S25/00, F24S25/20, F24S25/30, F24S25/617, F24S25/70), F24S30*, F24S40*, F24S50*, F24S60*, F24S80*, F24S90*, H02J7/35, H02S10*, H02S20*, H02S30*, H02S40*(Excluding H02S40/10, H02S40/12), H02S50*	
	C01B33/02	Silicon (forming single crystals or homogeneous polycrystalline material with defined structure)
	H01G9/042, H01G9/045, H01G9/052, H01G9/055, H01G9/06, H01G9/08, H01G9/10, H01G9/12, H01G9/20, H01L27/14, H01L51/42, H01L51/44, H01L51/46, H01L51/48	Perovskite, silane, high light use, heat-absorbing coating material, photovoltaic conductive glass, glass tubing for sealing with metal, graphite material for solar energy, getter, photovoltaic cell encapsulation material, cadmium telluride, special silver paste, photovoltaic cell material
	H01G9/04	Solar cell production equipment; Stirling generators; organic Rankine cycle power generation equipment; manufacturing of light and heat equipment and its components; manufacturing of solar power generation protection and control devices and equipment; manufacturing of photovoltaic equipment and components; solar batteries; solar battery charge and discharge controllers, solar energy storage materials and products, organic polymer electrodes

Appendix

Field of technology	International patent classification	Description
Solar energy industry	H01L31*	Solar energy prime movers, sliding parameter steam turbines, coating equipment for solar heat absorbing coatings, large-scale coating machines etc., manufacturing of pumps and vacuum equipment, highstrength curved mirrors, concentrators, concentrator field control devices, reducers for concentrators, controllers
	H02M7*	Sterling generators, organic Rankine cycle power generation equipment, multi-megawatt or tens megawatt-scale concentrated solar power systems and equipment, manufacturing of solar thermal equipment and components, manufacturing of protective control devices and equipment for solar power generation, battery charge and discharge controllers for solar energy
Biomass energy and other new energy industries	C10L5/44, F03B13/12, F03B13/14, F03B13/16, F03B13/18, F03B13/20, F03B13/22, F03B13/24, F03B13/26	
	A01F29*, F03B13/00, F03G4*, F23C10*, H02N11*	Equipment manufacturing for furnaces, such as biomass combustion boilers, geothermal water treatment equipment, generators and generator sets for new energy sources such as geothermal or hydrogen energy equipment
	C10B53*	Equipment for the degradation and conversion of biomass, heating with biomass fuels, manufacturing and supply of bio-gas
	C10J3*	Equipment for producing hydrogen from biomass and microorganisms, biomass electricity generation, heating with biomass fuels, manufacturing and supply of bio-gas
	E02B3*, E02B9*(excluding E02B9/08)	Engineering of power transmission equipment for biomass and other new energy power generation, construction of biomass energy generation projects, other new energy construction projects, geothermal power generation and heat use projects, and hydrogen energy projects
	E02B9/08	Tide or wave power plants (water-pressure machines, tide or wave motors)
	F23G5*	Equipment manufacturing for furnaces such as biomass combustion boilers, heating with biomass fuels
	G01R31*(Excluding G01R31/00, G01R31/08, G01R31/10, G01R31/11, G01R31/12, G01R31/14, G01R31/327, G01R31/333, G01R31/34, G01R31/36, G01R31/364, G01R31/367, G01R31/371, G01R31/374, G01R31/378, G01R31/379, G01R31/382, G01R31/3828, G01R31/3832, G01R31/3835, G01R31/3842, G01R31/385, G01R31/387, G01R31/388, G01R31/389, G01R31/392, G01R31/396, G01R31/40, G01R31/42, G01R31/50, G01R31/52, G01R31/54, G01R31/55, G01R31/56, G01R31/58, G01R31/62)	Maintenance of biomass power generation equipment, consulting services for biomass energy and other new energy sources, power generation project management, power generation project supervision, construction engineering surveys, technical promotion services, research and experimental development on engineering and technology, such as biomass energy and other new energy sources, engineering design activities such as the design of biomass power generation construction projects

Field of technology	International patent classification	Description
Smart grid industry	G01R19*, G01R21*(Excluding G01R21/127), G01R22*, G01R23*(Excluding G01R23/173, G01R23/175, G01R23/177), G01R25*, G01R27*(Excluding G01R27/12), G01R29*, G01R31/00, G01R31/08, G01R31/10, G01R31/11, G01R31/12, G01R31/14, G01R31/327, G01R31/333, G01R31/36, G01R31/364, G01R31/367, G01R31/371, G01R31/374, G01R31/378, G01R31/379, G01R31/382, G01R31/3828, G01R31/3832, G01R31/3835, G01R31/3842, G01R31/385, G01R31/387, G01R31/388, G01R31/389, G01R31/392, G01R31/396, G01R31/40, G01R31/42, G01R31/50, G01R31/52, G01R31/54, G01R31/55, G01R31/56, G01R31/58, G01R31/62, G01R33/00, H01B3*(Excluding H01B3/02, H01B3/30), H01B5*(Excluding H01B5/04), H01B7*(Excluding H01B7/20, H01B7/24, H01B7/282, H01B7/32), H01B9*, H01B13*(Excluding H01B13/016, H01B13/28), H01B17*(Excluding H01B17/04, H01B17/12, H01B17/16, H01B17/18, H01B17/32, H01B17/46, H01B17/48, H01B17/54), H01B19*, H01F17*, H01F19*, H01F21*, H01F27*(Excluding H01F27/18), H01F29*(Excluding H01F29/08, H01F29/14), H01F30*, H01F36*, H01F37*, H01F38/20, H01F38/22, H01F38/24, H01F38/26, H01F38/28, H01F38/30, H01F38/32, H01F38/34, H01F38/36, H01F38/38, H01F38/40, H01F41/00, H01F41/02, H01F41/04, H01F41/06, H01F41/061, H01F41/063, H01F41/064, H01F41/066, H01F41/068, H01F41/069, H01F41/07, H01F41/071, H01F41/073, H01F41/074, H01F41/076, H01F41/077, H01F41/079, H01F41/08, H01F41/082, H01F41/084, H01F41/086, H01F41/088, H01F41/092, H01F41/096, H01F41/098, H01F41/10, H01F41/12	Manufacturing of transformers, rectifiers and inductors such as intelligent large-scale, DC converter transformers and intelligent reactors, manufacturing of intelligent power distribution systems, facilities and other power distribution switch control equipment, cross-linked polyethylene insulated power cables and cable accessories
	H01H31*, H01H33*, H01H45*, H01H47*, H01H50*, H01H51*, H01H57*, H01H59*, H01H61*, H01H69*, H01H71*(Excluding H01H71/58), H01H73*, H01H75*, H01H77*, H01H79*, H01H81*, H01H83*, H01H85*(Excluding H01H85/42), H01H87*, H01H89*, H02B1*(Excluding H02B1/06), H02G1*, H02G7*(Excluding H02G7/06), H02G9*(Excluding H02G9/00), H02G13*, H02G15*(Excluding H02G15/072), H02H1*, H02H3*(Excluding H02H3/13), H02H5*, H02H6*, H02H7*, H02H9*, H02H11*, H02P1*, H02P3*(Excluding H02P3/16), H02P5/00, H02P5/46, H02P5/49, H02P5/50, H02P5/505, H02P5/51, H02P5/52, H02P5/54, H02P5/56, H02P5/74, H02P5/747, H02P5/753, H02P6*, H02P13*(Excluding H02P13/12), H02P21*, H02P23*, H02P25*(Excluding H02P25/064, H02P25/12), H02P27*(Excluding H02P27/06), H02P29*	Manufacture of power electronic components, such as metal oxide semiconductor field effect transistors, insulated-gate bipolar transistor chips and modules
	H02B3*, H02B5*, H02B7*, H02B11*, H02B13*, H02B15*(Excluding H02B15/04), H02J1*, H02J3*(Excluding H02J3/38, H02J3/40, H02J3/42, H02J3/44, H02J3/46, H02J3/48, H02J3/50), H02J4*, H02J5*, H02J9*, H02J11*, H02J13*, H02J15*, H02J50*, H02M3*, H02M5*(Excluding H02M5/297), H02M11*	Power supply: 750 kV or higher-class AC transmission, large-scale power grid protection and defence systems, and intelligent dispatching systems

Source: China National Intellectual Property Administration, Classification of Strategic Emerging Industries and International Patent Classification Cross-Reference Table (2021)

Appendix

Derwent Innovation search strategy

(IC=(F03D1 or F03D3 or F03D5 or F03D7 or F03D17 or E02D27 or F03D13 or F03D9 or F03D15 or F03D80 or H02J3/38 or H02J3/44 or H02J3/46 or H02J3/48 or H02J3/50 or F03G6 not (F03G6/00 or F03G6/04 or F03G6/06) or F24S10 or F24S25 not (F24S25/00 or F24S25/20 or F24S25/30 or F24S25/617 or F24S25/70) or F24S30 or F24S40 or F24S50 or F24S60 or F24S80 or F24S90 or H02J7/35 or H02S10 or H02S20 or H02S30 or H02S40 not (H02S40/10 or H02S40/12) or H02S50 or C01B33/02 or H01G9/042 or H01G9/045 or H01G9/052 or H01G9/055 or H01G9/06 or H01G9/08 or H01G9/10 or H01G9/12 or H01G9/20 or H01L27/14 or H01L51/42 or H01L51/44 or H01L51/46 or H01L51/48 or H01G9/04 or H01L31 or H02M7 or C10L5/44 or F03B13/12 or F03B13/14 or F03B13/16 or F03B13/18 or F03B13/20 or F03B13/22 or F03B13/24 or F03B13/26 or A01F29 or F03B13/00 or F03G4 or F23C10 or H02N11 or C10B53 or C10J3 or E02B3 or E02B9 not (E02B9/08) or E02B9/08 or F23G5 or G01R31 not (G01R31/00 or G01R31/08 or G01R31/10 or G01R31/11 or G01R31/12 or G01R31/14 or G01R31/327 or G01R31/333 or G01R31/34 or G01R31/36 or G01R31/364 or G01R31/367 or G01R31/371 or G01R31/374 or G01R31/378 or G01R31/379 or G01R31/382 or G01R31/3828 or G01R31/3832 or G01R31/3835 or G01R31/3842 or G01R31/385 or G01R31/387 or G01R31/388 or G01R31/389 or G01R31/392 or G01R31/396 or G01R31/40 or G01R31/42 or G01R31/50 or G01R31/52 or G01R31/54 or G01R31/55 or G01R31/56 or G01R31/58 or G01R31/62)) or IC=(G21C5 or G21C17/013 or G21C17/017 or G21C19 or G21C21 or G21C23 or G21D3 or E04G21 or E04H5 or G21C1 or G21C9 or G21C11 or G21C13 or G21C15 or G21C17 not (G21C17/013 or G21C17/017) or G21D1 or G21D5 or G21C3 or G21C7 or G21G1) or IC=(G01R19 or G01R21 not (G01R21/127) or G01R22 or G01R23 not (G01R23/173 or G01R23/175 or G01R23/177) or G01R25 or G01R27 not (G01R27/12) or G01R29 or G01R31/00 or G01R31/08 or G01R31/10 or G01R31/11 or G01R31/12 or G01R31/14 or G01R31/327 or G01R31/333 or G01R31/36 or G01R31/364 or G01R31/367 or G01R31/371 or G01R31/374 or G01R31/378 or G01R31/379 or G01R31/382 or G01R31/3828 or G01R31/3832 or G01R31/3835 or G01R31/3842 or G01R31/385 or G01R31/387 or G01R31/388 or G01R31/389 or G01R31/392 or G01R31/396 or G01R31/40 or G01R31/42 or G01R31/50 or G01R31/52 or G01R31/54 or G01R31/55 or G01R31/56 or G01R31/58 or G01R31/62 or G01R33/00 or H01B3 not (H01B3/02 or H01B3/30) or H01B5 not (H01B5/04) or H01B7 not (H01B7/20 or H01B7/24 or H01B7/282 or H01B7/32) or H01B9 or H01B13 not (H01B13/016 or H01B13/28) or H01B17 not (H01B17/04 or H01B17/12 or H01B17/16 or H01B17/18 or H01B17/32 or H01B17/46 or H01B17/48 or H01B17/54) or H01B19 or H01F17 or H01F19 or H01F21 or H01F27 not (H01F27/18) or H01F29 not (H01F29/08 or H01F29/14) or H01F30 or H01F36 or H01F37 or H01F38/20 or H01F38/22 or H01F38/24 or H01F38/26 or H01F38/28 or H01F38/30 or H01F38/32 or H01F38/34 or H01F38/36 or H01F38/38 or H01F38/40 or H01F41/00 or H01F41/02 or H01F41/04 or H01F41/06 or H01F41/061 or H01F41/063 or H01F41/064 or H01F41/066 or H01F41/068 or H01F41/069 or H01F41/07 or H01F41/071 or H01F41/073 or H01F41/074 or H01F41/076 or H01F41/077 or H01F41/079 or H01F41/08 or H01F41/082 or H01F41/084 or H01F41/086 or H01F41/088 or H01F41/092 or H01F41/096 or H01F41/098 or H01F41/10 or H01F41/12 or H01H31 or H01H33 or H01H45 or H01H47 or H01H50 or H01H51 or H01H57 or H01H59 or H01H61 or H01H69 or H01H71 not (H01H71/58) or H01H73 or H01H75 or H01H77 or H01H79 or H01H81 or H01H83 or H01H85 not (H01H85/42) or H01H87 or H01H89 or H02B1 not (H02B1/06) or H02G1 or H02G7 not (H02G7/06) or H02G9 not (H02G9/00) or H02G13 or H02G15 not (H02G15/072) or H02H1 or H02H3 not (H02H3/13) or H02H5 or H02H6 or H02H7 or H02H9 or H02H11 or H02P1 or H02P3 not (H02P3/16) or H02P5/00 or H02P5/46 or H02P5/49 or H02P5/50 or H02P5/505 or H02P5/51 or H02P5/52 or H02P5/54 or H02P5/56 or H02P5/74 or H02P5/747 or H02P5/753 or H02P6 or H02P13 not (H02P13/12) or H02P21 or H02P23 or H02P25 not (H02P25/064 or H02P25/12) or H02P27 not (H02P27/06) or H02P29 or H02B3 or H02B5 or H02B7 or H02B11 or H02B13 or H02B15 not (H02B15/04) or H02J1 or H02J3 not (H02J3/38 or H02J3/40 or H02J3/42 or H02J3/44 or H02J3/46 or H02J3/48 or H02J3/50) or H02J4 or H02J5 or H02J9 or H02J11 or H02J13 or H02J15 or H02J50 or H02M3 or H02M5 not (H02M5/297) or H02M11)) and py<=(2024)

4. Patent classification of biomedicine technology

Field of technology	International patent classification	Description
Biomedicine industry	A61K31*, A61K38*, A61K39*, A61K47*, A61K48*	Biological drug manufacturing, genetic engineering drug and vaccine manufacturing, pharmaceutical excipient and packaging material manufacturing, pharmaceutical special equipment manufacturing, medical device research, largescale cultivation of vaccine antigens, basic research on vaccine antigen purification technology and other medical research and experimental development, laboratory equipment and reagent testing and monitoring services, biological laboratory and pharmaceutical production workshop design services, biological resource collection, preservation and utilization services for animals, technology promotion such as drug information, biological treatment services for severe and incurable diseases, genetic testing services
	A61K33*, C07J*	Manufacture of chemical raw materials and preparations
	A61K9*, C07K*	Biological drug manufacturing, genetic engineering drug and vaccine manufacturing
	A61P*, C07C*(excluding C07C1*, C07C2/00, C07C2/30, C07C4/02, C07C4/12, C07C4/22, C07C5/333, C07C6/04, C07C7/13, C07C7/177, C07C9/10, C07C9/21, C07C9/22, C07C11*, C07C13/12, C07C13/20, C07C13/50, C07C13/68, C07C15*, C07C21/14, C07C27*, C07C29*, C07C31*, C07C35/28, C07C35/36, C07C37/18, C07C37/84, C07C39/23, C07C41/28, C07C41/40, C07C41/44, C07C43*, C07C45/49, C07C47/02, C07C49/00, C07C49/205, C07C49/258, C07C49/573, C07C49/713, C07C51*, C07C55/12, C07C59/00, C07C59/11, C07C61/13, C07C63/24, C07C63/38, C07C67*, C07C69*, C07C71/00, C07C203/00, C07C205/05, C07C209/22, C07C209/44, C07C211*, C07C215*, C07C217/14, C07C217/30, C07C217/76, C07C219/08, C07C219/10, C07C229/68, C07C231*, C07C233*, C07C235*, C07C237/32, C07C245/14, C07C251/20, C07C251/22, C07C253*, C07C255/20, C07C255/55, C07C269/02, C07C271/02, C07C271/68, C07C275/06, C07C275/10, C07C309*, C07C311/06, C07C311/49, C07C313/28, C07C319*, C07C323/41, C07C333/20, C07C403/16, C07C409/08, C07C409/12), C07D*(excluding C07D201*, C07D207/335, C07D209/76, C07D211*, C07D213*, C07D215*, C07D223*, C07D235*, C07D239*, C07D243/04, C07D249*, C07D251/38, C07D255/04, C07D277/84, C07D279/32, C07D293/12, C07D295/037, C07D295/10, C07D301*, C07D307*, C07D311/26, C07D311/68, C07D313*, C07D317*, C07D319*, C07D329*, C07D333/10, C07D333/78, C07D341/00, C07D401/00, C07D405*, C07D413/02, C07D421/14, C07D487*, C07D495/08)	Biological drug manufacturing, genetic engineering drug and vaccine manufacturing, manufacture of chemical raw materials and preparations, pharmaceutical excipient and packaging material manufacturing, pharmaceutical special equipment manufacturing, medical device research, largescale cultivation of vaccine antigens, basic research on vaccine antigen purification technology, and other medical research and experimental development, laboratory equipment and reagent testing and monitoring services, biological laboratory and pharmaceutical production workshop design services, biological resource collection, preservation and utilization services for animals, technology promotion, such as drug information, biological treatment services for severe and incurable diseases, genetic testing services
	C12Q1/68, C12Q1/70	Genetic testing services

Source: China National Intellectual Property Administration, Classification of Strategic Emerging Industries and International Patent Classification Cross-Reference Table (2021)

Appendix

Derwent Innovation search strategy

(IC=(A61K31 or A61K38 or A61K39 or A61K47 or A61K48 or A61K33 or C07J or A61K9 or C07K or A61P or C07C not (C07C1 or C07C2/00 or C07C2/30 or C07C4/02 or C07C4/12 or C07C4/22 or C07C5/333 or C07C6/04 or C07C7/13 or C07C7/177 or C07C9/10 or C07C9/21 or C07C9/22 or C07C11 or C07C13/12 or C07C13/20 or C07C13/50 or C07C13/68 or C07C15 or C07C21/14 or C07C27 or C07C29 or C07C31 or C07C35/28 or C07C35/36 or C07C37/18 or C07C37/84 or C07C39/23 or C07C41/28 or C07C41/40 or C07C41/44 or C07C43 or C07C45/49 or C07C47/02 or C07C49/00 or C07C49/205 or C07C49/258 or C07C49/573 or C07C49/713 or C07C51 or C07C55/12 or C07C59/00 or C07C59/11 or C07C61/13 or C07C63/24 or C07C63/38 or C07C67 or C07C69 or C07C71/00 or C07C203/00 or C07C205/05 or C07C209/22 or C07C209/44 or C07C211 or C07C215 or C07C217/14 or C07C217/30 or C07C217/76 or C07C219/08 or C07C219/10 or C07C229/68 or C07C231 or C07C233 or C07C235 or C07C237/32 or C07C245/14 or C07C251/20 or C07C251/22 or C07C253 or C07C255/20 or C07C255/55 or C07C269/02 or C07C271/02 or C07C271/68 or C07C275/06 or C07C275/10 or C07C309 or C07C311/06 or C07C311/49 or C07C313/28 or C07C319 or C07C323/41 or C07C333/20 or C07C403/16 or C07C409/08 or C07C409/12) or C07D not (C07D201 or C07D207/335 or C07D209/76 or C07D211 or C07D213 or C07D215 or C07D223 or C07D235 or C07D239 or C07D243/04 or C07D249 or C07D251/38 or C07D255/04 or C07D277/84 or C07D279/32 or C07D293/12 or C07D295/037 or C07D295/10 or C07D301 or C07D307 or C07D311/26 or C07D311/68 or C07D313 or C07D317 or C07D319 or C07D329 or C07D333/10 or C07D333/78 or C07D341/00 or C07D401/00 or C07D405 or C07D413/02 or C07D421/14 or C07D487 or C07D495/08) or C12Q1/68 or C12Q1/70)) and PY<=(2024)

5. Patent of quantum information technology

Field of technology		International patent classification	Description
Quantum measurement	Measurement of gravity, rotation, and acceleration	G01C21/10, G01P15*, G01V7*, G01C19*, G01B9/02, G01J9/02, G01C21/16, G01C21/18, G01C21/24, G01C21/26, G01S17*, G01S7*, G01P7/00, G01S1/70, G01S3/78, G01S5/16, G01S11/12, G01S19*	Measurement of quantum gravity, quantum rotation, quantum acceleration, quantum gravity, and quantum deceleration; cold atom interferometry; quantum gyroscopes, quantum rotation sensors; quantum accelerometers, quantum decelerometers; quantum gravimeters, gravity gradiometers, quantum gravimeters, etc.; quantum navigation, quantum positioning, quantum sensing, quantum trajectory, quantum satellites, quantum accelerometers, quantum gyroscopes, cesium clock, rubidium clocks, quantum steering
	Time and frequency primary standard	G04F5*, H04J3/06, H04N5/04, H04N21/242, G04F5/14, H03L7/26	Time-frequency, quantum entanglement, time synchronization, etc.; cold-atom clock
	Measurement of magnetic fields	A61B5/05, G01R33*, G01V3*, A61B5/0515, A61B5/0522, A61B5/055, G01B9/02, G01R35*, G01R19*, G01K7/36, G05F1/56, G05F1/563, G05F1/565, G05F1/567, G05F1/569, G05F1/571, G05F1/573, G05F1/575, G05F1/577, G05F1/585, G05F1/59, G05F1/595, H01L39*, H03L7/26, A61B5*, G01Q60*, G01R33*, G01N24*,	Quantum magnetic field measurement, quantum geomagnetic measurement, quantum biomagnetic measurement; quantum magnetic field intensimeter, quantum magnetometer, quantum geomagnetic intensimeter, quantum biomagnetic intensimeter; superconducting quantum interference, Josephson junction; diamond NV centre, magnetic field measurement, geomagnetic measurement, magnetic resonance, biomagnetic measurement
	Chemical testing	G01N21*, G01N24*, G01N27*, G01N23*	Quantum dot fluorescence, quantum dot luminescence; trace detection, micro-quantity detection, microelement analysis
	Target recognition	A61B1*, A61B5/055, G01J1/44, G01J3*, G01J5*, G01N15*, G01N21*, G01Q60*, G01R33*, G01S13*, G01S17/89, G01T*, G02B21*, G02B27*, G02F1/39, G06T*, H01L21*, H01L27*, H01L31*, H01L51*, H04N13/275, H04N5*, H04N9*, G01C3/08, G01S7*, G01S15/88, G01S17*, G06N99*	Quantum imaging, quantum graphics, quantum photon imaging, ghost imaging, correlated imaging, quantum microscopy; quantum lidar, quantum ranging, interferometric quantum radar, quantum-enhanced radar, quantum illumination radar, etc.

Field of technology		International patent classification	Description
Quantum computing	Quantum computing processor	B82Y10*, G06N10*, G06N99*, H01L21*, H01L27*, H01L29*, H01L39*, G01V*, G02B*, G02F*, G06F*, G06F15/78, G06N99/00, H01L25*, H04B*, H04L*	Quantum chips, qubits, superconducting qubits, Josephson effect, quantum anharmonic oscillators, distributed quantum processors, multidimensional integrated quantum chips, etc.; superconducting qubits, superconducting quantum computing, superconducting qubit gates, etc.; ion trap quantum computing, ion trap systems, quantum integrated circuits, ion trap qubits, etc.; Silicon semiconductors, silicon isotopes, quantum processing units, silicon-based spin qubits, etc.; photonic quantum chips, photonic qubits, photonic quantum computing, etc.; quantum topology, quantum annealing, nuclear magnetic resonance quantum computing, cold atom quantum computing, diamond NV centre for quantum computing, neutral atom quantum computing, spin-wave quantum computing
	Quantum software and algorithms	G06F17*, G06F30/20, G06F30/27, G06F30/28, G06K9*, G06N3*, G06N5*, G06N7*, G06N10*, G06N99*, G06Q*, G06T1*, G06T7*, B82Y10*, G06F8/20, G06F8/30, G06F8/34, G06F8/40, G06F8/41, G05B19*, G06F9*, G06N20*	Quantum algorithms, Shor's algorithm, Grover's algorithm, factorisation, quantum software, quantum coding; quantum software development, quantum programming, quantum compilation, quantum integrated development environments, etc.; quantum measurement, quantum control, quantum debugging, quantum logic gates, etc.; quantum approximate optimisation algorithms, variational quantum Eigensolver, hybrid quantum-classical algorithms, expectation value of a Hamiltonian, quantum graph decomposition algorithms, etc.; quantum machine learning, quantum neural networks, quantum inference models, quantum probabilistic graphical models; quantum-inspired algorithms, quantum ant colony optimization algorithm, quantum genetic algorithms, quantum simulated annealing algorithms; quantum error correction, quantum fidelity, CRSS coding, quantum error correction
	Quantum simulation	G06F16*, G06F17*, G06F30/20, G06F30/27, G06F30/28, G06K*, G06N10*, G06N3*, G06N99*, G06Q*, G06Q20*, G06Q30*, G06Q40*, G08G*, G16B*, G16B35*, G16C*, G16H50*	Quantum analogy, quantum computing simulation, quantum simulators, quantum circuit design, etc.
Quantum communications	Quantum key distribution (QKD)	G06F21/60, G06F21/70, H04H60/23, H04K1*, H04L9*, H04W12*, G06N10*, H04B10*	Quantum key distribution, optical quantum key distribution, quantum state properties, etc.; quantum key distribution deployment, quantum key distribution protocols, optical quantum key distribution management, etc.
	Quantum teleportation (QT)	H04K1*, G06N10*, G11C13/02, G11C13/04, H01L21*, H01L27*, H01L29*, H01L45*, H04B10*, H04B10/70, H04L9*, H01L39*, B82Y10/00	Quantum teleportation, quantum state transformation, entangled particles, Bell state discrimination, quantum state transfer; quantum entanglement, etc.; quantum storage, cold atoms, hot atoms, quantum repeater, atomic vapour, etc.

Appendix

Field of technology		International patent classification	Description
Quantum communications	Post-quantum cryptography (PQC) algorithm	H04K1*, H04L9*, G06F21/60, G06F21/70	Post-quantum cryptography
	Quantum random number generator (QRNG)	G06F7/58, H04H60/23, H04K1*, H04L9*, H04W12*, G06F21/60, G06F21/70, G06N10*, H04B10*, B82Y10/00	Quantum random number generation
	Quantum state detection	G06N10*, G06N99*, H04B10/70, H04K1*, H04L9/08, H04L9/40	Quantum state detection, entanglement detection

Resource: Classification System for Key Digital Technologies (2023) by the General Office of the China National Intellectual Property Administration.

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((IC=(G01C21/10 or G01P15 or G01V7 or G01C19 or G01B9/02 or G01J9/02 or G01C21/16 or G01C21/18 or G01C21/24 or G01C21/26 or G01S17 or G01S7 or G01P7/00 or G01S1/70 or G01S3/78 or G01S5/16 or G01S11/12 or G01S19 or G04F5 or H04J3/06 or H03L7/26 or H04N5/04 or H04N21/242 or G04F5/14 or A61B5/05 or G01R33 or G01V3 or A61B5/0515 or A61B5/0522 or A61B5/055 or G01R35 or G01R19 or G01K7/36 or G05F1/56 or G05F1/563 or G05F1/565 or G05F1/567 or G05F1/569 or G05F1/571 or G05F1/573 or G05F1/575 or G05F1/577 or G05F1/585 or G05F1/59 or G05F1/595 or H01L39 or A61B5 or G01Q60 or G01N24 or G01N21 or G01N27 or G01N23 or A61B1 or G01J1/44 or G01J3 or G01J5 or G01N15 or G01S13 or G01S17/89 or G01T or G02B21 or G02B27 or G02F1/39 or G06T or H01L21 or H01L27 or H01L31 or H01L51 or H04N13/275 or H04N5 or H04N9 or G01C3/08 or G01S15/88 or G06N99 or B82Y10 or G06N10 or H01L29 or G01V or G02B or G02F or G06F or G06F15/78 or G06N99/00 or H01L25 or H04B or H04L or G06F17 or G06F30/20 or G06F30/27 or G06F30/28 or G06K9 or G06N3 or G06N5 or G06N7 or G06Q or G06T1 or G06T7 or G06F8/20 or G06F8/30 or G06F8/34 or G06F8/40 or G06F8/41 or G05B19 or G06F9 or G06N20 or G06F16 or G06K or G06Q20 or G06Q30 or G06Q40 or G08G or G16B or G16B35 or G16C or G16H50 or G06F21/60 or G06F21/70 or H04H60/23 or H04K1 or H04L9 or H04W12 or H04B10 or B82Y10/00 or G11C13/02 or G11C13/04 or H01L45 or H04B10/70 or G06F7/58 or H04L9/08 or H04L9/40 or B81C or H04K) AND CTB=(quantum)) OR IC=(G06N10 OR H04B10/70) OR ACP=(G01B2290/55 OR G06F11/1691 OR H10N99/05 OR H01L29/66977 OR H04L47/527 OR H04L9/0852 OR H04B10/70) or (IC=(G01B9/02 or G01J9/02) and CTB=((Cold or Ultracold) adj Atom adj (Interferometry or Interferometer or Interference)) or IC=(G01C19 or G01C21/16 or G01C21/18 or G01C21/24 or G01C21/26 or G01S17 or G01S7 or G01P15 or G01P7/00 or G01S1/70 or G01S3/78 or G01S5/16 or G01S11/12 or G01S19) and CTB=(Cesium adj2 clock or Rubidium adj2 clock or (Cesium or Rubidium) adj frequency adj standard) or IC=(G04F5/14 or H03L7/26) and CTB=("Cold atomic clock" or "Ultracold Atomic Clock") or IC=(G01B9/02 or G01R33 or G01R35 or G01R19 or G01K7/36 or G05F1/56 or G05F1/563 or G05F1/565 or G05F1/567 or G05F1/569 or G05F1/571 or G05F1/573 or G05F1/575 or G05F1/577 or G05F1/585 or G05F1/59 or G05F1/595 or A61B5/05 or H01L39 or H03L7/26) and CTB=(Josephson adj (effect or junction)) or IC=(A61B5 or A61B5/0515 or A61B5/0522 or A61B5/055 or G01Q60 or G01R33 or G01N24 or G01V3) and CTB=((Nitrogen adj Vacancy or NV) adj3 center adj3 (Magnetic or Magnetometry) or (NV or Nitrogen adj Vacancy) adj3 Magnetometry) or IC=(A61B1 or A61B5/055 or G01J1/44 or G01J3 or G01J5 or G01N15 or G01N21 or G01Q60 or G01R33 or G01S13 or G01S17/89 or G01T or G02B21 or G02B27 or G02F1/39 or G06T or H01L21 or H01L27 or H01L31 or H01L51 or H04N13/275 or H04N5 or H04N9) and CTB=("Ghost Imaging" or "Correlated Imaging") or IC=(B82Y10 or G06N10 or G06N99 or H01L21 or H01L27 or H01L29 or H01L39) and CTB=(Josephson adj (effect or junction)) or IC=(82Y10 or G06N10 or G06N99 or H01L21 or H01L27 or H01L29 or H01L39) and CTB=("Silicon Isotopes" or Silicon adj (28 or 29 or 30) or "Nuclear spin free silicon" or "Isotopically enriched silicon" or "Spin qubits in silicon") or IC=(G06F17 or G06F30/20 or G06F30/27 or G06F30/28 or G06K9 or G06N3 or G06N5 or G06N7 or G06N10 or G06N99 or G06Q or G06T1 or G06T7) and CTB=("Shor's algorithm" or "Shor's factorization algorithm" or "Grover's algorithm" or "Grover's search algorithm") or IC=(G06F17 or G06N3 or G06N5 or G06N7 or G06N10 or G06N99) and CTB=("Expectation value of Hamiltonian" or "Hamiltonian Expectation Value") or IC=(G06N3 or G06N5 or G06N7 or G06N10 or G06N99) and CTB=("CSS codes" or "Calderbank-Shor-Steane codes") or IC=(G06N10 or H04B10 or H04K1) and CTB=(Entangled adj (particles or "photon pairs" or source) or "Bell State" adj (Discrimination or measurement or analyzer)) or IC=(G06N10 or G11C13/02 or G11C13/04 or H01L21 or H01L27 or H01L29 or H01L45 or H04B10 or H04B10/70 or H04L9 or H01L39 or B82Y10/00) and CTB=((Cold or Ultracold or Thermal) adj atoms or "Atomic vapor") or IC=(G06N10 or G06N99 or H04B10/70 or H04K1 or H04L9/08 or H04L9/40) and CTB=("Entangled state measurement" or "Bell state measurement")) or CTB=("Quantum Information" or "Quantum Measurement" or "Quantum Computing" or "Quantum Communication")) and py<=(2024)

6. Patent of controlled nuclear fusion technology

Patent number	Patent description
G21B	Fusion reactors (uncontrolled reactors G21J); Thermonuclear fusion reactors 1/00; Low temperature nuclear fusion reactors 3/00 (IPC)
H05H1/02	(Confining plasma) (IPC)
H05H1/24	Generating plasma [2006.01] (IPC)
H05H1/54	Plasma accelerators [2006.01] (IPC)
G21D7	Arrangements for direct production of electric energy from fusion or fission reactions (obtaining electric energy from radioactive sources G21H1/00) [2006.01] (IPC)
Y10S376/915	Fusion reactor fuels (CPC)
Y10S376/916	Methods of making fusion fuel targets (CPC)
Y02E30/10	Nuclear fusion reactors (CPC)

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(ALL=("Controlled Nuclear Fusion" or "Fusion Energy Control" or "Sustained Nuclear Fusion" or "Controlled Thermonuclear Fusion" or "Sustained Thermonuclear Fusion") or IC=(G21B) or ACP=(Y10S376/915 or Y10S376/916 or Y02E30/10) or IC=(H05H1/02 or H05H1/24 or H05H1/54 or G21D7) and CTB=(fusion and (Nuclear or Thermonuclear)) or CTB=("Fusion Energy" or (Nuclear or Thermonuclear) adj Fusion or (Fusion or Thermonuclear) adj (Reaction* or reactor* or plasma) or Deuterium adj Tritium adj Reaction or "D-T Reaction" or "Hydrogen Isotopes Fusion" or "Fusion Fuel" or "Deuterium Fuel" or "Tritium Fuel" or "Helium-3 Fuel" or ("Magnetic Confinement" or Superconducting or Spherical or Compact) near5 (Tokamak or Stellarator) or "Tokamak Configuration" or Reversed adj Field adj Pinch or "Inertial Confinement Fusion" or Laser adj2 Fusion or "Fusion Laser" or "Compression Fusion" or "Heavy Ion Beam Fusion" or "Indirect Drive Fusion" or "Magnetic Confinement Fusion" or "Fusion Reactor Magnets" or "Magnetized Target Fusion" or "Toroidal Magnetic Confinement" or Hybrid adj Fusion adj Fission or Fusion adj Assisted adj Fission or Fusion adj power adj plant* or (Plasma near2 (Heating or confinement) or (magnetic or inertial) adj sustainment or "Neutral Beam" adj (Heating or injection) or "Electron Cyclotron Resonance Heating" or "Ion Cyclotron Resonance Heating" or "Edge-Localized Mode Suppression" or "Radio Frequency Heating" or "RF Heating" or "Reactor Cooling" or "Heat Exchanger" or "Neutron Shielding" or Radiation adj Resistant adj Material* or "Radiation protection" or Neutron adj Damage adj Resilient adj Structure* or Superconducting or Plasma adj Facing adj Component* or Field adj Reversed adj Configuration) near15 fusion or "Fusion Blanket Cooling" or "Fusion Waste Management" or "Magnetic Mirror Fusion" or Fusion adj Hybrid adj System* or "Z-Pinch Fusion" or "Spheromak Fusion")) and py<=(2024)

Global Innovation Hubs Index, GIHI

The Global Innovation Hubs Index (GIHI), developed by the Center for Industrial Development and Environmental Governance (CIDEG) at Tsinghua University, with data services and translation support from Nature Research Intelligence, has been tracking and analysing year-on-year changes and the latest trends in global innovation since 2020. The GIHI is an index system that applies scientific, objective, independent and impartial principles in evaluating GIHs by their innovation capability and growth potentials, providing a reference for public policy-makers and innovation practitioners.

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The Center for Industrial Development and Environmental Governance (CIDEG), founded in 2005 at Tsinghua University, is a leading think tank in China. We focus on public policy research and academic exchanges in the areas of industrial development, environmental governance, and institutional change. Our mission is to improve the quality of research and education on public policy and governance in China, and to foster communication, understanding, and coordination among academics, industrial communities, non-governmental organizations, and government departments.

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