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Has China caught up to the U.S. in AI research? An exploration of mimetic isomorphism as a model for late industrializers

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Abstract
Artificial intelligence represents a twenty-first century critical technology. We test for and find rapid learning and differentiation characterizing China's AI development process as a model with a better fit than the Foreign Direct Investment/export-oriented growth of earlier Asian industrializers. China outproduces the U.S.A in both annual and cumulative numbers of AI papers, but quality measures show China lagging the U.S.; even so, China's AI development is impressive. China and the U.S.A both present a similar structure of citation impact and citation sources from important nations in the world. As for the collaborative structures, China plays a dominant role in AI research with other nations, showing its commitment to indigenous development. While the United States maintains a higher degree of diversity, China is gradually increasing its collaborative diversity from a relatively simple collaboration structure. Applying a measure of China's chasing of US research, we find the time lag between China and the U.S.A in AI research topics disappeared in 2019 suggesting that China has closed an important gap with the U.S.A and may now be on an independent trajectory.

Keywords Artificial intelligence · Computer science · Government investment · Research and development · National capacity · Competition · China

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Introduction

The rapid rise of China provides an opportunity to gain insight into a nation developing its science and technology (S&T) capacity within an established global science system. It is well known that nations invest in S&T to aid economic growth, improve health and infrastructure, and strengthen national security. Riberio et al. (2010) showed that S&T fuel economic growth. Japan and South Korea followed a strategy of foreign-direct investment, export-led growth, and import substitution to grow their technology-based systems. China offers the opportunity to study technology development in the "catching up" stage.

Malerba and Nelson (2011) posited that those nations seeking to catch up in technology engage in a learning process; they expected that significant differences in variables and mechanisms would manifest across sectors in a democratic/market-based political economy. This is not the case for China, which has exhibited significant differences in its latecomer status in a centralized economy model. This paper examines China's efforts to "catch up" in AI over the past 20 years by comparing China to the United States, which has been the world leader in AI. China outlined a comprehensive policy supporting AI research and development that commits to being a global leader in the field by 2025, becoming a world leader in AI innovation by 2030, and using AI to improve the country's overall competitiveness by 2045. This paper explores the policy and outputs towards this goal.

To support its AI goals, the Chinese government has established several national-level AI research institutes and innovation centers and has launched well-funded initiatives to support the development of AI technologies and applications (Hannas & Chang, 2023). AI policy states a commitment to responsible and ethical AI, with a focus on protecting privacy, security, and social stability (Xu et al., 2024). The policy includes provisions for international collaboration, including cooperation with international organizations and participation in international AI conferences and forums.

According to Amsden (1989), late industrializers who want to expand their S&T bases invest in research and development to imitate and catch up to the leaders. In a study of South Korea, Amsden found that firms developed links with foreign counterparts to manufacture, first lower-value, then higher-value-added products in a process of incremental improvement. An export-oriented strategy brought in capital and augmented learning. Hikino and Amsden (1994) suggested that this process constituted a common model for late industrializers of 'borrowing' and imitating technology from more advanced nations, often through foreign direct investment and associated technology transfer or spillover.

This raises the question of the process of late technological development in China and whether it follows the model suggested by Amsden (1992) and Hikino and Amsden (1994). At first glance, China shares the characteristics of late industrializers: making educational investments, engaging in export-led growth, and stepwise incremental technological change through Foreign Direct Investment (FDI). However, China[1] has notable differences from the model used by South Korea and other Asian developed economies (such as Hong Kong, Singapore, and Taiwan). Within China, the method of seeking FDI, as South Korea did, was not viewed as the most effective means of technology development—at least not as the sole method (Zhou, 2010). Within China, policymakers are committed to indigenous development and productivity enhancement through education and investment, supported

[1] Here we mean mainland China. Similarly hereafter.

by a process of global engagement of students and scholars with collaborations occurring across borders and within China, suggesting that internal development may play a greater role in China than was the case for other Asian industrializers. The differences cause us to question whether the late-industrialization theory of political economy, developed to explain the long growth processes of the West and the more rapid growth of East Asian capitalist nations, applies to China. We explore that question here.

We propose a process of rapid imitation and differentiation that may better reflect China's development process than does the FDI/export-oriented growth. Drawing from organization theory, we suggest that mimetic isomorphism, a concept proposed by DiMaggio and Powell (1983), can be applied to late industrializer's 'catching up' phase. The original concept applied isomorphism at the institutional level, particularly within industries. We propose to expand the concept to policy and policy implementation at the national level, assuming China aims at reaching a point where domestically led innovation, rather than imitation, begins to drive market position. We conduct tests to assess whether China is catching up with the U.S. in AI by following an isometric pattern. We expect to show that isomorphism better fits China's actions than does the FDI-led model derived from the Korean experience.

The catching up process involves multi-sectoral investments in developing financial systems, education, and public sector research (Nelson, 2006), all of which China has undertaken in the past two decades. Since 2016, Chinese public policy has targeted AI for development as one of the cutting-edge technologies in the twenty-first century. Chinese industry started later than other nations to develop this capacity, but catch-up has been rapid (Ernst, 2020). China has built significant capacity over the past three decades to join world nations in targeting AI and other critical technologies for development. China began this journey with information technology investments (Gu, 1997) and more recently with specific initiatives (Roberts et al., 2020). Keller (2004) showed that foreign sources account for most of the world's creation of new technologies in catch-up countries. Keller (2004) further suggested that no 'global pool of technology' exists; development remains both local and tacit. Domestic investment is necessary (Fu et al., 2011), but this is worth questioning, too. The U.S. leadership in AI over many years suggests that China might look to the United States for an example and a partner to grow its AI sector.

Using a dataset of Digital Bibliography & Library Project (DBLP), this study scrutinizes China's advancement in AI through the lens of mimetic isomorphism. Specifically, we decompose national capability in AI into five aspects, and evaluate whether China has transitioned from a phase of imitative development to an independent actor in AI and we test how China's AI capabilities and policies compare to those of the United States.

China and the U.S. in the global AI research

Previous studies have used bibliographic datasets to understand the patterns of global AI research and its evolution (AlShebli et al., 2024). In terms of productivity, Tang et al. (2020) painted a nuanced picture on the speed of producing AI innovations. Specifically, their analyses estimated that three AI papers were submitted to arXiv per hour, and ~ 5.3 new scientists started to work on AI each hour in 2019. Yuan et al. (2020) studied the evolution of AI research from three different perspectives, namely trend, mobility, and scientific collaboration. They found that, in a global view, people have been shifting from theoretical to applied sides of AI in their research and that elite AI scientists have

been highly clustered in the coauthorship network. In another work, Rahkovsky et al. (2021) examined research funding of AI by investigating 6 large funding organizations among the U.S., European Union, China, and Japan. These large-scale analyses untangled some regional differences for AI research: For example, National Science Foundation of the U.S. (NSF) and European Research Council (ERC) tend, per their mission, to support fundamental advancement of AI instead of their applications. Shao et al. (2020) illustrated company-level competition in the AI domain, suggesting that IBM is losing its academic influence advantage; they also found increased asymmetry of institutional attractiveness.

The rapid development of AI also co-evolves with other related disciplines (Chen & Huang, 2022; Hannas & Chang, 2023; Xu et al., 2024). Frank et al. (2019) concluded that AI studies tend to reference mathematics and computer science instead of philosophy, geography, and art (which they historically cited); these indicate a distinct flow of knowledge, as well as different patterns of the source and diffusion of AI innovations.

A short essay in Science (Brainard & Normile, 2022) reported on scholarship (Wagner et al., 2022) that China has risen to first place in most cited scientific publications. This milestone for most cited papers is an indicator of China's S&T development, following China's rise to the top in number of publications (Wagner & Cai, 2022). In many disciplines, the U.S. and China show intense competition in frontiers of science, technology, and engineering (Cady & Etzioni, 2019; Hu & Zhang, 2015). Bibliometric analyses have revealed that China published more AI papers and secured more AI patents than the US (Li et al., 2021).

China's AI publications and patents have not risen to US levels of citation (e.g., Simonite, 2019; Thomas & Murdick, 2020). Quantitative analyses shows that the average number of citations of China's AI publications is lower than that of US with field and age normalization, but that gap is decreasing continuously (O'Meara, 2019). Regarding international citations, the U.S. still had advantages, compared with China, as well (Acharya & Dunn, 2022). A data-driven prediction made in 2021 said that China would become the leader in the top 1% most cited AI scientific publications in 2023 (Yang & Etzioni, 2021). In terms of scientist mobility, based on the ArnetMiner dataset recording the bibliographic information of AI researchers, Yuan et al. (2020) demonstrated that scientists tend to move out from China than move in, compared with the in–out statistics of the U.S.

Despite U.S. and Chinese dominance in AI, the EU, Japan, and South Korea are also significant contributors to top-tier research. The EU, with its unique position as a supranational, regional, and political entity, has established a clear stake in AI development. According to Stanford's AI report (Maslej et al., 2025), Europe claimed the second-highest share of global AI publications (15.22%) and citations (20.90%) in 2023. That same year, the EU and UK together produced 25 notable machine learning models and 15 fundamental models, ranking third globally (Maslej et al., 2024). Concurrently, the EU introduced the Artificial Intelligence Act, which implements a risk-based regulatory framework categorizing AI systems by risk level while emphasizing transparency, ethics, and user safety (Smuha, 2025). Europe's prestigious universities and research institutions lead pioneering AI research, while cities like Amsterdam, London, Oslo, and Paris serve as flourishing innovation hubs that nurture leading AI startups. In Asia, both Japan and South Korea are advancing their AI capabilities. The Japanese government has established science and technology plans alongside dedicated AI projects (Lu et al., 2018). Meanwhile, the South Korean government has released several collaborative AI-related policies (Pinto, 2025). Both nations are actively exploring the future of artificial intelligence.

Methodology and data

Analysts often compare cross-country inputs (research and development spending and trained people) and outputs (articles, citations, and patents) as indicators of research activities and quality. While the field of AI is highly internationalized, national borders continue to represent policy and legal differences as well as cultural and natural assets that influence successful progress. To enable a comparison, this study isolates indicators for China and the United States to test for isomorphism (see Table 1). Collaborative work between them will be addressed in a separate article.

AI is a form of algorithm trained to accomplish complicated or complex tasks. Most AI algorithms are computationally intensive. Computer chips are often designed to the specific task of running AI algorithms (especially deep learning algorithms), and here, China may be at a disadvantage, since chipmaking is not an industry mastered by Chinese companies. For these reasons, we include AI and computer science (CS) in the analysis.

Data

This study employs the DBLP, a database encompassing metadata on CS publications—including authorship information, DOI, publication venue, citing relations, and other related information. We downloaded the DBLP version released on 1 January 2023 and parsed it into a local MySQL database[2] (Tang et al., 2008). The dataset contains approximately 5.26 million publications between 1936 and 2022 (in this data set, we have information only about publication year rather than publication date). Based on authors' affiliation information, we used regular matching techniques to identify the country of each author. We found that 81.76% of CS publications have at least one identified country. We retained publications for which the country information of all authors could be identified. The DBLP dataset has an additional feature, drawn from Microsoft Academic Graph (MAG) (Wang et al., 2020), which assigns fields of study (FOS) to each included paper. Following the method described by Frank et al. (2019), we constructed our AI dataset by focusing on papers from the subfields of AI, machine learning, pattern recognition, natural language processing and computer vision. After these steps, we obtained 3,501,177 CS publications and 808,224 AI publications published between 2000 and 2022.

Patent-to-paper citations are studied to identify knowledge flows from scientific research to practical applications. Marx and Fuegi (2020) curated a dataset of approximately 47 million citations from USPTO (United States Patent and Trademark Office) and EPO (European Patent Office) patents to OpenAlex-indexed publications. We use this dataset (Version v64, patent-to-paper citations updated through 2023) to assess the technological impact of AI papers.

Grouping research outputs

The methodology involves comparing indicators of China's AI-related output to research output from the U.S. To assess whether China's AI development process follows an isometric pattern, we define seven cohorts of research outputs in the AI and CS fields respectively

[2] Downloaded June 24th, 2024, https://originalfileserver.aminer.cn/misc/dblp_v14.tar.gz

Table 1 Country data sets, definition and numbers

Group	Countries	Definition	Numbers of articles (CS)	Numbers of articles (AI)
1	Purely China	All the authors of a paper are from China	591,126	176,628
2	Purely USA	All the authors of a paper are from the U.S	559,358	102,368
3	China	A paper with at least one author from China and no author from the U.S	711,870	209,018
4	USA	A paper with at least one author from the U.S. and no author from China	747,869	137,445
5	China & USA	A cooperative work with authors from only and both China and the U.S	64,316	16,012
6	China & non-USA	A cooperative work with authors from China and non-US countries	120,744	32,390
7	USA & non-China	A cooperative work with authors from the U.S. and non-China countries	188,511	35,077
8	China & Europe	A cooperative work with authors from only and both China and the European countries	43,299	11,326

Note: For pure comparison among the performance of China, the U.S., and their cooperative works, we exclude the two countries' cooperative works with other countries in Group 5

based on authorship addresses in scholarly articles curated in DBLP dataset and Microsoft Academic Graph.

Tests

We assess China's position in AI relative to the U.S. by examining five aspects of national capability. In each of these tests, we expect to see that China will follow (and possibly surpass) the lead of the United States in AI research. We introduce these aspects as follows. Table 2 shows the tests and measures being applied. The idea is to use multiple measures as a way to view the phenomenon of China's growth in the field.

Measures

To characterize China's catching-up in CS and AI, we will consider several key aspects including research volume, research quality, and research fields. Detailed measures regarding these aspects are introduced below.

Research volume

The number of publications and the percentage of the total number of publications are employed to quantify the research quantity.

Structure of scientific collaboration

The Shannon index has been widely used to quantify the diversity in numerous studies (Stirling, 2007; Yang et al., 2022). In this study, the Shannon index is used to measure the diversity of collaborative countries. The formula is as follows:

$$D_j = -\sum_{i=1}^{n} w_i \ln w_i$$

where D_j indicates the collaborators' diversity of country j, and w_i indicates the proportion of total collaboration count of country j made up of collaborator i. The higher the value of D_j, the higher the degree of diverse collaborators in country j.

Research quality

The PP-top1%, the share of high-quality journal/conference papers, academic impact and technological impact are served as proxies for research quality. Specifically, PP-top1% denotes the relative participation in the top-1% highly cited papers of each country (Wagner et al., 2022). We extend the analysis to top 5% as the threshold to obtain the highly cited segment, named PP-top5%. For the high-quality journal/conference, we select all Class A journals/conferences suggested by the China Computer Federation (CCF), to represent high-quality ones in CS, along with all Class A journals/conferences in the AI subfield recommended by the CCF, to represent those in AI. The high-quality journals/conferences lists are shown in Table A1. To measure academic impact, we employ 2-year and 5-year citation counts

Table 2 Tests and measures

Test	Measure	Purpose	Expectation
Stock of research	This measures the total volume of a country's research output in a specific field	It tests how China, starting from a low base, compares over time to the US	China will catch up with and surpass the US in the number of AI publications
Incremental research	Incremental research depicts the growing trajectories of China and the US	It examines whether one imitates the first mover in the timeline	This is accompanied by testing whether publications of policy statements lead or lag one another over time to see if the incremental growing of research coincides with policy investment
Structure of scientific collaboration	Scientific collaboration is also a vital aspect to evaluate the development of national capability	A reasonable scientific collaboration structure can catalyze scientific innovation	We will test whether China is imitating the US in choosing its own collaborators
Research quality	This aspect is measured using indicators of the two countries' performance in the AI field	Research quality is operationalized in four proxies	First, the PP-top n% as referenced by Wagner et al. (2022); Second, the number of papers published in top AI conferences and journals; Third, the 2-year and 5-year citation statistics; Fourth, the number of papers cited by USPTO and EPO patents
Research contents	The most direct outcome of mimetic isomorphism is the convergence of AI research between two countries	If China, as the latecomer, produces AI publications that are increasingly similar to the US	In content, it can be reasonably inferred that mimetic isomorphism plays a role

from scientific papers. For technological impact, we assess different cohorts using the number (or percentage) of papers cited by patents.

Research contents

To test the possible imitation or learning effect between China and USA, we devise an index of topic overlap for the research outputs of the two countries. This index is conceived as follows:

$$\text{Jaccard similarity} = \frac{the number of FOSs shared by Group1 and Group2}{total number of FOSs in Group1 and Group2}$$

Matching

We conducted a matching experiment to compare the impact of China-US co-authored and purely China (US) authored papers. Specifically, the China-US co-authored papers were regarded as treatment group, and the control group were selected from purely China (US) authored papers. To ensure a fair comparison, each China-US co-authored paper was matched with a paper authored by purely China (US) that shared the same basic information. This information includes year of publication, publication venue and the number of authors.

As shown in Table 3, the matching process produced three groups of papers: China-US co-authored papers, purely China-authored papers and purely US-authored papers. Each China-US co-authored paper was paired with one counterpart from the control group. For pairs with more than one counterpart, we randomly selected one paper as the control group counterpart and repeated the matching process ten times.

Policy actions

Comparing the AI policy between China and the U.S. provides insights into how these two nations engage in policy actions. Investigating just the timing of policy issuance suggested that the United States appears to be lagging behind China. In 2015, China released its first country-level AI policy, a year prior to the United States issuing its first state-level AI policy. However, upon examining the content of AI policies, China's first AI policy, namely Made in China 2025, focuses on the improvement of high-tech manufacturing with a limited emphasis on AI technologies. In 2016, the United States issued three AI strategic plans, including "Preparing for the Future of Artificial Intelligence", "The National Artificial Intelligence Research and Development Strategic Plan" (NAIRDSP), "Artificial Intelligence, Automation, and the

Table 3 Total data and matching sample, 2000–2022

Field	Total	Matching		
		Purely China	Purely US	China-US collaboration
CS	3,501,177	16,239	16,239	16,239
AI	808,224	3519	3519	3519

Note: A single matching process is employed in the Matching column

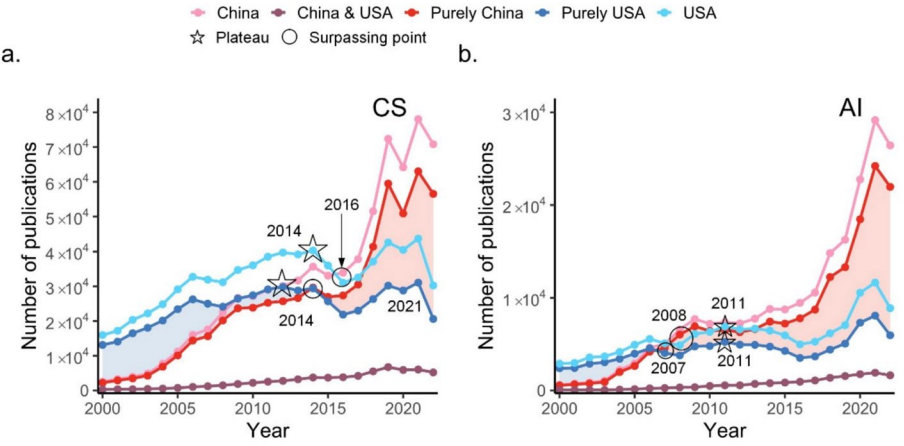

Fig. 1 Yearly growth of research outputs, with the gap highlighted between purely USA and purely China

Economy". To improve the technological prowess in AI, China issued the "Next Generation Artificial Intelligence Development Plan" (NGAIDP) in 2017. This was the first occurrence of the term, Artificial Intelligence, in the title of a state-led policy, and is considered the first AI policy in China in the strict sense. (Even this adoption of term acknowledges the long history of AI theory beginning in the USA.) Comparing the NAIRDSP with the NGAIDP, it's noticeable that both policies prioritize multiple aspects of technological research and development, including AI algorithms, AI systems, ethics of AI, and the development of AI training and testing resources. However, differences between the two policies also exist. The NAIRDSP focuses more on microscale details, while the NGAIDP aims to create a comprehensive layout of industrial chain from the macroscope. China further released the "Three-Year Action Plan to Promote the Development of a New Generation of Artificial Intelligence Industry" in the same year. This plan presented analysis of a gap between the current software and hardware foundations in domestic and foreign developed countries.

During the Trump Administration, nine AI-related policy statements were published, most of which underscored the protection of American AI technology, the development of AI standards, and the training of AI workforce. In contrast, China's country-level AI policies after 2017, such as "AI Innovation Action Plan for Institutions of Higher Education (2019)", "The Ethical Norms for the New Generation Artificial Intelligence (2021)", and "Guidelines for the Construction of a National New Generation Artificial Intelligence Standards System (2021)", concentrated more on AI technological standards, governance norms and education. Overall, China released fewer country-level AI policies compared to the U.S. Taken together, we believed that China's AI policymaking appears to be lagging behind that of the U.S., and these patterns support mimetic isomorphism.

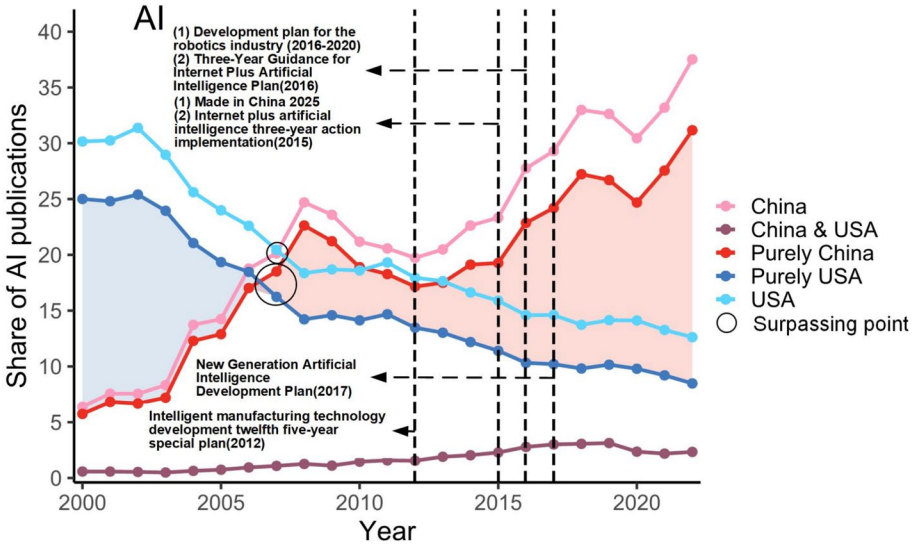

Fig. 2 AI publication share and China's AI related policies

Results of AI research output analysis

Dynamic trends and overturned disparity

From a dynamic aspect of research productivity, we find an emerging reversed disparity between China and the United States (Fig. 1). In the first decade of the twenty-first century, as expected, the United States (both USA and purely USA) produced the largest number of yearly publications. China (both China and purely China) produces fewer articles than the U.S.A; the United States' publication growth entered a local plateau starting from around 2014 in the CS field and around 2011 in the AI field, while China's productivity kept a strong upward trend, especially in AI related research. In fact, a reversed trend is emerging in the gap between the two countries' yearly research outputs. For the participative research every year in the CS field, China caught up to the United States in 2016; for the solely undertaken research, the catching up occurred even two year earlier (in 2014).

In the AI area, China outproduced the United Stated in 2008 in terms of participative research, and such a surpass happened in 2007 regarding the two countries' sole research, see Fig. 1. After the two time points, China kept producing even more AI papers every year than the United States did. From a temporal perspective, the U.S.-leading gap in production between the two countries has been shrinking, until China came to produce more papers yearly, and from then on a reversed gap led by China appeared and kept widening. It can be foreseeable that China will continue a high growth rate in the annual amount of AI publications in the future, leading to a fast-increasing total volume. The tendency becomes clear that China is catching up to the United States in yearly amount of AI papers.

Replacing publication counts with relative share in a research field, the disparity turns more prominent between the two countries. The United States' share presents an overall downtrend. This suggests that China's research in the AI field (as well as in the broad CS field) is not only growing itself, but it brings along the growth of the whole field. Such a growth of Chinese AI research would appear to benefit in part from a series of policy

measures implemented by the Chinese government in recent years for fostering the development of AI.

The key time-points regarding China's AI policies are marked in Fig. 2. It can be seen that by 2007, China had overtaken the United States in the annual share of AI publications. As early as in 2012, the Ministry of Science and Technology released a twelfth five-year plan for intelligent manufacturing technology development.[3] In 2015, the State Council issued two policies–Made in China 2025[4] and the Guidance on Actively Promoting the "Internet Plus" Action,[5] to invest heavily in China's own innovations and reduce its reliance on foreign technologies. One year later, the central ministries and commissions issued two development plans for the robotics[6] and Internet[7] industries, to accelerate the application of Artificial Intelligence technologies in various fields and promote the level of intelligent services in China. Furthermore, in 2017, a development plan[8] and an action plan[9] specific to a new generation of Artificial Intelligence were issued, aiming to make China one of the world leaders in AI in the future. These points in time regarding China's AI policies were accompanied by China's AI publication growth. China's first state-led policy targeting AI was released in 2017, one year after the U.S. AI policy was issued, "The National Artificial Intelligence Research and Development Strategic Plan (2016)". However, China was on an upward trajectory after 2000 and then surpassed the U.S. in 2007, which supports our hypothesis that China is rapidly catching up with the U.S. The effect of AI policy on promoting AI publication is therefore ambiguous. But one thing is certain, China's AI policy release is lagging behind that of the U.S. while paper counts rise. This suggests a certain degree of autonomy of activity within China's AI sector, independent of government policy to a certain extent.

Reduced disparity and similar research structure

We compared 3 fundamental aspects of research output in China and the United States: total research output, average citation impact, and citation sources. We anticipated that the two countries would share similar conditions reflecting mimetic isomorphism.

Figure 3a, b shows that, until 2022 the United States has more academic publications in CS but fewer in AI compared with China. According to the data, the two nations' volume of scientific and technical knowledge production is becoming increasingly similar in number. In the field of CS, the gap between the United States and China has significantly shrunk over time, with the United States producing only 35,999 (4.8%) more CS publications than China. However, when considering research conducted solely by each nation, China is found to produce 31,768 more CS papers (5.4%) than the United States. In the field of AI (Fig. 3b), China has published correspondingly 42.04% (74,260) more AI papers than the United States. This suggests that China has surpassed the United States in terms of total publication volume in both AI and CS.

[3] https://www.gov.cn/gzdt/2012-04/24/content_2121218.htm
[4] https://www.gov.cn/zhengce/content/2015-05/19/content_9784.htm
[5] https://www.gov.cn/xinwen/2015-07/04/content_2890205.htm
[6] https://www.ndrc.gov.cn/xxgk/zcfb/ghwb/201604/t20160427_962181_ext.html
[7] https://www.gov.cn/xinwen/2016-05/23/content_5075944.htm
[8] https://www.gov.cn/zhengce/content/2017-07/20/content_5211996.htm
[9] http://www.cac.gov.cn/2017-12/15/c_1122114520.htm

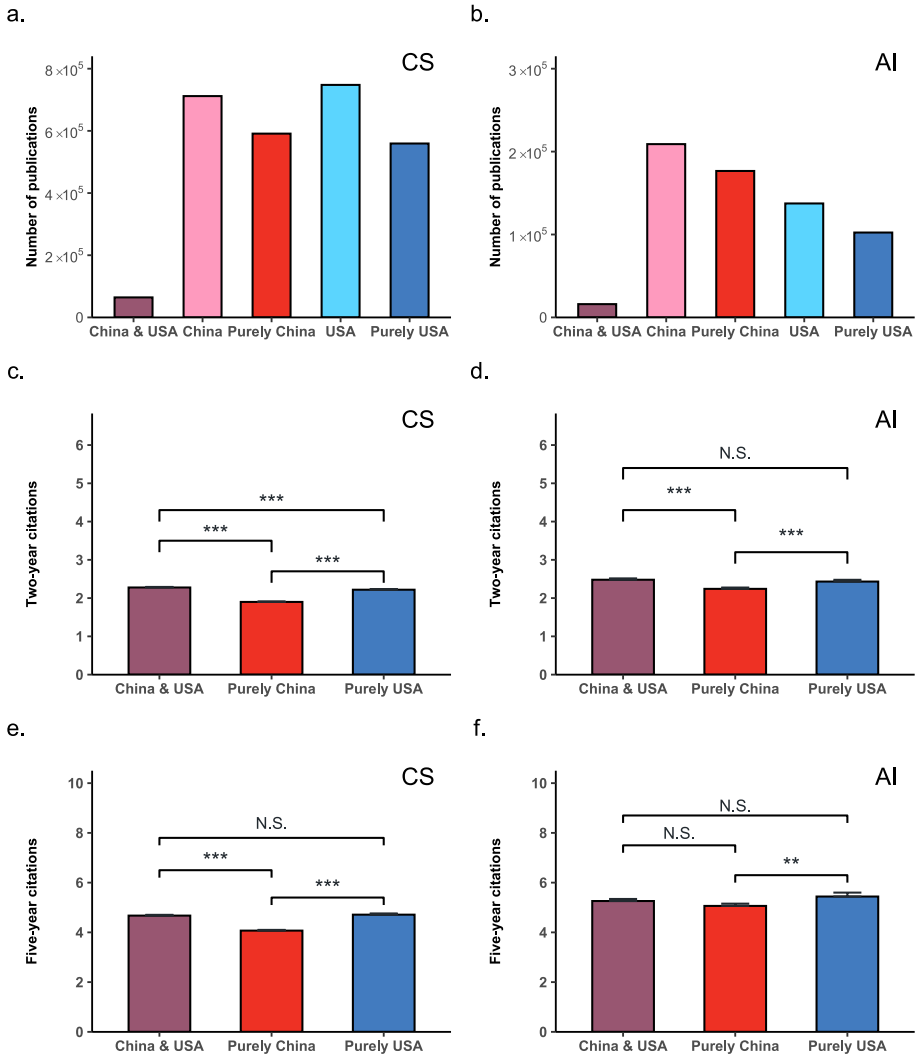

Fig. 3 Research output (**a**, **b**) and citation impact (two-year impact, **c**, **d**; five-year impact, **e**, **f**). *** indicates $P < 0.01$, ** indicates $P < 0.05$, and N.S. indicates not significant

As shown in Fig. 3c–f, purely USA publications tend to receive more citations than purely China publications, in both two-year and five-year citation windows. China-USA co-authored publications seem to be more impactful, especially when compared with purely China publications. But this collaboration effect is not significant when we compare the collaborative works with purely USA-authored publications, except for the two-year impact in the CS field.

Both China and the United States receive more citations from those within their own nation, but they also occupy a visible portion of citations from each other (Fig. 4). In addition, significant citation sources for both the two nations include Europe, South Korea, and Japan, presenting a similar structure of citation sources for the two nations. However, China receives a slightly lower proportion of international citations than does the U.S.

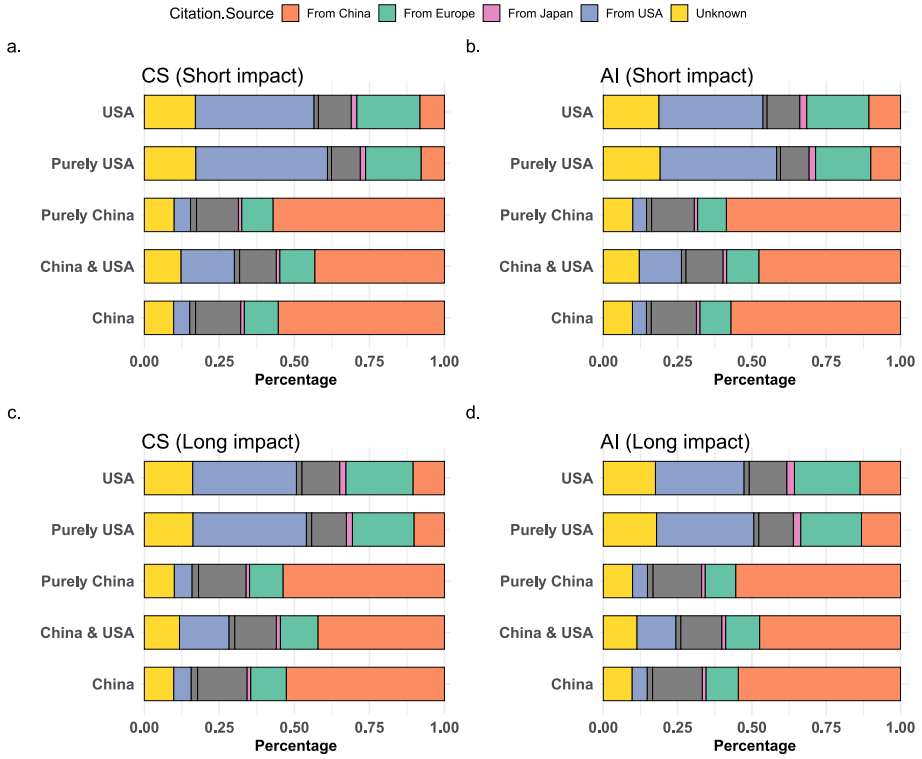

Fig. 4 Sources of citation (short impact = 2 years, long impact = 5 years)

Specifically, China's AI research receives less than half of its citations from other countries, whereas AI research of the U.S. receives more than half of its citations from other countries. It is unclear whether this is due to quality or to visibility.

Similarities in research volume, citation impact, and citation sources support our hypothesis that the fundamentals of AI research in the two countries are comparative.

China's independent growth and simplex collaboration

The coincident growth of publications by China and China-US collaboration depicted in Fig. 1 prompts further inquiry: what are the sources of Chinese AI research's growth? Does the growth stem primarily from the benefits of external collaborations (particularly with the United States), China's own commitment to AI research, or other factors? We sample a subset of AI publications with at least one Chinese author and then plot the proportions of the principal forms of authorship in Fig. 5. More than 80% of AI papers were written independently by Chinese authors. In contrast, China's non-US collaborations, including those with European nations, account for approximately 10% of China-authored publications. This suggests, as anticipated, that China's growth is primarily driven by its independent commitments and efforts in AI research, with external learning playing a secondary role. Significantly, China plays a dominant role in these collaborative relationships, as Chinese first-authored papers have accounted for more

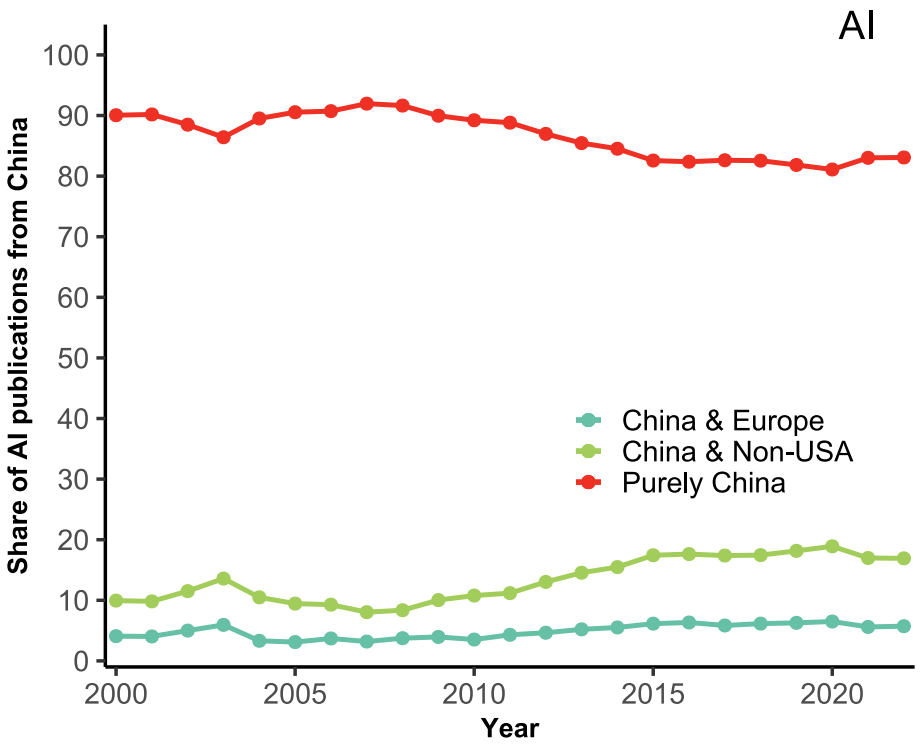

Fig. 5 China's independent growth in AI research

than half of all collaborative papers since 2000, and this percentage has increased to over 75% in recent years (after 2015) for US collaboration and European collaboration (Fig. 6a). The figure also suggests that in the field of AI, Chinese authors lead research

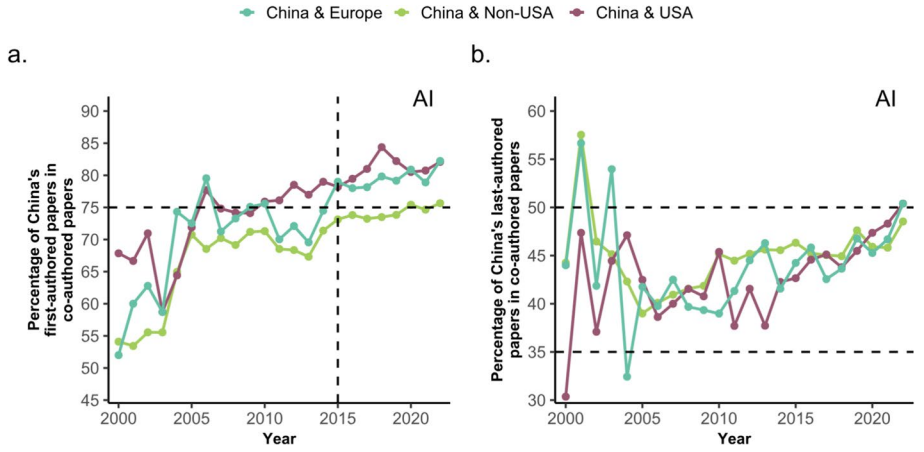

Fig. 6 China's dominant role in collaborative AI research. **a** Percentage of China's first-authored papers in co-authored papers. **b** Percentage of China's last-authored papers in co-authored papers

collaborations with American partners more frequently than with European or other non-American researchers. In recent years, Chinese authors have occupied between 35 and 50 percent of the last-author position, which can denote corresponding authors who may lead research projects (Fig. 6b).

Using Shannon diversity, we conducted additional tests to compare the diversity of the collaborative structures in China and the United States. The convergence of the two nations in terms of complexity was anticipated to illustrate mimetic isomorphism. Figure 7 demonstrates that the two are indeed converging, particularly in AI research, supporting our isomorphism hypothesis. While the United States maintains a more diverse structure for collaboration, China is gradually increasing its diversity.

Figure 8 depicts the relatively complex structure of the United States in AI research compared to the relatively simple structure of China. The United States' most frequent collaborators have shifted from the Canada to China over the past two decades, while China's top collaborator has always been the United States. The United Kingdom, Australia, Singapore, Japan, Canada and Germany are among China's top 10 collaborators, which have remained relatively stable. The United States continues to collaborate with numerous nations, the list of which is constantly evolving. Japan, for instance, once ranked first but dropped out of the top ten in 2013; India, which previously ranked outside the top ten, has recently risen to become the United States' fourth-ranked collaborator. Figure 8 demonstrates that, compared to the United States, China's collaboration structure is relatively simple, but growing diversity (Fig. 7).

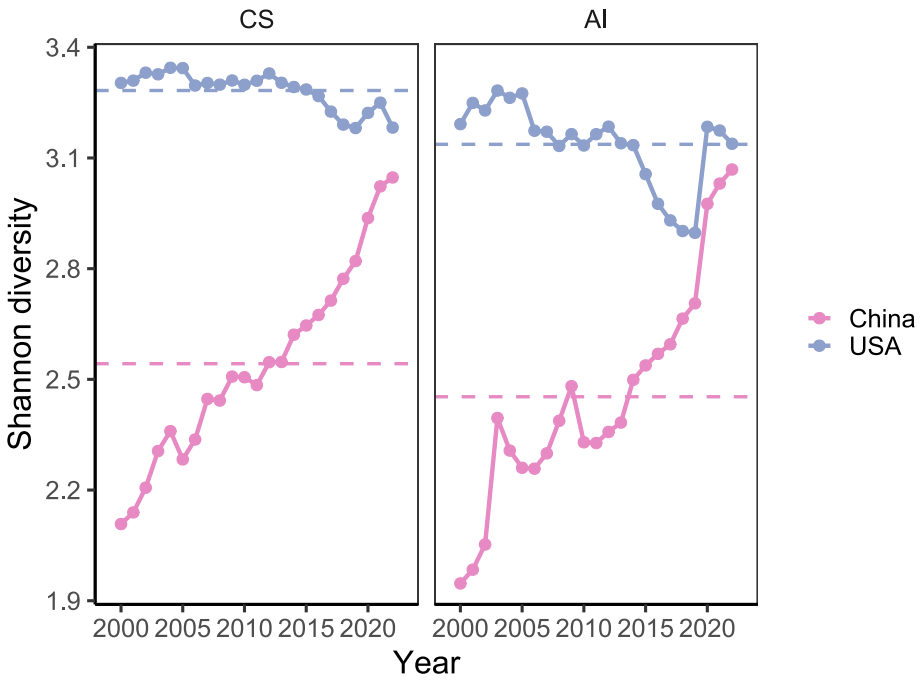

Fig. 7 Collaboration diversity of China and USA

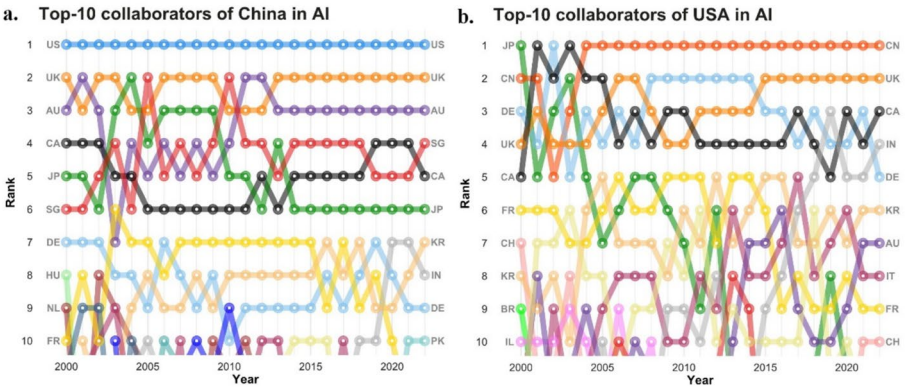

Fig. 8 The evolution of Top 10 collaborative partners of **a** China and **b** USA in AI research between 2000 and 2022. Each curve of the same color represents one of the Top 10 partner countries of China or the United States. For example, in **a**, the orange line shows that UK has been China's top second collaborator in most years since 2000; in **b**, the orange line shows that China has been USA's top second collaborator since 2015

Significant gap in research quality

The quality of AI research in China and the United States was evaluated. We anticipated that mimetic isomorphism would be manifested by a convergence of the two countries in terms of research quality, which is proxied by papers with a high impact factor, publication in prestigious academic venues and patent citations.

We use PP-top5%, an indicator similar to PP-top1% proposed by Wagner et al. (2022), to evaluate the research quality of each type of authorship. A PP-top5% value of 1 indicates that a country has exactly the expected number of highly cited papers.

Figure 9 depicts a gap between the United States and China in their PP-top5% values, but one that is narrowing. Our hypothesis that the two nations' research quality is similar is supported by the fact that the two nations' high-impact paper outputs are converging. The

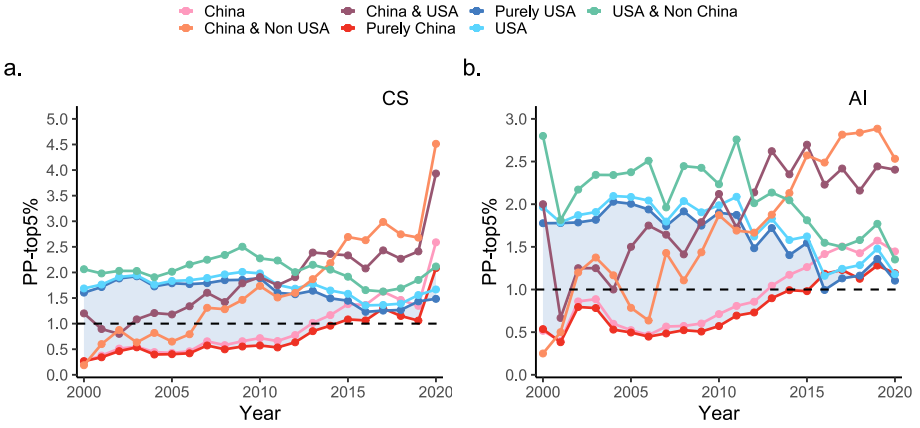

Fig. 9 Variation in the PP-top5% value as a measure of the quality of research

quality of AI research in the United States is higher. In particular, its PP-top5% value in the AI field (Fig. 9b) is consistently greater than 1.5 before 2015. In contrast, China began with a value of approximately 0.5, which was only half of the expected value, and caught up with the United States after 2015. A similar but more prominent situation exists in the CS field (Fig. 9a), with China's recent research in this field appearing to be of higher quality (PP-top5% value) than in AI. An intriguing finding is that despite China's mediocre performance in quality of research by itself, its collaborative research is of high quality and has strong growth momentum, regardless of whether the collaboration is from the United States or other countries (the China & USA curve) (the China & Non-USA curve).

However, after 2012, the United States' research collaborations with other nations (the U.S.A & Non-China curve) do not yield as high PP-top5% values as its collaborations with China (the China & USA curve) in both CS and AI fields. This suggests that the United States also benefits from collaboration with China, and that these benefits are even greater than those derived from collaboration with other nations.

Figure 10 indicates that China once lagged significantly behind the United States in terms of the proportion of publications in leading AI conferences and journals. However, China and the United States are also approaching one another in recent years, supporting

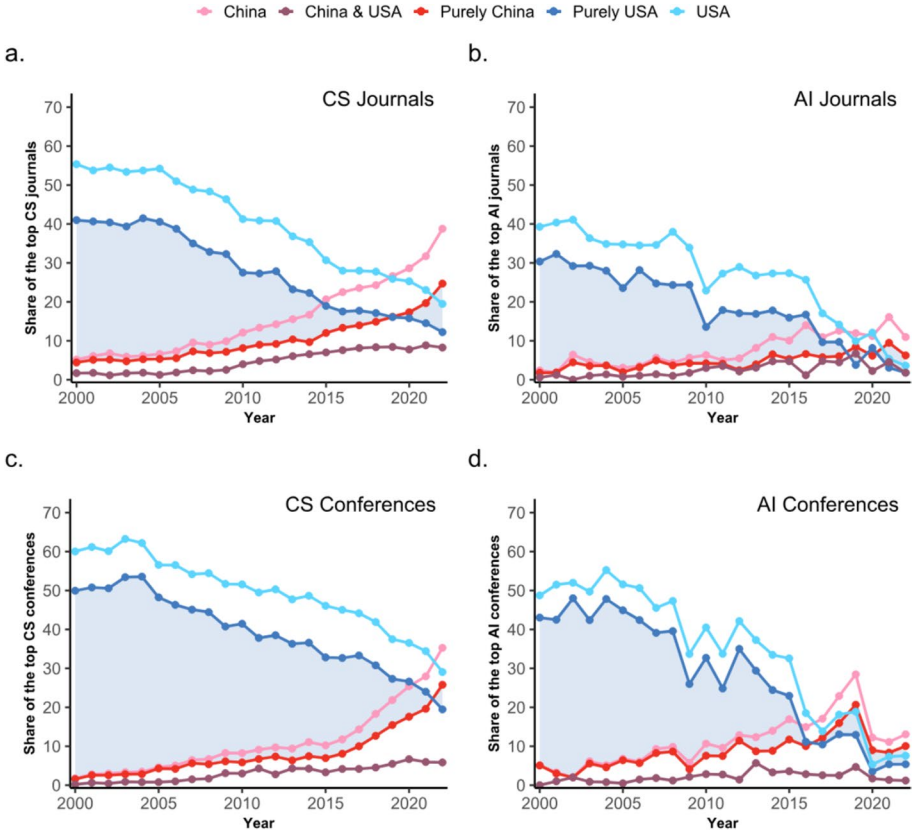

Fig. 10 Share in top publication avenues in the CS and AI fields. **a** Share of the top CS journals. **b** Share of the top AI journals. **c** Share of the top CS conferences. **d** Share of the top AI conferences

our hypothesis that research quality is isomorphic. In terms of top AI conference publications, the United States once held a substantial advantage over China (Fig. 10d) in terms of both total volume and annual output, but this advantage is shrinking. China publishes a growing proportion of papers at leading AI conferences, quickly reaching the United States' annual proportion but still lagging behind in total volume (the shaded area). A similar situation exists in the field of CS (Fig. 10c). In both AI and CS, conferences are the primary venue for academic publishing, and top conferences are the preferred venue for leading researchers to publish and disseminate their high-quality research. The United States' advantage over China in leading AI journals is also evident (Fig. 10b), although this disparity is rapidly narrowing. The share of US papers is gradually declining, as China's share slowly increases each year.

We further compare the technological impact of AI research for China and the United States. Figure 11 reveals that China trailed the United States in producing AI publications associated with technological benefit before 2013, but it surpassed the United States in this metric thereafter, with the gap continuing to widen. Regarding the percentage of AI papers cited by patents, the two nations maintained a significant gap until 2017, after which the disparity progressively narrowed. This convergence pattern supports our hypothesis of research quality isomorphism reflected in the translation of research into patents and commercial products. It is noteworthy that although the general trend suggests a rise in China's production of AI publications associated with technological impact and practical applications, there appears to be a downturn in the ratio of papers cited by patents. This phenomenon may be attributed to the requirement of an extended duration for papers to gain recognition from technological domain, to the possibility that research is held back from publication with the anticipation of commercialization, or to more research being carried out by industry.

Convergence of research topics

Finally, we examined the overlap of AI research topics between China and the United States. Research topics reflect the scope and velocity of research. We anticipated that

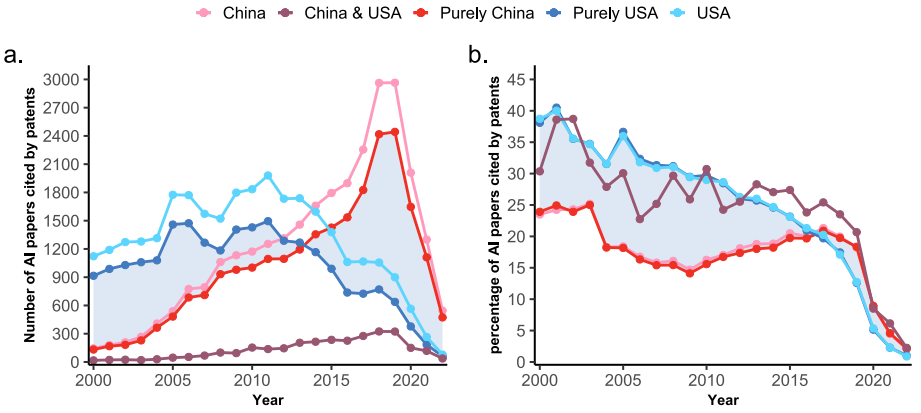

Fig. 11 The evolution of AI papers' technological impact across cohorts. **a** Number of AI papers cited by patents. **b** Percentage of AI papers cited by patents

mimetic isomorphism would be demonstrated by a time lag between the leader and the follower, as well as the convergence of their research pace.

We started with three scenarios: (1) China and the United States conduct AI research at the same rate; (2) the United States lags behind China in AI research; (3) China lags behind the United States in AI research. In Fig. 12b, d, where the U.S. is assumed to lag behind China in AI research topic, the highest similarity always occurs in the 0-year-lag line. Since the data show no lags, this rejects the assumption in scenario 2. Scenario 1 is also rejected, since in Fig. 12a, c, the highest similarity hardly occurs in the 0-year-lag line. Hence, only scenario 3 is true, presented in Fig. 12a, c. In the third scenario, there is a high probability that mimetic isomorphism will occur and that China will learn from the United States.

In fact, China's AI research profile is comparable to that of the United States in previous eras, although the gap between 2000 and 2022 has shrunk. This confirms Scenario 3, that China lags behind the United States in terms of scope of research topics, with similarities generally increasing and gaps narrowing over time as China imitates the U.S. Using China's publication date as the reference time (Fig. 12c) and basing our calculations on the greatest similarities, we determined the exact time lags in each year. From 2009 to 2018, the time lag between China and the United States kept an average value of 6.3 years, with

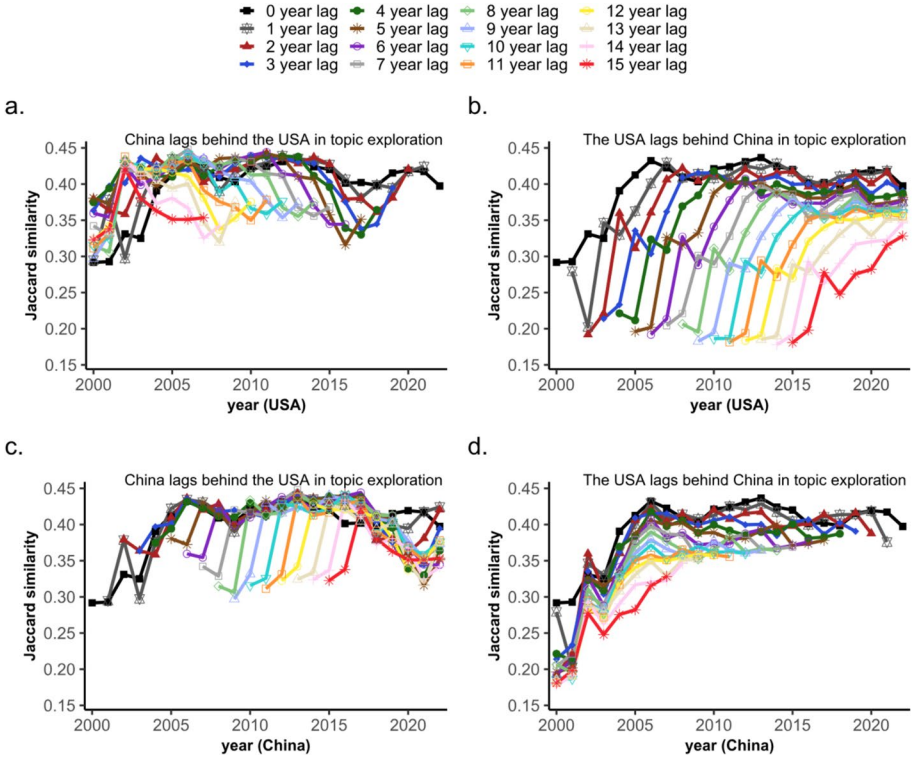

Fig. 12 Lead-Lag Between Frontier Research in China and USA. The Y axis shows the Jaccard similarity of AI research topics between China and the U.S.A year by year, with varying assumptive time lags: **a** and **c** assumes China lags behind the U.S.A, where **a** sets the U.S.A publication time as the X axis, and **c** sets China publication time as the X axis. **b** and **d** assumes the U.S.A lags behind China, where **b** sets the U.S.A publication time as the X axis, and **d** sets China publication time as the X axis. Interval = lag time

the largest time lag of 9 years occurring in 2015 (which means the AI research China did in 2015 most resembles AI research done by the U.S. in 2006). Eventually, however, the time lag shrank and then disappeared in 2019. The results presented above indicate that there is, in fact, a systematic delay in synchronization between AI research topics in China and the United States, and that this divergence in time has been decreasing over the past few years, supporting our hypothesis of isomorphism between the two nations.

Discussion

Our analysis shows similar AI research structure between China and the United States, suggesting a mimetic isomorphic process that China has undergone to grow a very substantial AI research sector. In just 22 years, China has closed a vast chasm of capability with the United States. Steered by policy, investment, engagement, and innovation, China is rapidly catching up to the United States in AI research through learning (including sending people abroad and attracting them back to China[10]). Since 2007, Chinese researchers have published more papers annually than US researchers in the field of AI. At the current rate of improvement, all things being equal, in terms of most highly cited papers, China will overtake the United States in AI research in numbers of papers in years to come. China's collaboration diversity is not as complex as that of the U.S., but it is steadily being enriched. China lagged the U.S. in researching frontier topics, but this gap appears to have closed, and China is researching at the frontiers.

China's emergence in the field coincides with several propitious developments in the research environment that have favored China's rapid rise. It has become the norm for researchers to share their most recent advancements on open sharing sites. This dissemination practice increases the opportunity for latecomers to quickly close the knowledge gap with the early adopters (Li et al., 2021). Moreover, China's large user base is generating massive amounts of data resulting in an abundance of material, that can be tapped for AI applications. China's regulatory structures around data use are comparatively lax, providing China with advantages in the implementation of AI applications and the advancement of related research (Zhang et al., 2024). Moreover, the Chinese government's role in establishing its national innovation system for AI development has been crucial (Lundvall & Rikap, 2022). In 2010s and 2020s, China released a series of AI development-promoting policies with accompanying policy environment conducive to AI's rapid expansion.

When it comes to translation into products measured by patents, China lags the United States and the European Union, according to Castro et al. (2019). Not only does China own fewer high-impact patents despite its large number of total patents, but the majority of its patents are issued only by the Chinese patent office, as opposed to foreign offices such as the U.S.PTO, EPO, and WIPO, suggesting a lower diffusion rate and less competitiveness worldwide. In addition, unlike the United States, the majority of patent owners in China are non-profit organizations such as universities, institutes, and government agencies (China Institute for Science and Technology Policy at Tsinghua University, 2018). China's lag in chip technology is a fundamental weakness, given its importance to AI development.

[10] In 2019, a report by Nikkei Asian Review stated that China had attracted over 1,600 AI experts and researchers back to China from the United States and other countries through various talent recruitment programs.

According to a report by Stanford University (Zhang et al., 2021), China is ranked ninth in the Global Vibrancy Ranking of AI, taking into account a variety of economic metrics such as skill penetration, AI hiring index, AI private investment, and number of AI firms. The ability of a nation to cultivate AI companies is crucial to its competitiveness. These companies provide organizations and individuals with the resources and services necessary to adopt AI in their operations. In 2020, only 398 Chinese AI companies received funding over $1 million. This is less than half the number of European AI firms (890) and a quarter of American AI firms (2130) that received the same amount of funding (Castro & McLaughlin, 2021). According to research (Castro & McLaughlin, 2021; Lundvall & Rikap, 2022; Zhang et al., 2021), China-based AI start-ups received $9.9 billion in private equity and venture capital in 2020, significantly less than the $23.6 billion received by AI start-ups in the United States. China must also devote a great deal of effort to the development of global AI leaders in order to advance its economy.

There are many reasons for the disparity in research quality between China and the U.S., among which the most prominent ones may include differences related to research funding investment, institutional support mechanisms, academic culture, and technology ecology. The investment in AI from the private sector in China is much less than that in the United States. In 2024, private AI investment in the U.S. grows to $109.1 billion, almost 12 times that of China ($9.3 billion) and 24 times that of the UK ($4.5 billion) (Maslej et al., 2025). In 2023, AI investment in the U.S. reached $67.2 billion, almost 8.7 times that of China, the second-largest investor (Maslej et al., 2024). In terms of institutional support mechanisms, AI research in China is dominated by universities, state-owned enterprises, and government-backed labs. CSET's 2022 report notes that the number of universities involved in AI research in China is more than that in the U.S. (Acharya& Dunn, 2022). This decentralized institutional ecology supports a large output of papers, but the quality of the research varies. In contrast, AI research in the U.S. is concentrated in a few top universities and tech giants. Concentrated research resources and a strong industrial drive ensure that the U.S. is always at the forefront of AI innovation, not only producing high-quality research results, but also rapidly transforming them into impactful technologies and applications. In terms of academic culture, the quantitatively oriented and application-driven nature of China's academic culture limits the output of groundbreaking research, while the innovation-driven culture and rigorous review mechanism in the U.S. drive high-quality papers. As far as the technology ecology is concerned, China has an advantage in data-intensive AI research, benefiting from a large user base and liberal data policies. This has driven the output of a large number of application-oriented papers, but data-driven research often lacks theoretical depth (Zheng et al., 2024). The U.S. leads in computational resources and open-source ecology, which can support high-quality outputs that are more theoretical and technically deep.

While the comparative timeline and thematic focus of AI policies in China and the U.S. provide foundational insights, a critical examination of their implementation efficacy and structural challenges reveals nuanced dynamics shaping research outcomes. China's Next Generation Artificial Intelligence Development Plan (2017) prioritized centralized investment in infrastructure and talent mobilization, aligning with its rapid growth in publication volume. However, this state-driven model, while effective in scaling output, faces challenges in fostering globally competitive innovation ecosystems, as evidenced by China's persistent lag in high-impact patents and reliance on domestic citations—a reflection of insular collaboration patterns exacerbated by geopolitical tensions and intellectual property barriers. Conversely, US policies like the National AI R&D Strategic Plan (2016) emphasize decentralized innovation,

leveraging private-sector dynamism and international networks, which correlate with higher citation diversity and industry-academia linkages. Yet, fragmentation in US federal coordination and underinvestment in workforce diversification risk diluting its leadership. The divergence in policy implementation—China's top-down mobilization versus the U.S.'s ecosystem-driven approach—partially explains China's ascendancy in quantity and the U.S.'s resilience in quality. Future policies must address these structural asymmetries, particularly China's need for translational R&D pipelines and the U.S.'s imperative to sustain inclusive innovation networks amid strategic competition.

It appears that China's policy and practice has involved active mimetic isomorphism in topics, training, and institution building. International engagement, especially training of students abroad, has been a lynchpin in China's strategy. The imitation of US output appears to have peaked in 2019; China may be moving into an independent phase of AI development. FDI has played a part, but to a lesser extent than has been reported of South Korea when it was growing its information technology industries. These observations suggest that China's model of development differs from that of other Asian developed economies (such as South Korea, Hong Kong, Singapore, and Taiwan) or earlier of Japan's export-led policy of the 1970s.

China and the U.S. face unique and complex challenges in the ethical, social, and regulatory aspects of AI research. At the ethical level, Chinese AI research uses massive amounts of data to drive applications, but model opacity and data privacy issues have sparked ethical controversies, such as the potential misuse of health code data (Zheng et al., 2024). The U.S. emphasizes algorithmic fairness, but it is difficult to eliminate AI bias, which affects decision-making fairness (Zhu, 2024). At the societal level, Chinese AI technology is widely used for surveillance, which may erode public trust and exacerbate social control (Zaidan & Ibrahim, 2024). AI in the U.S., on the other hand, may deepen social inequality, such as hiring algorithmic discrimination, triggering public discontent. At the regulatory level, China builds an ethical framework for AI through the New Generation Artificial Intelligence Development Plan (2017), which prioritizes the collective good but inadequately protects individual privacy (Qiao-Franco, 2024). The U.S. AI Risk Management Framework (2023) advocates transparency, yet regulation is fragmented and difficult to keep up with technological iterations (Zaidan & Ibrahim, 2024). China needs to strengthen privacy protection and theoretical research, and the U.S. needs to unify regulation to address social risks. However, the complex web of geopolitical tensions poses a significant obstacle to global cooperation on AI ethics. In light of this, there is an urgent need for enhanced international coordination to break through these barriers and foster a more harmonious and ethical AI ecosystem on a global scale.

Among potential future studies, institutional-level analyses of AI research would add to the literature. Existing studies have observed an increase in the number of institution-level collaborations in this domain (i.e., inter-institution collaborations, Shao et al., 2020). These and other authors find an increasingly central role of industrial contributions to AI, particularly in the United States (Ahmed et al., 2023; Frank et al., 2019). Industrial contributions can be more complicated to study because they are less likely to publish. Exploring in-depth industry and government AI application data such as patents would be an important and rewarding task. Investigating the various roles of academia, industry, and academia-industry collaborations, as well as the influence of these works, would also have significant implications for the future AI policies, workforce training, regulations, and developments of major nations.

Conclusion

In this study, we sought to characterize China's catching-up process from the mimetic isomorphism angle. We test whether the processes of China's AI development follow an isometric pattern based on five dimensions, including stock of research, incremental research, structure of scientific collaboration, research quality and research content. For the stock of research, the U.S. publishes more CS publications than China, but a lower total volume of AI publications. The gap between the two countries is gradually narrowing over time, and we see isomorphism in the dimension of annual publication. Moreover, China's AI policy lags behind that of the U.S., but China's AI publications are increasing over time, so we cannot conclude that policy investment is driving the incremental growth of research. The results thus do not support hypothesis (2). Regarding structure of scientific collaboration, the diversity measure of China and US is getting close over time, upholding the hypothesis (3). In terms of research quality, there is still a certain gap between the United States and China in their PP-top5% values and the proportion of publications in top venues, but China's attempt to close the gap is working, and it supports our hypothesis of isomorphism in research quality. Finally, we examined the overlap of AI research topics between China and the United States. The results suggest that the research scope of China and the United States in AI fields overlaps with a time lag, strongly upholds the hypothesis (5).

Appendix

See Table 4.

Table 4 The high-quality journals/conferences

No	Subfield	Type	Venue
1	Computer Architecture/Parallel and Distributed Computing/Storage System	Journal	ACM Transactions on Computer Systems
2			ACM Transactions on Storage
3			IEEE Transactions on Computer-Aided Design of Integrated Circuits and System
4			IEEE Transactions on Computers
5			IEEE Transactions on Parallel and Distributed Systems
6		Conference	ACM SIGPLAN Symposium on Principles & Practice of Parallel Programming
7			Conference on File and Storage Technologies
8			Design Automation Conference
9			High Performance Computer Architecture
10			IEEE/ACM International Symposium on Microarchitecture
11			International Conference for High Performance Computing, Networking, Storage, and Analysis
12			International Conference on Architectural Support for Programming Languages and Operating Systems
13			International Symposium on Computer Architecture
14			USENIX Annul Technical Conference

Table 4 (continued)

No	Subfield	Type	Venue
15	Computer Network	Journal	IEEE Journal of Selected Areas in Communications
16			IEEE Transactions on Mobile Computing
17			IEEE/ACM Transactions on Networking
18		Conference	ACM International Conference on Applications, Technologies, Architectures, and Protocols for Computer Communication
19			ACM International Conference on Mobile Computing and Networking
20			IEEE International Conference on Computer Communications
21			Symposium on Network System Design and Implementation
22	Network and Information Security	Journal	IEEE Transactions on Dependable and Secure Computing
23			IEEE Transactions on Information Forensics and Security
24			Journal of Cryptology
25		Conference	ACM Conference on Computer and Communications Security
26			European Cryptology Conference
27			IEEE Symposium on Security and Privacy
28			International Cryptology Conference
29			Usenix Security Symposium

Table 4 (continued)

No	Subfield	Type	Venue
30	Software Engineering/System Software/Programming Language	Journal	ACM Transactions on Programming Languages & Systems
31			ACM Transactions on Software Engineering and Methodology
32			IEEE Transactions on Software Engineering
33		Conference	ACM SIGPLAN Conference on Programming Language Design & Implementation
34			ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages
35			ACM SIGSOFT Symposium on the Foundation of Software Engineering/ sEuropean Software Engineering Conference
36			ACM Symposium on Operating Systems Principles
37			Conference on Object-Oriented Programming Systems, Languages, and Applications
38			International Conference on Automated Software Engineering
39			International Conference on Software Engineering
40			International Symposium on Software Testing and Analysis
41			USENIX Symposium on Operating Systems Design and Implementations
42	Database/Data Mining/Content Retrieval	Journal	ACM Transactions on Database Systems
43			ACM Transactions on Information Systems
44			IEEE Transactions on Knowledge and Data Engineering
45			The VLDB Journal
46		Conference	ACM Conference on Management of Data
47			ACM Knowledge Discovery and Data Mining
48			IEEE International Conference on Data Engineering
49			International Conference on Research on Development in Information Retrieval
50			International Conference on Very Large Data Bases

Table 4 (continued)

No	Subfield	Type	Venue
51	Computer Science Theory	Journal	IEEE Transactions on Information Theory
52			Information and Computation
53			SIAM Journal on Computing
54		Conference	ACM Symposium on the Theory of Computing
55			ACM-SIAM Symposium on Discrete Algorithms
56			Computer Aided Verification
57			IEEE Annual Symposium on Foundations of Computer Science
58			IEEE Symposium on Logic in Computer Science
59	Computer Graphics and Multimedia	Journal	ACM Transactions on Graphics
60			IEEE Transactions on Image Processing
61			IEEE Transactions on Visualization and Computer Graphics
62		Conference	ACM International Conference on Multimedia
63			ACM SIGGRAPH Annual Conference
64			IEEE Virtual Reality
65			IEEE Visualization Conference
66	Human–computer Interaction and Pervasive Computing	Journal	ACM Transactions on Computer–Human Interaction
67			International Journal of Human Computer Studies
68		Conference	ACM Conference on Computer Supported Cooperative Work and Social Computing
69			ACM Conference on Human Factors in Computing Systems
70			ACM International Conference on Ubiquitous Computing

Table 4 (continued)

No	Subfield	Type	Venue
71	Artificial Intelligence	Journal	Artificial Intelligence
72			IEEE Trans on Pattern Analysis and Machine Intelligence
73			International Journal of Computer Vision
74			Journal of Machine Learning Research
75		Conference	AAAI Conference on Artificial Intelligence
76			Annual Conference on Neural Information Processing Systems
77			Annual Meeting of the Association for Computational Linguistics
78			IEEE Conference on Computer Vision and Pattern Recognition
79			International Conference on Computer Vision
80			International Conference on Machine Learning
81			International Joint Conference on Artificial Intelligence

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Author contributions Chao Min: conceptualization, data analysis, writing, reviewing and editing; Yi Zhao: software, data analysis, writing; Yi Bu: writing; Yi Zhang: data collecting; Ying Ding: conceptualization, supervision; Caroline Wagner: conceptualization, data analysis, writing, reviewing and editing, supervision.

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Declarations

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

Acharya, A., & Dunn, B. (2022). *Comparing US and Chinese contributions to high-impact AI research*. Georgetown University.

Ahmed, N., Wahed, M., & Thompson, N. C. (2023). The growing influence of industry in AI research. *Science, 379*(6635), 884–886.

AlShebli, B., Memon, S. A., Evans, J. A., & Rahwan, T. (2024). China and the USA produce more impactful AI research when collaborating together. *Scientific Reports, 14*(1), Article 28576.

Amsden, A. (1992). A theory of government intervention in late industrialization. *State and market in development: Synergy or rivalry*, 53–84.

Amsden, A. (1989). *Asia's next giant: South Korea and late industrialization*. Oxford University Press.

Brainard, J., & Normile, D. (2022). China rises to first place in most cited papers. *Science, 377*(6608), 799.

Cady, F., & Etzioni, O. (2019). China may overtake US in AI research. *Allen institute for artificial intelligence*, 13.

Castro, D., McLaughlin, M., & Chivot, E. (2019). Who is winning the AI race: China, the EU or the United States. Center for data innovation. https://datainnovation.org/2019/08/who-is-winning-the-ai-race-china-the-eu-or-the-united-states

Castro, D., & McLaughlin, M. (2021). Who is winning the AI race: China, the EU, or the United States? 2021 update. Center for data innovation.

Chen, S., & Huang, W. (2022). Innovation input-output and output-lagged input relationships of the next-generation information industry in China. *Information Processing & Management, 59*(6), Article 103066.

China institute for science and technology policy at tsinghua university. (2018). China AI development report.

DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. *American Sociological Review, 48*(2), 147–160.

Ernst, D. (2020). Catching up in a technology war—China's challenge in artificial intelligence. East-West wire newsletter. https://scholarspace.manoa.hawaii.edu/server/api/core/bitstreams/4bd5e707-6783-4f48-9479-c192836b6337/content

Frank, M. R., Wang, D., Cebrian, M., & Rahwan, I. (2019). The evolution of citation graphs in artificial intelligence research. *Nature Machine Intelligence, 1*(2), 79–85.

Fu, X., Pietrobelli, C., & Soete, L. (2011). The role of foreign technology and indigenous innovation in the emerging economies: Technological change and catching-up. *World Development, 39*(7), 1204–1212.
Gu, S. (1997). China's national innovation system approach to participating in information technology: the innovative recombination of technological capacity. united nations university INTECH discussion paper series.
Hannas, W. C., & Chang, H. M. (2023). Chinese AI and neuroscience. In *Chinese power and artificial intelligence* (pp. 115–133). Routledge.
Hikino, T., & Amsden, A. H. (1994). Staying behind, stumbling back, sneaking up, soaring ahead: Late industrialization in historical perspective. *Convergence of productivity: Cross-national studies and historical evidence*, 285–315.
Hu, J., & Zhang, Y. (2015). Research patterns and trends of recommendation system in China using co-word analysis. *Information Processing & Management, 51*(4), 329–339.
Keller, W. (2004). International technology diffusion. *Journal of Economic Literature, 42*(3), 752–782.
Li, D., Tong, T. W., & Xiao, Y. (2021). Is China emerging as the global leader in AI. *Harvard Business Review*, 18. https://hbr.org/2021/02/is-china-emerging-as-the-global-leader-in-ai
Lu, H., Li, Y., Chen, M., Kim, H., & Serikawa, S. (2018). Brain intelligence: Go beyond Artificial Intelligence. *Mobile Networks & Applications, 23*(2), 368–375.
Lundvall, B. Å., & Rikap, C. (2022). China's catching-up in artificial intelligence seen as a co-evolution of corporate and national innovation systems. *Research Policy, 51*(1), Article 104395.
Malerba, F., & Nelson, R. R. (2011). Learning and catching up in different sectoral systems: Evidence from six industries. *Industrial and Corporate Change, 20*(6), 1645–1675.
Marx, M., & Fuegi, A. (2020). Reliance on science: Worldwide front-page patent citations to scientific articles. *Strategic Management Journal, 41*(9), 1572–1594.
Maslej, N., Fattorini, L., Perrault, R., Gil, Y., Parli, V., Kariuki, N., Capstick, E., Reuel, A., Brynjolfsson, E., Etchemendy, J., Ligett, K., Lyons, T., Manyika, J., Niebles, J. C., Shoham, Y., Wald, R., Walsh, T., Hamrah, A., Santarlasci, L., & Oak, S. (2025). Artificial intelligence index report. *arXiv*. https://doi.org/10.48550/arXiv.2504.07139
Maslej, N., Fattorini, L., Perrault, R., Parli, V., Reuel, A., Brynjolfsson, E., Etchemendy, J., Ligett, K., Lyons, T., Manyika, J., Niebles, J. C., Shoham, Y., Wald, R., & Clark, J. (2024). Artificial intelligence index report 2024. *arXiv*. https://doi.org/10.48550/arXiv.2405.19522
Min, C., Zhao, Y., Bu, Y., Ding, Y., & Wagner, C. S. (2023). Has China caught up to the U.S. in AI research? An exploration of mimetic isomorphism as a model for late industrializers. arXiv preprint arXiv:2307.10198.
Nelson, R. R. (2006). What makes an economy productive and progressive? What are the needed institutions? (No. 2006/24). LEM working paper series.
O'Meara, S. (2019). Will China lead the world in AI by 2030. *Nature, 572*(7770), 427–428.
Pinto, J. (2025). AI in South Korea. In C. Vaih-Baur, V. Mathauer, E. I. von Gamm, & D. Pietzcker (Eds.), *KI in Medien, Kommunikation und Marketing* (pp. 301–322). Springer.
Qiao-Franco, G., & Zhu, R. (2024). China's artificial intelligence ethics: Policy development in an emergent community of practice. *Journal of Contemporary China, 33*(146), 189–205.
Rahkovsky, I., Toney, A., Boyack, K. W., Klavans, R., & Murdick, D. A. (2021). AI research funding portfolios and extreme growth. *Frontiers in Research Metrics and Analytics, 6*, Article 630124.
Ribeiro, L. C., Ruiz, R. M., Bernardes, A. T., & Albuquerque, E. M. (2010). Modeling economic growth fuelled by science and technology. *Estudos Econômicos (São Paulo), 40*(2), 319–340.
Roberts, H., Cowls, J., Morley, J., Taddeo, M., Wang, V., & Floridi, L. (2020). The Chinese approach to artificial intelligence: An analysis of policy and regulation. *AI & Society, 36*, 59–77.
Shao, Z., Yuan, S., & Wang, Y. (2020). Institutional collaboration and competition in artificial intelligence. *IEEE Access, 8*, 69734–69741.
Simonite, T. (2019). *China is catching up to the U.S. in AI research—fast*. Wired.
Smuha, N. A. (2025). Regulation 2024/1689 of the Eur. Parl. & Council of June 13, 2024 (Eu Artificial Intelligence Act). *International legal materials*, 1–148.
Stirling, A. (2007). A general framework for analysing diversity in science, technology and society. *Journal of the Royal Society, Interface, 4*(15), 707–719.
Tang, J., Zhang, J., Yao, L., Li, J., Zhang, L., & Su, Z. (2008). ArnetMiner: Extraction and mining of academic social networks. In *proceedings of the fourteenth ACM SIGKDD international conference on knowledge discovery and data mining*, (pp. 990–998).
Tang, X., Li, X., Ding, Y., Song, M., & Bu, Y. (2020). The pace of artificial intelligence innovations: Speed, talent, and trial-and-error. *Journal of Informetrics, 14*(4), Article 101094.
Thomas, P., & Murdick, D. (2020). *Patents and artificial intelligence: A primer*. Georgetown University.
Wagner, C. S., & Cai, X. (2022). Changes in co-publication patterns among China, the European Union (28) and the United States of America, 2016–2021. *arXiv preprint* arXiv:2202.00453.

Wagner, C. S., Zhang, L., & Leydesdorff, L. (2022). A discussion of measuring the top-1% most-highly cited publications: Quality and impact of Chinese papers. *Scientometrics, 127*(4), 1825–1839.
Wang, K., Shen, Z., Huang, C., Wu, C., Dong, Y., & Kanakia, A. (2020). Microsoft academic graph: When experts are not enough. *Quantitative Science Studies, 1*(1), 396–413.
Xu, R., Sun, Y., Ren, M., Guo, S., Pan, R., Lin, H., Sun, L., & Han, X. (2024). AI for social science and social science of AI: A survey. *Information Processing & Management, 61*(3), Article 103665.
Yang, J., & Etzioni, O. (2021). China is closing in on the U.S. in AI research, AI2 Blog. https://blog.allenai.org/china-is-closing-in-on-the-us-in-ai-research-ea5213ae80df
Yang, Y., Tian, T. Y., Woodruff, T. K., Jones, B. F., & Uzzi, B. (2022). Gender-diverse teams produce more novel and higher-impact scientific ideas. *Proceedings of the National Academy of Sciences, 119*(36), Article e2200841119.
Yuan, S., Shao, Z., Wei, X., Tang, J., Hall, W., Wang, Y., & Wang, Y. (2020). Science behind AI: The evolution of trend, mobility, and collaboration. *Scientometrics, 124*(2), 993–1013.
Zaidan, E., & Ibrahim, I. A. (2024). AI governance in a complex and rapidly changing regulatory landscape: A global perspective. *Humanities and Social Sciences Communications, 11*(1), 1–18.
Zhang, D., Mishra, S., Brynjolfsson, E., Etchemendy, J., Ganguli, D., Grosz, B., & Perrault, R. (2021). The AI index 2021 annual report. *arXiv preprint* arXiv:2103.06312.
Zhang, J., Li, X., & Tong, T. (2024). A tale of two types of standard setting: Evidence from artificial intelligence in China. *Journal of Management, 50*(4), 1393–1423.
Zheng, C., Zhao, Y., Wang, C., & Shan, Z. (2024). The development trend of global artificial intelligence: Basic technology field. *Science Focus, 19*(4), 26–36.
Zhou, Q. (2010). The institutional foundation of China's economic growth. *China Economic Journal, 3*(1), 25–32.
Zhu, J. (2024). AI ethics with Chinese characteristics? Concerns and preferred solutions in Chinese academia. *AI and Society, 39*(3), 1261–1274.

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