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# Caught between cooperation and competition

EU–China research cooperation in artificial intelligence,  
quantum technologies, and semiconductors

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## Executive summary

- 1 EU–China research cooperation in critical technologies is extensive and expanding.** Between 2015 and 2025, researchers affiliated with EU and Chinese institutions jointly produced **34,161 publications in artificial intelligence (AI), 9,706 in quantum technologies, and 43,684 in semiconductors**. Cooperation is not confined to a small number of research institutions or countries; Chinese partners feature in research conducted across all 27 EU member states, with particularly extensive links involving Europe's leading research ecosystems.
- 2 The continuously expanding role of China in EU's critical tech research** coupled with the pervasive role of military-linked Chinese research institutions in this cooperation suggests that **EU's early efforts to adopt research security practices has not yet had significant impact** on pursuit of collaborations with Chinese scientists affiliated with higher-risk Chinese research institutions.
- 3 China's role in European critical technologies research has grown significantly over the past decade.** Between 2015 and 2025, **the volume of produced research output grew more than sixfold in AI and nearly doubled in quantum and semiconductors**. At the same time, cooperation with Chinese researchers has also become more frequent. While in 2015, co-authorships with Chinese researchers accounted for 2.4% of all AI research output in the EU, in 2025 that share grew to 8.1% of all outputs. In quantum technologies, the corresponding share increased from 6.9% to 11.6%, while in semiconductors it rose from 4.5% to 12.7%.
- 4 Cooperation is concentrated in Europe's strongest research ecosystems, but several smaller countries and institutions show particularly high levels of engagement.** Germany is the largest European contributor to EU–China cooperation across all three critical research fields, while France, Italy, Sweden, Spain and other major research systems also feature prominently. At the institutional level, however, the picture is more dispersed: Nordic universities are particularly prominent in AI, while Swedish, Spanish and Danish institutions appear among the most active in quantum research. In semiconductors, the most active European research organizations cooperating with China include universities from France, Sweden and Denmark

- 5** **EU–China AI research is concentrated in the technical foundations of modern AI.** Machine and statistical learning theory and classical algorithms account for the largest share of joint research, followed by deep-learning architecture, training methods and representation learning, followed by research on data centric AI and synthetic data.
- 6** **Quantum cooperation is concentrated predominantly in fundamental and enabling technologies.** Quantum materials and qubit platforms account for the largest shares of joint publications, followed by quantum devices and hardware engineering, and quantum information theory.
- 7** **Semiconductor cooperation is concentrated upstream in the technology value chain,** particularly in materials, photonics and device technologies. Semiconductor materials constitute the largest research category, followed by optoelectronics and photonic integrated circuits, with a further substantial body of work addressing manufacturing processes such as lithography, etching, deposition and fabrication flows.
- 8** **A large majority of EU–China research involves Chinese institutions with documented links to the People’s Liberation Army (PLA) or China’s military-industrial complex.** Overall, 68.8% of EU–China AI publications, 72.0% of quantum publications and 73.9% of semiconductor publications involved at least one Chinese institution tied to the Chinese military-civil fusion program or otherwise engaged with the PLA.
- 9** **The Seven Sons of National Defense represent a particularly sensitive part of this cooperation.** The seven universities are **deeply embedded in China’s defense research system** and are among the country’s most important research institutions in areas such as aerospace, electronics, maritime technologies and advanced engineering. European researchers have jointly produced **at least 3,176 AI publications, 747 quantum publications and 4,396 semiconductor publications** with researchers affiliated with the Seven Sons of National Defense universities during the period examined.
- 10** **For most academic research on cutting-edge technologies, it is difficult to predict dual-use potential. This is especially true for fundamental research, where the eventual fields of application are often not known when the research begins.** Only a few publications in the dataset are explicitly classified as having military use. Yet technologies such as computer vision, biometric recognition, autonomous systems, quantum sensing and communications, advanced semiconductor materials and photonics can support both civilian and military applications. **Examples identified in the research include AI-based control methods relevant to hypersonic flight control, facial recognition, satellite imagery analysis, and UAV swarms; quantum technologies for secure communications and radar sensing; and semiconductor and photonic technologies relevant to radar systems, LiDAR, and radiation detection.**

**11** **Chinese commercial actors, particularly Huawei, also participate in EU–China academic cooperation on critical technologies.** Huawei appears as an author affiliation in **668 AI-related and 161 semiconductor-related publications** in the dataset. Huawei is also active in funding research projects and development of research infrastructure in Europe. Not only has it established two in-house research and development (R&D) centers in Belgium, but it has also provided funding for research at the University of Augsburg (Germany) into recognition of human emotion from voice, speech and facial expressions, which has potential applications for human rights suppression in China, and also funded the establishment of a microelectronics research lab at Italy's University of Pavia.

**12** **A substantial proportion of collaboration takes place through broader international networks.** 48.3% of EU–China AI publications, 50.9% of quantum publications, and 44.0% of semiconductor publications involve at least one additional institution outside the EU and China. **Researchers therefore frequently work with Chinese partners alongside institutions from the United States (US), United Kingdom (UK), Japan, South Korea, Canada, Australia and elsewhere.** This structure of EU–China research cooperation makes risk assessment more complex than a simple bilateral screening model suggests. Thus, efficient research security requires not just improving the EU's own screening capacity, but also **better coordination of policies and enforcement among like-minded partners** that also participate in research with China.

**13** **Funding patterns reveal a significant asymmetry in the financial foundations of EU–China research cooperation.** Exclusive Chinese funding is acknowledged in 29.4% of AI publications, 20.1% of quantum publications, and 29.9% of semiconductor publications, compared with only 4.5%, 6.8%, and 6.7% respectively for exclusively EU-funded research. Chinese funding is particularly prominent through the **National Natural Science Foundation of China (NSFC)**, while more strategically oriented programs such as the **National Key Research and Development Program** also feature prominently. Some joint research is also funded through member-state schemes (either separately or jointly with China). Although the EU Commission has recently barred Chinese universities from working on some Horizon Europe-funded critical tech projects, **member-state-level funding presents a significant gap in Europe's research security framework.**

# Recommendations

- 1 Move from technology-wide restrictions towards project-level risk assessment.** AI, quantum technologies, and semiconductors are too broad to function as meaningful categories for deciding whether cooperation with Chinese scientists should proceed. They encompass research ranging from basic science with limited near-term application to highly mature technologies with direct military, surveillance, or industrial relevance. Assessments should consider the specific research topic, its maturity, potential applications and relevance to identifiable technological bottlenecks. This should support nuanced, proportionate decision-making. Lower-risk basic research projects may be greenlit with only ordinary safeguards—transparency and conflict-of-interest disclosures, for instance—while enhanced review, leading to strict mitigation measures and potential cooperation bans, should be reserved for higher-risk projects, either because of the partner's nature or the research itself.
- 2 Assess the institutional environment of Chinese partners.** Universities should examine not only the name of the partner institution but also known aliases as well as the relevant laboratory or department, their participation in talent recruitment programs, defense relationships, participation in military-civil fusion programs, and links to defense companies or military research organizations—both institutional as well as existing on the level of key personnel. Institutional risk databases should serve as screening tools.
- 3 Include funding provenance in research-security due diligence.** Universities and research funders should identify who finances international projects, the particular funding program involved and any conditions concerning data, intellectual property, personnel, or subsequent use of results. Funding from Chinese sources should not itself constitute grounds for exclusion, but programs linked to strategic or defense objectives should trigger an enhanced review, particularly where contractual terms create obligations incompatible with European research-security, export-control, or intellectual-property requirements. Due diligence should be conducted before accepting funding, and revisited periodically or whenever project conditions or partners change.
- 4 Coordinate research-security approaches with major scientific partners.** The EU should work with partners such as the US, the UK, Japan, South Korea, Canada, Taiwan and Australia on common disclosure standards, institutional information sharing and approaches to particularly sensitive research. Coordination should focus on specific risks, shared evidence standards, and practical safeguards rather than creating rigid geopolitical blocs that unnecessarily fragment international science. Greater consistency would reduce the risk of conflicting requirements across jurisdictions and help authorities identify patterns that may not be visible within one national system.

- 5 Preserve openness as a policy objective alongside security.** Research security should not aim to ban cooperation with China altogether. Instead, it should identify collaborations where the likely security or technological costs outweigh the scientific benefits, while maintaining access to international research networks where risks can be effectively managed. Protecting researchers from fraud is a necessary component of an open system.
- 6 Strengthen European alternatives to Chinese research funding.** Sustained EU and national funding in critical technologies should give researchers credible alternatives where dependence on foreign financing becomes significant. Policymakers should also highlight to academia that investing in robust research security frameworks can help them attract alternative funding, especially from businesses for joint R&D initiatives.
- 7 Monitor conflicts of commitment and foreign talent-program participation.** Universities should require disclosure of parallel appointments, external funding, and contractual obligations that could affect ownership of research, access to facilities or intellectual property. These disclosures should be updated periodically and verified, especially for scientists working on critical technologies.
- 8 Include human-rights risks in project assessment.** Research with plausible applications in mass surveillance, biometric monitoring or political repression should receive additional scrutiny. Assessments should look more closely not just at potential repression applications of research findings, but also at existing links between research partners and end-users of surveillance technology.
- 9 Invest in commercialization and scale-up.** Europe's ability to retain technological advantages depends on translating scientific strength into industrial capability through pilot facilities, spin-offs, growth financing, and procurement. Leveraging European research findings for the sake of the EU's competitiveness will not be possible unless there are meaningful pathways towards commercialization. Without those pathways, technology will inevitably transfer out of the EU. At the same time, research security should expand into a broader practice of innovation security, ensuring that similar standards of review and risk mitigation apply not just to academia but also to commercial innovation stakeholders, such as startups, especially when receiving public funding.
- 10 Track institutional concentration.** Universities and funders should identify laboratories or research groups that have become highly reliant on particular foreign partners for researchers, funding, infrastructure, or research output. Concentration does not necessarily indicate misconduct or unacceptable risk, but it can create vulnerability if a relationship is disrupted or if one partner gains disproportionate influence over a research agenda. Regular monitoring should therefore inform diversification strategies, contingency planning, and targeted support for groups that have become structurally dependent on a narrow set of foreign relationships.

# 11

**Harmonize research security frameworks across the EU.** While the EU has strengthened the scrutiny of Chinese involvement in Horizon Europe projects, divergent national approaches create gaps through which sensitive research can still be pursued with member-state funding. An EU-wide framework should establish common research security standards across both EU and national programs. Proposal assessments should also look beyond direct Chinese participation to applicants' broader research collaborations, including parallel work with entities of concern. Where such links create additional risks, stricter mitigation measures may be needed to silo projects, limit access to sensitive knowledge and infrastructure, and prevent indirect transfer of research outputs or expertise.

# Introduction: The changing politics of EU–China research cooperation

Since the signing of the 1998 Agreement on scientific and technological cooperation between the European Community and the People’s Republic of China, EU–China research ties have expanded substantially.<sup>1</sup> As China’s research system grew and became more internationally connected, collaboration between Chinese and European researchers deepened across a wide range of scientific fields. In recent years, however, the political context in which such cooperation takes place has fundamentally changed.<sup>2</sup> Science and technology have increasingly become intertwined with concerns over competitiveness and economic security, strategic dependencies, technological competition, and the transfer of knowledge with potential military applications.<sup>3</sup> The EU’s broader shift towards “de-risking” its relationship with China has been accompanied by tighter export controls on sensitive technologies and their components, as well as efforts to make international research cooperation more secure.<sup>4</sup>

These concerns are particularly pronounced in technologies considered strategically important for Europe’s economic and technological security. Artificial intelligence (AI), advanced semiconductors, and quantum technologies are among the areas the EU has singled out for particular attention because of their transformative potential, their importance for future economic competitiveness, and their possible civil-military applications.

The 2023 European Economic Security Strategy identified risks associated with the security and leakage of critical technologies as one of four principal categories of economic-security risk facing the EU.<sup>5</sup> Later that year, the Commission listed ten critical technology areas and flagged four of them—advanced semiconductors, AI, quantum technologies, and biotechnologies—for immediate collective risk assessment precisely because of their potential security and competitiveness ramifications.<sup>6</sup> Similarly, the 2025 Commission’s recommendation on reviewing outbound investments focused specifically on three technology areas: advanced semiconductors, artificial intelligence, and quantum technologies.<sup>7</sup>

The three domains are central to the EU’s wider technological and industrial ambitions. Semiconductors are foundational technologies underpinning digital infrastructure and numerous other advanced industries, reflected most prominently in the European Chips Act and subsequent efforts to strengthen European semiconductor capacity. AI is regarded as a general-purpose technology central to European competitiveness, productivity and technological sovereignty, while also raising security and dual-use concerns. Quantum technologies, although at an earlier stage of commercialization, are seen as potentially transformative for computing, communications, sensing, and cryptography and are increasingly treated as strategically significant for both economic and security purposes.

The Commission therefore approaches these technologies simultaneously as areas in which Europe needs to build greater domestic capabilities and as technologies whose international diffusion and associated dependencies may generate security risks. They are also fields in which China has made substantial investments in strengthening its domestic scientific and technological capabilities. However, the same advances that drive innovation in civilian sectors can contribute to military capabilities, making the boundary between open scientific cooperation and strategically sensitive knowledge transfer increasingly difficult to draw.

As a result, the EU has progressively incorporated research security into its wider economic security agenda. In 2024, the Council of the European Union adopted the non-binding Council Recommendation on Enhancing Research Security, providing a common framework for addressing risks associated with international research cooperation, including unwanted knowledge transfer, foreign interference, and violations of research integrity.<sup>8</sup>

Research security considerations are also becoming more directly embedded in access to EU funding. In 2023, the EU banned Chinese organizations from taking part in Horizon Europe Innovation Action projects which support the demonstration, piloting, and validation of innovations closer to deployment and market uptake.<sup>9</sup> Horizon Europe is the EU's largest research funding program (roughly €93.5 billion for 2021-2027), allowing universities and other research entities across the EU to partner also with non-EU countries on joint research. In 2026, it was followed by a ban on Chinese participation in research to develop new knowledge and technologies. As such, topics such as health, digital and civil security are fully closed to participation by Chinese entities, on the grounds of preventing "undesired" transfers of European IP.<sup>10</sup> The European Commission has been in active consultations with stakeholders on its ongoing plans to launch the European Research Area (ERA) Act to be presented in Q3 2026, and is expected to include measures to strengthen research security.<sup>11</sup>

The 2026 ban on Chinese participation specifically targets public universities supervised by the Ministry of Industry and Information Technology, which are excluded from all actions across the 2026–27 work program because of concerns over military-civil fusion and potential defense-related technology transfer.<sup>12</sup> These seven universities are collectively labeled "Seven Sons of National Defense": Beihang University, Beijing Institute of Technology, Harbin Institute of Technology, Harbin Engineering University, Northwestern Polytechnical University, Nanjing University of Aeronautics and Astronautics, and Nanjing University of Science and Technology. They are strongly involved in defense technology research and development and are among the best-funded universities in China. On average, around 30% of their employed graduates go on to be employed by China's defense research sector, and approximately half their research budgets are known to go on military research.<sup>13</sup> They are particularly active in research and development of critical dual-use technologies like aeronautics, nuclear technology, maritime technology, or armaments, which also increasingly intersect with the research in the three sectors that are the focus of this paper. Previous research has also found that partnerships with the Seven Sons universities have served as "prime pathways for harvesting US research and diverting it to military applications."<sup>14</sup>

These restrictions are particularly consequential for critical and emerging technologies, including the three areas examined in this paper. They reflect growing concerns that publicly funded research cooperation may strengthen China's technological base in ways that are difficult to separate from military and security applications.

Similar patterns can be observed outside the EU. The United States (US), Australia, the United Kingdom (UK), Taiwan, South Korea and Japan have all strengthened mechanisms intended to manage research-security risks, although the scope and design of these regimes vary considerably.<sup>15</sup> They increasingly tie access to public funding for research in critical and emerging technologies to requirements related to due diligence, disclosure, partner screening, research-security training, or restrictions on cooperation with selected foreign institutions. For instance, in Japan, the US and Australia, public funding agencies are screening applicants for potential risks, mostly by reviewing affiliations, requiring disclosure and assessing research partners. In Japan, this process began in 2021 with its Research Integrity Policy against Geopolitical Risks,<sup>16</sup> followed up by the 2024 Ministry of Education, Culture, Sports, Science and Technology Policy Directions, which specified security requirements in government funding.<sup>17</sup> In 2025, the Japan Science and Technology Agency, a major national funding agency, launched a pilot screening program at the candidate stage, specifically targeting research fields in quantum technologies and

semiconductors.<sup>18</sup> In Australia, following amendments to the Australian Research Council Act 2001 in 2024, the Australian Research Council, which covers over 7% of all research funding in the country, now conducts early-stage screening of applicants and partner institutions, looking beyond disclosures and employing open-source data collection through various means.<sup>19</sup>

The EU's shift to securitizing research can be partially explained by the slew of controversies at the old continent's universities, which have pushed individual member state governments to act. Examples include a 2021 case of at least 29 Chinese researchers from a military university working at TU Delft in the Netherlands, which raised concerns about forced technology transfers.<sup>20</sup> These, and many more, have helped propel discussions on research security across Europe, as the individual countries develop their own research security governance policies, with the Netherlands being considered one of the frontrunners with the most developed framework in the EU today. However, broader changes in how dual-use technologies are assessed, and the fact that the very innovations that drive civilian technology development also contribute to military technology development, have been important contributing factors.<sup>21</sup> Such cooperation has spurred discussion in the past, as PLA-linked institutions, such as the Seven Sons of National Defense, have been involved in various critical areas of research with European partners.<sup>22</sup>

At the same time, the growing securitization of research should not obscure the continued importance of international scientific cooperation. Frontier research increasingly depends on international networks that pool expertise, data, infrastructure, and talent across countries. This is especially true in fast-moving fields such as AI, semiconductors, and quantum technologies, where no single research system holds all relevant capabilities. Broad restrictions can therefore weaken access to leading research communities and slow knowledge exchange. Thus, European policymakers must distinguish between collaborations that create genuine security risks and those that remain important for Europe's own scientific and technological capacity.

Joint scientific publications provide useful insight into how scientific knowledge is produced through international collaboration. Tracked over time, co-publication patterns can show whether these ties are expanding or contracting, how important bilateral cooperation is relative to each side's wider research output, which countries and institutions sustain it, and where collaboration is concentrated within the European and Chinese research systems.

This paper therefore examines how EU–China scientific collaboration has evolved in artificial intelligence, semiconductors, and quantum technologies. The selection of these three fields follows the EU's own prioritization of technologies considered particularly consequential from the perspective of economic security and technology leakage. Based primarily on bibliometric data collected from Scopus and open-source database OpenAlex, the analysis traces joint publications over time, identifies the EU member states and research institutions most closely connected with Chinese partners, and assesses China's importance within European research networks and the continued importance of European cooperation within China's rapidly expanding scientific system.

## China's scientific rise changes the terms of academic cooperation on critical technologies

Scientific research has become increasingly internationalized over recent decades. Researchers collaborate across borders through joint projects, mobility, international funding schemes, and increasingly dense networks of co-authorship. In many research fields, particularly those at the technological edge, scientific capabilities are therefore not contained within individual national systems. New knowledge is produced through networks connecting universities, public research organizations, companies, and individual researchers across multiple jurisdictions.

China's position within these networks has changed particularly rapidly. Its expansion in research expenditure, scientific personnel, infrastructure, and publication output has transformed it from a relatively peripheral participant in global science into one of the world's largest research systems. In purchasing-power-parity terms, China accounted for around 30% of global research and development (R&D) expenditure in 2024, compared with less than 5% in 2000.<sup>23</sup> At the same time, China's share of the global publications on science and engineering grew to 31%, with over 1 million articles in 2024. The amount almost tripled between 2014 and 2024.<sup>24</sup> This growth has also altered the structure of international scientific cooperation. European researchers increasingly approach Chinese institutions not only as additional international partners but as leading research actors in fields where China possesses significant scientific capacity.

At the EU level, formal cooperation dates to the EU–China Science and Technology Cooperation Agreement signed in 1998, which established an institutional framework for bilateral scientific relations and has been periodically renewed, most recently tacitly in 2024.<sup>25</sup> Cooperation has subsequently developed through EU framework programs, bilateral arrangements between China and individual member states, university-to-university partnerships and researcher-driven collaboration. In 2018, the EU and China began exploring a roadmap for deeper science and technology cooperation, however it was never finalized, with the Commission citing lack of progress in the discussions in a 2026 report.<sup>26</sup>

The character of this relationship has, however, changed alongside China's growing scientific and technological capabilities and the broader transformation of EU–China relations. The EU's 2021 Global Approach to Research and Innovation already reflected the emerging tension as it described China as a major research and innovation power and a partner in tackling global challenges, while simultaneously calling for cooperation to be rebalanced in response to problems of reciprocity, unequal framework conditions, and China's role as an economic competitor and systemic rival.<sup>27</sup> The EU consequently sought to differentiate between areas where cooperation remained mutually beneficial and those where closer scrutiny or restrictions might be required.

Research cooperation is nevertheless a particularly difficult area in which to apply the logic of de-risking. Scientific openness is one of the mechanisms through which European research systems acquire knowledge, participate in frontier research, and remain internationally competitive. Restricting collaboration can reduce exposure to unwanted knowledge transfers, but it can also reduce European researchers' access to leading research groups and scientific networks. This trade-off becomes more consequential as China's own research capabilities expand. Reducing links with one of the world's largest research systems may involve considerably greater scientific opportunity costs.

OECD data indicate that China's overall international collaboration intensity declined between 2020 and 2023, driven largely by a sharp decline in collaborations with the US.<sup>28</sup> Over the same period, however, China's research ties with the EU continued to strengthen. More granular data are therefore needed to determine whether similar trends are visible in emerging and sensitive technologies, and whether growing geopolitical and research-security concerns have translated into changes in patterns of joint scientific production.

## Military-civil fusion in China

Military-civil fusion (MCF) in China is a strategy through which Beijing seeks to accelerate its military modernization. It encourages the People's Liberation Army (PLA) and various state-owned defense conglomerates to work together with the civilian sector. The principal goal is leveraging the improvements in civilian research and development (R&D) to modernize the military.<sup>29</sup>

While dating back to 2007 and Hu Jintao, it is most closely associated with Xi-era China. In 2015, Xi Jinping announced the "aligning of civil and defense technology development" as a national priority.<sup>30</sup> Since 2017, the strategy and implementation have been overseen by the Central Commission for Integrated Military and Civilian Development, a body directly under the Central Committee of the Chinese Communist Party, and directed, at least formally, by Xi Jinping.<sup>31</sup> In the same year, China issued the 13th Five-Year Special Plan for Science and Technology MCF Development, which sought to establish an integrated system to conduct basic cutting-edge R&D in critical areas such as AI, biotech, quantum and others, in order to "capture commanding heights of international competition."<sup>32</sup> Furthermore, a number of universities are officially described as a part of the defense system or are directly supervised by China's defense industry agency, bringing the risks of such cooperation to the forefront.<sup>33</sup>

As such, MCF, as a part of Beijing's long-term efforts, is used to position China to be better able 'to compete militarily and economically in an emerging technological revolution', by coordinating military and economic efforts.<sup>34</sup> In the early years, it was seen as Xi Jinping's strategic initiative since his ascent to power, being invoked in crucial initiatives such as Made in China 2025 and the Next Generation Artificial Intelligence Plan.<sup>35</sup>

## MCF and critical technologies

Research in AI, Quantum and Semiconductors is closely intertwined with China's MCF. The 2017 AI development plan called for greater use of AI in national defense and closer coordination among civilian and military research actors.<sup>36</sup> More recently, the PLA has placed AI at the center of its concept of "intelligentized warfare," integrating AI, big data and advanced computing into military operations.<sup>37</sup>

According to the US Department of Defense's 2025 assessment, Chinese leaders view quantum computing, sensing and communications as important for national security and future warfare, with potential applications including secure military communications, codebreaking, navigation without GPS, improved intelligence and surveillance, and detection of submarines and other targets. China is also building ground and space infrastructure for quantum communication networks that could serve both commercial and military users.<sup>38</sup>

Semiconductors are deeply embedded in China's military-civil fusion strategy. Under Xi Jinping, high-end chips and large-scale integrated circuits have been identified as priority areas for closer integration between civilian innovation and defense needs, with civilian firms increasingly expected to contribute to military modernization.<sup>39</sup> Microchips represent the implied foundation of the PLA's ambition for an "intelligentized" combat force, as they underpin military communications, command and control, sensors, radars, and advanced weapons systems.<sup>40</sup>

## Mapping the relationship: Data and methodology

Against this backdrop, this report maps and analyses research cooperation between the EU member states and China (2015-2025) in three strategically relevant technology areas—artificial intelligence, quantum technologies, and semiconductors—using bibliometric data indexed in Scopus and open-source database OpenAlex. As such, the data reflects both peer-reviewed academic publications and preprints and publications stored in arXiv and other archives, often covering relevant research in emerging technologies. The paper supplements the mapping exercise conducted by CEIAS in 33 European countries identifying formal academic cooperation partnerships between European universities and Chinese entities visualized and available in the CEIAS China-Europe Academic Engagement Tracker.

This analysis aims to produce a systematic evidence base identifying who collaborates with whom, in what research areas, which funding sources dominate, and the extent of potential exposure to Chinese institutions with military links. The unit of analysis is research output (mostly research papers and conference papers), and the analysis focuses on outputs with verifiable EU–China co-authorship based on recorded institutional affiliations of contributing researchers.

We analyzed each paper’s title and abstract. Papers were assigned one or more topic codes from a pre-defined topic list (domain-specific - see annex). If a paper covered multiple areas, it could receive multiple topic labels.

Each publication is classified by the geographical scope of cooperation based on the full set of participating countries, distinguishing between bilateral cooperation between China and an EU member state, European multi-country cooperation, and broader multilateral cooperation. While bilateral EU–China ties can reflect direct institutional or national relationships, multilateral outputs often indicate broader research consortia in which responsibility, governance, and knowledge flows are distributed across multiple partners and jurisdictions.

### China-Europe Academic Engagement Tracker

An online interactive database developed by CEIAS and partners from European countries that maps interactions between European academic institutions and Chinese entities. The Tracker records different forms of academic engagement across Europe, including institutional partnerships, research cooperation, and other academic exchanges. It allows users to filter interactions according to country, institution, and type of engagement. The Tracker currently covers almost 9,000 instances of cooperation between Chinese entities and European academic institutions from 33 analyzed European countries. In addition, the Tracker is complemented by country-level analyses that examine the specific dynamics of academic relations with Chinese entities, map existing institutional guidelines, and identify key trends, challenges, and areas for improvement.

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The paper's methodology also cross-references data with the 2019 version of the Australian Strategic Policy Institute's (ASPI) China Defence University Tracker, which allows us to note instances of cooperation with universities linked to the People's Liberation Army and assign approximate risk levels.<sup>41</sup> We also refer to RAND's Chinese Academy of Science Directory, which examines how and to what degree the Chinese Academy of Sciences and its specific research institutes participate in and support Chinese defense activities.<sup>42</sup> However, this is mainly for context, as most papers that list the Chinese Academy of Sciences as an author's affiliation fail to identify specific institutes, making a full statistical analysis of cooperation with Chinese Academy of Sciences institutes involved in defense research infeasible. This also means the actual share of papers co-authored with Chinese scientists affiliated with research institutions close to the PLA may be higher than indicated by cross-referencing with ASPI's China Defence University Tracker.

At the publication level, the report identifies whether an output includes at least one flagged Chinese partner institution. At the country level, it estimates how much of each EU member state's research output involves collaborations with Chinese research institutions. At the institutional and topic levels, it examines which Chinese institutions contribute most to flagged collaborations and how those collaborations are distributed across research themes.

# Artificial intelligence: Rapidly growing cooperation

## China's AI rise is no longer just an ambition

Artificial intelligence has become central to China's economic, technological and security ambitions. Beijing has promoted AI as a national priority since the 2017 New Generation Artificial Intelligence Development Plan, which set milestones for 2020 and 2025 and the longer-term objective of making China a major global AI innovation center by 2030. The strategy calls for developing both fundamental research and applications across the economy and treats international cooperation as a way to strengthen domestic AI capabilities. It encourages cooperation with leading foreign universities and research institutes, overseas R&D centers and investment, joint international research platforms, and greater Chinese participation in international AI organizations, standards and governance.<sup>43</sup>

This approach has since broadened from developing AI capabilities to integrating them across the economy and society. The 15th Five-Year Plan period (2026–2030) places AI among the technologies expected to drive technological and industrial upgrading, with priorities including multimodal AI, AI agents, embodied intelligence and swarm intelligence.<sup>44</sup> This builds on the AI Plus initiative, formalized by the State Council in August 2025, which seeks to integrate AI more deeply into scientific research, industry, consumption, public services, and governance.<sup>45</sup> It sets a target for next-generation intelligent terminals and AI agents to exceed 90% deployment by 2030, when AI is expected to become a major driver of economic growth.<sup>46</sup> Furthermore, China increasingly views AI applications, mainly AI-enabled robotics, as a way to offset demographic pressures and labor shortages. Beijing's 2026–2030 development plan promotes the use of robots in labor-scarce sectors and AI systems requiring minimal human intervention, as the country confronts a shrinking population and rapidly aging workforce.<sup>47</sup>

China's ambitions increasingly extend beyond domestic technological development. Through the Global AI Governance Initiative,<sup>48</sup> capacity-building programs, and the establishment of the World Artificial Intelligence Cooperation Organization (WAICO), a China-proposed intergovernmental organization, in July 2026, Beijing is seeking to embed its institutions into the global AI and emerging technology governance ecosystem.<sup>49</sup> No EU member state joined WAICO as a founding participant, underscoring continued European caution toward China-led governance initiatives. The initiative may matter less as a formal rule-setting body than as a platform for training officials, coordinating research, building long-term government networks and facilitating the deployment of Chinese AI models and infrastructure. This could broaden China's partner base, create a constituency supportive of its positions in forums such as the UN, and allow Chinese governance norms and technical standards to spread indirectly through technology adoption. Thus, the EU should continue to follow the initiative closely as China's effort to build parallel institutions increasingly competes with the EU's own attempts to shape global AI governance around rights-based principles and regulatory standards.<sup>50</sup>

These ambitions have increasingly translated into technological strength. The US continues to lead in the development of notable frontier models, producing 59 in 2025 compared with China's 35, but the performance gap has narrowed markedly.<sup>51</sup> DeepSeek-R1 briefly matched the leading US model in February 2025, demonstrating that Chinese developers could approach the US frontier at substantially lower cost.<sup>52</sup> Epoch AI estimates that Chinese models have trailed the US

frontier by around seven months on average since 2023, with the gap narrowing to as little as four months.<sup>53</sup> By early 2026, leading open-weight models (many of them Chinese) were only around four months behind the most capable proprietary models.<sup>54</sup> The emergence of Moonshot AI's Kimi K2.5 in January 2026 further demonstrated the breadth of China's model ecosystem as it became one of the most advanced open-weight models globally, with Epoch AI placing its capabilities around those of leading US models released several months earlier.<sup>55</sup>

China's progress is supported by an increasingly dense AI ecosystem connecting major technology companies, start-ups, universities and public research institutes. DeepSeek emerged internationally through its R1 reasoning model, while firms such as Moonshot AI, Z.ai and MiniMax compete alongside larger companies including Alibaba, Baidu, Tencent and ByteDance. Chinese developers have become particularly competitive in open-weight models, with DeepSeek and Alibaba's Qwen among the models that have gained substantial international uptake.<sup>56</sup>

These firms are closely connected to China's academic research system through talent flows, spin-offs and joint research. Z.ai, formerly Zhipu AI, is a notable example. It was founded in 2019 by researchers from Tsinghua University and grew directly out of work by Tsinghua's Knowledge Engineering Group.<sup>57</sup> It has since attracted substantial government-backed investment from Beijing, Shenzhen, Hangzhou, and Shanghai, including a RMB 500 million (€61.5 million)<sup>58</sup> investment from state-owned Huafa Group in 2025.<sup>59</sup>

DeepSeek founder Liang Wenfeng was trained at Zhejiang University,<sup>60</sup> while Moonshot AI founder Yang Zhilin studied at Tsinghua and worked on large-language-model research before establishing the company.<sup>61</sup> The boundary between academic and commercial AI development is therefore highly permeable, allowing advances generated in universities and research institutes to feed rapidly into China's wider technology ecosystem.

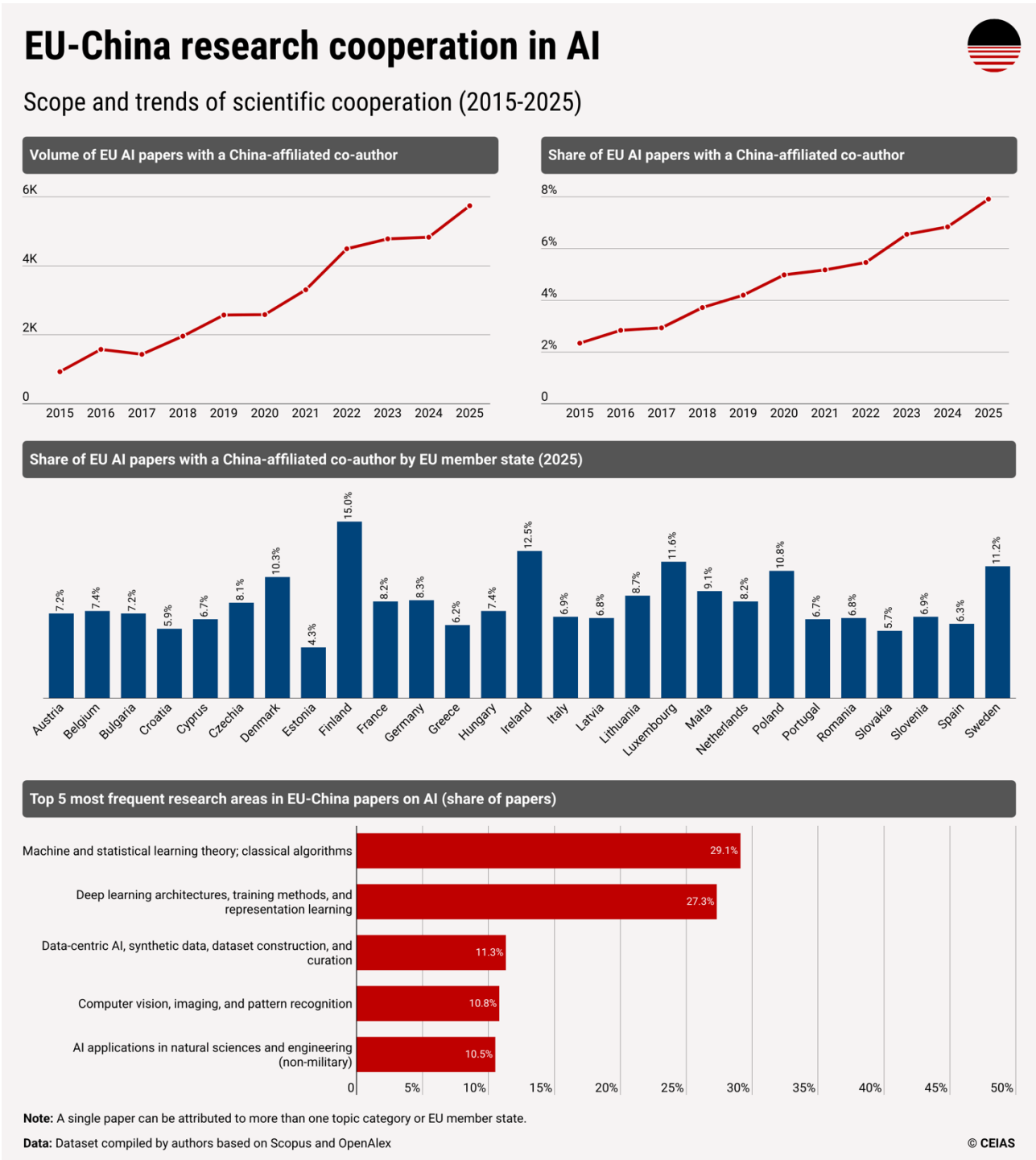
China's growing strength is particularly visible in academic research. The 2026 Stanford AI Index places China first globally in AI publication volume, citations and patent grants.<sup>62</sup> Chinese AI publications accounted for 20.6% of all AI citations in 2024, followed closely by Europe at 19.5% and the US at 12.6%. Its representation among the 100 most-cited AI papers increased from 33 papers in 2021 to 41 in 2024.<sup>63</sup>

Similarly, Center for Security and Emerging Technology (CSET) analysis suggests that China overtook the EU around 2015–2016 in its share of the world's top 1% most-cited AI publications.<sup>64</sup> Europe nevertheless remains a major center of AI research and an important partner for China. The EU collectively is China's third-largest international AI research partner after the US and the UK.<sup>65</sup> Furthermore, China's importance as a research partner for the EU has also increased.<sup>66</sup> Modern science increasingly rests on international collaboration, which is also associated with greater research impact. In 2019, internationally co-authored papers represented only around 21% of global AI publications but received 36.3% of all citations.<sup>67</sup> A 2024 study of more than 5.3 million AI papers also found that China–US collaborations consistently produced more impactful research than comparable papers without cross-border collaboration.<sup>68</sup>

## Scale and evolution of EU–China AI cooperation

The scale of EU–China cooperation in AI has grown substantially, encompassing both formal institutional partnerships and extensive researcher-level collaboration. The China-Europe Academic Engagement Tracker's comprehensive mapping of EU–China academic cooperation has identified at least 135 formal partnerships that explicitly name AI as a cooperation area; most (62 cases) are with French research institutions. Beyond formalized partnerships, our analysis identifies 34,161 AI-related publications jointly authored by researchers affiliated with Chinese and EU institutions between 2015 and 2025, covering all 27 EU member states.

Research cooperation is concentrated in several core areas that underpin how modern AI systems are built and improved. About one third of the publications concern machine and statistical learning theory and classical algorithms, which provide the mathematical foundations that enable computers to learn patterns from data and make predictions. The second-largest category covers deep-learning architecture, training methods and representation learning, with more than 9,000 joint publications focusing on how large neural networks are designed, trained and made more effective. This research is central to technologies such as large language models, image recognition and generative AI. Data-centric AI, including synthetic data, dataset construction and curation, and non-military AI applications in the natural sciences and engineering, both account for more than 3,000 outputs.



The relationship has become considerably more important relative to European AI research overall. In 2015, EU–China joint publications represented an average of 2.4% of EU AI research output overall; by 2025, this had increased to 8.1%. Only Finland, Ireland and Latvia had more than 5% of their AI research conducted with Chinese partners in 2015, compared with 26 EU member states in 2025 (only Estonia having less than 5%). Cooperation with China has therefore become a common feature of AI research across almost the entire EU, likely reflecting both China’s rapid rise as a leading AI research power, which made Chinese institutions increasingly attractive partners for European researchers, and Beijing’s state-led strategy to expand international AI cooperation through joint research and partnerships with leading foreign universities and research institutes. The Nordics maintained particularly high levels of cooperation, with Finland reaching 15.0%, Sweden 11.2% and Denmark 10.3% in 2025. Ireland and Poland also recorded substantial increases, rising from 5.3% in 2015 to 12.5% and from 2.0% to 10.8%, respectively.

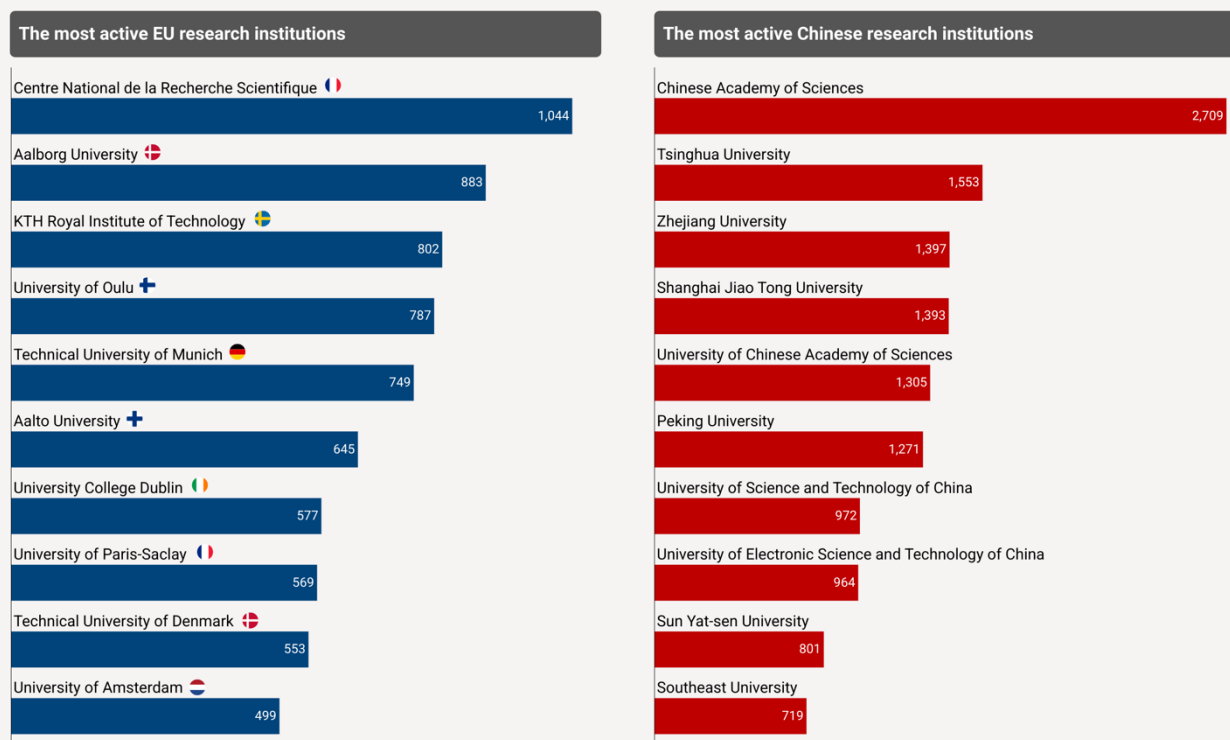
Germany records the largest number of joint AI publications with China, with 7,355 outputs between 2015 and 2025, roughly one-fifth of the EU total. Its prominence is consistent with the size of its wider AI research ecosystem. The 2026 Stanford AI Index identifies Germany as having the third-largest pool of top AI authors and inventors globally, following the US and India (excluding China from the ranking).<sup>69</sup> Germany also hosts major research organizations active in AI, with the Max Planck Society and the Helmholtz Association the only European organizations included in Nature Index’s top ten “rising institutions” in AI for 2019–2023.<sup>70</sup> France, Italy, Sweden and Spain follow Germany in our dataset, each recording more than 3,000 joint AI publications with China.

At the institutional level, however, Nordic universities are particularly prominent when it comes to cooperation with China, with two Danish and two Finnish institutions among the ten most active

## Most active players in EU-China AI research



Top 10 most active research institutions in EU and in China (2015-2025)



Data: Dataset compiled by authors based on Scopus and OpenAlex

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European partners, alongside two French institutions and universities from Sweden, Germany, Ireland and the Netherlands. This pattern may reflect the Nordic countries' high concentration of leading AI researchers and innovators, rather than an unusually strong orientation towards Chinese partners.<sup>71</sup>

On the Chinese side, the Chinese Academy of Sciences and its institutes, Tsinghua University and Zhejiang University are the three most active institutions in EU–China AI scientific cooperation. Tsinghua has particularly extensive European connections, ranking among the top Chinese AI partners for 12 EU countries (Austria, Bulgaria, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Romania, Spain, and Sweden).

## Security risks in AI research cooperation with China

Overall, 68.8% of EU–China joint AI publications involved at least one Chinese institution classified as presenting some level of risk due to proximity to the PLA per the ASPI China Defence University Tracker. Of these, 40.2% of papers were produced with scientists from Chinese universities considered very high risk, and 32.2% with those considered high risk. Finland, Estonia and Croatia recorded some of the highest proportions, with around three-quarters of their joint publications involving at least one flagged institution.

More importantly, this share has remained remarkably stable despite growing scrutiny of academic ties with China. Between 2015 and 2025, the proportion of EU–China AI publications involving flagged Chinese institutions fluctuated between 64% and 70%, with no clear downward trajectory. The EU's growing emphasis on research security has therefore not yet translated into a visible reduction in co-publication with Chinese institutions identified as having military or defense links.

Examples of research identified in our dataset with potential military applications include a study co-authored by a researcher holding both an affiliation with the PLA Air Force Engineering University (AFEU) as well as Delft Center for Systems and Control in Netherlands which proposed and derived a new control method for precise trajectory tracking of hypersonic flight vehicles.

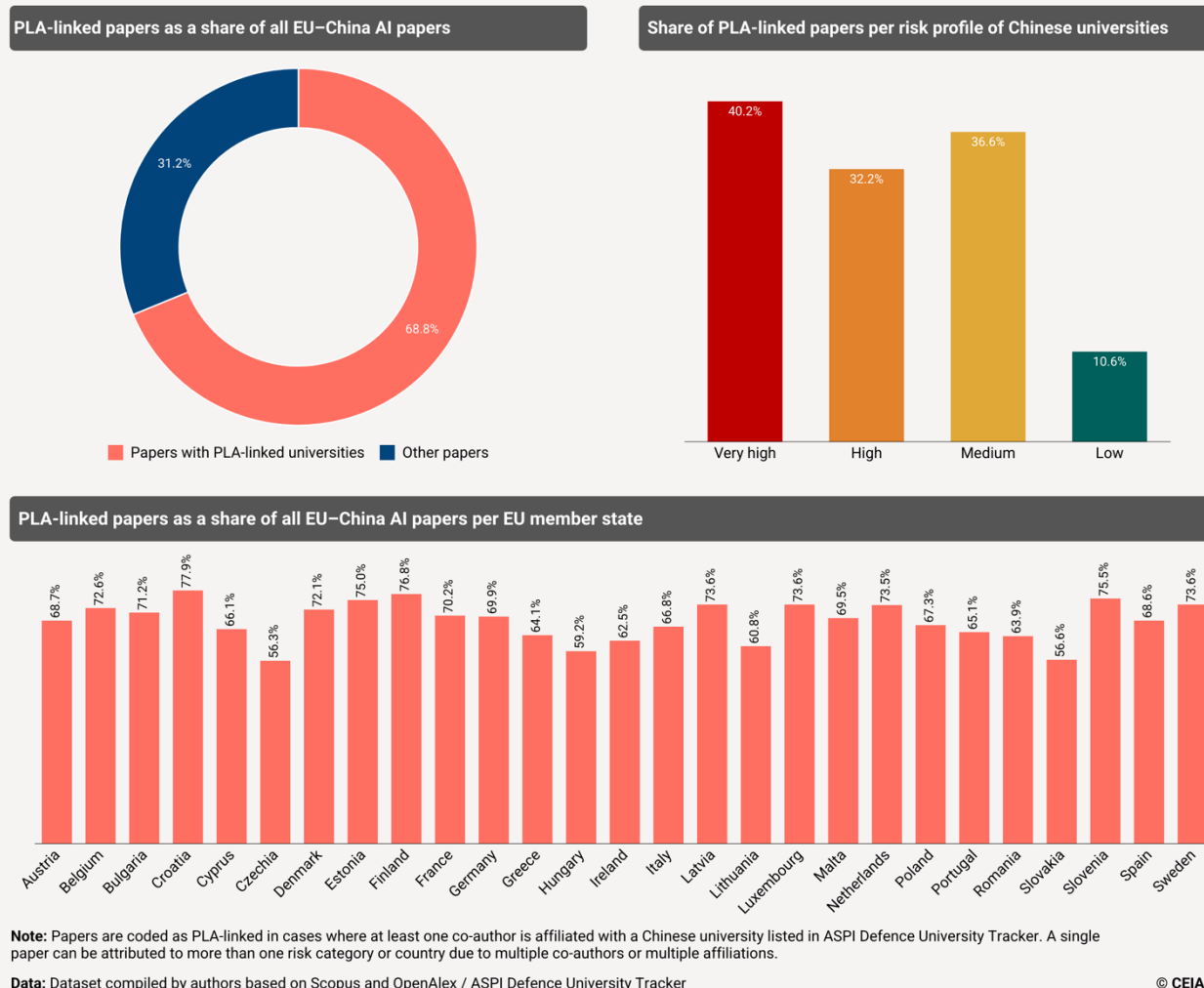
Another example is a 2023 study that adapted face anti-spoofing to surveillance cameras, so that facial-recognition systems can tell a real person from a photograph, video or 3D mask even when the face is captured at long distance and in poor image quality. This work involved researchers at the Chinese Academy of Sciences' Institute of Automation (CASIA), and a co-author affiliated with the University of Barcelona, the Computer Vision Center in Barcelona and Aalborg University in Denmark, and built a dataset of 101 people filmed in 40 surveillance scenes. While such research has clear civilian applications, including securing phones, payment systems and access controls, it can also strengthen biometric identification and surveillance capabilities. This is particularly worrisome considering CASIA's proven defense links. RAND Europe classifies CASIA as a "Core Defense Partner," an institution "deeply involved in research and programs that strengthen and sustain China's defense capabilities".<sup>72</sup> Furthermore, a Hoover Institution study has documented cooperation between CASIA's subdivisions and commercial affiliates and Chinese public-security organs on mass-surveillance technologies associated with human-rights abuses, particularly in Xinjiang.<sup>73</sup>

University of Barcelona and Aalborg University are far from being the only European partners of CASIA. Researchers affiliated with the institute produced 256 joint outputs with European partners between 2015–2025. For example, a 2015 evaluation of deep convolutional networks for face recognition was co-authored by two researchers from CASIA's Center for Biometrics Security Research, and a researcher affiliated with both the French National Institute for Research in Digital Science and Technology (INRIA) and a University of Surrey with other researchers from

# AI research with PLA-linked Chinese universities



Share of papers co-authored with scientists from universities tied to Chinese military (2015-2025)



University of Surrey and Queen Mary University of London. The study acknowledged Horizon 2020 funding, in which Queen Mary was a partner and a British project on signal processing in a networked battlespace supported by the Defence Science and Technology Laboratory held by a consortium that included University of Surrey.

Similarly, despite its extensive links to the Chinese military and defense industrial complex and its designation as a very high-risk partner by the ASPI China Defence University Tracker, Tsinghua University ranks as the second most active Chinese partner in our dataset and maintains extensive research ties across Europe.

The CEIAS China-Europe Academic Engagement Tracker lists nine formal partnerships between Tsinghua and EU-based research institutions which explicitly mention cooperation on AI.<sup>74</sup> This includes the University of Cyprus, France’s CentraleSupélec and Paris-Saclay University, RWTH Aachen University and the Technical University of Munich from Germany, as well as the University of Ljubljana (Slovenia) and Trinity College Dublin (Ireland). The University of Amsterdam (Netherlands) cooperates with Tsinghua through the Joint Research Center for Logic, founded in 2014, which recently conducted AI-related work on large language models (LLMs) and logical reasoning.<sup>75</sup>

Our dataset found joint research with potential dual-use applications. One paper, by two Tsinghua researchers and a researcher affiliated with both the German Aerospace Center (DLR) and the Technical University of Munich used a recurrent neural network to detect land cover change in satellite images over time. The method was built for environmental monitoring, but change detection of this kind can also support geospatial intelligence on military installations or other strategic sites.

The university plays an important role in China's military-civil fusion strategy and in advancing military applications of AI. Tsinghua Vice President You Zheng emphasized the university's contributions to military research and to enabling China's emergence as an "AI superpower."<sup>76</sup> He also referenced the research of Prof. Zhang Bo and his team on future human-machine cooperative (combat) operations, funded by the Central Military Commission (CMC) Science and Technology Commission National Defense Frontier Innovation Special Zone. With support from the PLA's CMC, Tsinghua also built the "High-End Laboratory for Military (Artificial) Intelligence."<sup>77</sup> In 2017, the university launched the Military-Civil Fusion National Defense Peak Technologies Laboratory, creating a platform for pursuing dual-use applications of emerging technologies.<sup>78</sup>

Zhejiang University, alma mater of DeepSeek founder Liang Wenfeng, was the third most active Chinese institution in the dataset despite being classified as high risk institution by ASPI Defence University Tracker. The cooperation also included research with dual-use potential. A 2024 conference paper co-authored by researchers from Zhejiang University and France's EURECOM proposed a new federated learning method for UAV swarms, allowing drones to collaboratively improve a shared AI model without exchanging raw data, even under unstable communication conditions. While such capabilities have civilian uses, they are also relevant to military UAV swarms operating under unreliable communication conditions.

Another paper, co-authored by researchers from Zhejiang University, China Academy of Space Technology and the Shanghai Radio Equipment Research Institute and one researcher affiliated with the University of Oulu in Finland introduced a new machine-learning method for automatically identifying and classifying ships in synthetic-aperture radar images.

Zhejiang University is co-administered by the State Administration for Science, Technology and Industry for National Defense, which coordinates scientific research related to national defense.<sup>79</sup> As the university also hosts several defense-related laboratories, research produced through such cooperation can feed into defense-related applications.<sup>80</sup>

The volume of joint publications between researchers from the Danish Aalborg University and China's University of Electronic Science and Technology of China (UESTC) indicates one of the most productive relationships in our dataset, with 192 joint outputs. The Aalborg-UESTC cooperation mainly focuses on controlling microgrids and power-distribution systems, making local electricity networks more efficient and better able to balance supply and demand using AI and multi-agent coordination, including improving the sharing of data and computing tasks across connected devices without centralizing all the data.

Located in Chengdu, UESTC is considered the "cradle of China's national electronic industry"<sup>81</sup> and has particularly deep roots in China's defense-industrial system. It was recognized as one of China's defense-industry academies as early as 1961<sup>82</sup> and today hosts multiple defense laboratories and designated defense research areas, including signal processing and anti-jamming technology, optics and radar-related materials.<sup>83</sup> It is institutionally linked to the State Administration for Science, Technology and Industry for National Defense, and China Electronics Technology Group Corporation (CETC), one of China's major state-owned defense electronics contractors. Its cooperation with Aalborg University included a Master's and PhD exchange agreement between 2019 and 2024.<sup>84</sup> Aalborg, however, faced wider scrutiny of its Chinese

partnerships in Danish media, and the university reviewed its existing agreements and tightened its procedures for approving new formal cooperation with Chinese institutions in 2020.<sup>85</sup>

In addition to its cooperation with Aalborg University, UESTC opened a joint center with the Dublin Institute of Technology in 2018 (the university has since then merged with two others to form Technical University Dublin).<sup>86</sup> The institute, the Sino-Irish Research and Innovation Institute for Novel and Emerging Sciences and Technologies, focuses on artificial intelligence.<sup>87</sup> UESTC is also included in the US Entity List, the Canadian Named Research Organizations List, and the Japanese Ministry of Economy, Trade and Industry's (METI) End User List.<sup>88</sup> The US Department of Defense has further listed the university as "engaging in problematic activity such as the unwanted transfer of US research and technology, together with foreign talent recruitment programs confirmed as posing a threat to US national security interests."<sup>89</sup> Furthermore, in the past it has been linked to Chinese state-sponsored hacking activities<sup>90</sup> and has close links to China's state-owned military drone industry.<sup>91</sup>

While cooperation with the Chinese universities in the Seven Sons of National Defense group is not among the most productive in terms of output volume, it may present the highest risks, given the seven universities' deep embeddedness in the Chinese military-industrial complex. Our dataset included a paper published in 2017, involving three researchers from Harbin Institute of Technology, including its Center for Control Theory and Guidance Technology, and a researcher from Aalto University in Finland. The paper proposed an algorithm for selecting the aiming points of missiles attacking a group of targets, with funding that included the China Academy of Space Technology.

The China-Europe Academic Engagement Tracker has recorded 13 formal partnerships between EU research institutions and the Seven Sons universities which include AI cooperation. Beijing Institute of Technology (BIT) cooperates with four European partners: the Institute of Physics in Croatia,<sup>92</sup> the Tallinn University of Technology in Estonia,<sup>93</sup> the Technical University of Košice in Slovakia,<sup>94</sup> and the University of Groningen from the Netherlands. In the latter case, BIT and the University of Groningen have agreed in 2019 to establish a Joint Research Laboratory on Intelligent Systems and Control, which aims at "developing new theories and methods on learning, control, and computational intelligence for autonomous systems." Beihang University cooperates with the Belgian Université Libre de Bruxelles and French Grenoble Alpes University and CentraleSupélec, one of France's top AI research institutions, part of the Université Paris-Saclay ecosystem. Harbin Institute of Technology also cooperates with CentraleSupélec, as well as two other French schools, the University of Bordeaux, and the University of Clermont Auvergne. The Northwestern Polytechnical University cooperates with Croatia's University of Zagreb and Belgium's Vrije Universiteit Brussel. Meanwhile, the Nanjing University of Science and Technology has an ongoing partnership with the University of the Balearic Islands in Spain.

But cooperation with the Seven Sons of National Defense on AI also happens outside formal partnerships, likely driven by the personal interests of the researchers involved. Approximately 9% of all recorded papers (3,176 papers) in the sample have at least one co-author affiliated with one of the Seven Sons of National Defense. Most activity is recorded with Beihang University (729 papers), Northwestern Polytechnical University (698 papers), and Harbin Institute of Technology (663 papers). From a longitudinal perspective, we also observe growth in jointly produced papers, consistent with AI-related cooperation with China overall, not just the Seven Sons. While in 2015 we identified only 73 co-publications between European research institutions and the Seven Sons, by 2025 the volume of co-authored papers on AI per year grew to 542 publications. This cooperation has been most productive with the French National Center for Scientific Research (CNRS), the University of Oulu (Finland), Université Paris-Saclay (France) and Delft University of Technology (Netherlands). Overall, collaborative research on AI with the Seven Sons of National Defense tends to focus mostly on deep learning (34.8% of papers), core machine learning (31.3%), and computer vision (15.8%).

Partnerships also exist on the academia-to-business level. The China-Europe Academic Engagement Tracker has recorded 10 AI-focused partnerships between EU academia and Huawei. In some cases, this supports the establishment of research infrastructure, as at the Technical University in Košice (Slovakia), which opened a research center on artificial intelligence with Huawei in 2021.<sup>95</sup>

Huawei is also recorded as an existing affiliation of at least one co-author in 668 analyzed EU–China papers on AI. In 26 papers, Huawei is also acknowledged as a funder of the research. Given the business nature of Huawei’s operations, the actual scope of its cooperation with European researchers is likely broader, as commercially contracted research services from European academia are unlikely to appear in academic publications. Conducting research with or for Huawei (or other Chinese businesses) carries a clear risk to European competitiveness, as it can siphon innovations away from the EU.

Cooperation on AI with Chinese tech companies, especially in areas like facial and voice recognition, also carries potential risks of abuse through domestic surveillance within China and suppression of ethnic and religious minorities like Tibetans and Uyghurs. In 2021, a Huawei patent filed three years earlier with the Chinese Academy of Sciences drew attention for applying deep-learning artificial-intelligence techniques for racial recognition based on photography or video.<sup>96</sup> European research institutions can be potentially complicit in surveillance and repression applications of AI within China as well. For instance, the University of Augsburg, together with Huawei, conducted research on recognizing human emotion from voice, speech and facial expressions,<sup>97</sup> which has potential applications for repression in China and elsewhere, as China increasingly exports its governance model and the technological solutions underpinning it.

Separate CEIAS research has also shown that a significant portion of EU–China cooperation in AI innovation happens at the business-to-business level.<sup>98</sup> While this issue stands outside the scope of this paper, it warrants at least a cursory note, as it helps illustrate the need to broaden research security practices beyond academia to business-driven innovations in critical technologies.

# Quantum technologies: Basic research today, strategic capabilities tomorrow

## China's quantum bet

Quantum technologies are increasingly treated as strategically important because of their potential to transform computing, communications, sensing, and cryptography. Their applications could range from solving complex computational problems and developing new materials or drugs to secure communications and highly precise navigation and detection systems. Much of the field nevertheless remains closely connected to fundamental science, while the eventual commercial and military applications of many quantum technologies are still uncertain.

China considers quantum technology important for technological competitiveness and national security. In October 2020, Xi Jinping described accelerating quantum science and technology as important for both high-quality development and safeguarding national security, while calling for greater investment in universities and research institutes, breakthroughs in core technologies and stronger technological self-reliance.<sup>99</sup>

### Quantum technologies: Key terminology

| Area                         | Description                                                                                                 | Main civilian applications                                                                                | Security or military relevance                                                                                                                                    | Current maturity                                                                                                                  |
|------------------------------|-------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| <b>Quantum computing</b>     | Use of quantum processors to solve certain problems that are extremely difficult for conventional computers | Drug and materials discovery, optimization, finance, logistics, chemistry, machine learning               | Cryptanalysis, optimization of military logistics, simulation of materials and weapons-related processes, and support for complex intelligence analysis           | Low maturity. Existing technology is useful mainly for experimenting; large-scale fault-tolerant systems remain under development |
| <b>Quantum communication</b> | Use of quantum properties to transmit or protect information, especially through quantum key distribution   | Secure government and corporate communications, financial networks, protection of critical infrastructure | Particularly relevant for highly secure military and government communications. Quantum networks can help detect interception and protect sensitive command links | Most mature of the three in some applications. QKD networks and satellite demonstrations already exist                            |
| <b>Quantum sensing</b>       | Use of quantum effects to measure physical phenomena with extremely high precision                          | Medical imaging, geology, navigation, infrastructure monitoring, scientific measurement                   | Navigation without GPS, submarine detection, radar, magnetic and gravitational sensing, and precision intelligence and surveillance                               | Some technologies are already usable; others, especially long-range military sensing applications, remain experimental            |

The 14th Five-Year Plan subsequently identified quantum information as one of the frontier technologies targeted by major national science and technology projects, alongside AI and integrated circuits. The same plan also called for coordinated military-civil development in quantum technology, shared research infrastructure, and the two-way transfer and application of research results between civilian and military research systems.<sup>100</sup> The subsequent 15th Five-Year Plan period (2026–2030) identified quantum technology as one of the future industries in which China aims to achieve further technological breakthroughs.<sup>101</sup>

Advances in quantum communications could provide highly secure military communications, while quantum sensing could improve navigation where satellite signals are unavailable and potentially enhance the detection of submarines and other targets. More capable quantum computers could eventually strengthen cryptanalysis and undermine existing encryption. China continues to invest heavily in these capabilities. China's 15th Five-Year Plan for 2026–2030 calls for faster military technology innovation, the transfer of advanced technologies into defense, and closer integration between civilian technological capabilities and new forms of combat power.<sup>102</sup>

China's approach is strongly state-driven. A 2025 US-China Economic and Security Review Commission study describes China's quantum ecosystem as heavily shaped by government coordination and state ownership, in contrast to a more decentralized and commercially driven US system.<sup>103</sup> Hefei has emerged as the center of this ecosystem, bringing together the University of Science and Technology of China (USTC), major Chinese Academy of Sciences quantum laboratories and a growing cluster of quantum companies along the city's "Quantum Avenue."<sup>104</sup> QuantumCTek and Origin Quantum, for example, both grew out of USTC-linked research, illustrating the close relationship between publicly supported science and commercialization. QuantumCTek was founded in 2009 by a USTC research team, while Origin Quantum was established in 2017 by USTC quantum researchers to commercialize more than a decade of laboratory work.<sup>105</sup>

China has established its clearest advantage in quantum communications. RAND assesses China as the global leader in both high-impact research and demonstrated technical capability in this area.<sup>106</sup> In 2016, China launched *Micius*, the world's first dedicated quantum communications satellite, and subsequently connected it with an over 2,000-kilometer quantum key distribution backbone between Beijing and Shanghai. More recently, Chinese researchers demonstrated quantum key distribution between China and South Africa using a quantum microsatellite, extending the international reach of these capabilities.<sup>107</sup>

China has also made significant progress in quantum computing. USTC has demonstrated several advanced quantum-computing systems, including the photonic Jiuzhang series and the superconducting Zuchongzhi processors. Its 105-qubit Zuchongzhi-3 system was unveiled in 2025, while companies such as Origin Quantum are working to commercialize domestically developed hardware.<sup>108</sup> At the same time, the US ecosystem is much more heavily driven by a stronger private sector, with over 150 US firms active in quantum technologies, while only a handful of Chinese quantum-computing firms are globally competitive.<sup>109</sup> Meanwhile, major technical barriers remain unresolved globally, particularly scaling qubit systems while maintaining reliability and achieving effective error correction, meaning practical large-scale quantum computers are still under development.<sup>110</sup>

China's rise in quantum science is increasingly visible in publication performance. Since 2022, China has produced more quantum-related research papers annually than any other country and led globally in highly cited quantum publications between 2019 and 2023, with particularly strong performance in quantum communications.<sup>111</sup> The picture is more mixed in quantum computing, where the US retains a stronger research position. Europe meanwhile remains an important center of fundamental quantum science. The EU's Quantum Europe Strategy, adopted in 2025, builds on what the Commission describes as Europe's world-class research base while seeking

to strengthen commercialization, infrastructure, start-ups, and dual-use applications, with the objective of positioning Europe as a global quantum leader by 2030.<sup>112</sup> Against this backdrop, substantial and long-standing scientific ties between Europe and China create both opportunities and research-security challenges.

## Europe's quantum ties with China are deepening

The China-Europe Academic Engagement Tracker has identified and mapped 104 formalized partnerships that appear to focus on quantum technologies, among other areas. As many as 77 partnerships have been identified in France, with 65 formed with Chinese universities known for their links to the PLA.

In terms of research outputs, between 2015 and 2025, our dataset records 9,706 quantum-related publications co-authored by researchers affiliated with institutions in China and the EU. The cooperation is concentrated in a relatively small number of research areas. The largest category is quantum materials, with 2,829 outputs examining materials and physical systems used to create, manipulate, and preserve quantum states. The second-largest category is quantum devices and hardware engineering, with 2,171 publications focused on fabrication, integration and scaling, the steps needed to move from laboratory demonstrations towards stable and deployable quantum systems. A further 1,310 publications concern quantum information theory, entanglement and foundational research, while 734 focus on quantum sensing. Quantum communications, an area in which China holds a particularly strong international position, account for another 556 publications.

Very few publications were explicitly classified as dealing with military, defense or security applications. This should not, however, be interpreted as evidence that the research lacks security relevance. Because many advances in quantum technologies are inherently dual-use, the security implications of quantum research may emerge downstream rather than being visible in the stated purpose of individual academic publications.

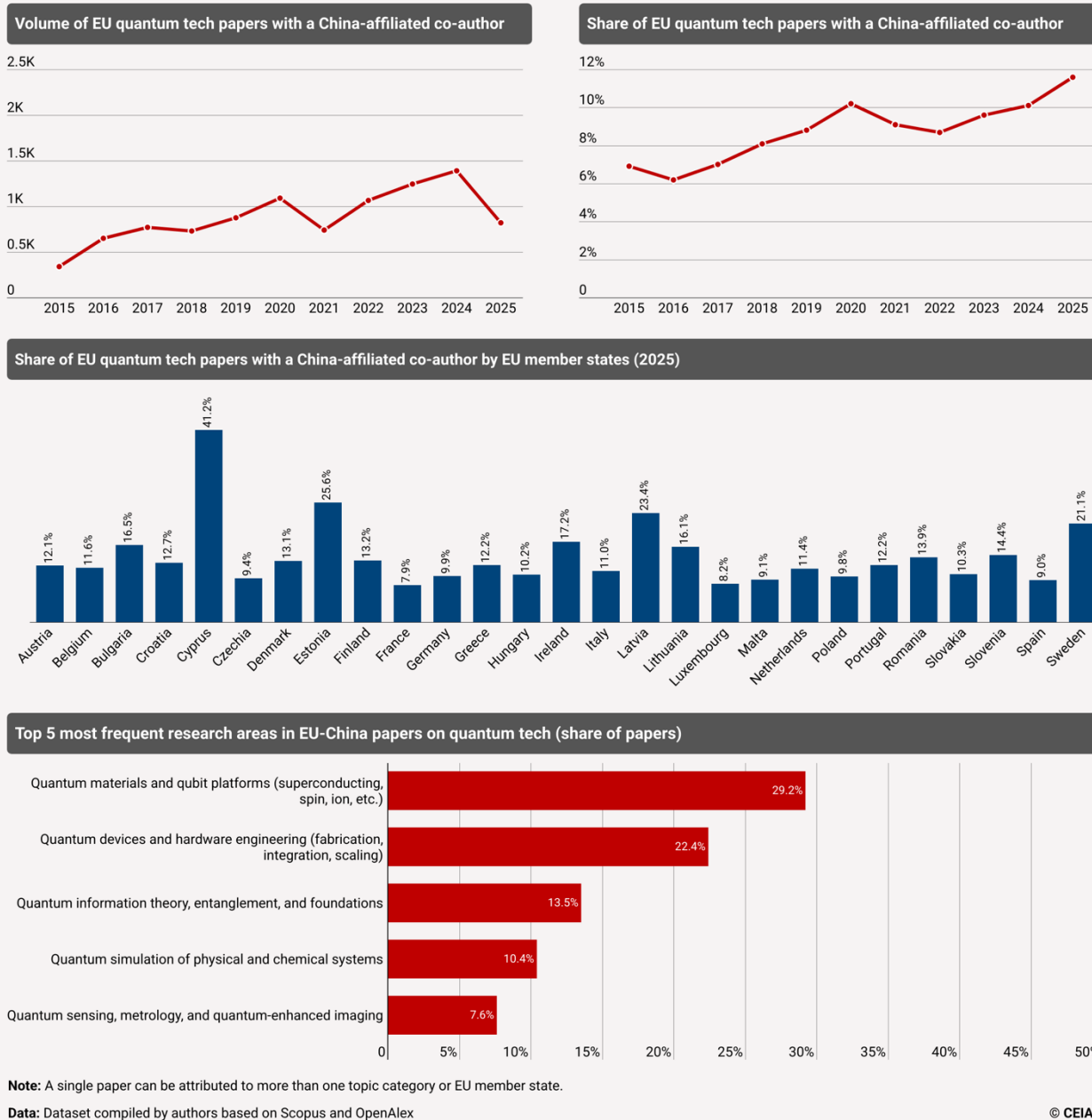
The overall trajectory points to a strengthening of EU–China research ties. The share of European quantum research involving Chinese partners rose from 6.9% in 2015 to 11.6% in 2025 of all quantum-related papers having at least one European affiliation. In absolute terms, the annual number of joint outputs peaked in 2024 at 1,376 publications. Sweden stands out among the larger research systems, with its share rising from 11.6% to 21.1%, while Finland and Denmark also recorded substantial increases. Although the absolute volume of papers in 2025 has sharply dropped, the share of China-related co-publications on overall quantum technology papers has still increased. Despite year-to-year variation, cooperation became substantially more embedded in European quantum research over the decade, even as research security and technological de-risking gained greater prominence in EU policy.

The geographical distribution broadly reflects Europe's strongest quantum research systems. Germany is by far the largest European contributor to EU–China quantum cooperation in terms of publication volume, with 3,226 joint publications between 2015 and 2025, consistent with its position as one of the world's leading centers of quantum research. Germany currently ranks third globally in the Nature Index for quantum physics, behind China and the US.<sup>113</sup> Its research base includes several internationally prominent institutions such as the Max Planck Society, which ranks third globally among institutions.<sup>114</sup> Germany is also considered among the leading countries in quantum computing and post-quantum cryptography, supported by major research clusters such as Munich Quantum Valley, which brings together the Technical University of Munich, Ludwig Maximilian University of Munich, the Max Planck Society and other research organizations.<sup>115</sup> France, Spain, and Italy follow Germany as the most active EU countries in cooperation with China.

# EU-China research cooperation in quantum technologies



Scope and trends of scientific cooperation (2015-2025)



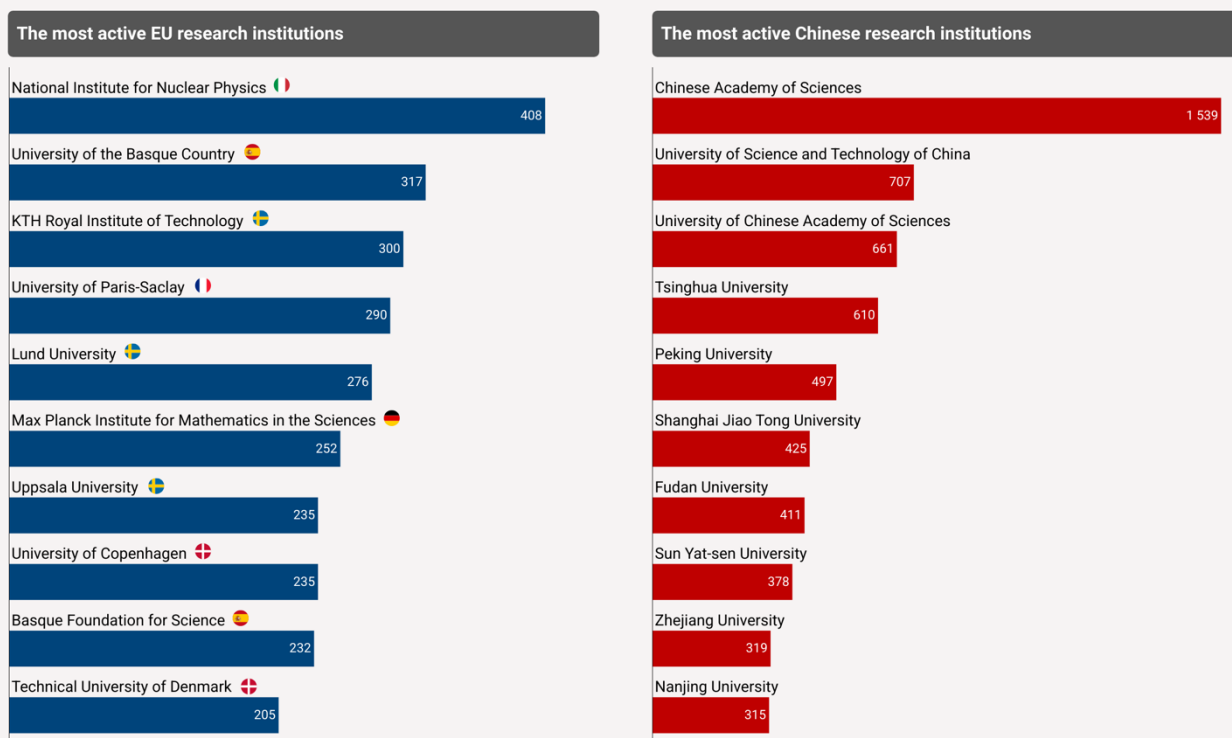
At the institutional level, however, the pattern is somewhat different. The Italian National Institute for Nuclear Physics, the University of the Basque Country, and KTH Royal Institute of Technology in Sweden record the largest numbers of joint publications.

On the Chinese side, cooperation is dominated by the Chinese Academy of Sciences, the University of Science and Technology of China (USTC) and the University of Chinese Academy of Sciences (UCAS), China's leading institutions in the field. In the 2026 Nature Index ranking for quantum physics, USTC ranked first globally, followed by the Chinese Academy of Sciences ranked second.<sup>116</sup>

# Most active players in EU-China quantum research



Top 10 most active research institutions in EU and in China (2015-2025)



Data: Dataset compiled by authors based on Scopus and OpenAlex

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Large international physics collaborations can generate co-authorship that does not necessarily reflect close interaction between the researchers involved. In the quantum dataset, this is particularly relevant for hyper-authored publications from collaborations such as ATLAS, CMS, LHCb and BESIII, where a single paper can include hundreds or thousands of authors from many institutions. As a result, these publications can inflate the apparent intensity of particular institutional partnerships and, where defense-linked Chinese universities appear in the author list, also increase the measured share of publications involving high-risk institutions.

## Security risks in quantum cooperation with China

Overall, 72.0% of EU–China quantum publications involved at least one Chinese institution flagged by the ASPI China Defence University Tracker. Among these, papers co-authored with scientists based at Chinese PLA-linked universities labeled as very high risk represented 32.7% and high risk 30.7%. As a single publication can involve partners at more than one risk level, these categories overlap.

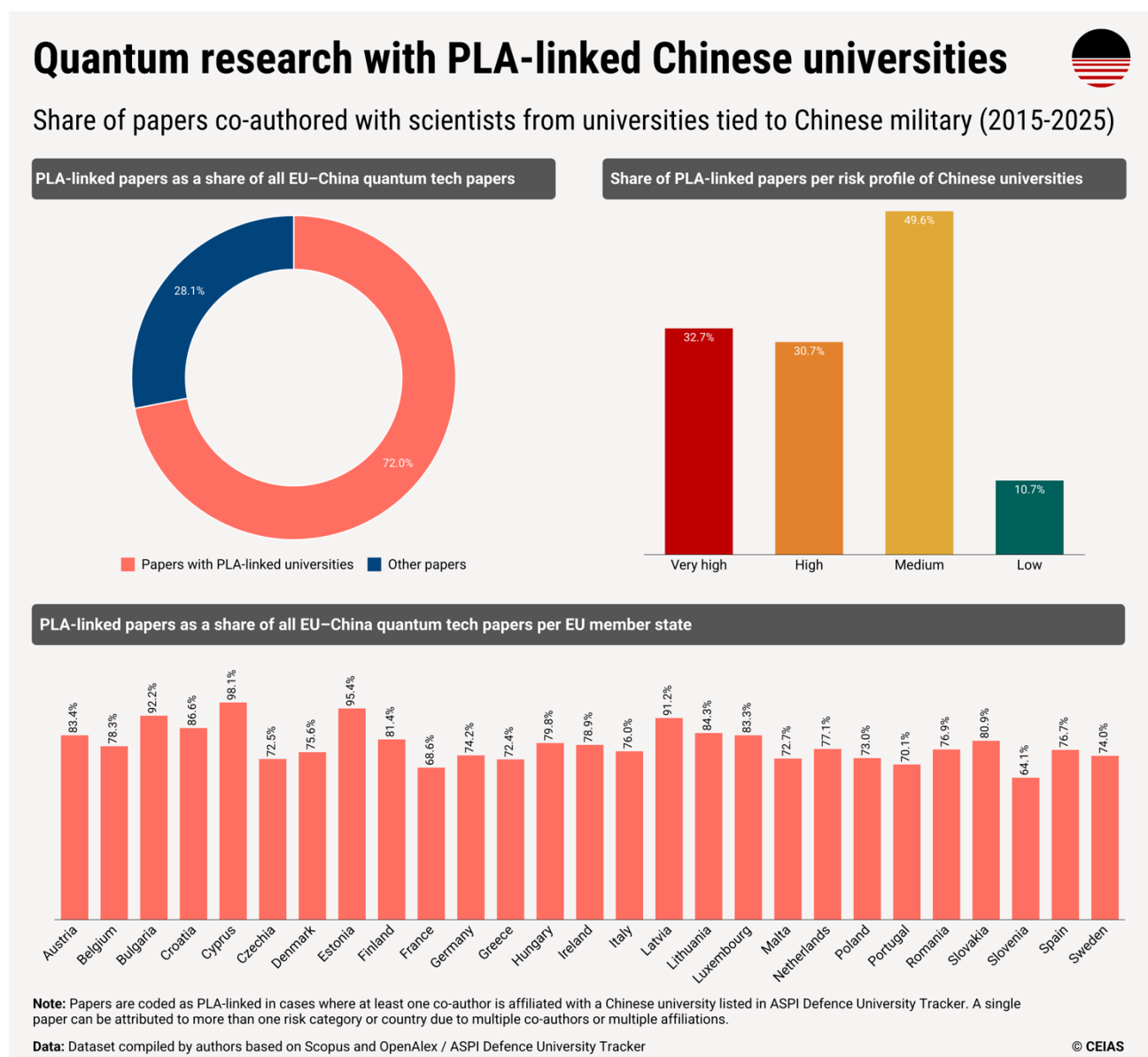
In every EU member state, publications involving flagged Chinese partners outnumbered those involving non-flagged institutions. This share was particularly high in Bulgaria, Cyprus, Estonia, and Latvia, where publications with PLA-linked partners accounted for more than 90% of all collaborative papers. On the lower end, between 60% and 70% of papers, we found Greece, France, Portugal, and Slovenia.

This pattern did not change substantially over time. Collaboration with high-risk institutions increased modestly between 2018 and 2020 and has remained broadly stable since 2022. The

publication record therefore provides little evidence that growing European concern over research security has yet produced a significant shift away from Chinese institutions with documented defense links.

The data show that European quantum research is deeply connected to Chinese institutions that also participate in China's defense and military-civil fusion system, creating risks that Chinese partners may use results for further (applied) research, with the PLA as the primary beneficiary. This underscores the need to conduct further due diligence, considering not only the project topic but also the institutional setting and potential downstream applications of the research.

Several of the most active Chinese partners also have documented links to the defense sector. Four of the ten leading institutions in our dataset—Peking University, Tsinghua University, Zhejiang University and Shanghai Jiao Tong University—are classified as high or very high risk in the ASPI China Defence University Tracker. Tsinghua University and Peking University have especially broad European networks. Both universities rank among the ten leading Chinese partners in quantum research in more than twenty EU member states.



The Chinese Academy of Sciences and its institutes are among the most active Chinese partners in quantum research with European institutions. Among them is the Shanghai Institute of Optics and Fine Mechanics of the Chinese Academy of Sciences (SIOM), which focuses on high-power lasers, optical security, and photon detection. According to RAND, SIOM is a Regular Defense Partner due to holding several military-technology patents and its researchers regularly cooperating with PLA academic institutions and defense laboratories.<sup>117</sup> SIOM also jointly built the Shenguang-II laser facility with the Shanghai Institute of Laser Plasma of the China Academy of Engineering Physics (CAEP),<sup>118</sup> China's principal nuclear weapons research institution, responsible for much of the research, development, testing, and production associated with the country's nuclear weapons program.<sup>119</sup> The Shenguang-II facility supports research in inertial confinement fusion and high-energy-density physics, both of which have potential applications in nuclear weapons development. Among other papers, SIOM researcher contributed to a paper with French and Belarussian co-authors, which focused on how to stretch and compress squeezed-light signals in time while preserving their quantum properties. While not directly dual-use, this research is seen as fundamental enabling research with potential downstream dual-use applications in areas like quantum communications and quantum sensing.

The most productive relationship is between the Max Planck Institute for Mathematics in the Sciences and Capital Normal University, with 235 joint outputs. Much of the high publication volume appears to be driven by the long-running work of one particular researcher who has held affiliations with both institutions. Some of this work also includes research on quantum key distribution, quantum information masking and quantum non-locality in networked quantum systems. Although these papers are primarily theoretical studies, they concern concepts that underpin the future of secure communications and cryptography.

The second-largest number of joint publications was recorded between the Institute of High Energy Physics of the Chinese Academy of Sciences and the Italian National Institute for Nuclear Physics (INFN), with 190 publications, reflecting a long-standing partnership in high-energy and fundamental physics. Beyond this partnership, researchers affiliated with INFN have also collaborated with other Chinese research institutions. For example, a researcher from the Italian National Institute for Nuclear Physics in Padova co-published a study on quantum radar with a researcher affiliated with the CAS Chongqing Institute of Green and Intelligent Technology. Their paper proposes a quantum radar protocol that uses entangled photons to locate a non-cooperative target in three dimensions with greater precision than classical light of the same average intensity. While the paper itself does not test a military system, military applications include more precise target detection and localization, air and missile defense, tracking aircraft or missiles, surveillance and reconnaissance, and potentially improved radar performance against difficult or non-cooperative targets. In another case, researchers from the Italian National Metrology Institute (INRIM), including one also affiliated with the INFN Turin, collaborated with researchers from Beijing Academy of Quantum Information Sciences to develop a method to make quantum-secured communication more reliable over long-distance fiber networks, and successfully tested it over 206 km of real-world fiber. Its military relevance lies in highly secure communications for command and control, defense networks, intelligence, and links between sensitive facilities, although the paper itself focuses on civilian telecom infrastructure. This research illustrates an increasingly broad grey area in which it is difficult to balance preserving open scientific cooperation with avoiding contributions to technological capabilities that could ultimately strengthen China's military or security systems.

Although Heidelberg University does not feature among the ten most active European institutions in our dataset, Strider Technologies described it in 2019 as "arguably the most important foreign partner behind China's rapid progress in dual-use quantum technologies."<sup>120</sup> Central to the relationship was physicist Pan Jian-Wei, who worked at Heidelberg from 2003 to 2008 before returning to USTC. During this period, he built research teams linking Heidelberg and Hefei. According to CORRECTIV and DW, laboratory equipment and several research projects were later

transferred from Heidelberg to USTC, while researchers were recruited through Chinese talent programs.<sup>121</sup> Pan's Heidelberg group had also benefited from substantial German and EU research funding.

Shortly after his return, Pan co-founded QuantumCTek, which later participated in military-related projects and developed links with the state-owned defense electronics conglomerate CETC. In 2018, USTC and CETC signed a strategic cooperation agreement covering quantum detection and communication technologies.<sup>122</sup> Cooperation with Heidelberg nevertheless continued. The two institutions signed a student and staff exchange agreement in 2011 and produced 86 joint quantum publications between 2015 and 2025.<sup>123</sup> Plans announced in 2016 for a joint quantum research center also referenced the National University of Defense Technology, although the center was never established. Heidelberg subsequently created an export-control unit in 2022 as scrutiny of dual-use cooperation increased.<sup>124</sup>

While most Heidelberg–USTC publications in our dataset are large multilateral consortium papers, we also see a continuation of the cold-atom and quantum-simulation research conducted by Pan Jian-Wei's group, which he built at Heidelberg from 2003 onwards and where he has been an honorary professor since 2009. USTC's wider European collaborations extend further into security-relevant technologies. These include single-photon sources, which generate the individual light particles used in photonic quantum computing and quantum communication, developed with DTU and Würzburg, device-independent quantum key distribution, which aims to make secure communication possible even when the underlying devices cannot be fully trusted, reviewed jointly with researchers from Munich and Vigo, and quantum digital signatures, which use quantum methods to verify that a message is authentic and has not been altered, demonstrated over a metropolitan fibre network in Hefei with researchers from the University of Vigo and Heriot-Watt University, with the Vigo co-author supported by the Horizon 2020 project QCALL. Together, these technologies form part of the technical foundation for quantum-secure communications, making them relevant to the same strategic capabilities that China has been developing at national scale.

In Austria, a bilateral, publicly funded Sino-Austrian program has seen Anton Zeilinger, an Austrian physicist, cooperate on quantum physics with his Chinese counterparts since the late 1990s.<sup>125</sup> Zeilinger's former Chinese PhD student Pan Jianwei, now a Vice-President at USTC, has also worked in Austria in the past.<sup>126</sup> The prior links between Zeilinger and China's research environment have later enabled the "flight" of his research to China after failing to secure adequate funding for launching and operating a quantum satellite. This became possible only after the project received Chinese funding, resulting in China launching Micius, the world's very first quantum satellite, in August 2016.<sup>127</sup> The case of Zeilinger's cooperation with China shows how scientists might be motivated to move their research to China when they fail to raise sufficient funds in Europe, resulting in loss of opportunities for the European research environment.<sup>128</sup>

Similar to AI, cooperation with the Seven Sons of National Defense is not the most productive, albeit it carries a significant risk of technology transfers to China. The China-Europe Academic Engagement Tracker has recorded formal partnerships between Beihang University and two French universities, Grenoble Alpes University and Paris-Saclay University. The Tracker also records partnerships between Northwestern Polytechnical University and Germany's Technical University of Kaiserslautern and France's Rennes Institute of Physics.

Under a joint Sino-Polish funding mechanism, which was last run in 2024, administered by the National Science Center (NCN) in Poland and the National Natural Science Foundation of China (NSFC), universities could apply for funding for projects undertaken by joint Polish-Chinese research teams.<sup>129</sup> Under this mechanism, an institute of the Polish Academy of Sciences has cooperated with the Beijing Institute of Technology, one of the Seven Sons of National Defense,

and the Institute of Physics, Chinese Academy of Sciences, to research topological materials with potential applications in the production of memory units and devices for quantum computing in 2021.<sup>130</sup> The Polish Academy of Sciences was granted over 2 million PLN (approximately €460,000) through this joint funding mechanism.<sup>131</sup> However, the two Chinese institutions have long been known to be closely linked to the PLA. Researchers from the Institute of Physics, CAS have received defense funding, its laboratories have contributed to defense-critical research and have often collaborated with Chinese defense entities. RAND has classified the institute as a “Core Defense Partner.”<sup>132</sup> It has also been on the US Entity List since May 2024.<sup>133</sup> Beijing Institute of Technology (BIT) is also included on the US Entity List, the Canadian Named Research Organizations List, and the Japanese METI End User List.<sup>134</sup> BIT has been very public about its contributions to military-civil fusion, with its President noting in 2018 that the university has been at its forefront for years.<sup>135</sup> Furthermore, a BIT-affiliated professor was convicted in Japan for leaking sensitive technological information.<sup>136</sup>

Joint research between scientists affiliated with the Seven Sons and European academic institutions has yielded at least 747 papers (7.7% of papers recorded in our dataset). Beihang University is the most active institution, appearing in 307 papers, followed by Beijing Institute of Technology with 144 papers and Harbin Institute of Technology with 101 papers. Over time, the number of published papers has risen from 18 co-publications in 2015 to a peak of 145 in 2024. In 2025, the volume fell to just 81 papers. But this should be viewed in light of typical time lag in bibliometric indexing, and not necessarily as an indication of early success in implementing research security policies across Europe, though further research is needed to confirm this.

Among the top ten most active European research institutions collaborating with the Seven Sons of National Defense, six are from Italy: the National Institute for Nuclear Physics, the University of Perugia, the University of Turin, the University of Eastern Piedmont, and the University of Padua. The remainder includes two academic institutions from Germany (RWTH Aachen University, Karlsruhe Institute of Technology), and two from Belgium (Ghent University, University of Antwerp). Almost all of their joint papers with the Seven Sons come from large collider experiments such as CMS at CERN and BESIII in Beijing, whose publications list hundreds or thousands of authors, so this ranking reflects shared membership of physics consortia.

Joint research involving the Seven Sons is concentrated in technically consequential areas of quantum science and technology. Quantum materials account for 33.7% of Seven Sons-linked papers, followed by quantum devices (25.6%), quantum information (9.5%), quantum simulation (8.7%), and quantum applications (7.0%). This profile spans foundational and enabling research relevant to advanced sensing, computing, communications, and materials technologies, several of which may have dual-use implications.

# Semiconductors: The technology behind everything

## China's race to close the chips technology gap

Semiconductors, often described as an “industry of industries,” underpin virtually all advanced digital technologies, from artificial intelligence and quantum technologies, to telecommunications, autonomous systems, industrial automation, and modern weapons platforms. Their strategic significance derives not only from the chips themselves, but from an exceptionally complex value chain spanning materials, chip design, manufacturing equipment, fabrication, packaging, and testing. No single country currently controls all of these stages. Concentration of key capabilities in a small number of countries and companies has consequently turned semiconductors into one of the principal areas of technological competition between China and the West.

For China, reducing reliance on foreign semiconductor technologies and boosting its chip self-sufficiency has been a national priority for more than a decade. Beijing placed integrated circuits at the center of its industrial-upgrading agenda under Made in China 2025 and subsequently strengthened support for domestic capabilities across the value chain.<sup>137</sup> The push has accelerated as US and allied (especially the Netherlands and Japan) export controls have restricted Chinese access to advanced chips, semiconductor manufacturing equipment, high-bandwidth memory, or electronic design automation (EDA) software.<sup>138</sup> Furthermore, under the Foreign Direct Product Rule (FDPR), US export control laws extend to items made outside the US if those products are created using American technology, software, or manufacturing equipment. These constraints also increase incentives to acquire strategically important know-how through academic and research cooperation, particularly where collaboration can help narrow technological gaps or provide access to technologies that are increasingly difficult to obtain through commercial channels. State support is substantial: the third phase of the China Integrated Circuit Industry Investment Fund, established in 2024, has registered capital of RMB 344 billion (€44.2 billion), making it larger than either of its two predecessors.<sup>139</sup> The Chinese fund is also somewhat larger in direct funding volume than either the EU or the US. The EU 2023 Chips Act aimed to mobilize €43 billion of public and private investment (with €3.3 billion from the EU budget).<sup>140</sup> According to the Commission evaluation, around €52 billion has been committed in public and private investments in semiconductor production facilities. In June 2026, the Commission presented its proposal for a Chips Act 2.0, which is now subject to negotiations with the European Parliament and EU governments. There are indications, however, that the EU level funding under the revised framework “will be scarcer.”<sup>141</sup> Meanwhile, the US Chips Act provided for \$39 billion (€37 billion) in direct grants and loans, but also included around \$46 billion (€43.7 billion) in tax credits for chip manufacturing.<sup>142</sup> The Chinese fund’s investments are expected to focus particularly on semiconductor manufacturing equipment, materials and other parts of the value chain where China remains dependent on foreign suppliers or has been denied access entirely. However, the sector is moving from largely policy-driven localization toward performance-driven competitiveness.<sup>143</sup>

The current 15th Five-Year Plan period (2026–2030) identified integrated circuits as a priority area and called for “decisive breakthroughs” in key and core technologies across the entire

industrial chain.<sup>144</sup> China has already made substantial progress in some parts of the value chain. It is a major producer of mature-node semiconductors and a leading player in chip assembly, testing and packaging, while homegrown capabilities in chipmaking equipment and materials have expanded steadily.<sup>145</sup> However, the process remains uneven across technologies. According to Yole Group, the share of domestically produced equipment used by Chinese chipmakers increased from 8% in 2021 to 23.2% in 2025 and could reach 39% by 2030.<sup>146</sup> China is already making relatively rapid progress in equipment used for etching, depositing materials onto wafers, polishing and wafer thinning, while domestic capabilities in inspection, measurement, cleaning and ion implantation are improving more gradually. Lithography remains the most important technological bottleneck (both in DUV and EUV lithography) and the area where China continues to depend most on foreign suppliers (chiefly ASML from the Netherlands).<sup>147</sup>

China accounted for around one third of global manufacturing capacity at mature nodes in 2024 and could produce over 38% of such chips by 2030.<sup>148</sup> These chips are widely used in cars, industrial equipment, communications and other applications, but they are not the processors used to train the most advanced AI models. China's main weakness remains at the leading edge. The best Chinese chips remain closer in performance to NVIDIA hardware from around five years ago.<sup>149</sup>

Chinese firms have put substantial efforts into working around some of these restrictions and indigenizing the supply chain. SMIC has already manufactured Huawei processors, including the Kirin 9000s, using its second generation 7 nm process without access to EUV lithography using older deep-ultraviolet lithography combined with repeated patterning and other more complex production techniques.<sup>150</sup> This allows Chinese manufacturers to approach the performance of more advanced processes without access to the most sophisticated lithography equipment, but at the cost of greater complexity, lower yields and higher production costs.

Huawei is also pursuing alternative technological pathways to mitigate restrictions on advanced manufacturing equipment. In May 2026, it unveiled LogicFolding, a chip architecture designed to improve transistor density and performance without relying on the most advanced extreme-ultraviolet lithography.<sup>151</sup> The architecture was for the first time employed in a commercial chip with Huawei's Kirin 9050 Pro, launched in September 2026, powering the Mate XT 2 smartphone.<sup>152</sup> According to Huawei, the chip's performance increased by 42% compared with the previous generation with better power efficiency. In July 2026, it was also reported that an unnamed Chinese company, believed to be Shanghai Aishengna Electronic Technology Group, began manufacturing an immersion deep ultraviolet lithography (DUV) machine.<sup>153</sup> However, this is unlikely to shake ASML's position, as adoption will depend on the machine's performance and its ability to scale production.<sup>154</sup>

Chinese equipment manufacturers such as Naura and AMEC have also expanded their capabilities and market share. Thus, export controls meant to restrict China's technological advances have simultaneously created strong incentives for domestic substitution and intensified cooperation across China's corporate and state-backed research ecosystems.

Europe occupies a different position in the semiconductor value chain. The EU accounts for a relatively modest share of global chip manufacturing but retains globally significant capabilities in semiconductor research, manufacturing equipment, power electronics, automotive and industrial chips, and specialized materials. The Netherlands-based ASML holds a unique position in advanced lithography equipment supported by specialized European suppliers such as Germany's ZEISS, which provides the ultra-precision optical systems used in its most advanced machines. Research centers such as Belgium's imec, France's CEA-Leti and Germany's Fraunhofer institutes are globally leading semiconductor R&D organizations. The European Chips Act, in force since 2023, sought to strengthen these capabilities and contribute to the EU's target of reaching 20% of the global semiconductor production by 2030. The proposed Chips Act 2.0,

unveiled in June 2026, revised this target and moved away from the concept of strategic autonomy towards greater emphasis on resilience and technological indispensability, strengthening areas in which Europe can remain essential to global supply chains while relying on trusted partners for capabilities concentrated elsewhere.<sup>155</sup>

China's growing strength is particularly visible in research fields that underpin semiconductor development. In the 2025 Shanghai Global Ranking of Academic Subjects, Tsinghua University ranks first globally in Materials Science & Engineering and first in Electrical & Electronic Engineering, while Zhejiang University ranks 9th and 6th, respectively.<sup>156</sup> Shanghai Jiao Tong University ranks 10th in materials science, and the University of Science and Technology of China (USTC) 12th.<sup>157</sup> By comparison, no EU university appears among the global top 30 in materials science. In electrical and electronic engineering, the highest-ranked EU institution is Aalborg University at 18th and Paris-Saclay ranks 33rd.<sup>158</sup>

The gap is even more pronounced in nanoscience and nanotechnology, a field directly relevant to semiconductor materials, nanoscale devices and fabrication. Chinese universities occupy the top four positions globally: Tsinghua ranks 1st, Zhejiang 2nd, Shanghai Jiao Tong 3rd, and USTC 4th. Peking University ranks 7th, Fudan 9th and Huazhong University of Science and Technology 10th; no EU university appears in the global top 30.<sup>159</sup> China's advantage is less pronounced in the underlying fundamental physics. Here, Paris-Saclay ranks 6th globally, ahead of Peking University (12th), Tsinghua (13th) and USTC (17th), indicating that Europe retains considerable strength in basic physical science even as Chinese universities have built a much larger presence in applied materials, nanoelectronics and electronic engineering.<sup>160</sup>

## Growing research cooperation amidst technological rivalry

The China-Europe Academic Engagement Tracker has identified at least 65 formal partnerships focused on semiconductors between Chinese entities and EU academic institutions. As with AI and quantum, French academia is the most active partner, representing approximately half of the identified partnerships (32), followed by Belgium (8) and the Netherlands (6).

In terms of research output, between 2015 and 2025, our dataset identifies 43,684 semiconductor-related research outputs jointly authored by researchers affiliated with institutions in China and the EU. Much of this cooperation occurs relatively far upstream in the semiconductor value chain. The largest research category concerns the materials from which advanced semiconductor devices are built, including techniques for growing precisely controlled crystalline layers, combining different materials into layered structures, and developing materials such as silicon carbide and gallium nitride for high-power and high-temperature applications, accounting for 16,099 publications. This work examines the materials, nanoscale structures and device-level properties that determine the performance, reliability, and scalability of future electronic systems.

A further 9,377 outputs concern optoelectronics, photonic integrated circuits and electro-optic devices which are becoming an increasingly important part of the semiconductor ecosystem as optical technologies become critical for high-speed communications, AI data centers, sensing, and quantum technologies. Photonics is also one of Europe's comparatively strong deep-tech sectors and retains substantial capabilities in high-value segments such as industrial photonics, instrumentation, optical components and integrated photonics, even though China is the world's largest photonics producer overall. Research more directly connected to manufacturing processes, including lithography, etching, deposition and fabrication flows, accounts for another 5,091 publications.

Only 22 publications were classified as explicitly addressing military applications or dual-use systems, primarily focusing on improving the resilience, durability, and reliability of semiconductor-enabled technologies for defense, aerospace, and space systems. However, this figure says relatively little about the eventual dual-use application of the underlying work. According to the European Commission study, advanced materials, nanoelectronics and photonics are key enabling technologies with high potential for both civilian and defense applications,<sup>161</sup> while MERICS similarly describes semiconductors as inherently dual-use because they underpin both commercial industries and military modernization.<sup>162</sup>

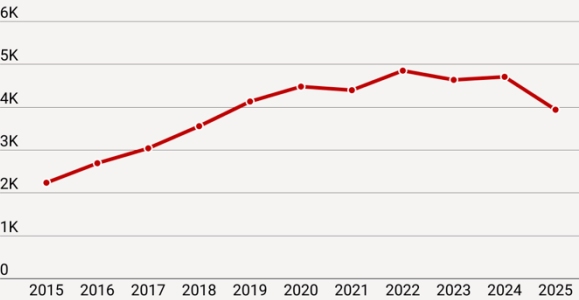
Advances in semiconductor materials can improve high-power radar, electronic warfare and space systems, including through the use of gallium nitride technologies in advanced radar and

## EU-China research cooperation in semiconductors

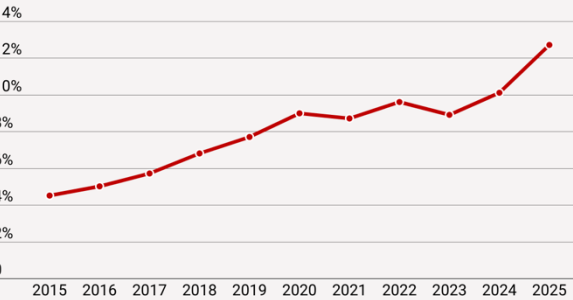


### Scope and trends of scientific cooperation (2015-2025)

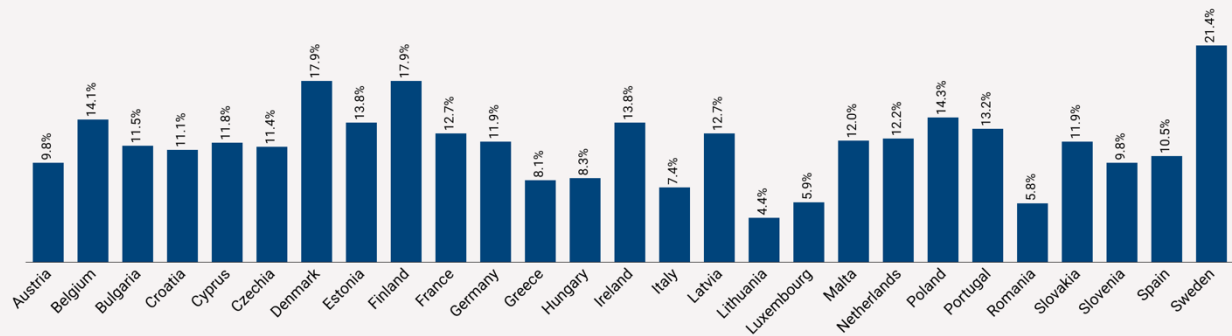
Volume of EU semiconductor papers with a China-affiliated co-author



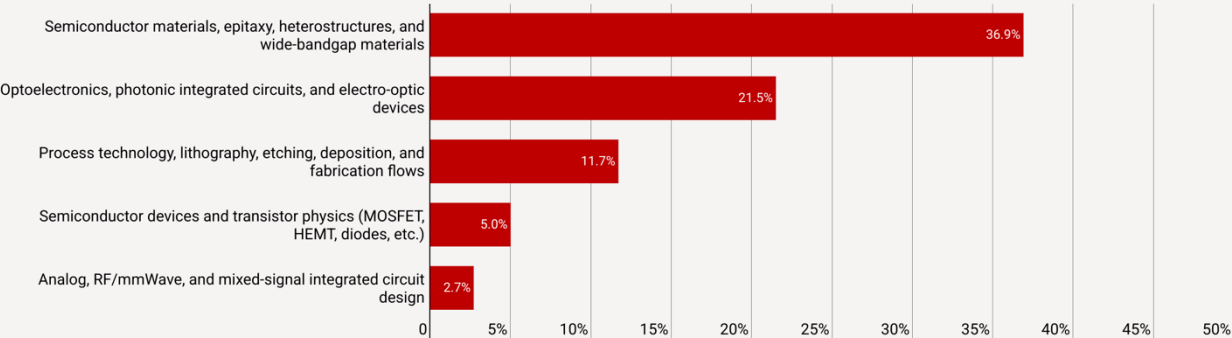
Share of EU semiconductors papers with a China-affiliated co-author



Share of EU semiconductor papers with a China-affiliated co-author by EU member states (2025)



Top 5 most frequent research areas in EU-China papers on semiconductors (share of papers)



Note: A single paper can be attributed to more than one topic category or EU member state.

Data: Dataset compiled by authors based on Scopus and OpenAlex

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jamming applications.<sup>163</sup> Photonic and optoelectronic technologies can support lidar, precision targeting, communications, navigation and sensing.<sup>164</sup> Advanced sensors can be incorporated into drones, satellites, and surveillance systems to monitor activity and identify threats.<sup>165</sup> More broadly, semiconductor technologies developed primarily for commercial applications can subsequently become important components of military systems.<sup>166</sup> Thus, technological development is increasingly blurring the boundary between civilian and military technologies, making it difficult to identify eventual security applications from the original research purpose alone.<sup>167</sup>

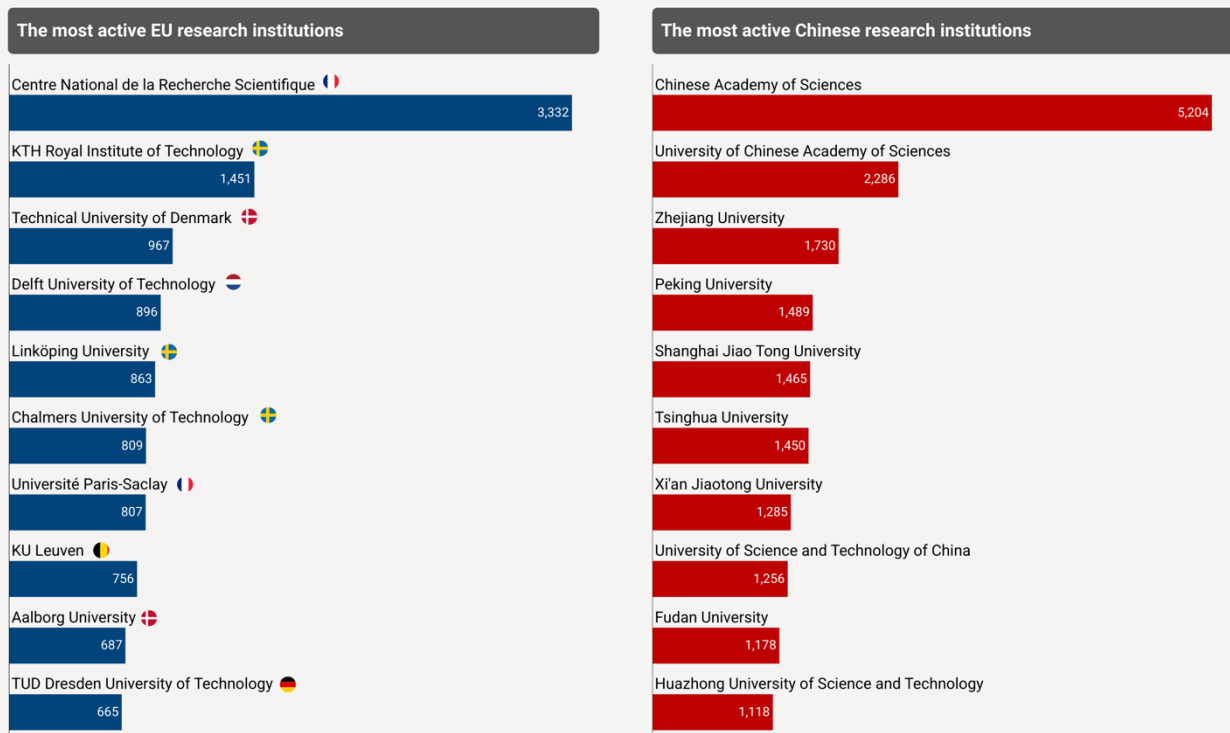
EU-China semiconductor research ties expanded considerably over the decade. Across EU member states, the average share of semiconductor research involving Chinese partners rose from 4.5% in 2015 to approximately 12.7% in 2025, almost tripling. In 2015, only Sweden had more than 10% of its semiconductor co-publications with China. By 2025, nineteen EU countries had more than 10% of their semiconductor research co-authored with Chinese partners.

The geographical pattern broadly corresponds to Europe's major semiconductor research and industrial ecosystems. Germany is by far the largest European contributor, with 12,680 joint publications between 2015 and 2025, followed by France with 8,074 and Sweden with 4,952. Germany's prominence is consistent with its wider position in the European semiconductor sector. More than one third of chips produced in Europe are manufactured in Germany, while German inventors account for around 5.6% of global semiconductor patents, making Germany by far the largest EU contributor.<sup>168</sup> France similarly combines a substantial semiconductor industrial base with major public research capacity, particularly around CNRS and CEA-Leti, while Sweden has strong university research in semiconductor materials, photonics and compound semiconductors.

## Most active players in EU-China semiconductors research



### Top 10 most active research institutions in EU and in China (2015-2025)



Data: Dataset compiled by authors based on Scopus and OpenAlex

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### Caught between cooperation and competition

EU-China research cooperation in artificial intelligence, quantum technologies, and semiconductors

While Germany dominates in absolute publication numbers, the share of semiconductor research conducted with Chinese partners has risen faster in several other member states. In Czechia, for example, it more than tripled, from 3.1% in 2015 to 11.4% in 2025, even as research security came to the fore of public debate from 2019 onwards, when Czech intelligence services began warning more explicitly about Chinese interest in universities, technology transfer and cooperation with defense linked institutions.<sup>169</sup> These concerns, together with a broader EU push on research security, later led to government guidance on foreign interference and research security risk management.<sup>170</sup> Despite the growing scrutiny, semiconductor cooperation with China continued to expand overall.

Among the ten European organizations producing the most joint semiconductor publications with China are three Swedish institutions, two French and two Danish institutions, as well as universities from the Netherlands, Belgium and Germany. On the Chinese side, the Chinese Academy of Sciences, the University of Chinese Academy of Sciences (UCAS), and Zhejiang University lead cooperation.

## Security risks in doing chip research with China

The share of EU–China semiconductor publications involving at least one Chinese institution flagged by ASPI increased from 70.2% in 2015 to 76.6% in 2025. Among these, co-publications with authors from very-high-risk PLA-linked Chinese universities accounted for 35.6%, with 32.3% linked to high-risk universities.

In every EU member state examined, publications involving flagged institutions were more prevalent than those involving non-flagged Chinese partners. This share was highest in Latvia, Estonia, Luxembourg, Ireland, Croatia, and Bulgaria, each reaching more than 75% of all outputs.

Five of the ten most active Chinese organizations in the semiconductor dataset are classified as high or very high risk under the ASPI China Defence University Tracker, including Tsinghua University and Zhejiang University.

Zhejiang University has extensive cooperation with European universities, with 1,730 joint outputs in the dataset. Much of this work concerns photonics and semiconductor materials, but several collaborations also involve strategically sensitive enabling technologies. One example is a study, co-authored by researchers at Zhejiang University and the Swedish KTH and RISE and Riga Technical University, which proposes and experimentally demonstrates a system that combines radar sensing and wireless communication using advanced photonic and semiconductor components, allowing the same platform to detect nearby objects and transmit data. The technology has potential military applications in radar detection, target discrimination, and integrated sensing and communication systems.

The Institute of Semiconductors (IOS) of the Chinese Academy of Sciences also has substantial cooperation with European partners, particularly TU Delft, CNRS, TU Ilmenau, Lund University and TU Berlin, and European funding appears frequently in these collaborations. Several projects involve technologies whose relevance extends well beyond ordinary civilian electronics. Together with a researcher from the Universitat Politècnica de València, scientists affiliated with the IOS published a study experimentally demonstrating a new way to generate stable, high-purity microwave signals using microwave photonics, by controlling gain and loss in a coupled optoelectronic oscillator. The system uses components such as laser diodes, Mach-Zehnder modulators and photodetectors to generate and process microwave signals, with potential applications in communications, sensing and millimeter-wave systems.

IOS researchers have also worked with the PLA Air Force Engineering University on photonic direction finding for radar warning receivers, which detect incoming radar signals and locate their source. This is particularly relevant given the institute's extensive links to China's defense research network. RAND Europe's 2026 CAS Directory classifies IOS as a "Core Defense Partner" and identified 25 defense-funded publications and 13 military technology patents, while around 22% of IOS researchers had participated in at least one defense-related collaboration.

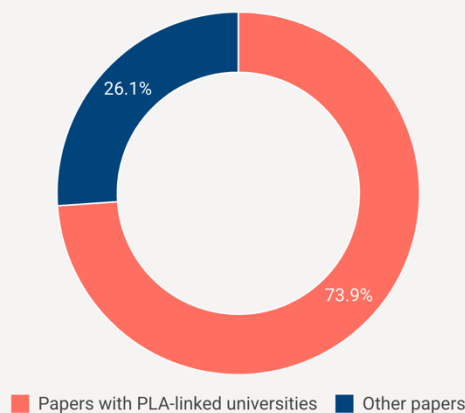
Similarly, the Institute of Microelectronics of the Chinese Academy of Sciences has collaborated extensively with European partners including imec, TU Delft, KTH Royal Institute of Technology, KU Leuven and Grenoble INP. Much of the research concerns semiconductor devices and the processes used to manufacture them. One study, co-authored by researchers from IME CAS Key Laboratory of Microelectronics Devices and Integrated Technology together with a researcher from KTH Royal Institute of Technology in Sweden, and the University of Tehran examined how silicon-germanium, a semiconductor material used to improve transistor performance, can be integrated into advanced 14 nm FinFET transistors. The researchers identified suitable manufacturing conditions for growing the material and developed a model to predict how it would form across different chip layouts. Such advanced transistor technologies are enabling

## Chips research with PLA-linked Chinese universities

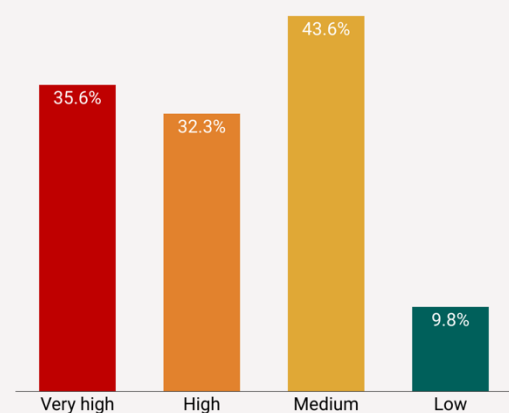


Share of papers co-authored with scientists from universities tied to Chinese military (2015-2025)

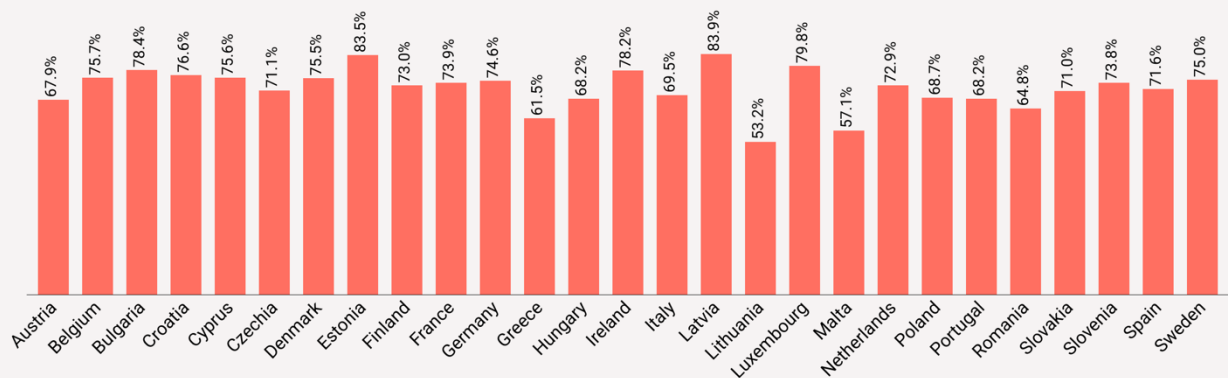
PLA-linked papers as a share of all EU-China semiconductor papers



Share of PLA-linked papers per risk profile of Chinese universities



PLA-linked papers as a share of all EU-China semiconductor papers per EU member state



**Note:** Papers are coded as PLA-linked in cases where at least one co-author is affiliated with a Chinese university listed in ASPI Defence University Tracker. A single paper can be attributed to more than one risk category or country due to multiple co-authors or multiple affiliations.

**Data:** Dataset compiled by authors based on Scopus and OpenAlex / ASPI Defence University Tracker

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### Caught between cooperation and competition

EU-China research cooperation in artificial intelligence, quantum technologies, and semiconductors

components for both civilian electronics and military systems requiring high-performance computing, sensing and communications.

The cooperation is concerning, as in December 2024, the US Department of Commerce added IME to the Entity List, citing its support for advanced node integrated circuits and China's military modernization, including chips intended for military end use.<sup>171</sup> IME is also included on the US Department of Defense Section 1286 research security list.<sup>172</sup>

Chinese Academy of Sciences research has also targeted some of the technological bottlenecks created by foreign export controls. Researchers linked to the Academy have developed a prototype solid-state deep-ultraviolet laser source relevant to semiconductor photolithography.<sup>173</sup> The technology remains far from replacing the high-power commercial systems used in advanced chip production, but it illustrates efforts to develop domestic alternatives in an area in which China remains heavily dependent on foreign equipment.

The largest relationship is between the French National Center for Scientific Research (CNRS) and CAS. This collaboration rests on a formal institutional relationship extending back almost five decades. CNRS and CAS first concluded a cooperation agreement in 1978, and their current framework agreement was renewed for 2023–2028.<sup>174</sup> CAS remains CNRS's principal institutional partner in China, while CNRS has maintained a representative office in Beijing since the 1990s. Cooperation in the semiconductor field is broad, with most joint work focused on semiconductor materials and optoelectronics. One notable example involves the Université de Technologie de Troyes with its joint CNRS unit, the Southern University of Science and Technology in Shenzhen and the CAS Changchun Institute of Optics, Fine Mechanics and Physics, or CIOMP, on metasurfaces that enable precise control of light and can be used in applications such as LiDAR. CIOMP also develops optical technologies for Chinese defense applications. Its own research department lists aerial reconnaissance, target tracking, fire control aiming and laser countermeasures among its areas of work, and reports optical systems deployed on reconnaissance drones and tested with the Chinese military.<sup>175</sup>

Much of the cooperation concerns fundamental materials science, photonics and device physics, and institutional classifications cannot determine how knowledge from individual projects is eventually used. Semiconductors nevertheless differ from less directly industrial technologies because academic advances in materials, devices and fabrication processes can feed comparatively directly into commercially and strategically important technological capabilities. The combination of rapidly deepening research ties, China's drive for technological self-reliance and the extensive involvement of institutions connected to its defense system therefore makes the content of individual projects, the connections of participating institutions and the potential downstream use of research particularly important considerations for due diligence.

Another interesting institutional relationship in our dataset is between the Institute of Physics of the Czech Academy of Sciences and the Chinese Academy of Sciences, which produced about 120 joint semiconductor-related outputs between 2015 and 2025. The Institute of Physics of the Czech Academy of Sciences cooperates with CAS across several areas, particularly quantum and topological materials, scintillator materials for radiation detection, and laser technologies. One of the clearest research security concerns appears in its work on scintillators with the Shanghai Institute of Ceramics. These are materials that produce light when struck by radiation and can therefore be used to build detectors for X-rays, gamma rays and neutrons.

In 2022, researchers from the Institute of Physics of the Czech Academy of Sciences, the Shanghai Institute of Ceramics and the CAS Institute of High Energy Physics coauthored research on a new scintillator capable of distinguishing between neutrons and gamma radiation. The objective was to make such detection more sensitive and reliable. This capability has important civilian uses, but it is also strategically significant. The ability to distinguish neutrons from gamma

rays is used in nuclear security, radiation monitoring, isotope identification and searches for fissile material. One of the researchers also had an affiliation with China's Northwest Institute of Nuclear Technology. The institute has provided diagnostic support for China's nuclear weapons testing and has also been associated with research on high-power microwave weapons.<sup>176</sup> Canada now includes it on its list of research organizations considered a national security risk for sensitive technology cooperation.<sup>177</sup> However, it also needs to be noted that in the Czech context, the Czech Academy of Science, and in particular its Institute of Physics, already has in place relatively robust research security framework which contributes to mitigating potential risks in cooperation with Chinese entities.

Cooperation with the Seven Sons of National Defense Universities has yielded 4,396 papers (10.1% of the analyzed sample), with the Northwestern Polytechnical University being the most active, having co-authored 1,020 papers. Researchers affiliated with Harbin Institute of Technology contributed to 906 papers co-authored with EU-based scientists, with Beihang University contributing 783 papers, 740 in the case of Beijing Institute of Technology, 541 for Nanjing University of Science and Technology, 317 for Nanjing University of Aeronautics and Astronautics, and 239 papers in the case of Harbin Engineering University. Most of the co-authored papers focused on semiconductor materials (36.9%) and optoelectronics (22.8%), as well as process technology, including lithography, etching, deposition, and fabrication flows (11.8%).

When it comes to cooperation with Chinese businesses, Huawei appears prominently yet again. We identified 161 papers in which at least one co-author indicated affiliation with Huawei, and in 5 cases Huawei was acknowledged as a funder of the research. These papers were co-authored with scientists based in, for instance, Delft University of Technology (Netherlands), Politecnico di Milano (Italy), KTH Royal Institute of Technology (Sweden), Vienna University of Technology (Austria), Fraunhofer Heinrich-Hertz-Institut (Germany), or Universitat Politècnica de Catalunya (Spain). Furthermore, in 3 cases, Huawei-linked papers also listed affiliations to the Seven Sons of National Defense Universities.

Huawei also operates its European research and development center in Belgium (Leuven and Ghent), where it develops silicon photonics and radio frequency transceivers that support 4G (LTE) and 5G systems.<sup>178</sup> Huawei's R&D presence in Belgium is noteworthy given the concentration of talent associated with IMEC, a leading global chips R&D center. Beyond its direct R&D presence, Huawei has also provided funding (about €1.52 million) to Italy's University of Pavia to open a Microelectronics Innovation Lab focused on microelectronics and high-frequency technologies.<sup>179</sup> Huawei's chips subsidiary, HiSilicon, has also entered into cooperation with the Dutch University of Twente, albeit details of the cooperation are not readily available.<sup>180</sup>

## Collaboration frameworks and funding patterns

EU–China research cooperation in critical technologies is not a single, centrally organized relationship but a diverse ecosystem of bilateral partnerships, multilateral research networks, and funding arrangements involving institutions across multiple jurisdictions. Understanding these structures is important for assessing both the scale and potential risks of cooperation. This chapter examines how EU–China collaboration is organized across AI, quantum technologies, and semiconductors; who funds it; and how existing research security measures are adapting to these patterns. It then considers the broader implications for Europe, balancing the security risks associated with sensitive technologies against the scientific and competitive costs of restricting international cooperation.

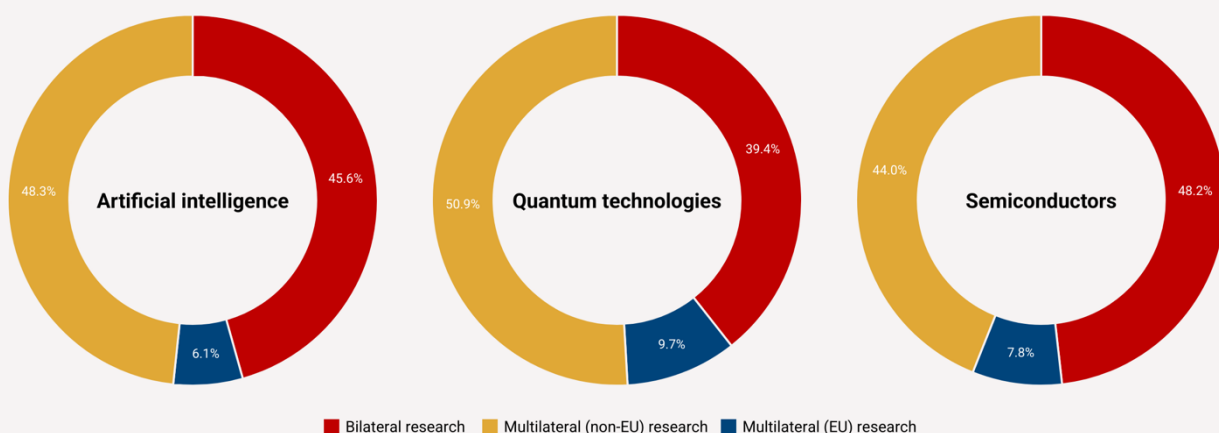
### EU–China research is not happening in isolation

The structure of EU–China research cooperation differs across the three critical technologies. AI and quantum research are particularly internationalized. In AI, 48.3% of joint EU–China publications involved at least one additional institution from outside the EU and China, while bilateral cooperation between Chinese institutions and institutions from a single EU country accounted for 45.6%. The pattern is even more pronounced in quantum research, where 50.9% of publications were produced through broader multilateral networks, compared with 39.4% through bilateral cooperation. This may reflect large international experimental collaborations built around major shared research facilities, where hundreds or even thousands of scientists from institutions across many countries jointly contribute to experiments and are listed as coauthors on the resulting publications. Finally, only a relatively small proportion in either field involved

### EU-China tech research relies on multilateral networks



Bilateral and multilateral cooperation in AI, quantum and semiconductor research (2015-2025)



**Note:** Bilateral = co-authors from China and single EU member state. Multilateral (EU) = co-authors from China and multiple EU member states. Multilateral (non-EU) = co-authors from China, at least one EU member state, and at least one third state.

**Data:** Dataset compiled by authors based on Scopus and OpenAlex

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Chinese researchers and institutions from several EU countries without participation from a non-EU country.

Semiconductor research follows a somewhat different pattern. Bilateral cooperation is the largest category, accounting for 48.2% of publications, while 44.0% were produced through multilateral networks involving at least one institution outside China and the EU.

The high prevalence of multilateral cooperation has important implications for research security. Knowledge exchange in these fields frequently takes place within larger international consortia in which US, British, Japanese, Canadian, Australian or other researchers may also participate. It can, therefore, become more complex to assess how knowledge circulates among participating institutions.

Research security therefore cannot be managed by the EU in isolation. When European researchers participate in the same international networks as partners from other technologically advanced countries, approaches to due diligence, disclosure, and high-risk collaborations need some coordination among research funders and institutions. Furthermore, if European institutions apply substantially weaker research security standards than other like-minded partners, their researchers may increasingly find it more difficult to join international consortia with countries operating stricter regimes, particularly in sensitive technology areas where partners are expected to demonstrate comparable safeguards.

## Follow the money: Who funds EU–China research on critical tech?

The funding data reveal another important asymmetry. Chinese funding alone is substantially more prominent than EU funding alone in joint AI and semiconductor research. Publications supported exclusively by Chinese funding sources account for 29.4% of EU–China AI publications and 29.9% of semiconductor publications. By comparison, exclusively EU-funded research represents only 4.5% of AI publications and 6.7% of semiconductor publications.

Quantum research is different. Multilateral funding, where support came from funding sources in more than one jurisdiction, is the largest category, accounting for 29.9% of joint publications. Exclusively Chinese funding represents 20.1%, while exclusively EU-funded publications account for 6.8%. This corresponds with the relatively greater involvement of European programs such as the European Research Council (ERC) and Horizon 2020 in international quantum research.

These figures should be read as indicative, as funding information was unavailable for 47.3% of AI publications, 35.6% of semiconductor publications, and 23.5% of quantum-related papers. Moreover, acknowledging a funding organization does not show how much it contributed, which partner received the funding, or what conditions accompanied the grant.

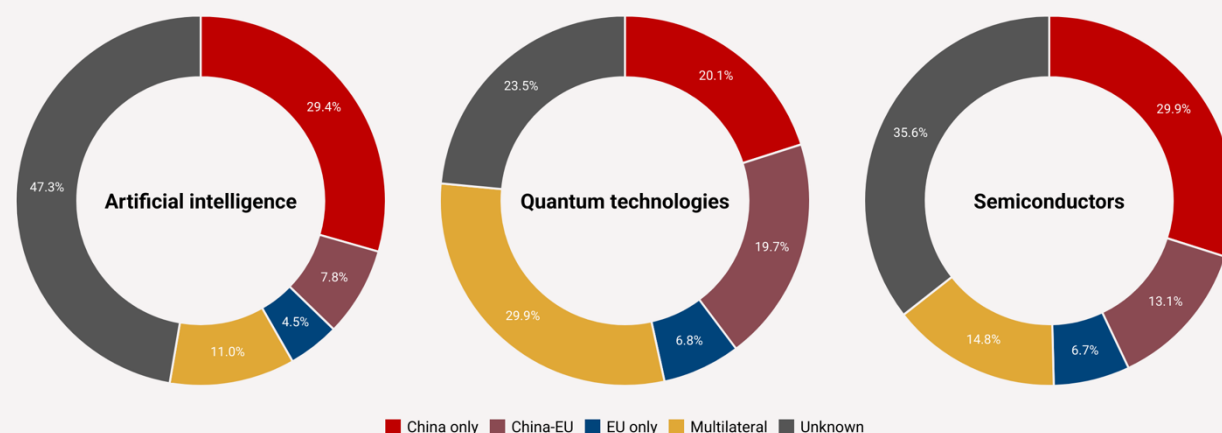
The disparity is nevertheless significant. It suggests that Chinese public funding plays a much larger role in sustaining EU–China research cooperation in strategically important technologies than EU funding, particularly in AI and semiconductors. Several factors may contribute to this pattern, including the availability of Chinese research funding, Beijing's strategic prioritization of these fields, and more limited European willingness to finance projects involving Chinese partners.

The National Natural Science Foundation of China (NSFC) is by far the most frequently acknowledged funder in the dataset, appearing as the top funder across the three categories. Established in 1986, NSFC has developed into China's principal public funding organization for fundamental research and currently operates under the Ministry of Science and Technology.<sup>181</sup>

# Funding of EU-China research in critical technologies



Origin of funding per disclosures made in co-published papers (2015-2025)



**Note:** China only = funding exclusively from Chinese sources. China-EU = joint funding from Chinese and EU sources. EU only = funding exclusively from EU-level or EU member-state bodies. Multilateral = funding from China and/or the EU plus at least one third country. Unknown = No information on funding.

**Data:** Dataset compiled by authors based on Scopus and OpenAlex

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The organization administers the National Natural Science Fund, whose budget grew to RMB 41.86 billion (approximately €5.37 billion) in 2026, up 6.1% from the previous year.<sup>182</sup>

NSFC supports basic research, research infrastructure, talent development and international scientific cooperation across China's universities and research institutes. At the same time, it has played an explicit role in China's civil-military fusion strategy. In August 2016, NSFC and the Science and Technology Commission of the Central Military Commission signed a strategic cooperation agreement intended to promote civil-military integration in basic research, strengthen collaborative innovation between civilian and military researchers and better connect basic research with national defense.<sup>183</sup> NSFC has funded research at Chinese universities under the direct purview of the PLA, such as the National University of Defense Technology, PLA Naval Engineering University, and PLA Air Force Aviation University.<sup>184</sup> NSFC's 2019 annual report records funding for research on supersonic combustion at the National University of Defense Technology, while a 2025 funding announcement includes a further NUDT project on autonomous evolution of intelligent algorithms.<sup>185</sup>

Together with the China Aerospace Science and Technology Corporation (CASC), one of the major Chinese state-owned enterprises producing ballistic, cruise, air-to-air, and surface-to-air missiles for the Chinese military and for export,<sup>186</sup> it established the Joint Fund for Advanced Aerospace Manufacturing Technology Research in 2014 to support basic research addressing technological challenges in aerospace manufacturing.<sup>187</sup> Projects under the program included technologies for launch vehicle manufacturing and autonomous systems for an unmanned lunar base, and researchers were explicitly encouraged to cooperate with CASC research and production units.<sup>188</sup>

Despite its role in China's MCF, the organization maintains extensive relationships with European research funders. In 2000, NSFC and the German Research Foundation (DFG) jointly established the Sino-German Center for Research Promotion in Beijing, supporting cooperation in natural sciences, life sciences, engineering and management sciences.<sup>189</sup> The center continues to operate and fund bilateral scientific exchange and joint projects. NSFC also signed an Implementing Arrangement with the European Commission in 2015 allowing NSFC-funded Chinese researchers to undertake research visits and collaborate with teams supported by the ERC.<sup>190</sup>

NSFC lists partner organizations from 17 EU countries, including Belgium's Fund for Scientific Research (F.R.S.-FNRS), France's Agence nationale de la recherche (ANR) and National Research Council of Italy (CNR).<sup>191</sup> However, the information on NSFC's website does not appear to have been updated since 2021, and some of the listed partnerships are no longer active. According to information provided to the authors, the Austrian Science Fund (FWF) currently has no joint funding activities with Chinese funding organizations, and its cooperation with NSFC has been on hold, with no joint call since 2016. Similarly, between 2015 and 2021, the Swedish Foundation for International Cooperation in Research and Higher Education (STINT) operated a joint mobility program with NSFC, but discontinued it following a review of its mobility programs.<sup>192</sup> STINT currently has no funding activities in China.

In both AI and semiconductors, the second most prominent Chinese funding source is the National Key Research and Development Program of China (NKRDPC). Unlike the more basic research-focused NSFC, the NKRDPC is explicitly organized around national strategic objectives. Chinese government regulations define its remit as including strategic, fundamental and forward-looking scientific problems related to industrial competitiveness, indigenous innovation capacity and national security, alongside key technologies, product development and major international science and technology cooperation.

The program is therefore particularly relevant when assessing international collaboration in AI and semiconductors. A European researcher participating in a project supported by the NKRDPC may contribute to high-quality fundamental or applied science, but the funding program is explicitly designed to channel research toward technologies considered important to China's wider economic, technological and security objectives.

European funding has a more visible role in EU-China quantum collaboration than in AI or semiconductors, with the ERC and Horizon 2020 recorded as the 2nd and 3rd biggest funders. This is consistent with the long-standing role of EU programs in quantum research. The European Commission had already invested around €550 million in quantum technologies over the two decades preceding 2016,<sup>193</sup> before launching the €1 billion Quantum Technologies Flagship in 2018, a 10-year large-scale research and innovation initiative.<sup>194</sup> The current phase of the Quantum Flagship (funded under Horizon Europe) has a budget of more than €400 million. It is complemented by additional EU funding for quantum technologies through the Digital Europe Programme and other instruments, supporting major initiatives such as the European High-Performance Computing Joint Undertaking (EuroHPC JU) and the European Quantum Communication Infrastructure (EuroQCI).<sup>195</sup>

A 2019 investigation by Strider Technologies argued that Chinese government talent programs and return incentives were used to bring researchers trained at leading Western quantum laboratories back into Chinese research programs, including at USTC. The report also documented cases in which Chinese researchers received training supported by Western public funding and later contributed to Chinese dual-use quantum programs. Importantly, Strider explicitly stated that it found no evidence that the Western researchers or institutions involved knew Chinese collaborators were also working with China's defense sector or that their research would contribute to military capabilities.<sup>196</sup>

## Can Europe secure critical tech research without isolating itself?

European universities, research organizations and funding agencies are becoming increasingly attentive to research-security risks and are beginning to incorporate them into decisions on international cooperation. The EU's 2024 Recommendation on Enhancing Research Security encouraged member states, funders and research organizations to introduce proportionate risk assessment into international cooperation, while the Commission is developing a European due-diligence platform and common methodology for research-security assessments.<sup>197</sup> The EU recognizes that member states have recently begun to develop or strengthen their individual approaches, in line with the Council Recommendation. Furthermore, while they differ at the individual level, member states generally try to involve all relevant public authorities through a "whole-of-government approach" as a first step.<sup>198</sup> Different stakeholders have different expectations: research funders play a key role in getting beneficiaries to assess risks, individual researchers or organizations turn these into reality, and member states or the EU put in safeguards and promote consistency.

However, policy maturity still differs across member states.<sup>199</sup> The Netherlands is often seen as a trailblazer on the issues. It started developing a national approach to research security in 2020 through joint initiatives by the involved ministries. A dialogue with the sector was established, allowing regular meetings among the involved organizations, universities, research centers, national research funders, and the Academy of Sciences to discuss perceptions of the issue. In 2022, national guidelines were introduced, providing a way for cooperation with security agencies in the form of a National Contact point that can help provide guidance on risks related to international cooperation, and in the same year, the ministry started requiring universities to actively treat research security as part of their responsibilities at the board level. Following the audit of all research organizations, the Netherlands has recently started pushing for a dedicated research security screening act which would allow for screening of individual researchers, especially in fields with high risk to national security.<sup>200</sup>

National research security regimes or guidelines (of varying degree of comprehensiveness) have also been adopted in, for instance, Denmark, Sweden, Finland, France, Germany, Belgium, and Czechia. However, many EU member states still have a long way to go to adopt meaningful research security practices that would protect critical research conducted at their universities and research centers.

For instance, the Austrian Science Fund (FWF) is currently developing a mandatory research-security self-assessment for grant applicants, expected to be introduced in late 2026.<sup>201</sup> The assessment is planned to cover the independence of foreign partner institutions from state interference, their involvement in military research, and possible conflicts of commitment among cooperation partners. Comparable mechanisms have already been introduced elsewhere: the Research Council of Finland requires applicants to conduct a research-security self-assessment and prepare a risk-management plan that identifies risks.<sup>202</sup>

To overcome the existing fragmentation of approaches to research security and slow rollout in some of the member states, the European Commission also announced in late 2025 plans to further institutionalize research security through the forthcoming European Research Area Act.<sup>203</sup>

The planned framework includes a European Center of Expertise on Research Security, a platform to support due-diligence assessments of international cooperation, and a common methodology for member states to assess the resilience of research-performing organizations.

These measures point to a broader recalibration of international research cooperation in Europe. Despite this development, this report's findings show that EU–China research ties remain extensive in technologies that have become central to competitiveness, economic security and geopolitical competition. Cooperation in AI, quantum technologies and semiconductors continued to grow between 2015 and 2025, even as these fields moved to the center of European de-risking and research-security policies. This creates several distinct challenges for Europe.

China treats AI, quantum technologies, and semiconductors as strategic capabilities linked to economic upgrading, technological self-reliance, and national security. Universities and public research institutes play an important role in this effort. Many of the Chinese institutions most active in cooperation with Europe are among the country's strongest research organizations, while some also maintain substantial links with the defense sector.

These relationships must be understood in a broader geopolitical context. China has become more assertive in the Taiwan Strait and South China Sea, and a future military confrontation would depend heavily on technologies such as advanced computing, autonomous systems, secure communications, sensing, and semiconductors. Research cooperation that contributes to advances in these fields therefore has potential strategic consequences even where the individual project has no military purpose.

This creates particular problems in technologies with strong dual-use potential. While the number of publications in our dataset that explicitly refer to military applications is very small, the potential downstream applications can be military. Advances in computer vision can support industrial automation as well as surveillance and autonomous weapons. Quantum sensing may improve scientific measurement while also contributing to navigation and detection systems. Semiconductor research on materials, photonics or fabrication processes may eventually support civilian electronics and military systems alike.

European institutions also operate with incomplete information. China's political system has become increasingly opaque, while publicly available information on defense programs, institutional relationships, technological capabilities, and government funding can be limited or difficult to verify. This makes it difficult to establish how a particular university laboratory fits within the wider state, commercial and defense innovation system.

The problem is particularly relevant under military-civil fusion, where civilian research institutions and companies can contribute to defense-related technological development. Formal university-level information may therefore give only a partial picture of the actors ultimately able to access or benefit from research results.

China has developed extensive mechanisms for attracting scientists trained abroad, including talent programs, targeted recruitment, research grants and well-funded laboratory positions. These initiatives have helped Chinese universities and research institutes acquire expertise and international research networks in strategically important fields. Undisclosed affiliations can prevent European institutions from understanding a researcher's obligations to another university or funding organization. Parallel appointments and conflicting contractual commitments can create uncertainty over ownership of research results, access to facilities and intellectual property. Return incentives can accelerate the movement of expertise acquired in leading European laboratories into Chinese priority programs.

Documented cases of trade-secret and intellectual-property theft point to a broader, state-driven effort to acquire strategically valuable technologies, know-how and research capabilities through illicit channels. This risk should be factored into research-security assessments involving Chinese institutions and personnel, particularly in sensitive technological fields. At the same time, such safeguards must not result in discrimination against Chinese researchers or in treating nationality itself as a proxy for security risk.

The potential downstream use of research extends beyond military applications. AI, computer vision, biometric technologies, advanced sensors, and data-processing systems can support surveillance and social-control systems. Research cooperation can therefore raise questions about whether European-generated knowledge may eventually contribute to applications inconsistent with European standards on privacy, individual rights and human dignity.

Research cooperation also has implications for Europe's competitive position. China is actively seeking to overcome technological bottlenecks and reduce dependence on foreign technologies. European research can contribute knowledge in areas where Europe still possesses important strengths, including semiconductor materials and equipment, photonics, quantum science, and parts of advanced engineering.

Europe therefore has an interest in understanding where cooperation may accelerate Chinese capabilities in areas where European technological advantages remain significant. Particular attention is warranted when joint research directly addresses known bottlenecks in China's technological development.

Restricting cooperation with China also carries costs. Chinese institutions are now among the leading global research actors in several fields examined in this report, and European researchers benefit from access to their expertise, infrastructure, datasets and scientific networks. Broad restrictions could therefore weaken European participation in frontier research, particularly if researchers in other advanced economies continue to maintain such links.

This matters for Europe's competitive position. Scientific strength depends partly on sustained exposure to developments elsewhere, especially in fast-moving technologies where no national research system can reproduce all relevant capabilities. China's increasing strength in AI, quantum communications, nanoscience, materials science and electronic engineering raises the scientific cost of disengagement.

Research-security assessments should therefore weigh the scientific value of cooperation alongside potential security risks. Projects presenting limited identifiable risks should remain open, while collaborations involving sensitive capabilities, problematic institutional links, or clearly strategic downstream applications warrant stronger safeguards or restrictions. This requires project managers, research security officers, and involved scientists to use out-of-the-box foresight, adopting a "mad scientist" approach in which they imagine how seemingly benign research outputs might be used maliciously by bad-faith actors in downstream applications.

The appropriate level of cooperation will therefore differ across projects. Some relationships create security concerns that justify restrictions. Many others remain scientifically valuable and pose manageable risks. A research-security system capable of distinguishing between them will serve Europe better than broad attempts to reduce overall cooperation.

Research security cannot compensate for weaknesses in European science and innovation policy. Europe will have less freedom to reduce particular foreign dependencies if its researchers lack competitive alternatives at home. This requires sustained investment in fundamental and applied research, stable academic careers and internationally competitive research positions. European universities and institutes need sufficient resources to retain leading researchers and

attract talent from abroad. Research infrastructure in expensive fields such as semiconductor fabrication, advanced computing and quantum technologies also requires long-term public support.

Europe's difficulties in translating research into commercial technologies deserve particular attention. Better support is needed for proof-of-concept development, pilot facilities, spin-offs, scale-ups and access to growth capital. Maintaining technological leadership depends on Europe's ability to commercialize research produced within its own institutions. But this also means research security practices need to broaden their scope to cover not just academic institutions, but also commercial innovators like start-ups, lest the EU risk technologies being siphoned away not directly from academic environments, but once they reach commercial ecosystems unprepared to handle China-related technology risks.

Greater cooperation with other advanced research systems can reduce excessive reliance on particular Chinese partners while preserving the benefits of international science. The US, Japan, South Korea, Taiwan, the UK, Canada, and Australia provide important complementary capabilities across the technologies examined in this report.

These partnerships can also support more effective research-security coordination. Many EU-China publications already emerge from multilateral networks involving third-country institutions. Large differences between national screening systems can therefore reduce the effectiveness of unilateral measures.

Coordination should focus on information sharing, disclosure standards and clearly defined high-risk areas. Europe still has an interest in maintaining broad international scientific networks, including cooperation with China where risks remain manageable.

At the same time, most of the aforementioned countries (especially the US, UK, Canada, and Australia) already have significantly more mature research security frameworks than the EU. Stakeholders from these countries interviewed by CEIAS repeatedly said that, for them to cooperate more extensively with European researchers on critical technologies, Europe must meet similar standards of risk evaluation, management, and mitigation. Until then, cooperation with European scientists is seen as a potential source of risk due to second-degree exposure to Chinese science ecosystems, which raises concerns about the potential siphoning of research outcomes and data to China via underprepared European universities.<sup>204</sup>

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## Annex: Methodology notes

This report maps and analyses research cooperation between European Union member states and China (2015-2025) in three strategically relevant technology areas—artificial intelligence, quantum technologies, and semiconductors—using bibliometric data indexed in Scopus and open-source database OpenAlex. As such, the data reflects both peer-reviewed academic publications and pre-prints and publications stored in arXiv and other archives often covering relevant research in emerging technologies.

The purpose is to produce a consistent evidence base on who collaborates with whom, in what research areas, under which funding conditions, and with what level of potential exposure to Chinese institutions with military links. The unit of analysis is the research output (mostly research paper and conference papers), and the analysis focuses on outputs that contain verifiable EU–China co-authorship through recorded institutional affiliations.

Each publication is classified by the geographical scope of cooperation based on the full set of participating countries, distinguishing between bilateral cooperation between China and an EU member state, European multi-country cooperation, and broader multilateral cooperation. This distinction matters for policy interpretation because bilateral EU–China ties can reflect direct institutional or national relationships, while multilateral outputs often indicate wider research consortia where responsibility, governance, and knowledge flows are distributed across multiple partners and jurisdictions.

A central part of the methodology is ensuring that institutions are counted accurately. Academic affiliation data frequently contains multiple spellings of the same institution, different language variants, and appended subunits such as departments, laboratories, or schools. If left uncorrected, these inconsistencies fragment collaboration counts and distort network analysis by turning one institution into many. To address this, a local large language model standardized affiliation entries to a single official English name for the parent organization wherever possible.

### Coding of paper topics

Each publication is assigned thematic topic codes by a local LLM within the selected domain—AI, quantum, or semiconductors—based on the title and abstract. The topic labels are designed to be policy-relevant: in AI they capture areas such as deep learning, natural language processing, computer vision, robotics, and governance-related work; in quantum they cover computing, communication, sensing, devices, materials, and security-relevant applications; and in semiconductors they distinguish device physics, fabrication processes, chip design, packaging, manufacturing and supply-chain issues, and defense-relevant technologies. When a paper does not fit a specific topic reliably, it is placed in an “other” category, which makes uncertainty explicit rather than forcing an inaccurate assignment. This topic layer enables analysis of whether collaboration concentrates in upstream science, enabling technologies, applications, or areas with clearer dual-use potential.

Topic coding is carried out once per publication and uses only two fields: the title and the abstract as recorded in the source database. No use is made of the full text, the journal or conference name, keywords, author names, or affiliations, so a paper's thematic code cannot be influenced by where it was published or by who wrote it. Each domain has its own closed list of codes,

reproduced in the tables below. The classifier receives that list in full, together with the title and abstract, and is instructed to return only codes drawn from the list, as a semicolon-separated string, with no explanation or free text.

More than one code may be returned where several themes are genuinely central to a paper, which is why topic totals exceed the number of publications. Where no specific category fits, the paper is assigned OTHER rather than being pushed into the nearest available label. Because the classifier sees only the title and abstract, records whose abstract is missing from the source database are systematically more likely to fall into OTHER; the OTHER share should therefore be read as a combined indicator of thematic breadth and of metadata incompleteness, not as a residue of failed classification.

The three code lists were designed to be policy-relevant rather than to mirror any existing bibliometric classification: each contains upstream-science categories, enabling-technology categories, application categories, and an explicitly defense-related category, so that collaboration can be read along the spectrum from basic research to dual-use application.

## Artificial intelligence

| Topic code     | Explanation                                                                                                                                                                                                                           |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>ML_CORE</i> | Machine and statistical learning theory and classical algorithms: learning theory, kernels, ensembles, probabilistic and Bayesian methods, classical supervised and unsupervised learning that is not specific to deep architectures. |
| <i>DEEP</i>    | Deep learning architectures, training procedures and representation learning: network design, transformers and convolutional architectures as such, pretraining, transfer and self-supervised learning.                               |
| <i>NLP</i>     | Natural language processing: text understanding and generation, machine translation, speech and dialogue, and work on large language models as language systems.                                                                      |
| <i>CV</i>      | Computer vision, imaging and pattern recognition: detection, segmentation, tracking, recognition, image and video analysis, including remote-sensing and medical imaging where the contribution is a vision method.                   |
| <i>RL</i>      | Reinforcement learning, planning and sequential decision-making, including control policies learned from interaction and multi-agent decision problems.                                                                               |
| <i>MULTI</i>   | Multimodal models that combine two or more modalities, such as image–text, audio–text or video–language systems, and cross-modal alignment and retrieval.                                                                             |
| <i>GEN</i>     | Generative models: diffusion models, generative adversarial networks, autoregressive generators, variational autoencoders and synthesis of images, audio or video.                                                                    |
| <i>ROBOT</i>   | Robotics, embodied AI and autonomy: perception–action loops, manipulation, navigation, autonomous vehicles and drones, human–robot interaction on the robotics side.                                                                  |
| <i>EDGE</i>    | Edge, mobile, embedded and neuromorphic AI hardware: on-device inference, model compression and quantization for deployment, accelerators and spiking or neuromorphic implementations.                                                |
| <i>EXPLAIN</i> | Explainable, interpretable and trustworthy AI: attribution and interpretability methods, robustness, uncertainty quantification, verification and auditing of model behavior.                                                         |
| <i>ETHICS</i>  | Societal impact, safety, policy, governance and regulation of AI: normative and legal analysis, standards, risk frameworks, fairness and bias as a policy question rather than as an algorithmic technique.                           |

## Artificial intelligence

| Topic code      | Explanation                                                                                                                                                                                              |
|-----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>AUTOML</i>   | Automated machine learning: neural architecture search, hyperparameter optimization, meta-learning and automated pipeline construction.                                                                  |
| <i>OPT</i>      | Optimization methods for learning: optimizers, convergence analysis, distributed and federated training procedures, and the numerical machinery of model fitting.                                        |
| <i>DATA</i>     | Data-centric AI: dataset construction, curation, labelling and quality, synthetic data generation, benchmarks, data augmentation and data governance in the technical sense.                             |
| <i>KG</i>       | Knowledge graphs, symbolic reasoning and neuro-symbolic AI: ontologies, reasoning engines, semantic representation and hybrid symbolic–neural systems.                                                   |
| <i>HCI</i>      | Human–AI interaction: interface and interaction design for AI systems, co-creativity, user studies, human-in-the-loop workflows and the user experience of AI.                                           |
| <i>APP_HEAL</i> | AI applied in healthcare, biomedicine and the life sciences: clinical decision support, diagnostics, drug discovery, genomics and bioinformatics applications.                                           |
| <i>APP_FIN</i>  | AI applied in finance, business, management and economics: risk and credit modelling, trading, forecasting, operations, marketing and organizational applications.                                       |
| <i>APP_SCI</i>  | AI applied in the natural sciences and engineering outside military contexts: physics, chemistry, materials, climate and earth sciences, energy, transport, civil and industrial engineering.            |
| <i>APP_MIL</i>  | AI applied in defense, security and explicitly military contexts: target recognition, military autonomy, battlefield or weapons-related systems, and security applications stated as such in the record. |
| <i>OTHER</i>    | Other or unclassified AI-related work: papers that are in scope for the AI corpus but do not map reliably onto any category above, and papers whose title and abstract are too thin to code.             |

## Quantum technology

| Topic code     | Explanation                                                                                                                                    |
|----------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Q_COMP</i>  | Quantum computing proper: algorithms, computational architectures, error correction and fault tolerance, and qubit-level computing operations. |
| <i>Q_SOFT</i>  | Quantum software: programming languages, compilers and transpilers, toolchains, and classical simulation software for quantum systems.         |
| <i>Q_COMM</i>  | Quantum communication: networks, repeaters, entanglement distribution, satellite and fiber links, and quantum-internet architecture.           |
| <i>Q_CRYPT</i> | Quantum cryptography and post-quantum cryptography: quantum key distribution, quantum-safe protocols and cryptanalysis in a quantum setting.   |
| <i>Q_SENS</i>  | Quantum sensing and metrology: magnetometry, gravimetry, timing and clocks, quantum-enhanced imaging and precision measurement.                |

## Quantum technology

| Topic code    | Explanation                                                                                                                                                                                                |
|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Q_MAT</i>  | Quantum materials and qubit platforms: superconducting, spin, trapped-ion, photonic and topological platforms, and the materials science underpinning them.                                                |
| <i>Q_DEV</i>  | Quantum devices and hardware engineering: fabrication, packaging, cryogenics, integration and the scaling of physical systems.                                                                             |
| <i>Q_INFO</i> | Quantum information theory and foundations: entanglement theory, channel capacities, non-locality, measurement and the conceptual basis of the field.                                                      |
| <i>Q_CTRL</i> | Quantum control and characterization: pulse and gate control, readout, calibration, tomography, noise characterization and error mitigation.                                                               |
| <i>Q_SIM</i>  | Quantum simulation of physical and chemical systems, including analogue and digital simulation of many-body, molecular and lattice models.                                                                 |
| <i>Q_APP</i>  | Applications of quantum technologies in chemistry, optimization, machine learning, finance, logistics and other end-use domains outside defense.                                                           |
| <i>Q_MIL</i>  | Quantum technologies for defense, security or military use, where the record states such an application (for example navigation without satellites, submarine detection or secure military communication). |
| <i>OTHER</i>  | Other or unclassified quantum-technology work: in scope for the quantum corpus but not reliably assignable to a category above, including records with insufficient abstract text.                         |

## Semiconductors

| Topic code     | Explanation                                                                                                                                                             |
|----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>S_DEV</i>   | Semiconductor devices and transistor physics: MOSFETs, FinFETs and gate-all-around devices, HEMTs, diodes, device modelling, transport and reliability physics.         |
| <i>S_MAT</i>   | Semiconductor materials: epitaxy, heterostructures, wide-bandgap materials such as SiC and GaN, two-dimensional and compound semiconductors, doping and defect studies. |
| <i>S_PROC</i>  | Process technology: lithography, etching, deposition, cleaning, planarization, metrology and complete fabrication flows.                                                |
| <i>S_ICDIG</i> | Digital and logic integrated circuits: CPUs, GPUs, digital ASICs, FPGAs, accelerators and digital circuit and microarchitecture design.                                 |
| <i>S_ICANA</i> | Analog, RF, millimeter-wave and mixed-signal integrated-circuit design, including data converters, transceivers and sensor front ends.                                  |
| <i>S_MEM</i>   | Memory technologies: DRAM, SRAM, NAND flash and emerging non-volatile memory such as MRAM, ReRAM and phase-change memory, including in-memory computing.                |

## Semiconductors

| Topic code    | Explanation                                                                                                                                                                               |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>S_PWR</i>  | Power electronics and high-voltage or high-efficiency devices, converters and modules, including automotive and grid-oriented power semiconductors.                                       |
| <i>S_PKG</i>  | Packaging and interconnect: advanced packaging, 2.5D and 3D integration, chiplets, through-silicon vias, bonding, thermal management and assembly.                                        |
| <i>S_DES</i>  | Electronic design automation: CAD tools, design methodology, simulation, verification, test and hardware security tooling for chip design.                                                |
| <i>S_OPTO</i> | Optoelectronics and photonics: LEDs, lasers, detectors, photovoltaic devices, photonic integrated circuits and electro-optic components.                                                  |
| <i>S_MFG</i>  | Manufacturing and industrial aspects: yield, process control, reliability engineering, fab operations, supply chains, economics and industrial policy of chip production.                 |
| <i>S_MIL</i>  | Semiconductor technologies for defense, aerospace or explicitly dual-use systems, including radiation-hardened, space-qualified and military-grade RF components.                         |
| <i>OTHER</i>  | Other or unclassified semiconductor or microelectronics work: in scope for the corpus but not reliably assignable to a category above, including records with insufficient abstract text. |

## Funding coding

Funding is treated as a separate analytical dimension because financial origin can shape incentives, governance, and risk exposure. Funding acknowledgements are analyzed by a local LLM to classify the geographical origin of support using only the funding text provided in the publication record. Each output is assigned to one of five categories: China-only funding, EU-only funding, joint China–EU funding, multilateral funding that includes third-country sources, or unknown when disclosures are missing or insufficiently specific.

## Coding of PLA-linkages

The methodology also integrates the China Defence University Tracker by ASPI, which allows to note instances of cooperation with entities linked to the People’s Liberation Army and assign approximate risk levels. At the publication level, the report identifies whether an output includes at least one flagged Chinese partner institution. At the country level, it estimates how much of each EU member state’s collaborative output involves. At the institutional and topic levels, it examines which Chinese institutions contribute most to flagged collaborations and how those collaborations distribute across research themes.

## Use of local large language models

Every model-assisted step in this methodology runs on an open-weight model hosted locally on the research machine. No publication metadata, abstract or funding text is sent to a commercial application programming interface, nothing is retained by a third-party provider, and the licensing conditions attached to the underlying bibliographic data are not breached by transmission. Running locally also removes per-call cost as a constraint, which is what makes exhaustive coding of the full corpus feasible rather than coding only a sample.

The model used throughout is gpt-oss-20b, an open-weight model of roughly twenty billion parameters released under the Apache 2.0 license. It is served locally through LM Studio.

## Caught between cooperation and competition

EU–China research cooperation in artificial intelligence, quantum technologies, and semiconductors

Prompts are deliberately constrained. In every task the model is given a closed list of permitted outputs and instructed to return only a token or a list of tokens from that list, with no explanation, no reasoning text and no commentary. Returned strings are then normalized and checked against the permitted set in code, so that anything unexpected is caught rather than silently carried into the tables.

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# About CEIAS

**Central European Institute of Asian Studies (CEIAS)** is an independent think tank focusing on Europe-Asia relations and developments in the Indo-Pacific region. Originally founded in 2007 in Slovakia, CEIAS is today a **transnational think tank with main branches in Bratislava (Slovakia), Prague (Czech Republic), and Vienna (Austria)**, and further regional presence in Poland, Hungary, Canada, Singapore, Taiwan, Hong Kong, and beyond.

We strive to combine **academic and policy advisory role**, producing **data-driven, methodologically rigorous, reliable, and practically relevant research** that is highly valued by experts and policymakers.

Our activities focus are focused into several topical and geographic workstreams:

- **Global Perceptions of China Center**
- **Geo-economics & Technology Center**
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- **Indo-Pacific Program**
- **EU-China Relations Program**
- **Southeast Asia Program**
- **Human Rights & Law Program**

Since its establishment in 2007, CEIAS has consistently worked towards becoming a **go-to think-tank in the CEE for matters related to East Asia and the Indo-Pacific region**. We have a track record of successful project implementation **supported by regional and international donors**,

including the European Commission; Government of Taiwan; US State Department; UK Foreign, Commonwealth and Development Office; the Government of Japan; the Government of Slovakia; National Endowment for Democracy (NED); the Center for International Private Enterprise (CIPE); Konrad Adenauer Stiftung; Fridrich Naumann Stiftung; International Visegrad Fund; International Republican Institute (IRI); Korea Foundation, and many others.

CEIAS is **embedded into the key European networks of premier East Asia scholars**. Examples include the European Think-Tank Network on China (ETNC), European Association of Taiwan Studies (EATS), or China in Europe Research Network (CHERN).

**CEIAS researchers regularly comment for and publish op-eds in leading CEE and international media**. Our work has been featured in the Wall Street Journal, Foreign Policy, South China Morning Post, NHK, Deutsche Welle, Euractiv, CNA, The Diplomat, Voice of America, Radio Free Asia, Radio Free Europe/Radio Liberty, Euractiv, and other media.

Our outputs are referred to in the work of other thinktanks, e.g. Brookings (USA), Clingendael (Netherlands), MERICS (Germany), Institute for Security & Development Policy (Sweden), IFRI (France), ISPI (Italy), Global Taiwan Institute (USA), Prospect Foundation (Taiwan), ISEAS (Singapore), Elcano Royal Institute (Spain) and many others.

CEIAS analysis was also highlighted in the outputs of the **European Parliament** and the **U.S. Congress**.

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## **Caught between cooperation and competition**

**EU–China research cooperation in artificial intelligence,  
quantum technologies, and semiconductors**

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