RECONNECT CHINA POLICY BRIEF 3

— October 2023 —

EU27/AC-China: Current patterns, drivers, barriers, challenges and future cooperation options in the big data-related scientific fields

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Measured by co-publications and co-patents, the EU's science, technology and innovation cooperation with China in big data-related fields is flourishing. Latest results from ReConnect China's report on EU-China research cooperation in the fields of Artificial Intelligence (AI), Machine Learning (ML) and Big Data (BD) (D1.1; September 2023) show that European-Chinese co-publications have continuously grown in number between 2011-2022. The same is true for joint co-patents between European and Chinese companies that have also significantly grown in number over the same period. Against this background, this policy brief discusses the report's results in the light of current developments in EU-China STI cooperation, including China's current ambitions to advance its own STI system and to harness STI policy making in view of strategic national interests. It draws preliminary conclusions about the EU's future cooperation options with China, taking into account new major STI initiatives described in the current 14th Five-year Plan.

WHERE IS COOPERATION BETWEEN THE EU27/AC AND CHINA IN AI, ML AND BD STANDING?

The background to this policy brief is the ReConnect China public report on EU-China research cooperation, published in September 2023. For this analysis, we used data on co-publications and co-patents between R&I institutions (including universities, research institutes and private companies) from the EU27/AC and China (an institution qualifies as "European" if it is located in any of the EU27/AC countries and as "Chinese" if located in China). As "EU27/AC" we define the 27 EU Member States plus the United Kingdom, Norway and Switzerland as associated countries to Horizon Europe. While only the UK and Norway have formally been associated to Horizon Europe at the time of writing the report, we decided for subsuming Switzerland under this term as well, given the country's role as a strong performing country on the whole European R&I landscape.

Regarding data availability on co-publications from "Web of Science" and on co-patents from "PATSTAT", in both cases the latest data accessible from 2022 (with the caveat that co-patent data for 2021 and 2022 is incomplete due to a considerable time lag between the date of patent submission and the date of its publication in PATSTAT).

Co-publication findings

On the level of cooperation on co-publications in comparison, the EU27/AC cooperated most with US partners (with about 12,500 records counted in the last available year 2022), followed by EU27/AC-China and China-USA cooperation.

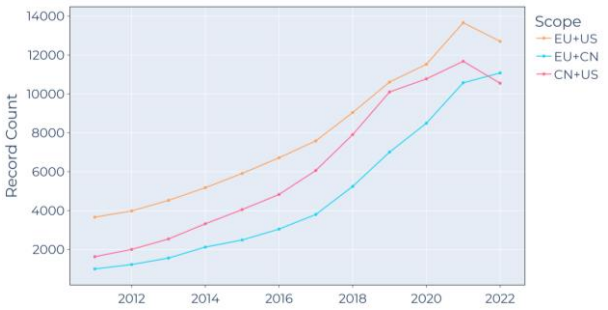

Figure 1 Number of co-publications per year related to artificial intelligence, machine learning and big data published between regions

In terms of most publications on AI, ML and BD per region, China's count is largest.

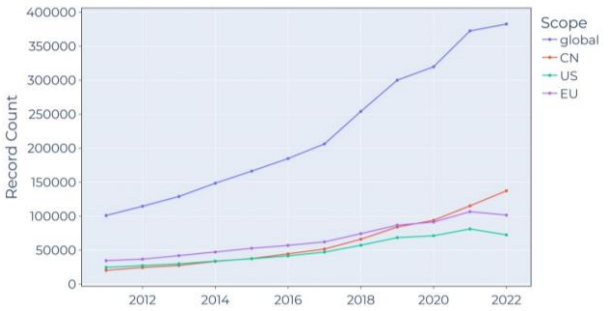

Figure 2 Number of publications per year related to artificial intelligence, machine learning and big data published by region

The relative growth of co-publications between EU27/AC and China over the past ten years is staggering, hitting a growth rate for more than 1000% in 2022.

Figure 3 Number of co-publications per year and relative growth of yearly output (indexed to 2011) related to artificial intelligence, machine learning and big data published between China and EU27/AC countries

On the national level, the United Kingdom, as an associated country, is by far the largest contributor of co-publications in the cooperation with China (44.3%).

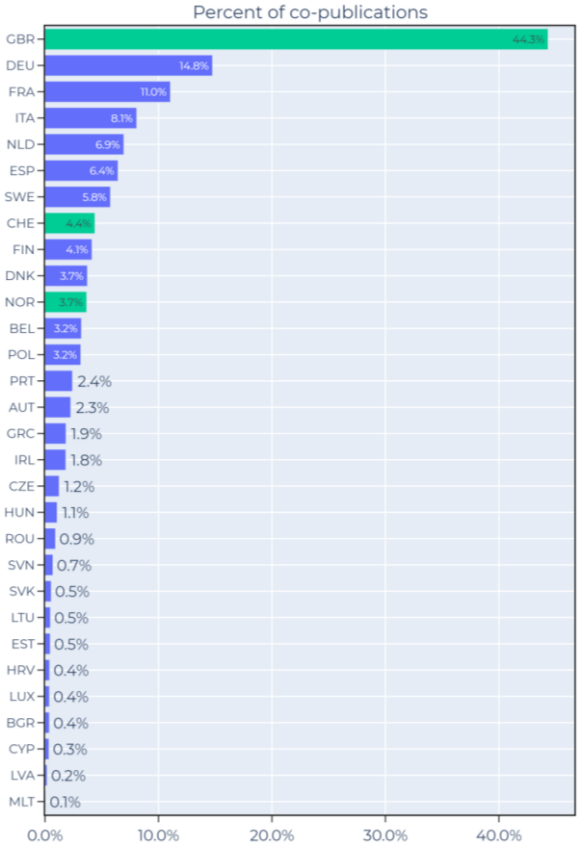

Figure 4 Overall country level contribution to co-publications of EU27/AC countries (in percent of entries related to country

The ranking of the most involved institutions resonates with the results on the country level. The

omnipresence of British universities is striking with nine universities among the top-10.

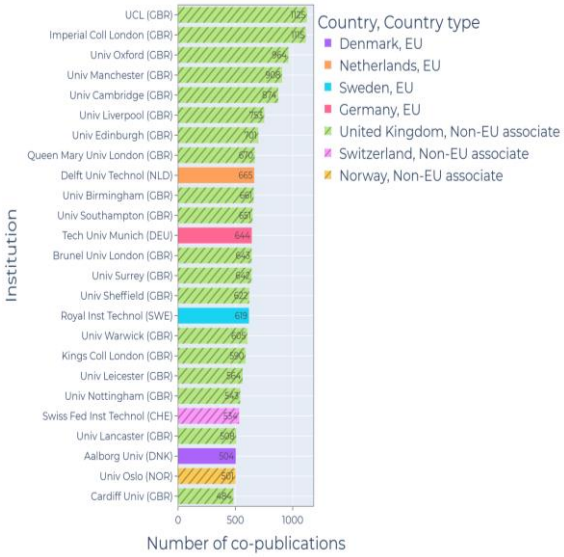

Figure 5 Top 25 most active institutions (EU27/AC countries) publishing on AI-related topics in collaboration with Chinese institutions

In order to mitigate this bias on UK institutions, we did another analysis limited to EU27 institutions only. The results are interesting, with Delft University of Technology (NL), Technical University Munich (DE) and Royal Institute of Technology (SE) at the top.

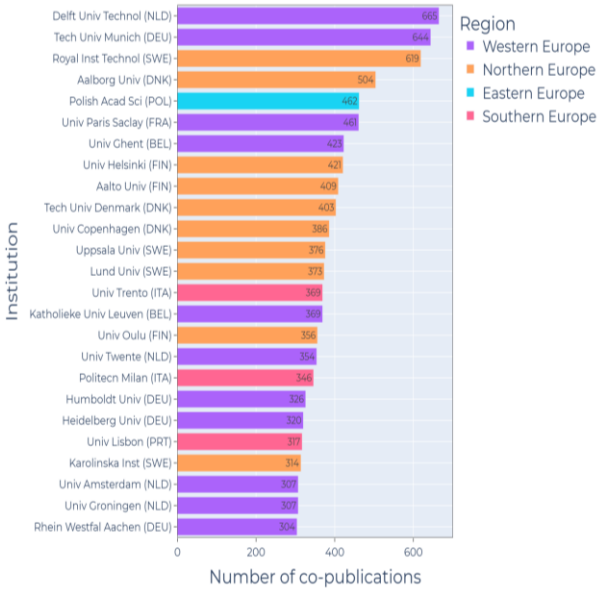

Figure 6 Top-25 most active institutions (only EU27 countries) countries) publishing on AI-related topics in collaboration with Chinese institutions

Lastly, on the side of China's institutions in co-publications, the Chinese Academy of Sciences is by far the most represented actor, followed by Tsinghua University.

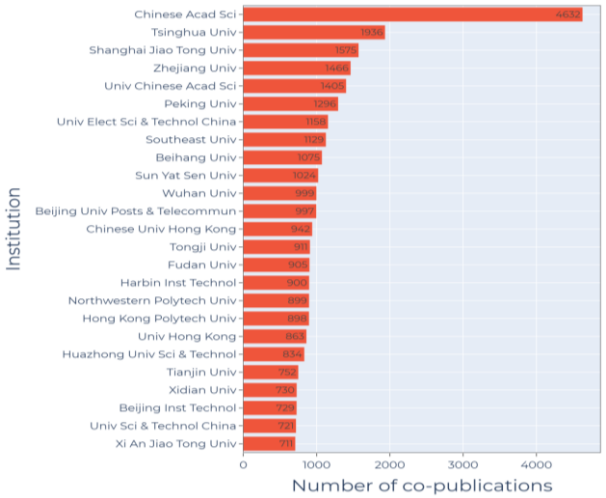

Figure 7 Top-25 most active Chinese institutions publishing on AI-related topics in collaboration with European institutions

Co-patent findings

The scope of our co-patent analysis followed a similar structure like for co-publications, yet without the comparative view on regions globally (EU, USA, China). For EU27/AC-China jointly submitted co-patents published in the European Patent Office PATSTAT, there is a relative growth visible from 2010 until 2020. Between 2020 and 2022 the number of co-patents significantly drops, but this has to do with the **time lag between patent submission and its publication in PATSTAT** (as already mentioned earlier). On the contrary, we strongly assume that the observed trend continued in 2021 and 2022 with even higher numbers of submissions.

Figure 8 Overall trends in China-EU27/AC co-patent submissions; submitted co-patents per year and the relative growth in the annual submissions (indexed to 2011)

Another bottleneck in the patent registration process to PATSTAT, potentially leading to false (smaller) numbers, is in the details of information on patents provided by national or regional patent offices (PATSTAT relies on the data provided by these offices). We have found that in some patent offices the initial filings of PCT (Patent Cooperation Treaty) patents frequently omit the country of the applicant or inventor. In particular China's national patent office often submits only fragmentary data to EPO/PATSTAT.

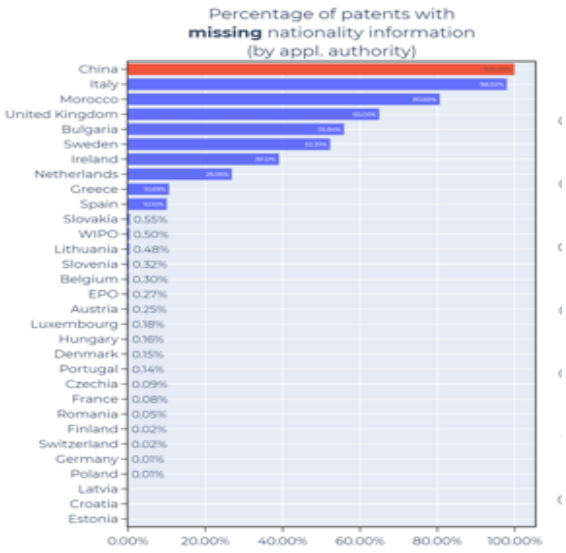

Figure 9 Percentages of patents containing mission information about the applicant's and/or inventor's country based on application authority

Slightly more than half of the co-patents (57.5%) contain at least one Chinese applicant. We are speaking about the **applicants for patents** here, which is at the centre of our analysis. Under the remaining 42.5% China is included as well, but on the **level of inventors**. Germany, Finland, Sweden and France are the most active countries in patent applications with China on the EU's side.

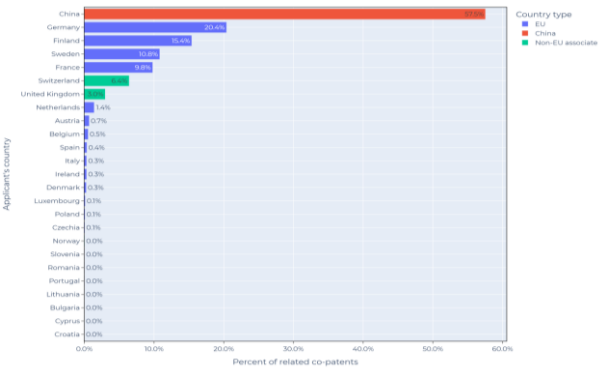

Figure 10 Distribution of co-patents by applicant country; percent of co-patents having at least one applicant from the respective countries

On the institutional level for EU27/AC (predominantly private companies, with the French CNRS – Centre National de la Recherche Scientifique as the only exception), Nokia Corporation, registered in Finland, is the top-collaborator with China, followed by Ericsson (Sweden) and another sub-division of Nokia, namely Nokia Tech Ltd. The telecommunications sector is obviously the most dynamic when it comes to technology-oriented patent development between Europe and China. Other business sectors emerging are automation and vehicle production (e.g. ABB, Bosch, BMW, and Geely) and chemistry and consumer goods sectors (e.g. L'Oreal, Rhodia, and Henkel).

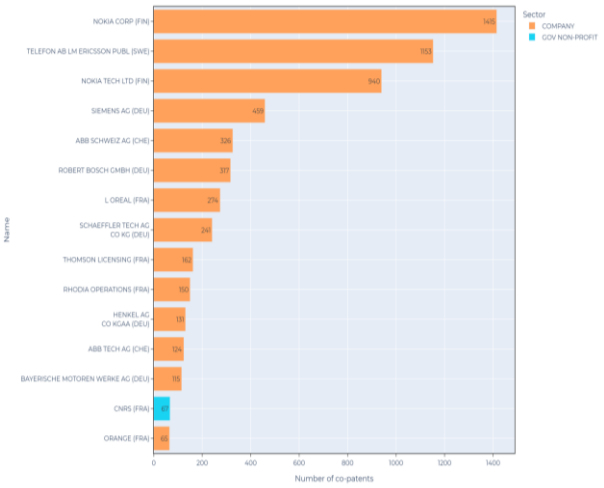

Figure 11 Top-15 most active EU27/AC applicants submitting co-patents with Chinese participants (either applicant or inventor)

For China, it is no surprise that Huawei, the country's largest telecommunications operator tops the list. Nokia, apparently, involves its China-based subsidiaries in co-patenting as well (Nokia Shanghai Bell Co. Ltd.) and with Ningbo Geely there is an e-vehicle company third.

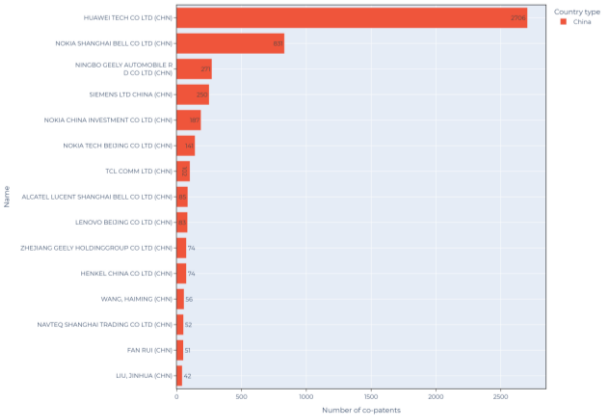

Figure 12 Top-15 most active Chinese applicants submitting co-patents with EU27/AC participants (the European participants are either applicants or inventors)

WHAT CHARACTERISES CURRENT STI COOPERATION? DRIVERS AND BARRIERS IN THE FIELD

The findings presented so far allude to an intense, but at the same time varying cooperation pattern between European and Chinese actors in science, technology and innovation. Whereas **co-publications** in the discussed fields are generally on the rise, the **bias caused by the dominance of British universities** must be taken into account. Without co-publications including the UK, the volume of cooperation would be almost halved. This is particularly relevant given that the UK is not a member of the EU any longer, thus it does not contribute to EU policy-making on research and innovation. The massive experience in research cooperation with China accumulated by British universities is not accessible for the EU policy-makers any longer, and this is certainly detrimental to forging best-value policies on China speaking to the EU's interests. Consequentially, in order to support future R&I policies on China with practical experience and expertise from those who are involved, a **closer integration of the leading cooperation partners from the EU27 is recommended**. EU-wide research consortia involving China experts on different scientific fields like "ReConnect China" and "China Horizons" are already a good step in the right direction.

In terms of **co-patents** relating to the discussed fields, it is advisable to engage more with companies from the sectors most represented, first of all from telecommunications. Similar to our recommendation for research partners, a **closer interaction between EU policy-makers and companies heavily tied to China** in patenting (Nokia, Ericsson, Siemens, ABB, Bosch etc.) definitely merits to be considered. More of such exchange will be conducive to better understanding the intention why protecting intellectual property shared with Chinese partners is attractive (drivers) for European business, but also which difficulties or concerns (barriers) this involves. Among the difficulties are the current legislation on sharing of IPR in China and knowledge security risks. Current Chinese law is set to treat any joint patent filings with a non-Chinese partner residing outside China but involving Chinese nationals or organisations, as

Chinese technology [1]. At the same time it is questionable whether China is able to enforce this law in the case of a joint patent filing between a Chinese and a European representative aimed at registration in EPO's PATSTAT. The topic of **knowledge security risks concerns scientific and technological/innovation cooperation alike.** As an overarching term, it entails a series of sub-questions like how to avoid undesirable transfer of sensitive knowledge and technology, how to deal with covert influencing of education and research by states with malign intent or how to warrant that civil technology is not misused for military purposes (dual-use)?

The "DREAMS lab" project [2] became a reference case for many of these questions. DREAMS lab is a research project on AI between the University of Amsterdam, the Free University of Amsterdam and Huawei which also is the donor of the project. Running since 2021 until 2025, the project aims to provide the next generation of search technology, taking into account Europe's different languages and cultures. Amidst mounting political concerns about China's largest telecom operator tendering to supply and maintain 5G networks across the EU[3], allegedly using this as a backdoor for massive observation of European data traffic, the DREAMS lab project suddenly found itself highly politicised. Triggered by reports in Dutch media, the universities' decision to collaborate with Huawei in light of concerns over state espionage and data theft on the one, and of the company's role in the oppression of the Uyghurs minority by the Chinese government on the other hand was more than questioned. Also if the implementation of DREAMS lab continues until now, the topic of knowledge security moved up high on the agenda. In July 2021, a new framework on knowledge security for Dutch universities was published [4], helping research institutions assess the security risks and ethical implications of international research collaborations with countries such as Russia, China or Iran. Other EU countries are following this example and launched similar initiatives (see also the recommendations).

WHERE ARE THE OPPORTUNITIES? MEDIUM- AND LONG-TERM INITIATIVES ON STI

China's current 14th Five-Year Plan (FYP) for the period 2021-2025 and many of its subordinated strategies bear important implications for both domestic and international STI performance (sector-specific plans cover topics like defense industry or science, technology and innovation – 14th S&T FYP). Generally, the **FYP must be interpreted against current geopolitical dynamics and the competition with the USA and the EU on supremacy in key emerging technologies** like quantum computing, semiconductors, and AI in particular. As a means to reach this end, research on and investments in these key emerging technologies attain a pivotal role. In total, the FYP defines seven "frontier technologies" (sometimes replaced with "frontier sciences") to be supported with large-scale state support.

The 2021-2035 Medium- and Long-Term Science and Technology Development Plan (MLP) is another key planning document related to STI, steered and implemented by the Ministry of Science and Technology (MOST). What we note compared to their predecessor plans is a new form of public

[1] https://asia.nikkei.com/Spotlight/Supply-Chain/Joint-patents-with-China-pose-pitfalls-in-U.S.-led-decoupling

[2] https://amsterdamdatascience.nl/news/uva-vu-and-huawei-launch-dreams-lab/

[3] https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_23_3312

[4] https://www.universiteitenvannederland.nl/files/documenten/Domeinen/Integrale%20veiligheid/VSNU%20Framework%20Knowledge%20Security%20Dutch%20Universities.pdf

information embargo regarding all topics at the crossroads of STI and national security matters. Whereas the 2006-2020 MLP and the 13th S&T FYP were published and fully accessible for Western scholars, the publication of both current versions is pending, and potentially they will not be published at all. Notwithstanding, some of the content has found its way onto the desks of Western experts. In the following two of the most interesting references to China's ambitions in terms of international cooperation are shortly discussed:

1. China's openness for international cooperation: In spite of geopolitical tensions and rivalry between the USA and China, involving also the EU, China seems not to have lost complete faith in the cooperation with the West.

In February 2023, president Xi Jinping chaired a study session on science and technology of the Political Bureau of the 20th CPC (Communist Party of China) Central Committee and illustrated a few examples representative for the country's ambitious scale in STI. These study sessions are closely linked to the preparation and implementation of China's FYP in sector-specific areas. The translation of Xi Jinping's remarks on China's role for international scientific cooperation reads like this: "*It is necessary to build an international basic research cooperation platform, set up a global scientific research fund, increase the opening up of national science and technology plans, and expand and deepen Sino-foreign joint scientific research around global issues such as climate change, energy security, biosafety, and outer space utilization. It is necessary to plan forward and deeply participate in global science and technology governance, participate in or initiate the establishment of international science and technology organizations, and support domestic universities, scientific research institutes, and science and technology organizations to connect with the international community. Efforts should be made to enhance openness, trust, and cooperation in the international scientific and technological community, to make new and greater contributions to the progress of human civilization with more major original innovations and breakthroughs in key core technologies, and to effectively safeguard my country's scientific and technological security interests*."[5] We interpret this as clear signals that China is willing to pursue international cooperation in STI to tackle those shared global problems which affect the country most.

2. New large-scale STI projects and related initiatives

After 2014, major governmental reforms re-organised the R&D funding landscape in China, impacting considerably on national STI projects and initiatives ever since. Several policy-oriented reports dealing with these governmental reforms have been published by Western institutions aiming to make sense of this new promoted role of STI. As a synthesis of all reports studied by the authors of this paper, there are two new funding lines considered the most important for boosting research and accelerating investment in the seven frontier technologies defined by the government[6].

National S&T Major Projects: They match the country's top priorities in each specific sector laid out by the FYP and are also known as "Innovation

[5] https://english.news.cn/20230222/e8834b5679814537b72d6bb3ce9f2c4b/c.html?utm_source=substack&utm_medium=email (short news in English; full text in Chinese available to the author)

[6] Brugner P., Schindowski R. (2023): R&D subsidies in China: A methodological map using clean energy technologies as an example (EUSPRI-2023 conference paper)

2030". In regard to the frontier technologies as mentioned, projects shall be funded in the areas of artificial intelligence, quantum information, integrated circuit, public health, brain science, breeding biotechnology, deep-earth and deep-sea research, and space technology. Funding, administration, and management are overseen by MOST. It is expected that the National S&T Major Projects have a mandate to support the development of Beijing, Shanghai and Guangdong-Hong Kong-Macao as regional hubs with international orientation for S&T innovation as well. [7]

National Key R&D Projects: China's National Key R&D projects support R&D in areas of social welfare and people's livelihood, such as agriculture, energy and resources, environment, and health. They focus in particular on key and strategic technologies, featuring several well-targeted and defined objectives and deliverables to be achieved in a period ranging from three to five years, and reflecting a top-down and industry-university-research cooperation design which integrates basic research, technology application, demonstration and commercialisation. Funding, administration and management is overseen by the MOST.

Among those projects already funded and where public information is available, the ones in the table deal with topics that relate to AI, BD or ML. It could be interesting for EU27/AC universities to study these Key R&D projects more closely and explore partnership opportunities with the Chinese actors implementing them.

2015-2020	Cloud computing and big data 云计算和大数据 High-performance computing 高性能计算 Cybersecurity 网络空间安全 Quantum control and quantum information 量子调控与量子信息
2017-2022	Smart robotics 智能机器人 Key scientific issues of disruptive technologies 变革性技术关键科学问题 Network integrated manufacturing, and smart factory 网络协同制造和智能工厂 Key technologies and demonstration of IoT and smart cities 物联网与智慧城市关键技术及示范

Table 1 China's Key R%D projects relating to AI, BD or ML[8]

POLICY RECOMMENDATIONS

This policy brief elucidated on the science, technology and innovation cooperation between research institutions (universities) on the one, and between private companies one the other hand from the EU27/AC and China, with a specific focus on the fields of big data, machine learning and artificial intelligence. The results brought forward by the report can be of added value to European R&I stakeholders, as they provide a comparative view on the most active players at both ends of the cooperation networks. Usually institutions from the

[7] Poo M. (2021): Innovation and reform: China's 14th Five-Year Plan unfolds, *National Science Review*, Volume 8, Issue 1

[8] https://chinainnovationfunding.eu/national-key-rd-programmes/ (data from 2022)

EU27/AC only monitor their own cooperation networks with Chinese partners, meaning they know their strongest partners and in which scientific field or technology area respectively the cooperation flourishes most. The background report to this policy brief adds on this by dissecting the cooperation networks of all institutions leading in their respective fields.

In a second step, the policy brief aimed to embed these results in the current dynamics regarding STI development in China. As the title of this policy brief indicates, we decided for a bird's-eye view on everything what "dynamics" may entail in this regard. Firstly, we touched upon some of the characteristics (**barriers, challenges**) of current STI-cooperation (dominated by the currently prevalent discourse on both the asymmetries and the risks in today's EU-China STI cooperation). Secondly, we quickly discussed the major implications on China's STI development stemming from the 14th FYP and the STI MLP with special attention to the country's self-defined "frontier technologies". And finally, we made a glimpse on the country's national S&T major (very limited information publicly available) and the national key R&D projects with relevance to the fields of AI, ML and BD in order to quickly navigate European R&I actors through. We hope this may prompt European partners to look more closely on the Chinese institutions involved in these projects and to develop sound potential cooperation opportunities granted that they are of equal benefit to both sides (**future cooperation options**).

In conclusion, we would like to make the following short policy recommendations targeting EU R&I actors involved in cooperation with China in AI, ML and BD.

1. Establishing a closer dialogue with individual researchers involved in cooperation: Taking the results of our analysis on the institutional level, we recommend entering into a dialogue with the individual researchers closely engaged in cooperation with China. Except from general developments in China's STI sector and our interpretation how those may impact on the bilateral STI cooperation, other incentives (drivers) often remain unclear, in particular on the individual level. More and systematic dialogue formats between policy-makers and individual researchers about their past experience and future motivation to work with China may remedy this lack of information. The recommendation for more dialogue, at the same time, is true for the EU policy-making level alone. As the study by Yuzhuo Cai from 2023 suggests, to build more and more sustainable transnational university-industry co-innovation networks between the EU and China, two policy areas must be more connected through dialogue: EU-China higher education cooperation and EU-China industry cooperation[9].

2. Risk-benefit assessment for cooperation: We join in the growing number of public voices which call for a new approach to STI cooperation with China based on a clear risk-benefit assessment. These assessments should both integrate the public information made available by experts on the topic and be case-specific. To facilitate a case-specific approach, individuals engaged in cooperation must be closely consulted (see point 1). Risk assessments should involve several perspective levels, starting with the EU's point of view. Additionally, the national, the regional and the institutional perspective on cooperation with China are important levels too. Germany's current ambitions

[9] Cai (2023): Towards a new model of EU-China innovation cooperation: Bridging missing links between international university collaboration and international industry collaboration, Technovation, Volume 119, p.12

to fund regionally embedded information networks on China provide a good example in this regard. Under the name "Regio-China"[10] regional clusters of higher education institutions are built to cross-fertilise information sharing, awareness-raising and the drafting of guidelines about research cooperation with China. Other EU countries should follow suit.

3. Building more expertise on China: The findings of our report show a high concentration in the number of EU27/AC institutions involved in AI, BD and ML cooperation with China. The underlying hypothesis for our report suggests that the level of China expertise directly correlates to the intensity of cooperation, also if not the only factor. In other words: The pool of institutions between Delft University of Technology and Technical University Aachen (see figure 6) amasses a lot of China-related cooperation expertise already, whereas those on the other end (and not covered in the report) only make their first steps. Therefore, we recommend to offer capacity and skill building trainings focused on STI cooperation with China more widely in Europe and for all R&I actors alike. These trainings should also deal with China's own aspirations in STI, in order to equip European actors with better anticipation capacities regarding developments within China. This could contribute to cultivating a more pronounced understanding of the larger framework in which research cooperation between Europe and China takes place.

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[10] https://www.kooperation-international.de/aktuelles/bekanntmachungen/detail/info/geaendert-bekanntmachung-des-bmbf-zur-foerderung-des-regionalen-ausbaus-der-china-kompetenz-in-der-wi

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Funded by the European Union

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