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Sharpening Europe's approach to engagement with China on science, technology and innovation

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INTRODUCTION

China's emergence as a leading force in global science, technology, and innovation (STI) is one of the key geopolitical developments prompting a rethink of the European Union (EU)'s approach to international cooperation in research and innovation (R&I). The country's rapid progress towards the frontier of knowledge, combined with the potential of new technologies such as artificial intelligence (AI) and fifth-generation network technology (5G) to change the balance of power, raises difficult questions for Europe's future competitiveness, security, and autonomy.

As the EU and China negotiate the next Joint Roadmap for the future of R&I cooperation (the Roadmap), disagreement over the framework conditions persists. Points of contention include reciprocity in access to innovation funding, data, and research results, intellectual property protection, and research integrity and ethical standards. Policy makers across Europe also have concerns about China's state-driven foreign technology acquisitions. This is visible in policy developments on foreign investment screening and is increasingly spilling over into scientific research. The Chinese Communist Party (CCP)'s efforts to harness advanced technologies in order to modernize its military and strengthen its authoritarian governance system, meanwhile, are bringing new risks to scientific cooperation projects.

Against this backdrop, the EU is recalibrating its stance of unconditional openness in STI exchanges, balancing it with measures to protect its economic and security interests and safeguard European values. In the new strategy for international R&I cooperation endorsed by the Council on 28 September 2021, the EU stresses "open strategic autonomy" as its response to a rapidly changing world, where openness and international cooperation remain essential and desirable, but where science and technology capabilities influence and interact with economics, politics, and security in ways and to a degree not previously witnessed.

At the EU level, several policy measures have been introduced or are under development that have implications for research cooperation. The Horizon Europe R&I funding program can, in exceptional circumstances, exclude certain partners in order to safeguard "strategic assets, interests, autonomy or security." The Commission is also expected to issue country-agnostic guidelines on tackling foreign interference in higher education and research organizations. National governments both within and outside the EU are taking steps to safeguard research integrity and security. Some are also making efforts to identify and nurture strategically important technologies. Germany's Federal Ministry of Education and Research, for example, recently established a Council for Technological Sovereignty tasked with developing recommendations for strengthening the technological sovereignty of Germany and the EU in key fields.

The escalating confrontation between the United States and China, described by some as a "tech Cold War," increasingly complicates and politicizes cross-border STI cooperation between the two countries. Yet despite geopolitical tensions and political rhetoric, knowledge flows and cooperation between Chinese and US scientists and businesses

continue to deepen. This begs the question whether Europe risks being marginalized at a time when the stakes of technological strength, competition, and cooperation may never have been higher. Until recently, many European policy makers and academics held an enthusiastic and generally uncritical view of STI cooperation with China, visible in the plethora of agreements signed as late as fall 2019. They have gradually moved beyond this, developing a greater awareness of the challenges and risks posed by cooperation with China. It will now be critical to ensure that this does not translate into an overly cautious approach, or even general reluctance to engage with China on science and technology across the board.

China's impressive rise as an innovation powerhouse warrants a strategic, clear-eyed, and informed vision of how Europe can grasp the opportunities while managing the risks arising from STI engagement with the world's second-largest economy. China remains a challenging but indispensable partner, including in tackling pressing global challenges such as the climate crisis and infectious diseases. The joint decision to continue the EU-China cooperation flagship on biodiversity despite difficulties in the Roadmap negotiations is clear illustration of this. Europe must sharpen its approach to STI engagement with China in order to balance cooperation and competition, position itself vis-à-vis the United States and other foreign countries as a defender of a rules-based world order and international cooperation, and safeguard its long-term prosperity, security, and values.

The present paper aims to provide a considered contribution to such a vision. It begins by examining China's STI strategy and governance and identifying certain elements of its approach that might offer lessons for Europe, such as the active use of STI open-source intelligence (OSINT) and the integration of STI and adjacent policy fields. This is followed by a summary of the drivers and challenges of EU STI cooperation with China, as well as recent EU and national government actions to recalibrate the relationship. Finally, it puts forward a series of proposals for collaborating with and relating to China, which could be further explored in relevant fora such as the European R&I Knowledge Network on China (EU KNoC).

1 CHINA'S STI STRATEGY AND DRIVERS OF ITS INTERNATIONAL STI ENGAGEMENT

1.1 China's STI strategy and governance

The 14th Five-Year Plan for National Economic and Social Development (14th FYP), passed in March 2021, places innovation at the heart of China's modernization drive, doubling down on the 2016 national strategy of "innovation-driven development." Beijing is determined to address the enduring weaknesses in China's innovation system, such as shortcomings in the area of basic research which constrain the development of indigenous breakthroughs in in key science and technology fields.

By emphasizing self-reliance in STI, the CCP aims to insulate China from the external shocks that could threaten its economic and national security and, by extension, the party's own hold on power. Beijing's perspective on globalization and interdependence has shifted, particularly since the escalation of tensions with Washington in 2018. US

actions targeting Chinese technology firms and supply chains have accelerated Beijing's push for indigenization as a way of building resilience and reducing external dependencies on "core technologies," especially semiconductors. In 2016, China's president Xi Jinping stated that these dependencies represent China's "greatest hidden danger."

Technological security, a dimension of Xi Jinping's all-encompassing national security concept, is the imperative that guides China's STI strategy. Despite the new urgency, this preoccupation is not new, dating as far back as Deng Xiaoping's Four Modernizations which linked independent STI advancements with China's economic and social rejuvenation. The "indigenous innovation" campaign launched in 2006 highlighted the Chinese leadership's resolve to catch up with advanced industrialized nations, and reflected a renewed focus on state intervention in technology development. With the 13th Five-Year Plan, Made in China 2025, and other plans and policies, Xi Jinping has shifted the focus from playing catch-up to surpassing the West and "seizing the commanding heights," with a view to turning China into an STI superpower by 2049.

This strategic prioritization of STI at the highest levels of government sets China apart from Europe. While Europeans' quest for technological sovereignty was catalyzed by US-China tensions and the Covid-19 pandemic, Chinese leaders have long identified emerging fields such as AI, 5G, and the Internet of Things (IoT) as the engines of the Fourth Industrial Revolution. They view this as a window of opportunity for China to upgrade its economy, bring about high-quality growth, solve pressing domestic challenges such as environmental degradation and a shrinking labor force, and reclaim the country's status as a global power which can prevail over the West in the strategic contest for global leadership. Although a number of its priorities mirror those of its European counterparts (e.g. investments in STI to power the green transition, build resilience, and advance competitiveness), Beijing also views scientific and technological innovation as a "battlefield of the international strategic game."

As a result of this top-level, strategic embrace of innovation, China's approach to STI policy and governance stands out in comparison to the European approach in a number of key ways:

- **State direction and central, long-term planning**. China's party-state capitalism blends market mechanisms and competition with macro-economic planning to serve centrally set objectives. The same approach is applied in the STI sphere: state intervention at the national and subnational levels to plan, guide, and support research and innovation is omnipresent, while private initiatives, competition, and experimentation are encouraged by means of different channels and policy tools. The state attempts to steer public-private collaboration through innovative forms of industrial policy (e.g. guidance funds that bring together public and private financing to advance strategic industries such as AI and semiconductors).
- **Policy linkage**. China's governance approach structurally integrates STI with other policy domains, particularly industrial and economic development policies. Vice Premier Liu He, Xi's top economic adviser and head of the party commission overseeing strategic policy making on finance and the economy, also heads the State Council's Leading Group of State Science and Technology (S&T) Reform and

Innovation System Construction. Earlier this year, he was tasked with overseeing China's efforts to boost the chip industry. STI is also integrated with trade and investment, education, cyber, and defense policies.

- **Integrated civilian and military innovation**. China's national "military-civil fusion" (MCF) strategy, which drew inspiration from elements of the US Defense Advanced Research Projects Agency (DARPA) model, embodies the strong linkage between military and civilian innovation in China. While not always successful, the scale of its ambition is remarkable and stands in stark contrast to Europe's reluctance to engage with the military applications of new technologies such as AI.
- **Prioritization of information collection and management**. Intervention requires knowledge of STI advancements. While they largely perform a political signaling function, it is noteworthy that the Politburo's collective study sessions have dealt with emerging technologies several times in recent years. Additionally, the Institute of Scientific and Technical Information of China (ISTIC), a research institute under the Ministry of Science and Innovation (MOST), manages extensive databases of domestic patents, talents, and the achievements of major S&T funding programs. ISTIC is building an integrated national information system to support and guide decision making.

1.2 The international component of China's STI strategy

In its first Long-term Plan for the Development of Science and Technology, launched in 1956, China attached strategic importance to learning from foreign countries as a way of catching up technologically and compensating for its missed industrial revolution. The 14th FYP, meanwhile, emphasizes "open S&T cooperation," particularly in the health and climate fields, including the "opening up of national S&T programs" and "open talent policies." This chimes with the open science movement, but here, as in other contexts, the term "openness" carries different connotations for Chinese and European actors: that of a historical strategy of "opening up," carefully crafted to serve China's own interests for the former, versus an approach of "openness by default" for the latter.

Today, the international component of China's STI strategy aims at much more than learning from foreign countries to catch up or joining international efforts for open science. The underlying objective is to develop indigenous innovation and import substitution to allow China to move up the technological ladder, reduce dependence on imported technology, and leapfrog in next-generation fields such as green technologies and AI.

To achieve these goals, China's STI strategy pursues three broad courses of action, with centralized guidance and support:

- **Acquiring foreign knowledge, technology, and assets** (e.g., through mobility programs, patent purchasing, foreign direct investment, and espionage).
- **Attracting mobile factors of production in the STI sphere** (e.g., high-tech research and development, foreign funding, and foreign talent).
- **Protecting Chinese assets and ensuring their circulation** (e.g., through active lobbying at international regulatory and standard-setting bodies, particularly with

a view to shaping standards for emerging technologies; active participation in the governance of key international institutions; international patenting; development cooperation and partnerships with developing countries).

The achievement of the first two objectives is facilitated by a sophisticated and systematic approach to monitoring foreign advancements, which gives China **an information advantage vis-à-vis Europe**. For example, science and technology diplomats stationed in Chinese embassies abroad "monitor host country technological breakthroughs, identify investment opportunities for Chinese firms, and serve as the overseas arm of the International Cooperation Department of MOST," according to Georgetown University's Center for Security and Emerging Technology (CSET). These S&T diplomats focus specifically on priority technologies relevant to China's strategic objectives, such as the 35 "stranglehold" technologies constraining China's industrial development listed in a series of articles in *Science and Technology Daily*.[2]

China's monitoring of STI through open-source intelligence (OSINT), a system set up at the end of the 1950s, covers both domestic and foreign sources (patents, publications, etc.). At the heart of the civilian (non-military) dimension of this system is the above-mentioned, which compiles and analyzes information on domestic and foreign STI sources, trends, and achievements. This system helps China's government monitor and scan foreign STI policies, strategies, inputs, and outputs, and provides strategic advice to decision makers. This was well captured in Xi Jinping's speech at a conference on science and technology in May 2021: "The CCP Central Committee has comprehensively analyzed the competitive situation of international scientific and technological innovation." This OSINT system also provides support for "technology transfer from foreign sources to national industries," according to the ISTIC website.

2 STI ENGAGEMENT WITH CHINA: DRIVERS, DEPENDENCIES, AND CHALLENGES

2.1 Why cooperate with China? From drivers of collaboration to dependencies

European cooperation with China on science, technology, and innovation is motivated by several factors. Various analyses indicate that China is at, or close to, the frontier of knowledge in areas such as biotech, space, and AI, making it an indispensable player in advancing science and tackling pressing global challenges. The nature of the country's STI system, its resources, and the results it achieves make it an attractive partner for Europe.

Exhibit 1 Indicators of China's STI strength

INDICATOR	RANKING/SHARE/NUMBER	YEAR	SOURCE
Ranking, total research and development (R&D) spending	2 (after the United States)	2019	OECD
Ranking, number of scientific publications	1 (followed by the United States)	Since 2016	National Science Foundation (NSF) National Science & Engineering Indicators
Number (increase), co-publications	United States 186,886 (12.1%) UK 53,934 (35.4%) Australia 46,486 (29.8%) Canada 32,926 (24.2%) Germany 29,422 (31.5%) Japan 27790 (20.5%) Singapore 19,231 (30.6%) France 18,871 (24.2%)	2018 – 2020	SciVal (accessed December 19, 2021)
Share, global R&D expenditure[3]	23.9% United States 29.9% EU 20.0% (2017)	2019	Congressional Research Service and NSF National S&E Indicators 2020
Ranking, number of top 10% most cited STI publications	1	Since 2019	SciVal
Ranking, number of top 1% most cited STI publications	1	Since 2020	SciVal

Ranking, number of top 1% most cited publications on AI	1	Since 2014	SciVal
Ranking, number of top 1% most cited publications on renewable energy, sustainability, and the environment	1	Since 2013	SciVal
Ranking, number of companies among top 100 R&D spenders	3 (after the United States and Germany)	2020	fDi Markets
Ranking, number of companies among top 2,500 R&D spenders	2 (after the United States)	2019	2020 EU R&D Scoreboard
Share, companies among top 2,500 R&D spenders	21.4% United States 31.0% EU 16.8%	2019	2020 EU R&D Scoreboard
Companies' share in top 2500 companies' R&D	13.1% United States 38.5% EU 20.9%	2019	2020 EU R&D Scoreboard
Ranking, source of EU high-tech imports	1	2020	Eurostat
Ranking, destination of EU high-tech exports	2 (after the United States)	2020	Eurostat

A number of the factors contributing to China's STI strong "gravitational field," to quote the 14th FYP, may progressively differentiate China from other partners and, in some areas, confer the country a unique comparative advantage. These include:

- **China's massive investment in large and very large research infrastructures** (see, for instance, the Medium- and Long-Term Plan for the Construction of Major National Science and Technology Infrastructure, 2012-30, and the Chinese Academy of Sciences' Major Technological Infrastructure Development Roadmap to 2050).[4]
- **A scale advantage** conferred by large teams of well-trained and highly skilled researchers and technicians, which can be critical in areas such as biotech and gene sequencing research.
- **The availability of large datasets**. The 14th FYP, for example, announced the construction of "scientific big data centers."

Of course, the resources of China's innovation system are often not as readily available to foreign businesses and researchers as they are to their Chinese counterparts, a longstanding concern on the EU's side. Access to factors such as those listed above, or a lack thereof, increasingly impacts foreign actors' ability to innovate. For example, Chinese data handling laws and regulations, particularly the new Data Security Law and Personal Information Protection Law, could further complicate foreign access to China-based data sets. The 2018 regulation on the management of scientific data has already created hurdles for businesses and researchers, for example in the pharmaceutical sector.

In the academic field, other factors such as access to **funding** and **personal benefits** and honors for researchers also motivate partnerships. The 14th FYP, for example, announces support for "foreign scientists filling positions in Chinese academic S&T organizations." Inviting retired European researchers to lead Chinese teams is also common practice.

Turning to **business-led collaboration**, European companies have an interest in establishing R&D centers and large-scale R&D operations in China, employing Chinese nationals, generating Chinese patents, and developing innovations into Chinese products. Despite the regulatory and policy hurdles driving the decoupling of innovation systems, 40 percent of respondents to the European Business in China Business Confidence Survey 2020 reported that China's innovation and R&D environment is at least as favorable as the global average, if not more so. Competencies, cost considerations, and market intelligence, as well as the possibility to benefit from government support for commercialization, motivate the relocation of R&D activities to China.

Market access continues to be a determining factor in attracting foreign research and technology development to China. China's government continues to be successful at leveraging the lure of its vast market to acquire and absorb foreign technology. Despite the Foreign Investment Law (January 2020), which expressly prohibits unfair technology transfers, the European Business in China Business Confidence Survey 2021 found that "European companies are still being compelled to transfer technology in order to maintain market access."

The attractiveness of China's market and innovation system also raises the issue of potential **dependencies** arising from it. Just as the development of China-centric supply chains has created European reliance on China in several sectors, European companies could also gradually become more dependent on the country for their capacity for innovation. While access to European technology and know-how remains indispensable for China in many sectors, in emerging sectors such as the electric vehicle (EV) industry, European companies are growing more reliant on China as an R&D hub.

China's objective to become more self-reliant raises issues of openness, fairness, competitiveness, and strategic autonomy for EU. In deciding what kind of collaborations to pursue with Chinese partners, companies and universities alike will find it increasingly difficult to evade such long-term considerations.

2.2 Challenges posed by STI cooperation with China

Compared to a few years ago, the main challenges of European STI collaboration with China are now more widely understood and debated. From longstanding discussions about the lack of reciprocity in innovation exchanges (e.g. in terms of research funding and researchers mobility) to cases of espionage and concerns around political interference in European universities, research ties with Chinese partners are under increased scrutiny.

The challenges can be grouped into three broad categories:

- **Threats to industrial competitiveness and economic security**. As MERICS research on Made in China 2025 has highlighted, basic and applied R&D partnerships in sectors in which China aims for dominance, such as smart manufacturing and emerging technologies, may erode Europe's industrial base if they are not subject to a sound cost-benefit analysis. The recent controversy around alleged industrial espionage in the Danish wind energy sector shows that competition dynamics sometimes complicate cooperation, even in sectors where Europe and China have a strong shared interest in working together to solve pressing global challenges.
- **National security risks.** This is exemplified by the undercover Chinese military scientists sent out to universities around the world, including in Europe, to acquire knowledge and technology. While not always successful, China's MCF efforts are uniquely ambitious, posing a dilemma for democratic governments, whose policy tools were designed to confront illegal practices (such as intellectual property (IP) theft) rather than manage engagement with entities that operate in inherently grey-zone, non-transparent areas, such as Chinese defense universities. Collaborations leading to the transfer of technology and know-how to military end-users can pose a risk to European security and strengthen the capabilities of the Chinese People's Liberation Army. Leveraging technology to modernize the military and expand the CCP's global influence is a major goal of Beijing.
- **Value-based and human rights threats.** These range from documented threats to research integrity (infringements of academic freedom, the violation of ethical standards, political influencing, and interference) to the risk that European knowledge and technology may end up supporting the CCP's human rights abuses,

particularly with regard to the persecution and internment of ethnic minorities in Xinjiang. With some exceptions, informed debate on the latter is still largely lacking in Europe.

Exacerbating these challenges are two features that set China apart from other non-democratic research partners that pose growing dilemmas for open societies such as Europe. Given China's sheer size and growing global influence, the consequences of these two aspects can be particularly far-reaching.

Firstly, the Chinese state's system to **acquire and transfer foreign technology and talent** from abroad through various channels is unique in scale and sophistication.[5] This phenomenon has been widely documented but remains poorly understood in Europe, where equity investments have received most attention.

Secondly, the CCP is increasingly capable of **pressuring and coopting private actors**, including businesses and researchers who engage in R&I collaboration with European partners and who lack the legal tools to resist state requests. Calls for Chinese scientists to serve the "motherland" have become more pressing under Xi Jinping's leadership, while new data laws are designed in part to facilitate state access to private sector-held data. Additionally, the national military-civil fusion strategy increasingly seeks to leverage the R&D work of China's elite universities to drive defense innovation.

Notably, conversations with universities and individual scholars reveal that high-level discussions of China-related risks do not always translate into widespread and actionable knowledge about when and how R&I partnerships can run into trouble. In the absence of information-sharing and evidence-based advice, some stakeholders engaging in collaborations with Chinese partners may find the concerns articulated by policy makers, the intelligence community, or China experts excessively abstract.

3 STI ENGAGEMENT WITH CHINA: GOVERNANCE

3.1 Recent EU actions to recalibrate STI cooperation with China

The EU has recently taken important steps to assert its sovereignty and protect its interests while confirming its commitment to a rules-based approach to trade and investment, multilateralism, and openness. Its "open strategic autonomy" concept introduces a new balancing act between openness and protecting security and strategic interests, strengthening critical STI capacities, and diversifying supply chains. It is particularly applicable within sensitive industrial ecosystems such as health, defense, energy, and aerospace. This strategic recalibration will also clearly impact international R&I cooperation, with implications for both research and business exchanges.

What stands out within this new approach is a series of measures that seek to define either the conditions or the red lines for cooperation with China, or to build defenses to protect the EU's knowledge security (see exhibit 2). Striving to go beyond the technology protection agenda, the EU R&I Knowledge Network on China (KNoC) initiative, launched in June 2020 by the Directorate-General for Research and Innovation (RTD) and the Council of the EU's Strategic Forum for International Scientific and Technological Cooperation

(SFIC), has made a substantial contribution to awareness-raising, knowledge pooling, and the exchange of experiences (with the potential for better coordination) between national ministries of research and education on STI engagement with China.

Also worthy of mention are certain instruments in areas that go beyond the European Commission's R&I policy competencies due to their implications for engagement with China on research and STI more broadly. The foreign direct investment (FDI) screening regulation, for instance, affects foreign investments in critical technologies and R&D-intensive industries and also considers potential threats to projects or programs of interest to the EU as a whole, such as R&I innovation framework programs. Export controls are another relevant tool. Mirroring similar efforts by national governments to ensure compliance in academic and research environments (e.g. in Germany), the European Commission's Directorate-General for Trade published a non-binding recommendation for research involving dual-use items.

Besides protecting existing technological assets and advantages, proactive measures aimed at reinvigorating Europe's industrial and innovation base are essential to match China's strategic and integrated approach to nurturing high-tech value chains, as a major Joint Research Center (JRC) report on China concluded in 2019. Prompted by the US-China conflict over the domination of future technologies and the painful realization that it was falling behind, the EU has launched sweeping strategies to develop its industrial policy toolbox and inject public money into innovation. The Commission has also published a review of the bloc's dependencies and capacities along strategic supply and value chains. However, this exercise has yet to translate into an articulation – let alone an operationalization – of European priorities in R&I cooperation with China.

Exhibit 2 Measures to protect European interest

NON-SPECIFIC EU MEASURES			
Guidelines on Tackling Foreign Interference in Higher Education Institutions and Research Organizations (forthcoming) *Soon-to-be-published guidelines focusing on the safeguarding of academic freedom and research integrity, drafted with China in mind but without an explicit focus on China.*	Communication on the Global Approach to Research and Innovation (May 2021) *Reiterates a commitment to openness while stressing the need to promote reciprocity and a level playing field and uphold European values in light of new geopolitical realities; stresses the importance of framework conditions and concrete benchmarks in R&I cooperation roadmaps with non-EU countries.*	Horizon Europe Regulation (April 2021) *Article 22(5) provides grounds to limit or exclude participation by specific legal entities based outside of the EU or associated countries, or entities controlled by non-associated countries, in exceptional and justified circumstances to safeguard "strategic assets, interests, autonomy or security."*	Code of Practice for the smart use of intellectual property in an international context (forthcoming in 2022) *Aimed at raising awareness among universities, research organizations, and businesses in accordance with the intellectual property action plan.*

CHINA-SPECIFIC EU MEASURES			
Joint Roadmap negotiations *Main channel for selecting safe cooperation areas and projects; negotiation of framework conditions to ensure reciprocity and rules-based collaboration.*	Comprehensive Agreement on Investment (CAI) *The text on which the two sides reached a political agreement includes strong rules on forced technology transfers, although uncertainty remains high about the prospects of ratification, as well as on the enforceability of the provisions.*	EU R&I Knowledge Network on China (EU-KNoC) *Launched by DG RTD and the SFIC to pool existing knowledge on China and promote common approaches among Member States.*	China Innovation Funding *EU-funded resource for European researchers and industry on Chinese innovation funding programs.*

3.2 Measures taken by national governments

Government control of technological and knowledge exchanges with, and transfers to, foreign countries is not new. For many Western European countries, the foundations were put in place during the Cold War in the context of the Coordinating Committee for Multilateral Export Controls (CoCom). In recent years, EU Member States have adopted new measures or reinforced existing ones to protect their scientific and technological assets, for example mechanisms to screen foreign direct investment. These act in concert with EU-level measures and respond partly to the rapid shift in stance on cooperation with China. Several countries are also revising their approaches to research cooperation with China, as documented by researchers at the Leiden Asia Centre.

Measures taken by EU Member States to safeguard knowledge security and research integrity generally mirror EU-level actions and focus on: i) screening partnerships and delineating areas of cooperation and non-cooperation; ii) establishing rules and framing conditions for cooperation with China; and iii) strengthening China competence, raising awareness of the risks and challenges of cooperation, and providing guidance to relevant stakeholders. Non-EU European countries have also taken notable steps, including the establishment of a new team responsible for protecting research security within the UK Department for Business, Energy and Industrial Strategy (BEIS); the team will advise researchers on security-related topics ranging from export controls to cybersecurity.

National policy frameworks for collaboration with China and other foreign countries vary. When it comes to setting red lines for cooperation, for instance, France has a screening mechanism, in place in its current form since 2011, which defines protected research zones and research areas. Countries differentiate cooperation from non-cooperation areas according to different criteria and with varying levels of granularity. Outside of the EU, the Norwegian government is considering the introduction of a similar mechanism, which would require actors who plan to engage in international research cooperation or transfer in certain areas or technologies to obtain approval from the government.

Over the past few years, countries including Sweden, the United Kingdom, Germany, and the Netherlands have issued non-binding guidelines on how to cooperate with or relate to challenging (often non-democratic) partners in general, or China in particular. Finland is the latest country to embark on a similar effort. Except for the United Kingdom, which has also developed relevant guidelines for industry, national guidelines tend to have a strong focus on academia, and especially on academic freedom. Other countries such as Denmark have set up committees to discuss cooperation with challenging partners, or have launched initiatives to strengthen China competence (e.g. the Netherlands).

It is worth noting that when it comes to safeguarding scientific freedom, European countries generally tend to take a country-agnostic approach. The Bonn Declaration on Freedom of Scientific Research, spearheaded by the German Presidency of the EU Council and adopted at the ministerial conference on the European Research Area (ERA) in October 2020, demonstrates the commitment to this issue at the European level. In describing the role of governments, the declaration calls for "a healthy equilibrium between bottom-up and top-down research and innovation policy approaches."

3.3 The European approach: Issues and challenges

China's STI rise and its increasingly important contribution to the global knowledge economy; the dynamism and relevance of the Chinese economy, market, and innovation system; and the need to work together to tackle global challenges mean that disengagement is not, and should not be, an option.

Rather, Europe needs to ensure it has the appropriate frameworks and instruments in place to engage with China in an informed way, develop a comprehensive understanding of its R&I system, and identify areas in which cooperation is mutually beneficial. Sound engagement also entails being proactive and strategic in setting the agenda for interaction. Currently, Europe has shortcomings in all of these areas. Furthermore, it is important to point out that some of the difficulties Europe encounters in relating to China's STI strength and policies stem from internal challenges related to its own institutional structures and governance, resources, strategy, and agility.

In order to develop a more conscious, informed, and effective approach to STI relations with China, Europe must address the following issues and challenges:

- **Information and knowledge asymmetries**. Many European actors lack information on or knowledge of both Chinese actors and the broader, fast-changing R&I landscape in China. Researchers, higher education institutions, and companies, particularly small and medium-sized enterprises (SMEs), often know too little about China's R&I strengths, its government's strategic objectives, and the importance of those objectives in driving and directing research, innovation, and international cooperation. Overcoming such a knowledge asymmetry is a prerequisite for making informed decisions on cooperation while managing potential risks.
- **Arbitration between different interests and coordination challenges** (within and between different EU countries):
    - **STI cooperation with China has become more relevant to and interconnected with policy areas such as national security, diplomacy, trade, and industry.**[6]This is due to China's increasing economic, technological, and innovative strength, combined with geopolitical frictions and the growing relevance of key technologies for long-term economic strength and national security. The coordination of research and STI cooperation with China increasingly implies arbitration between different objectives or interests rather than being an isolated policy issue. Frictions and at times incompatibilities between commercial, academic, scientific, and national or collective interests complicate the development of effective policy approaches and instruments. Although China's state-led approach to innovation cannot, and should not, be replicated in Europe, its ability to link adjacent policy fields to serve strategic objectives does confer an advantage.
    - **There is a certain asymmetry between short-term gains (which often accrue to individual actors) and long-term interests (national or European security, competitiveness, or sovereignty)**. Lack of awareness is not always the issue: large corporations or researchers may choose to

prioritize short-term gains from research cooperation that eventually lead to the transfer of sensitive scientific and technological know-how from Europe to China.

- **The governance of STI cooperation with China suffers from coordination gaps between different levels of government and relevant policy areas**. National-level STI cooperation with China often tends to be reasonably well aligned, but only loosely coordinated, with cooperation at the EU, regional, and municipal levels. Furthermore, coordination between different projects, ministries, and agencies relating to or cooperating with China in areas relevant to and affected by developments and trends in technology research (such as ministries of research, industry, trade, foreign affairs, etc.) is often underdeveloped.[7]
- **Coordination and information exchange between countries on STI cooperation with China is rather weak.** The differences between and fragmentation of both innovation policies and China strategies in different European capitals sometimes allow Chinese actors to set the terms of cooperation. There are also instances of European entities – at national but also subnational and institutional level – competing with each other with regard to their cooperation with China. The EU KnoC initiative seeks to address some of the coordination gaps, with a particular focus on EU Member States' ministries of research and education.
- **Policy responses are complicated by the specificities of different disciplines, sectors, and fields.** Examples range from basic versus applied research and the social sciences versus STEM (science, technology, engineering, and mathematics) disciplines, down to individual lab results and technology applications. These specificities render one-size-fits-all policies ineffective, or even counterproductive. Conversations with researchers and policy makers have shown that efforts to identify safe areas of collaboration with China require careful assessments of the risks and benefits of individual projects and programs. This can be highly complex and resource-intensive. Policy makers need to ensure that they provide guidance and tools to support risk management by scientists and research institutes, while at the same time avoiding (or being prepared to mitigate the costs of) policy overreach.

- **Weaknesses in Europe's STI system**. A number of the frictions and concerns caused by China's increasing scientific and economic strength can be explained by weaknesses in Europe's own STI system and resources:
    - **China's top-down innovation policy has its inefficiencies, but sometimes allows for faster resource mobilization and decision making than is possible in Europe**. For example, whereas China has rapidly increased its R&D expenditure, the EU has consistently fallen short of its longstanding goal of raising R&D expenditure to 3 percent of gross domestic product (GDP). Chinese strides in quantum communications, an area in

which the country is quickly outpacing Europe, can be at least partly traced back to bureaucratic constraints in Europe making China a more attractive destination for some scientists.

- **Fragmentation has long been an issue for the ERA**, which the Commission is working to revamp. The fast pace of technological change and pressing global challenges, such as climate change, require interdisciplinary private-public cooperation and agile structures allowing the development of technological solutions collectively, quickly, at scale, and around a common mission. Agility is also essential to respond and relate to China's rapidly maturing STI capabilities.

- **A reactive and defensive approach**. Europe's responses have tended to place a narrow and somewhat reactive focus on reciprocity, academic freedom, and the containment of foreign interference. This approach carries the danger that Europe will prioritize short-term imbalances or gains instead of assessing the long-term, strategic risks and benefits of engagement.

    - **While the EU is right to insist on greater reciprocity in R&I cooperation with China, a nuanced strategy of engagement would be based on a realistic assessment of Beijing's objectives**, as well as a clear articulation of Europe's own priorities and red lines. To some extent, the lack of reciprocity affecting European researchers and businesses – from mobility barriers to unequal access to funding, data, and research results – is an inbuilt feature of China's international R&I cooperation strategy. Addressing the imbalances in innovation relations with Europe is arguably not in China's government's interests.[8]Rather than merely emphasizing reciprocity in a rather mechanistic and short-sighted fashion and as an end in itself, a clearer vision of long-term goals and benefits seems warranted.

    - **Recently developed guidelines for actors cooperating with Chinese partners tend to be heavily risk-focused**, concentrating on threats to academic freedom and foreign interference. While these instruments are useful, they may reinforce passivity and reactivity at the expense of a proactive and strategic approach. These guidelines also often fall short of providing practical and concrete guidance and support, particularly to non-academic actors such as SMEs and startups.

    - **Europe should become more proactive in setting the agenda for interaction with China according to clear priorities and strategies**. This entails being more concrete and transactional in interactions and negotiations with Chinese counterparts. A lack of decisiveness in this area gives China the opportunity to set the agenda. Furthermore, statements on the importance of academic freedom should be complemented by concrete demands and enforceable consequences when China crosses Europe's red lines.

4 CONCLUSIONS AND RECOMMENDATIONS

China's emergence as an STI power to be reckoned with, combined with its ambitions in and approaches to knowledge generation, appropriation, and utilization, has caused the EU and many Member States to rethink their approaches to cooperation in this field. The country is at the forefront of innovation in areas such as AI and renewable energy and remains an essential partner, but its multi-pronged strategy to acquire foreign knowledge, technology, and assets, attract mobile factors of production in the STI sphere, and protect Chinese assets poses challenges to Europe's long-term interests.

Measures to define conditions for engagement with China, draw red lines, and protect the EU's knowledge assets and security are already being developed or reinforced. To maintain beneficial cooperation, Europe must develop a coherent and informed strategy that consolidates these protective measures and ensures their implementation, while developing a more precise definition of the priorities for cooperation and devising effective risk management structures.

The United States, which invests considerable resources in studying China's system, policies, and capabilities, dominates the narrative around STI engagement with China. It is important for Europe to make its own assessment of the risks and benefits of cooperating with China and craft its own, balanced approach that resonates with its interests and values. The controversy across the Atlantic around the Department of Justice's China Initiative offers a lesson on the danger of policy overreach not just threatening democratic values but also leading to a disconnect of Western research from China.

Ongoing efforts at the EU level and in Member States to reinforce R&D and the research-industry nexus are fundamental to ensure that the European STI system stays competitive vis-à-vis China and other foreign players. Some of the measures proposed below to sharpen Europe's approach to cooperation with China could in fact greatly contribute to reinforce Europe's own competitiveness.

1) A shared understanding for a common European response. The development of a shared European understanding of the extent, benefits, and risks of collaboration with China requires an effective methodological approach and the collection of more extensive and detailed information.

Proposals for consideration:

- **Adopt a shared methodology at the EU level to measure the scope of Member States' collaboration with China**. Indicators may include joint patenting, R&D cooperation in the corporate sector, and joint publications in emerging tech fields. This would allow both the identification of trends in different European countries and the monitoring of the impact of EU-level measures (as seen for instance with Chinese FDI in Europe).
- **Produce a more accurate picture of the drivers, benefits, potential risks, and challenges of collaboration with China,** through sustained dialogue between policy makers and the actors who manage and implement cooperation projects – from universities and research labs to public innovation agencies, large scientific

organizations, and businesses. Conduct surveys with major national research institutions such as the members of the G6 Group. Inspiration could be drawn from a survey conducted by the Swedish National China Centre with 200 researchers. Lessons could also be learned from the ex-post evaluation of bilateral, publicly funded cooperation projects, as well as those undertaken under the Horizon 2020 Framework Program.

- **Draw lessons from past cooperation projects to assess the risks and possible shortcomings of European engagement strategies**. For example, the experience of the Galileo project, which may have contributed to China's dual-use BeiDou satellite navigation system, demonstrated the lack of strategy that sometimes accompanies cooperation programs in sensitive fields. In Denmark, the recently reported case of a university's collaboration with a Chinese surveillance firm implicated in human rights abuses in Xinjiang, as well as military researchers, highlighted a lack of China knowledge and insufficient due diligence. An incident tracker could take stock of cooperation failures and prevent similar situations from occurring in the future.

2) A better understanding of the comparative advantages of China's national innovation system and STI OSINT efforts. Further research is needed to deepen Europe's knowledge of China's advancements and comparative advantage, the infrastructure and services supporting the Chinese STI sphere, and its efforts to acquire foreign technology.

Proposals for consideration:

- **Invest in further research on the use of China's STI OSINT institutions by Chinese researchers, companies, and officials, as well as their concrete impact** on, *inter alia*, technology transfer and the allocation of research support.
- **Monitor the development of large data sets and very large research infrastructures**, and the comparative advantages these confer to China.
- **Develop indicators of inter-dependencies between Europe and China along entire value chains**, from basic research to industrial production.

3) Stronger coordination and policy linkages. The EU and its Member States are already developing policies and instruments to tackle many of the challenges outlined in this paper. Efficient implementation and coordinated action between different Member States, levels of governance, and policy areas are key to ensuring that Europe's response conforms to its objectives. Coordination can be facilitated by exchanges of experience between national governments, as well as by the development of a shared information infrastructure.

Proposals for consideration:

- **Continue developing mechanisms through which Member States can compare and share best practices** (including the China Core Group, which brings together national ministries of research and innovation). Member States would benefit from sharing information and comparing notes in areas including, but not limited to, screening and due diligence practices, risk management at the project level, requirements for cooperation, guidelines on risk identification and prevention, frameworks for co-funding, student exchange programs, parliamentary oversight, and the protection of European SMEs and startups operating in China.
- **Broaden the scope of reflection on STI engagement with China beyond the remit of DG RTD and ministries of research and higher education**, reinforcing coordination with ministries of economic affairs and industry as well as with the intelligence community. At the EU level, one concrete option to foster better policy integration is the extension of DG GROW's work on assessing strategic dependencies in industrial ecosystems to the STI sphere. The JRC's Observatory for Critical Technologies could take the lead on this.

4) A proactive approach to the cooperation agenda, based on a granular knowledge of China's STI strengths and weaknesses. High-level planning documents such as the 14th FYP give an idea of China's priorities (AI, quantum, space, etc.), but in terms too broad to help Europe devise a nuanced strategy of engagement that differentiates between areas where cooperation is mutually beneficial, and those where it should be restricted. More granular knowledge of China's – and also Europe's – strengths and weaknesses would allow for greater discernment of specific areas and sub-areas in which cooperation is desirable from the viewpoint of European interests, including within the climate sciences. The EU and national governments also need to have the necessary information and data at their disposal to allow more assertiveness in articulating their priorities and negotiating with Chinese counterparts.

Proposals for consideration:

- **Consider developing a European STI OSINT system to compile and analyze information on China's STI system and its implications for Europe.** This could help improve the governance of Europe's collaboration with China by producing granular data on the areas in which the benefits of collaboration outweigh the risks. It would also help assess the quality of Chinese partners, support due diligence, detect STI breakthroughs, and identify the research teams undertaking high-potential work. A first step could be to compile information produced by existing private and public initiatives that shed light on European and foreign STI ecosystems.
- **STI OSINT could also reinforce the governance of the European STI system.** For instance, it could help: i) identify disruptive research and innovations with a potentially high economic impact; ii) identify innovative startups and SMEs that could contribute to the emergence of European tech giants; iii) monitor foreign investments and R&I/R&D collaborations in high-tech sectors; and iv) guide funding allocation (e.g., Horizon Europe).

- **Support research that documents China's state-driven technology acquisition program and disseminate the findings among relevant stakeholder groups.** Such information could also play a key role in supporting negotiation processes with Chinese actors.
- **Make more active use of scientific attachés and the representatives of research institutions based in China.** Consider developing an equivalent to China's list of foreign technology targets; this could help inform a more proactive and strategic approach to cooperation programs and projects.

5) A more effective and collaborative approach to risk management. There is a growing awareness of the need to raise awareness within universities, research labs, public innovation agencies, and even private sector actors on the risks and pitfalls of cooperation, and how best to manage them.

Proposals for consideration:

- **Devise risk management mechanisms for large and strategic cooperation projects with China**, learning from past experiences (e.g. Galileo, Wuhan P4 laboratory) and involving actors at multiple levels, including the intelligence community and China experts.
- **Explore the development of guidelines for the private sector, especially SMEs and startups**, to help frame and manage cooperation with China. The UK experience could provide inspiration for other European countries in this regard.
- **Encourage public and possibly also private-sector funding for partnerships with China to be in line with the framework conditions** to be agreed upon in the context of the Roadmap negotiations.
- **Explore options for coordination instruments to help enterprises resist technology transfer requests made in exchange for market access or other short-term gains** (industry-specific or not, relying on regulatory or voluntary commitments, etc.), through multi-stakeholder consultations, including with the scientific community. Inspiration could be drawn from the process that led to the OECD Anti-Bribery Convention, which criminalizes active bribery in international commercial transactions, or from private sector-led initiatives such as the UN Global Compact.
- **Encourage and support experimentation and the development of different approaches**, such as toolkits, advisory functions, coordination mechanisms, and best practice in information and intelligence collection, following a variable geometry approach and then scaling successful approaches to the EU level.
- **Share information, experiences, and best practice with non-EU countries**. The EU-US Trade and Technology Council, which among other tasks will promote coordination on investment screening and export controls, could also help foster joint approaches to research security. But the EU also has plenty to learn from East Asian countries, including Taiwan, which have historically demonstrated greater pragmatism in balancing mutually beneficial cooperation with measures to mitigate risks to economic and technological security.

ENDNOTES

[1] This report is the updated version of a discussion paper prepared by the authors for the third workshop of the ECFR-MERICS European Caucus on China on October 5, 2021, from which it draws many ideas and insights. The authors are grateful for the contributions of the researchers and representatives of national governments, public innovation agencies, the European Commission, and the OECD who took part in the workshop. Any errors of fact or interpretation remain the sole responsibility of the authors.

[2] For example, issues with chip performance due to the relatively low precision of photolithography machines produced in China.

[3] A significant trend over the past two decades has been China's growing share of global R&D expenditure, compared to a relative decline in the United States, Japan, Germany, France, the United Kingdom, and Italy. From 2000 to 2019, China's share of global R&D rose from 4.9 percent to 23.9 percent, while the United States' share fell from 39.8 percent to 29.9 percent. See Congressional Research Service (2021). "Global Research and Development Expenditures: Fact Sheet." Updated September 27. https://sgp.fas.org/crs/misc/R44283.pdf.

[4] The 14th FYP lists several impressive new major projects: "Hard X-ray free-electron laser devices, high-altitude cosmic ray observation stations, comprehensive extreme condition experimental devices, deep underground cutting-edge physical experimental facilities with very low background radiation, precision gravity measurement research facilities, and strong current heavy ion accelerator devices."

[5] For a detailed and up-to-date account of the working and impacts of the system, see Hannas, W. C. and Tatlow, D. K. (eds.) (2020), *China's Quest for Foreign Technology: Beyond Espionage*. London: Routledge.

[6] An EU expert group identified the need for a more strategic approach to international STI cooperation as early as 2012. Schwaag Serger, S. and Remoe, S. (eds) (2012). "International Cooperation in Science, Technology and Innovation: Strategies for a Changing World." Report of the Expert Group established to support the further development of an EU international STI cooperation strategy, European Commission Directorate-General for Research and Innovation.

[7] A report on Swedish cooperation with China found that coordination within the public sector – both between ministries and between regions, municipalities, and the national level – could be improved. Schwaag Serger, S. and Shih, T. (2018). "Sweden and China - strengthened collaboration for a sustainable future: A knowledge base on innovation, research and higher education" (in Swedish). https://www.regeringen.se/4aac8b/contentassets/5f0e9147360c4940a8cac5139fa949b3/sverige-och-kina_starkt-samverkan_-rapport.pdf.

[8] As Anna Puglisi, a leading expert on China's technology transfer strategy, puts it, China has "put in place policies and programs that undermine the very values we hold dear: a fair and level playing field, transparency, reciprocity and market-driven competition." Puglisi, Anna B. (2021). Testimony before the Senate Select Committee on Intelligence on "Beijing's Long Arm: Threats to U.S. National Security." https://cset.georgetown.edu/publication/anna-puglisis-testimony-before-the-senate-select-committee-on-intelligence/.

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