



**Franziska Bergmann, Eduardo Herrmann |  
Steinbeis 2i GmbH (Ed.)**

# **Understanding the Chinese STI landscape in the context of EU-China innovation cooperation**

**ENRICH – European Network of Research and  
Innovation Centres and Hubs, China**





*Franziska Bergmann, Eduardo Herrmann*  
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## **Imprint**

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## List of abbreviations

|      |  |
|------|--|
| AML  | Anti-Monopoly Law                            |
| CAS  | Chinese Academy of Sciences                  |
| CCM  | Chinese Co-Funding Mechanism                 |
| CPC  | Communist Party of China                     |
| EC   | European Commission                          |
| EU   | European Union                               |
| FAB  | Food, Agriculture and Biotechnology          |
| FDI  | Foreign Direct Investment                    |
| GDP  | Gross Domestic Product                       |
| GHG  | Greenhouse Gas                               |
| GHG  | Information and Communication Technologies   |
| IoT  | Internet of Things                           |
| IP   | Intellectual Property                        |
| IPR  | Intellectual Property Rights                 |
| JPI  | Joint Programming Initiative                 |
| JRC  | Joint Research Centre                        |
| JV   | Joint Venture                                |
| MoE  | Ministry of Education                        |
| MOST | Ministry of Science and Technology           |
| NGO  | Non-Governmental Organisation                |
| NSFC | National Natural Science Foundation of China |
| R&I  | Research and innovation                      |
| R&D  | Research and Development                     |
| RMB  | Renminbi / Chinese Yuan                      |
| SME  | Small- and medium-sized Enterprise           |
| SOE  | State-owned Enterprise                       |

## Executive summary

China's Science and Technology (STI) market is a very dynamic sector offering considerable opportunities for potential collaboration. At the same time the European Union (EU) and China have a long track of cooperation on STI subjects. There are several points of coincidence, common trends and a political commitment to deepen existing collaboration.

A key question remains nonetheless, how can European organisations seize all potential opportunities and successfully collaborate with their Chinese counterparts?

This report provides current insights in that direction, by analysing the core elements shaping the Chinese STI landscape, highlighting trends and by identifying key challenges as well as main opportunities for international STI collaboration. This document pretends to deliver an overview on main issues to be considered by European organisations when intending to get engaged in STI collaboration with China.

A thorough documentary analysis has been performed and a set of key stakeholders has provided their views on the topics scrutinised. Indeed, whereas there is a common agreement on the strategic relevance of fomenting and reinforcing international STI collaboration between European and Chinese actors, there is also a clear view that it is a process requiring perseverance and decisive steps towards building up a relationship based on mutual trust.

# 1 Introduction

China has made an impressive progress on its journey from imitation to innovation in the last years. The rapid evolution witnessed in China has resulted, on the one hand, that cities like Shenzhen belong now to the world's largest innovation hubs and, on the other hand, China is now facing the unusual context that the country is losing low-skilled jobs to lower-costs labour countries. The paradigm of China being perceived as the world's manufacturing house is indeed changing. Moreover, on its race of becoming a high tech country, Chinese companies are following an aggressive policy of buying European top-notch enterprises. These are all reasons to take a closer look at China's rapidly changing STI landscape and to analyse what are the implications of all this changes on the EU-China STI collaboration.

This report presents a summary of the ENRICH project activities in order to analyse the underlying factors of the Chinese STI landscape in respect to their relevance and influence on EU-Chinese cooperation in this field. The information provided reflects a *status quo* analysis of current developments the Chinese science and innovation landscape, policies and ongoing activities within EU-China STI cooperation. It highlights trends and tendencies, as well as current opportunities and challenges for stakeholders directly involved in EU-China STI cooperation.

The presented information was gathered through a desktop research and was later validated and complemented through an online survey and three expert workshops. In the online survey, 68 STI stakeholders from the EU and China provided feedback and rated the findings. In June 2017, the findings were presented in an interactive workshop format to further experts and key stakeholders in Beijing, Shanghai and Brussels. Over 60 participants were representing European and Chinese government STI experts from public bodies, industry, research organisations and other STI service providers in these events. They contributed to this report through a fruitful exchange on valuable experiences in and know-how on EU-Chinese STI cooperation.

To logically structure the findings, all identified information on the Chinese STI landscape and the underlying EU-Chinese cooperation was grouped according to different factors and sorted out into the six **PESTLE** categories:

- **P**olitical factors
- **E**conomic factors
- **S**ocial factors
- **T**echnological factors
- **L**egal factors
- **E**nvironmental factors

Participants of the mentioned survey were also asked to rate the single factors of all PESTLE categories, which had been identified during the desktop research. The information was provided to them in a neutral and random order, thereby minimising the risk of bias. For the rating, participants were asked to evaluate to positive or negative impact of each factor on the Chinese STI system. Based on the results, we came up with the following rankings per category, starting with the most relevant factor.

### **Political Factors**

1. (Willingness for) STI system reforms in China
2. Overall political stability
3. China's own STI prioritisation
4. China's standing on the global political stage
5. Political efforts towards EU-China joint funding programmes
6. Improved national, provincial and municipal integration of international cooperation programmes
7. EU-China cooperation dialogue / strategic agenda

8. Diplomatic tensions leading to incidents (e. g. with Japan, Korea, Norway)
9. World Class 2.0 University Policy supporting the development of Chinese elite universities
10. Role of Joint Ventures for foreign organisations

### **Economic Factors**

1. China's strategic key industries
2. Transformation towards a productivity / innovation-driven knowledge based economy
3. Chinese government's risen R&D expenditures
4. Tax incentives
5. EU-China economic cooperation
6. Thousand Talents Programme
7. Financing of innovation activities by banks and VC
8. Increased private R&D investment
9. Vocational training
10. Slowed down economic growth rate (GDP)
11. Plenty of funds but only provided to a very select number of institutions and / or individuals

### **Social Factors**

1. Increased mobility of people, goods and ideas
2. Growing Chinese middle class
3. Education system
4. Free movement of students and researchers between the EU and China

5. Improved English language skills
6. Fostering of creativity and entrepreneurship in the education system
7. Accommodation costs and academic salaries (particularly at the early to mid-career levels)
8. Cultural differences related to work ethics (between EU & China)
9. Lack of support for foreign experts to settle in China in the longer term (particularly outside of Beijing and Shanghai)
10. (Uneven) geographic distribution of talent across the country

### **Technological Factors**

1. EU-China Joint technological priority areas
2. University-industry links
3. Technical / R&D infrastructure in China
4. Chinese R&D performance
5. Existence of incubators and science parks
6. Big data
7. EU-Chinese R&D collaboration
8. The Great Firewall of China / National cyber security
9. Better communication through ICT advances (online / virtual meetings, etc.)
10. Higher education Joint Venture Models (with foreign universities in China):  
“Sino-foreign universities”
11. Chinese dependency on foreign technologies
12. Access of EU stakeholders to Chinese R&D infrastructure

## **Legal Factors**

1. IPR protection & enforcement
2. Patenting and number of patent applications in China
3. Entrepreneurial climate for foreigners in China
4. Development of standards in China based on top-down approach
5. Anti-monopoly law enforcement
6. Anti-bribery / corruption measures
7. China's market protectionism
8. China's new Foreign NGO Management Law

## **Environmental Factors**

1. Air pollution
2. Water
3. Soil pollution
4. Food safety
5. Blue Economy
6. Access to environmental data
7. Health care and aging populations
8. Reduction of GHG emissions in China
9. China's intl. cooperation on climate change
10. Energy
11. Antibiotic resistance

All factors were carefully assessed and validated during the interactive workshops held in China and Europe with regard to their status quo, their role as main drivers,

impact on relevant STI actors in China, as well as on EU-China STI collaboration in general. In a next step and in order to get an understanding of their influence on the STI landscape, they were also analysed according to **Strengths, Weaknesses, Opportunities and Threats (SWOT)** aspects. Thus, a SWOT-analysis of each and every individual factor allows to understand the factors at a deeper level and to consider internal and external influences. The aspects highlighted in this SWOT exercise entailed:

- The advantages for ENRICH services (strengths) → **internal impact**
- The disadvantages for ENRICH services (weaknesses) → **internal impact**
- Their advantages in relation to the Chinese STI landscape (opportunities) → **external impact**
- Their disadvantages in of the Chinese STI landscape (threats) → **external impact**

Hence, this report focuses on the PESTLE results and the identified opportunities and threats. Its main chapters follow the PESTLE logic and category order. Each chapter will first of all present the main findings per category, secondly highlight the trends and reveal relevant opportunities and challenges as a third step.

We wish you an interesting reading!



## 2 Analysis of the Chinese STI landscape

### 2.1 The political climate in China for Science, Technology and Innovation work and EU Cooperation

#### Identified and rated political factors:

1. (Willingness for) STI system reforms in China
2. Overall political stability
3. China's own STI prioritisation
4. China's standing on the global political stage
5. Political efforts towards EU-China joint funding programmes
6. Improved national, provincial and municipal integration of international cooperation programmes
7. EU-China cooperation dialogue / strategic agenda
8. Diplomatic tensions leading to incidents (e. g. with Japan, Korea, Norway)
9. World Class 2.0 University Policy supporting the development of Chinese elite universities
10. Role of Joint Ventures for foreign organisations

#### Main findings

China has been enjoying a decade of social and **political stability** after a period of change and situational turmoil (internal conflicts with Hong Kong, Taiwan, Tibet, Uyghurs, economic & market reforms, human rights issues, etc.). The country is politically stable at the moment and there is also a political call coming from the

government for stability rather than development. More than 80 % of the population are satisfied with the current political leadership of the country. The “visible” economic growth is a sign for the people that the country’s leadership is functioning. This has also positive influences on the Chinese science, technology and innovation (STI) landscape. Premier Li Keqiang has shown a very reform-oriented stance and innovation has been placed high on the political agenda. Nevertheless, it should be distinguished between stability on a political and on a policy level when considering its influences on STI.

- (13<sup>th</sup>) Five-Year Plan
- Medium and Long Term S&T Development Plan 2006–2020
- The National Plan for Building Indigenous Innovation Capabilities (2011–2015)
- One Belt, One Road Initiative
- Made in China 2025

In the past years the Chinese government has invested many efforts to rank the renovation of the national STI system on a top spot on the list of national priorities. The efforts underlining the **willingness for an STI system reform** can be found in different plans and programmes, among those that can be found in the box on the left.

The readiness and willingness of the Chinese government for STI system reforms has also led to an opening up and improved **international cooperation** in this field. One example would be the Joint Programming Initiative (JPI) Urban Europe initiative, which aims at creating joint STI calls for EU-China urbanisation projects. Other JPIs are involved in international pilot calls as well; from the Chinese side the National Natural Science Foundation of China (NSFC) is very interested in EU cooperation programmes.

The current **research and innovation priorities** of China are defined in the 13<sup>th</sup> Five-Year Plan. Furthermore, STI activities are priorities in many sector-specific and sub-plans of the 13<sup>th</sup> Five-Year Plan. Hence, China nowadays can present an interesting innovation ecosystem, which is becoming more and more competitive and attractive. In this ecosystem, the role of the government is to set the framework, but private companies (e. g. TenCent, Alibaba and others) and other non-governmental stakeholders play a key relevance in shaping the playground.

Recent public investments into research have been high. A current key focus has been the aerospace and defence research, where significant infrastructure investments have been made and an expenditure increase of 7% was announced for 2017 (Perlo-Freeman, 2016). Worth to be mentioned is as well China's first passenger jet C919, which took off to its first flight in May 2017. It is aimed at competing with commercial aircrafts of Airbus and Boeing (You and Pettit, 2017).

Additionally, China has defined further research focus areas in engineering, physics and astronomy, material science, and chemistry.

Besides, emerging research fields in China are linked to immunology and microbiology. The environment for foreign investment in these sectors is therefore good (FFG, 2015).

Since 2015 a new programme supports the development of Chinese universities towards world class standards, known as the **“World Class 2.0 University Policy”**. Its aim is to support nine Chinese elite universities (identified through the C9 League programme) and to get six universities into the leading group of universities globally by 2020. By 2030 some of them should be ranked among the top 15 universities worldwide (Sharma, 2015).

China's research and innovation priorities according to the 13<sup>th</sup> Five-Year Plan:

- Quantum communications and computation
- Brain research
- National cyberspace security
- Deep space exploration
- Clean, efficient use of coal
- Industrial, medical and military robots
- Applications of gene science
- Big data applications
- Deep-sea experimental platform
- New Arctic observatory, Antarctic station

- Tsinghua University
- Peking University
- Zhejiang University
- Nanjing University
- Fudan University
- Shanghai Jiao Tong University (SJTU)
- Xi'an Jiaotong University (XJTU)
- University of Science and Technology of China (USTC)
- Harbin Institute of Technology (HIT)

The nine universities are listed in the box on the left.

This policy introduces competition into the Chinese education system. Non-985 and 211 universities<sup>1</sup> will be able to compete if their academic disciplines are reaching top-notch national standards. The new programme will also have a medium-term review, the performance assessment results will be linked to future funding. At the same time universities that fail can be excluded from the programme. Some Chinese universities disagree with the

programme, as negative grades and remarks in the assessment could weaken their current reputation.

Indeed, improvements in the national STI system have effects on **China's standing on the global stage** and vice versa. 60% of the world population lives in Asia and around 19% in China. Measured by its population, the country is the largest worldwide. On a global stage China is gaining more and more relevance as an acknowledged partner, especially for the EU and its Member States, since the current US government led by Donald Trump is estimated with a relatively high factor of uncertainty (Sui Noi, 2017).

A decisive stepstone on consolidating China's geopolitical role in the world scene is the "One Belt, One Road" initiative, which connects China along pathways of the ancient Silk Road of the Han dynasty with Europe and Africa. This programme is aimed as well at securing China major influence on the global infrastructure. In the context of this initiative, it can be expected that STI collaboration opportunities with, in particular, EU Eastern European Member States can emerge.

<sup>1</sup> Universities supported in the Projects 985 and 211 of the Chinese government, which aimed at a general support of the development of the Chinese higher education landscape towards high-level education.

In fact, China is considered today as an emerging superpower in Asia, of which other less developed Asian nations can profit. However, currently the goal of playing a dominant role in this region is overruled by the aim of internal stability and the creation of similar standards of living in different regions across China. Next to India China has positioned itself as a key investor and partner in Africa. It is supporting the region with the South-South Cooperation Scheme, which is partly overshadowed by the high attention the One Belt, One Road project is currently getting. With the South-South initiative, China supports the involvement of least-developed countries into WTO activities (OECD, 2012). Nevertheless, China is as well in the critics regarding the exploitation of resources and the abuse of local labour standards especially in African countries.

Furthermore, the “maritime” Silk Road initiative, which follows the maritime pathways of the Ming dynasty, was initiated by China with mainly Southeast Asian countries. It is of strategic, but lower relevance, as China has never been a maritime superpower. The maritime Road stresses the importance of coastal defence and offers new room for Chinese STI activities.

On the other hand, there are still some incidents or **diplomatic tensions** shaping China’s perception from outside. Some examples are:

Japan: Tensions are related to disputes on the uninhabited East China Sea Isles. Current developments include China’s activities in the East China Sea such as fishing boats, coastguard vessels in waters which are officially seen as Japanese territory. Formal complaints from Japan were presented to the Chinese ambassador in Tokyo on this. On the other hand, Japan installed a military-grade radar on a gas platform near the median line between the two nations area. Military activities around the island from both sides have picked up. China is working to “properly” manage this situation (Reynolds, 2016; Mazza, 2015).

South Korea: In July 2016, South Korea agreed to host the US Terminal High Altitude Area Defence (THAAD) missile defence system, which China saw as an affront – thereof, China’s tourist offices were forbidden to sell tour packages to Korea (they make of 43 % of tourists in Korea) (Jibson, 2017). China now also blocks Korean cosmetics and levelled a number of other unofficial economic sanc-

tions on South Korea has led the U.S. and South Korea to call China out for its coercive measures. Beijing, though, has shown no intention of lifting its sanctions, causing many inside and outside South Korea to wonder how much longer the country will be subjected to Beijing's pressure (McGuire, 2017).

Norway: Relations were frozen in 2010 after the nomination of (deceased) Liu Xiaobo for the Nobel Peace Prize. Norway tried to normalise relations e. g. by accepting Beijing's application to join the Arctic Council as an observer as well as opening the China-Nordic Arctic Research Centre in Shanghai in 2013 and other acts. Relations are fully normalised since December 2016, after continuous dialogue that helped to re-establish confidence. Part of the agreement is that Norway reiterates its commitment to the "One China"-policy (Bos, 2016)<sup>2</sup>.

Although the EU follows carefully the evolution of these diplomatic tensions they have played no major influence on the intensity level of EU-China STI collaboration. Indeed, these sort of topics are to a certain extent approached of the annually organised EU-China Summit (its 19<sup>th</sup> edition took place in Brussels in June 2017, where European and Chinese government representatives meet to discuss relevant cooperation topics.). An important side event of it is the **EU-China innovation cooperation dialogue**, which took place for the third time in 2017. It was co-chaired by Carlos Moedas, Commissioner for Research, Science and Innovation, and Wan Gang, China's Minister of Science and Technology. In this dialogue meeting, new and updated actions for collaboration in science, technology and innovation are approved. A document for the basis of cooperation is the EU-China 2020 Strategic Agenda for Cooperation, in which both the EU and China committed to promoting the EU-China Comprehensive strategic Partnership in the current decade (European Commission, 2013a).

Over the past years the EU and China have put strong **political efforts into joint funding** mechanisms. The most known and relevant is the Chinese co-funding mechanism (CCM), in which the Chinese government offers full funding to Chinese researchers who successfully participate in a Horizon 2020 funded research or innovation project. However, since the CCM is only running for very few years

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2 The One-China-policy is followed by governments which declare that there is only one Chinese country called China besides the two existing governments.

there is still not enough feedback gathered on it in order to draw up an impact evaluation and conclusions on its success.

**China's research and development (R&D) priorities differ partly from European priorities.** Many of China's priorities can be interpreted as being relevant to guarantee "national security" and play an indirect role for national defence (protecting and securing the people, borders as a whole) – whilst in Europe current security debates are aligned around the topic of possible threats by individual groups (terrorists, refugees).

In China, much attention of foreign stakeholders is still put on the biggest coastal cities (Beijing, Shanghai and others) while the western, inner-country provinces are often lagging behind in various sectors and infrastructural aspects. The Chinese government is however already supporting the inner-China provinces towards favouring equal conditions and standard of living across the country. This can also be said for the **implementation and integration of international cooperation programmes at provincial and municipal level**. As reported in the ENRICH workshops, new cooperation schemes between larger Chinese cities and less developed provinces allow the latter to profit from the experience and reputation of the former. The perception that in certain provinces and regions not all programmes are being implemented can also be derived from the fact that not all thematic sectors are similarly represented in all regions. There are always some sectors that are more prominent and relevant to a city or region than others, one example are thematic clusters and hubs.

## Trends

Innovation has a strong priority on the Chinese political agenda and is going to strongly influence the perception of China in the future. Through the government's top-down approach and their willingness to push STI reforms, their enforcement throughout the STI landscape is expected to be very firm. Different national plans highlight the necessity for innovation and define short- to long-term goals. Hence it can be expected that science, technology and innovation remain as a top priority in the future. Furthermore the quality of political reforms to support STI is

increasing, as the government staff responsible for STI programmes at different bodies is gaining more experience and expertise in monitoring and setting up suitable and targeted funding and support programmes. Additionally, a rising number of ministries' employees have gained international experience and are able to transfer fresh views and new concepts into STI policies and programmes. The ministries also receive external advice from specialised non-governmental bodies when evaluating existing and setting up new STI programmes, which improves the quality of such programmes with long-term impacts.

A further political trend to be seen is that STI policy processes are still approached in a very technocratic manner. They are based on rational technological and economic results. This may always favour technological over social STI topics and decisions and may inhibit innovative reforming.

A factor forstoring innovation across China is the current political stability inside the country, and most indicators predict a continuation of this trend. Simultaneously, a steady and growing STI system supports political stability in a reciprocal way. Nevertheless, 2017 can still turn out to be a determining year for the future of STI in China, as the country's political stability very much depends on the re-election of President Xi Jinping and the consolidation of economic growth. In 2017, five of the seven members of the Communist Party of China (CPC) leadership will also retire, which leaves room for uncertainty on how current strategies are being continued. On the shadow side, economic deacceleration, potential instability and rapid changes could negatively impact the STI systems by decreasing activities, or even lead to STI capital outflow from investors.

Moreover, there is still a lack of opportunities for local and provincial governments to go abroad and create their own network of international cooperation stakeholders, as ENRICH workshop participants confirmed. Similarly, international STI stakeholders should be offered more incentives to move to less developed regions. The government is aware of this issue and new programmes (e. g. city cooperation) supporting less developed regions and provinces are on the way. On the other hand, China is supporting its universities across the country through its World Class 2.0 University Policy. Through this STI policy, universities can profit from support, which is granted independently from their physical location.



The economic growth and the political stability of China in the recent years have also helped to improve the overall STI partnership between the EU and China. It has further gained more weight since US President's Trump inauguration. There are currently also no relevant diplomatic incidents between the EU and China indicating that their relations could worsen in the near future. Naturally, the last area to be influenced by diplomatic tensions is usually collaboration in the field of STI, while effects on political and cultural cooperation are at first affected. At the second stage of intensification, diplomatic tensions would affect the economy and business relations.

Concerning the EU-China relations, a powerful political instrument is the innovation cooperation dialogue, which helps EU STI stakeholders to get a political foundation and an understanding of politically defined priorities for STI activities in China. These diplomatic talks have, for example, also led to a continuation of the CCM and other joint funding programmes. They are a positive signal for future opportunities for EU-Chinese STI collaboration. However, a strong global political player such as China needs a decisive Europe, a unified political counterpart in order to further boost, reinforce and consolidate international STI collaboration.

## **Opportunities**

Considering the STI cooperation between the EU and China the current political stability on China, as well as the good relations between the EU and China, which have led to joint STI agreements are positively influencing collaboration. China's government is highly promoting innovation and is welcoming international STI cooperation. Research programmes with international outreach can also be expected in an increasing number from China.

An essential tool, next to other programmes supporting EU-Chinese STI collaboration is the CCM. The Chinese co-funding mechanism is one of the clearest and most transparent funding support instruments currently existing between the EU and China. Although still in its early moments of implementation, it has already led to the financial support of 47 Horizon 2020 collaborative research projects and the participation of 117 Chinese organisations in Horizon 2020.

Besides bilateral cooperation agreements between the EU and China, other cooperation and funding schemes should be observed. An opportunity for the support of STI collaboration lies also in China's One Belt, One Road initiative. It is the most relevant opportunity and tool that secures China's current global standing and it can be estimated that China will also allocate parts of this budget into STI collaboration. During the past One Belt, One Road Summit in May 2017 China presented 270 concrete results, among those were memoranda of understanding with 11 countries and nine international organisations (Lei, 2017).

For European STI stakeholders the universities entitled to be part of China's World Class 2.0 University Policy could also be very interesting collaboration partners. The policy has the potential to bring competition and new level of quality into the Chinese higher education system. It might offer room for high-class exchange and joint research.

Last but not least China's influence as a provider of foreign direct investment (FDI) should not be underestimated (Rhodium, 2016). With 180 bn EUR in 2016, China was the second largest FDI investor abroad, of which 36.9 bn EUR were invested in the EU (while EU companies invested 7.7 EUR in China). A high share of this amount was invested into high-tech and innovation products and companies.<sup>3</sup>

## Challenges

Although the Chinese government is demonstrating a clear **willingness to carry out STI system reforms** and is introducing new support programmes, some of the experts in the ENRICH workshops fear that the impact of some reforms on underlying the system is still too low. The difficulty of the top-down approach carried out by the government is that it does not always catch the needs of the STI stakeholders and the support is not always as meaningful as intended. New policies and programmes therefore have to be carefully assessed according to their advantages and disadvantages.

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3 <https://www.youtube.com/watch?v=hRGdki55pjA>

The different Chinese government bodies dealing with STI policies and programmes have to better interact with each other in order to achieve the most out of the system reforms. ENRICH experts emphasised that a better coordination of ministries, at both national and provincial level, is necessary in order to not miss opportunities to design useful support programmes. However, designing and pushing reforms sometimes is, at governmental level, rather a challenge in terms of lack of sufficient employees and time than a problem of experience.

Another challenge in relation to EU-China STI cooperation is that programmes supporting the creation of indigenous innovation or the Made in China 2025 Initiative are rather excluding the involvement of international experts and researchers. The Made in China 2025 initiative strongly promotes own national developments and leads towards many new Chinese standards, which give domestic producers an advantage. Within the workshops participants claimed that only supporting indigenous innovation will not function as expected, as innovation needs creativity, openness and international collaboration.

The CCM is generally celebrated as an improvement for EU-China STI cooperation. From the first experiences it was reported that the networking – in order to find the right partner from the other region before setting up a consortium, has to be facilitated. This is currently reported as a difficult task. The establishment of new relations very often depends on single persons and often researchers do not know enough relevant stakeholders from the other region. This results in many missed opportunities.

Other challenges, when it comes to identifying joint funding opportunities that have been mentioned include:

- Application processes are too often very complex and need high efforts, while at the same time the probability of a successful application is very low.
- For Europeans there are a lot of unwritten rules, which complicate the transparency of Chinese funding procedures. In some cases, politically favoured stakeholders benefit from rules and conditions.

- For Chinese STI stakeholders it can be sometimes difficult to get the right overview of the EU and its individual Member States' STI priorities. In the end, the EU does not offer a coherent market as such, since STI priorities are very different in each Member State or even region. This is neither reflected in the EU legal / political framework nor in the EU-China innovation cooperation dialogue

Although there are defined joint STI priorities derived from the EU-China strategic agenda, EU Member State priorities may be different, which was described by the ENRICH experts as a clear challenge. Chinese stakeholders are more aware of priorities in economically strong EU Member States such as Germany and know little about economic priorities and legal conditions in smaller EU countries, which has an impact on, for instance, where R&D investments might be going.

It should be considered that regarding China's World Class 2.0 University Policy an increasing international cooperation with these favoured universities might neglect or cut funding or support for STI collaboration between other Chinese and European universities. It may be the case that "non-elite" Chinese universities are not overall high-level performers, however they can still belong to the leading experts in single specific research fields.

## 2.2 Economic developments in China influencing EU-Chinese STI collaboration

### Identified and rated economic factors:

1. China's strategic key industries
2. Transformation towards a productivity / innovation-driven knowledge based economy
3. Chinese government's risen R&D expenditures
4. Tax incentives
5. EU-China economic cooperation
6. Thousand Talents Programme
7. Financing of innovation activities by banks and VC
8. Increased private R&D investment
9. Vocational training
10. Slowed down economic growth rate (GDP)
11. Plenty of funds but only provided to a very select number of institutions and / or individuals

### Main findings

For many years China has been a reference when it came to citing an outstanding example for national economic growth. However, in the past years China's economy has reached a 'new normal' (xin changtai) level, distinguished by **slower growth**: Its gross domestic product (GDP) was advancing by only 7.4% in 2014, which marks its lowest growth rate within 24 years. China is progressively giving up its rank as 'the world's factory', due to rising (labour) costs and newly introduced laws and regulation for environmental protection. In this context China is

becoming less attractive to the manufacturing sector while other (neighbouring) countries are more competitive due to lower wages and less environmental protection regulations. Xin chantai also stands for the necessity for China to transform its economic development model from one that is labour-, investment-, energy-, and resource-intensive into one that is progressively reliant on technology and innovation (UNESCO, 2015).

Hence, due to the mentioned combination of a slowed down economic growth, a growing middle class demanding higher salaries and standards of living, as well as other countries competing with low labour cost in the production of goods, China has to change its strategy for economic growth. To move up and on, China has been putting its forces at stake and promotes **innovation** as a key driver for its economic future.

Also Premier Li encourages innovation and entrepreneurship. The 13<sup>th</sup> Five-Year Plan highlights science spending by increasing it to 9.1 % (34 bn EUR) (McLaughlin, 2016). The risen R&D expenditures reflect significant determination of the Chinese government to ramp-up the transformation of the Chinese economy to a more productivity-driven, **knowledge-based economy** (Sociedade Portuguesa de Inovação, 2014). The export of Chinese medium- and high-tech goods has also increased. Its current economic slowdown however also shapes the way how China innovates.

A very good example on how China copes with the slowed growth but simultaneously tries to boost innovation is the Made in China 2025 initiative, which deeply supports the local creation of new technologies and standards. Other support mechanisms are the existing incubators focused on fomenting and supporting entrepreneurship or the Thousand Talents programme, which supports very creative minds. A further landmark is that many universities have opened schools for entrepreneurship by now.

In a rapidly changing Chinese STI landscape there are **strategic key industries** especially relevant, as they are politically supported with a long-term vision. Their definition also gives a better understanding where R&D investments might be

useful. China's ten key industries are laid down in the Made in China 2025 Initiative and comprise those sectors listed in the text box below (Orr, 2015).

Nevertheless, other economic sectors in China -which are not mentioned here- are almost equally important. It can be argued that in particular the services sector has become a very dynamic economic sector as it offers high potential for employment and revenue. A further strategically important sector is China's healthcare market.

- Energy Saving & Clean Energy Vehicles
- Power Equipment
- Biomedical & High Performance Medical Devices
- New Materials
- Next Generation IT
- Advanced Rail Transportation Equipment
- Advanced CNC Machine Tools & Robots
- Agricultural Machinery
- Aerospace Equipment
- Marine Engineering Equipment & High-Tech Ships

The Chinese government has steadily **risen its R&D expenditures** over the past decade. Especially thematic fields of political priority have been profiting from those investments. The numbers mentioned below demonstrate this development and stress the importance of R&D for China.

China's R&D expenditures more than doubled between 2002 and 2009, from 5.0% to 12.1%. During the financial crisis of 2008 / 09, a period shaped by decreasing R&D expenditures in some countries, China's total R&D expenses continued to grow. In 2013 spending on science and technology accounted

for 11.6% of the central government's public expenditure (236 bn Renminbi (RMB) / 29 bn EUR) (UNESCO, 2015). Around the same time over 30 public agencies administered around 100 competitive STI programmes to distribute the funds. System reforms have been trying to streamline the administrative structure for these services (UNESCO, 2015). Today, next to the government the private sector is also devoting considerable investments into STI. Nevertheless, aside from available funding, successful R&D needs the right partnerships and a skilled workforce.

**Financing of innovation activities and new ventures by banks** however occurs very seldom in China. There is still a lack of capital to support entrepreneurs, particularly for early-stage investment. Business Angels investment has grown in absolute terms, though it is still scarce in China. The government has begun to see venture capital (VC) as important for the support of indigenous innovation and by now is a main sponsor and has also begun to develop new regulations which should simplify exit strategies (Sociedade Portuguesa de Inovação, 2014).

To enforce their indigenous innovation policies, Chinese public bodies at the central and local level have published an “indigenous innovation catalogue” as well as procurement policies to give priority to qualified indigenous innovation goods. They have also announced tax and other financial incentives to motivate Chinese companies in the creation of indigenous innovation products (Sociedade Portuguesa de Inovação, 2014).

Attention should be paid to Chinese small- and medium-sized enterprises (SMEs, the so-called small above scale enterprises, as they are defined in China), as they have been increasing their own R&D budgets remarkably and contribute to China's **increased private R&D investment**. They are already cited as important new drivers in R&D and are making up quite a share of the R&D expenditures. In 2011 they accounted for 11.9 mio EUR expenditures in R&D, while in 2012, their spending were already estimated to lie around 14.9 mio EUR (Sociedade Portuguesa de Inovação, 2014). The R&D expenditure share of Chinese companies is sometimes higher than European average. On the other hand, it is fair to mention that large State-owned enterprises (SOEs) normally receive a generous R&D budget from the Chinese government at both the national and local level.

A comparison, the industry's share of R&D spending of the Chinese GDP lay around 1.4% in 2012, while for the European Union the same factor laid around 1.3%. China's business R&D spending were therefore much higher than those e. g. of Spain (0.68%) and Italy (0.69%), but lower than of Germany (1.95%). Spending on innovation (non-R&D) of the Chinese companies was accounted with 1.19% in 2010, while EU companies averaged around 0.56%. Chinese classified SMEs spent a 17.5% share for in-house innovation in 2010, while the EU average was 31.8% (Sociedade Portuguesa de Inovação, 2014).



An additional interesting factor is **Vocational training**. While its level of penetration is still modest in China in comparison to many countries in Europe, a high demand for it has been identified. Due to the rapid development of the Chinese economy, industry is demanding a growing number of highly skilled professionals (KPMG, 2010). China's existing education system cannot fully meet this demand, so the Chinese government is encouraging private investment in vocational education. China also currently lacks industry standards for teachers' certification for vocational training, but also for the growing market of early education (Chen et al, 2013). This opens up a good opportunity for European countries already having well established vocational training systems to position themselves as service providers in the Chinese educational market.

Moreover, the international **economic cooperation** is also influencing the cooperation between the **EU and China**. In the EU-China 2020 Strategic Agenda joint efforts are listed as follows (European Commission, 2013a):

- Ensure the stability of financial markets, also through the recently established Chinese Yuan / Euro Bilateral Currency Swap Arrangement between the People's Bank of China and the European Central Bank, which is to serve as a back-stop liquidity facility reassuring euro area banks of the continuous provision of Chinese yuan, increase the use of RMB in cross-border trade and investment, promote EU-China trade and investment facilitation and maintain financial stability
- Explore innovative modes of financial cooperation to improve access to finance for enterprises, in particular SMEs, and make full use of the advantage of financial institutions in providing diverse financial services.

Furthermore, the EU and China are currently in the process of negotiating an investment agreement in order to strengthen the joint economic cooperation. The common goal of this agreement lies in the creation of new market opportunities, market access and the protection of investments for both Europeans and Chinese. As negotiations are still ongoing, final results remain an open issue. It could however include topic-specific investment packages (e. g. for environment protection activities) and approaches towards a free trade agreement.

Apart from political negotiations China tries to attract innovation-driven companies by offering **tax incentives** for R&D intensive companies, particularly if they are located in high-tech zones. There are also some tax incentives for high-tech and new-tech enterprises located in science parks. An information document found in our research lists the following examples for companies for 2016 (KPMG, 2016):

- **Reduced Corporate Income Tax rate of 15 % for** High and New Technology Enterprises status and Advanced Technology Service Enterprise status
- **Customs Duty and VAT exemption / Refund** for the purchase of R&D equipment
- Tax concessions on technology transfers
- 150 % Super Deduction for certain R&D activities for companies resident in China

Within our discussions with experts from China it was proven that tax incentives for STI stakeholders coming from the EU are not the main motivation to settle in high-tech zones. There are other reasons, such as transport infrastructure and geographic location that play a role in the decision for settling at a specific location. Moreover, the bureaucratic burden of applying and maintaining such tax benefits is considerable heavy and not always easy to manage, even for Chinese companies.

A special role in the economic cooperation between the EU and China, especially on Chinese ground, play **Joint Ventures (JV)**. JVs are business arrangements in which the participants create a new business entity or official contractual relationship and share investment and operation expenses, management responsibilities, and profits and losses (Path to China, 2017). They are sometimes the only way to register in China if a certain business activity is still controlled by the government, such as it is the case in the car production sector or in aviation.

Moreover, the **Thousand Talents Programme** was introduced in 2008 by the Chinese government having as main aim to identify and support talented high-level people worldwide in order to permit them to continue their careers at Chinese universities, institutes and corporations. By being involved into the Thousand Talents Programme host organisations and the Chinese Government grant sup-

port to selected individuals to continue their profession in China in STI or in business development. The selection criteria are based on a strong technical background of the candidates (CAS, 2017).

The categories of the national Thousand Talents Programme are (see text box below):

- Thousand Talents Programme for Long-term Projects
- Thousand Talents Programme for Short-term Projects
- Thousand Talents Programme for Foreign Experts
- Thousand Talents Programme for Young Scientists

(CAS, 2017)

A new 10.000 Entrepreneurs Programme to support the start of entrepreneurship has been recently launched by the Chinese government. There are further initiatives supported by TORCH but also other smaller local or national, public or private funds that provide support.

It can be thus concluded that whereas there are **plenty of different funds** available, in practice they are many times granted **only to a very restricted number of institutions or individuals**. Although the enormous investment in STI in China has been well publicised, it is actually extremely difficult to get hold of these funds without having privileged connections (*guanxia*). Also, although large investments are often advertised, the funds fail often to be delivered, as confirmed by ENRICH consulted stakeholders.

## Trends

As seen before, the Chinese economy is highly influenced political decisions. Based on the current political and economic signs the slowdown in the economic growth will continue in China. GDP growth rates are still decreasing, although they are still higher than in many European countries. Nonetheless, it seems that the Chinese government is accepting this trend and has realised that it also needs phases of consolidation in order to achieve a qualitative and sustainable long-term growth. As previously mentioned, stability is currently a priority over growth.

One sign that the Chinese government has reacted to the economic slow-down are the noticeable risen public R&D expenditures. Through these, the government is supporting the growth of a modern, innovative STI infrastructure and high-class STI stakeholders in order to become a future leading country in high-tech and innovative products. In parallel, many Chinese SMEs are also investing into their own R&D, thus special attention also has to be paid to them in the future. China's innovative companies will soon become – if they not already are – serious competition for European STI pioneers.

European STI stakeholders in China will very likely still face a limited market access in China – in some way or another – in the near future. For some sectors there is still no evidence whatsoever that they will be opened up completely. The global internet access is also likely to remain restricted, even despite new regulations put in place in June 2017. Through the current official support for the introduction of new Chinese standards European STI stakeholders will be forced to adapt their products according to Chinese requirements.

In order to react on these developments Europe and China will have to economically collaborate closer and strengthen their ties. Joint economic priorities and joint support of strategically relevant sectors will help to manage EU-Chinese economic cooperation in the future successfully. For the STI stakeholders IPR issues and further economic laws and regulations have to be clear in order to achieve level playing field conditions.

## **Opportunities**

The slowed down economic growth can set free the possibility to invest into new innovative technologies and areas to support new expertise. A considerable opportunity is related to key sectors politically supported in China, which offer excellent potential for growth. These sectors therefore entail high potential for innovations. As R&D costs in China can be lower than in other European countries developing new technologies in China's key industries could be a “cheaper” route into new markets, as this would lower the initial investment costs for European STI

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organisations. Also, there is an overall improvement in the IPR protection, as was estimated by ENRICH workshop experts.

A good sign for STI stakeholders is that the EU-China economic cooperation has increased and continues to do so. Numbers for investments have risen for both sides. Programmes such as the Thousand Talent Programme allow STI exchange and cooperation. It helps to support Chinese researchers in advancing their work as well as it improves bringing international researchers to China.

Furthermore, in the context of increased R&D expenditures new STI infrastructures and cooperation opportunities have been created. Incubators and investors support creativity and innovation. Similarly, private investments in R&D are rising in China. Chinese SMEs are an important driver for the Chinese STI landscape, as they appear to be very dynamic and innovative. They highly profit from private R&D investments and are better enabled to initiate innovation projects than larger STI stakeholders, as ENRICH workshop participants confirmed.

An important influencing aspect for industrial STI international collaboration is that foreign companies still have to form JVs in some sectors. Finding the right partner is the most relevant factor for the success of a JV. This can save foreign stakeholders in the Chinese market time and financial investment when introducing an own product in the Chinese market. For instance, the existing production lines of the Chinese partner can be used to speed up the process, mitigate initial investments and share risks. A JV can open up new markets faster and allow access to local investors and the networks of the Chinese partner. In successful cases, JVs are an opportunity and can be the best form of cooperation with a win-win situation for both parties: IP is transferred to the Chinese partner (advantage for the Chinese) while the foreign partner has the full support of the Chinese partner in all legal, administrative and financial issues and typically, the Chinese partner also brings certain investment into the JV (advantage for the European partner).

## Challenges

Although the **slowed down economic growth** seems not to cause any obvious nervousness among the Chinese government and the leadership is supporting the country with stabilisation measures, this situation can still generate a climate of uncertainty among STI and industry stakeholders. The slowed-down growth is a dangerous signal for China and could easily lead to political instability and a change of policies, which can eventually impose certain constraints on the Chinese STI landscape.

Indeed, current initiatives are already affecting the EU-China STI cooperation, as some of the current STI programmes such as *Made in China 2025* or support programmes for indigenous innovation are reducing opportunities for international STI projects. Critics say that for instance the *Thousand Talents programme* means significant investment in bringing ‘international talent’ to China, but most talents are actually returning Chinese and therefore the programme does not fully meet its potential impact – while the [negative] perception abroad could potentially affect the Chinese STI landscape and jeopardise international collaboration.

It is a good sign that the Chinese government has risen its R&D expenditures, which is also drawing European STI stakeholders into the country. However, often the **infrastructure** that is provided to them is lacking the necessary services, such as soft landing services, to be appealing for European stakeholders. Furthermore, relevant information on IP protection, (tax) laws and other regulations is not always available in English, making it difficult to make an informed decision and expand businesses. Even Chinese STI stakeholders claim that public financial support for STI is often only provided for applied research and here to a limited number of priority areas.

A further challenge for European STI stakeholders is the imposition of creating a **JV**, as it is currently mandatory in certain sectors, whose success strongly depends on the quality of the partnership. This has to be carefully considered, especially in sectors where JVs are the only choice. Sharing know-how and IP of the foreign cooperation partner is sometimes a deciding factor against a JV – and can even mean a missed market opportunity. When highly sensitive and crucial know-how

and IP are at stake, thus strategies to protect them have to be seriously considered. Merging the work culture between European and Chinese companies is also not always an easy task. This has effects and is relevant for all company departments starting from different recruitment processes and requirements of new staff, going through sales, production and marketing strategies.

On the other hand, when it comes to economic cooperation between the EU and China experts in the ENRICH workshops stated that economic cooperation with the EU is not always easy for Chinese STI companies either. It remains a difficult issue for them that ultimately, the EU as such does not represent a coherent economic market, as priorities, sectors, economic and STI performance, as well as laws and regulations still differ from country to country. From an outside view, and depending on the individual knowledge and awareness, it seems challenging to understand the differences between EU laws and regulations and those of single Member States. This causes a certain limitation to access EU Member State markets for some Chinese STI stakeholders.

## **2.3 Social factors influencing the STI landscape in China as well as EU-China STI collaboration**

### **Identified and rated social factors:**

1. Increased mobility of people, goods and ideas
2. Growing Chinese middle class
3. Education system
4. Free movement of students and researchers between the EU and China
5. Improved English language skills
6. Fostering of creativity and entrepreneurship in the education system

7. Accommodation costs and academic salaries (particularly at the early to mid-career levels)
8. Cultural differences related to work ethics (between EU & China)
9. Lack of support for foreign experts to settle in China in the longer term (particularly outside of Beijing and Shanghai)
10. (Uneven) geographic distribution of talent across the country

## Main findings

The fiery **growth of China's emerging middle class** has resulted in a far-reaching economic and social change – with a still open end. A study by McKinsey stated that by 2022, more than 75 % of China's citizens living in urban areas will earn 60,000 to 229,000 RMB (7,500 EUR to 29,000 EUR) annually, compared to 4 % in 2000 and 68 % in 2012 (Barton et al, 2013). By then, China's population will have a similar purchasing-power-parity as Brazil and Italy. The study furthermore stated that in the coming years the growth of China's middle class will be driven further due to labour-market and policy initiatives, which are expected to lift up wages, but also financial reforms stipulating the increase of income and employment (Barton et al, 2013).

Further, in a global comparison, China offers the largest **education system**. In both 2016 and 2017, 9.4 million Chinese students participated in the National Higher Education Entrance Examination (Gao Kao). Indeed, in terms of Chinese GDP investment, education holds a share of 4 %. It is officially estimated that 99.7 % of all citizens have achieved universal nine-year basic education by today. However, the quality of China's education system still differs between the east and the west regions. In the past years the Ministry of Education (MoE) has put many efforts in reducing the illiteracy rate in western China (KPMG, 2010). Despite this, universities and other institutions for higher education are experiencing a growth as well. China is seeking to improve the quality of teaching and training with high efforts by reforming the school curriculum. By now, over 20 % of China's high school graduates are also enrolling into universities, compared to 1.4 % in 1978 (China Education Center, 2017).



It is more and more common for Chinese students to go (at least for a limited time) and study abroad; in 2015 520,000 Chinese students studied abroad (Nylander, 2016). The UK is a very popular destination for technological sciences. The USA and Great Britain, they make up over one third of all foreign students (Svoboda, 2015; HESA, 2017). On the other hand, China becomes as well more popular for foreign students to study there. The MoE reported at the beginning of 2017, that in 2016 442,773 international students studied in China. International students have enrolled in over 829 higher education institutions in China (China Education Center, 2017).

An increase of the private education and tuition has also been observed: With the steady growth of the Chinese economy and continued rise in Chinese household educational expenditures, China's private education industry has also maintained steady growth (Chen et al, 2013, Gamian 2016)).

The focus on **creativity and shaping an entrepreneurial mind-set is considered as not sufficient in the Chinese education system** by many. Subjects are taught very theoretically and too much focus is still put on learning and memorising content for exams. However, like in any other nation there are still people who are more creative or have a stronger interest in business than others. Luckily, nowadays there are more opportunities for such people to be supported in their affinities than before: Many universities provide incubators to encourage students to develop new technologies and create new businesses. Professors are encouraged to be involved in technology transfer activities and create spin-off companies.

When focusing on the (higher) education system in China it has been observed that there exists an **uneven geographic distribution of talent across the country**. Studies proved that students from better socio-economic families, more renowned schools, and more urban homes are more likely to be admitted into prominent universities in China (Jia and Ericson, 2016). An additional issue aggravating the current situation is that there is a large inconsistency in the range of higher education institutions across Eastern, Central, and Western China. Looking at a comparison of universities in general and all those participating in the 211 and 985 programmes, it is evident that the inequality of spread is stronger among those elite-universities and institutions participating in the 211 (60%) and 985 (72%)

programmes than the overall inequality (48 % in an East-West comparison). The situation of uneven geographical distribution is alike for international higher education partnerships (Montgomery, 2016). The particularities of the rural versus urban contexts in China the provision of higher education demonstrates and underlines the uneven economic distribution between the urban eastern and central areas. This development confirms that entering into universities, and increasingly into elite institutions, differs according to the social situation (Montgomery, 2016).

The world is moving faster and faster and this development definitely did not stop in front of China's borders. An **increased mobility of people, goods and ideas** can also be observed in China, if not even more intense than in Europe. Chinese are curious and ambitious and have a huge affection to technology. The Chinese population is getting more and more mobile, with massive investments into the infrastructure and rising salaries conditions for spontaneous business travels inside and also outside of China are accessible and affordable to many. The current working generation in China can also be considered as very mobile in general – about 10% of them are working migrants, rural citizens who have moved to cities to look for work opportunities (Sinomania, 2017).

Chinese are very well digitally connected. Social media (esp. WeChat) are used widely also for business purposes. The 13<sup>th</sup> Five-Year Plan foresees the expansion of infrastructure construction and the acceleration of the introduction of infrastructure projects that are high-speed, mobile, safe and universal (Lyn and Wu, 2015).

When it comes to international STI collaboration, several programmes support the **free movement of students and researchers both from the EU and China**, which has been better and to some extent easier than before. Next to the EU-funded projects several national EU (and bilateral) programmes make it possible for EU citizens to travel to China in order to study or work in an STI-related field in China. From the Chinese side, the most prominent example for travel support is the Thousand Talents programme (UNESCO, 2015). This tool is open to Chinese and foreigners. For Chinese citizens, the Thousand Talents programme is one of rather few opportunities to go abroad. Very often, it is difficult for Chinese STI stakeholders to go abroad, approval and visa processes are very complex,

the organisational ratio behind very high. Nevertheless, ‘Returnees’ (Chinese researchers returning to China from abroad after longer research stays abroad) are seen as an important source of knowledge and a number of programmes have been introduced to attract them to come back to China.

EU-China STI collaboration is also positively influenced by **improved English language skills** of many Chinese. Nowadays English is spoken better and better by Chinese students and researchers, there is a high demand for English language classes, courses and innovative tools that allow practicing the language (Chen et al., 2013). Chinese citizens, especially the new middle class, are very aware of its relevance in today’s working environment in China. Many parents try to get their children in contact with English speaking people from an early age on. At Chinese schools, English is taught at age nine, other schools even start teaching the language at age six (Gamian, 2016).

More than 520,000 Chinese students went to study abroad in 2015, at British universities they make up about one third of all students. English is also the official language in all international activities of the “One Belt, One Road” initiative. In Education First’s (EF) English Proficiency Index for non-native countries nevertheless China still lags well behind other Asian countries: 39<sup>th</sup> while Singapore was ranked 6<sup>th</sup> and Hong Kong 30<sup>th</sup> (although English is still one of the official languages) (Nylander, 2016). Despite these developments, European and other foreign STI stakeholders should not take for granted that all Chinese will learn English and should instead also evaluate the possibilities of learning some Chinese.

A further aspect exerting an influence on the STI landscape in China is the development of **accommodation costs and academic salaries**, which clash particularly at the early- to mid-career levels. While careers and offered monetary benefits for high-class researchers at Chinese elite universities are very attractive and can easily compare to international standards it is a different picture for young scientists in China (Chu, 2013). Low salaries actually cause a brain drain in China. While tuition fees for studying in China are relatively low, it is not easy for early-career level researchers to feed a family from their salaries, especially in larger cities (Nordling, 2016).

Awareness about **cultural differences related to work ethics** between the EU and China is of paramount importance when it comes to STI collaboration between the two regions. Within a study we found the main lines of differences in the work ethics are:

Power-distance orientation is high in China (e. g. hierarchical and decision-making is a top-down process), while it is low in Europe (e. g. flat organisations, decentralized power structures, equality or privileges, and consultation in decision making) (Jones, 2016).

Individualism vs. collectivism: Collectivism is high in China, while individualism is low (workers are generally group / team oriented, collective responsibility for members in a group to save face, and decisions are made to benefit the entire group; loyalty is high, turnover is low, and firing of employees is rare, Confucianism-based ethics). In Europe, individualism is high, while collectivism is low (ties among employees are generally “loosely-bound”, society is largely independent, competitive, highly task oriented and focused on getting things done (Jones, 2016).

Uncertainty avoidance is rather low in China (fewer rules and generally no high emphasis on controlling all results and outcomes – bearing in mind that decisions are aimed at promoting group cooperation, there is a higher level of tolerance for ambiguity and variation), while being average to high in Europe (seeking reassurance in predictable rules-based systems, some rules-based cultures can become complex and dysfunctional bureaucracies, the notion of high uncertainty avoidance is intended to promote professionalism, transparency and logic-based communication) (Jones, 2016).

Although foreign talent is welcome, most foreign experts receive **little practical and informative support when settling long-term in China**, even despite the fact that there are specific support programmes for this in place (Thousand Talents programme) This is particularly crucial for those interested to settle outside Beijing and Shanghai. More foreign talent is welcome to China for. The Chinese government intends to support foreign talent 8in particular in areas like innovation, technology transfer and commerce) e. g. by handing out “green cards”.

## Trends

The most striking social trend is the increased use of electronic communication devices among the Chinese population, covering basically all age groups. Smartphones seem to be always in use in China. They are **the** device for virtual and online communication, but also for the exchange of information. For these purposes they are not only used in private but nearly equally in the work life. The degree of penetration of smartphones is much higher than in Europe, and these devices serve as a service instrument for information exchange and also e-finance. These opportunities have been well seized by Chinese innovative companies and they are already reaping the benefits of. Hence, when talking to ENRICH experts and stakeholders about the increased mobility of Chinese, mobility in virtual space seems to be more relevant than the actual increase in physical mobility. The improvements in the Chinese physical infrastructure (esp. in the railway and flight systems) should nevertheless not be neglected.

Basically every Chinese citizen has access to education; more or less all Chinese children are enrolled into the school system. Compared to national systems in the EU, the education system in China is still not fostering the development of creativity and entrepreneurial skills to large extends, but based on the evidence collected there are some examples where this is happening. More and more high schools, and in particular universities, offer business classes and support the creation of start-ups. There is a young generation coming up in China, which has similar entrepreneurial spirits as can be found in the EU.

Surely having benefited from an improved education system, China can present a growing middle class, which has enjoyed a very good education, relevant work experience and has the capacities to turn their own ideas into innovative businesses. They are able and willing to take their opportunities, work hard and ultimately help to generate new jobs in their companies for others. This new middle class in China can be a trendsetter and also adaptor for new innovative technologies.

Another observation, in which most of the ENRICH experts agreed, is the trend and boom to learn English in China. This trend will definitely continue, as with online tools practice will increase even for those that have no opportunities to

travel so far. At the same time, in order to allow EU-China STI cooperation on an equal and fair level, European STI stakeholders should consider learning Chinese as well. The importance of the Chinese language, due to the increase of its educated population is on a rise.

## **Opportunities**

A key opportunity is that increased mobility facilitates EU-Chinese STI cooperation, although a clear major issue are visa application processes and it remains more difficult for Chinese to go for STI purposes to Europe than vice versa. Plenty of national and bilateral initiatives are worth to be mentioned in relation to EU-China cooperation, such as the French mobility programme, German DAAD, or programmes offered through a Lithuanian Innovation Centre, Tsinghua University or Torch.

Language skills should be improved from both sides. Also Europeans, when doing business with China should consider learning at least some basic Chinese, especially when contacts lead them away from larger to Tier-2 cities. There are already good apps and digital tools that support the communication in Chinese, and this is perceived as a factor helping to facilitate STI collaboration with China.

An interesting opportunity for EU-China STI collaboration is that especially incubators at Chinese universities are considered a very important driver for creativity and entrepreneurship in China. Compared to science and technology parks, they can be considered as the hub for technology transfer, start-up support and exchange.

There is a young Chinese generation open for collaboration opportunities, as this generation is similarly creative and with entrepreneurial mind-set as other foreign stakeholders. Special support is offered for young Chinese, e. g. through the Shilin Centre for young entrepreneurs (incubator).

While in the traditional industries much investment has gone into real estate companies, today a rising number of S&T parks and incubators focus on investing into

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support for young entrepreneurs. The competitiveness comes nowadays from both China and the EU. There are also international exchange programmes for students focussing especially on entrepreneurship. This is mostly happening at bilateral basis between European and Chinese universities.

Generally speaking, China's middle class is a very important target group for innovation. From an STI perspective, the middle class could be defined as a big number of successful spin-offs from big companies. These entrepreneurs started even second start-ups and recruit more staff. Most of them used to work in big companies but designed their own business.

## Challenges

China's education system, as mentioned by many stakeholders, needs to better foster entrepreneurship and creativity, a process, which is fortunately slowly improving. This will help Chinese students to compete in STI topics internationally. There are some great ideas for projects but too often the focus on exams (especially the GaoKao) puts these opportunities aside.

Although happening in some regions, the Chinese education system is not putting enough focus on critical thinking, which is an attractive skill for Chinese to learn within the EU (higher) education system. This aspect goes slightly along with the possible threat that the education system is too strict and too structured to leave room for own opinions and personal interests to focus on. However, this system is also very much shaped by the culture of obeying the advice of teachers and parents and the high competition Chinese students face often leaves them no further option than studying.

The Chinese entrepreneurial mind-set is associated with focussing on short-term, pragmatic results – to the contrary of the sometimes necessary endurance and patience needed in innovation. This can be a threat for STI work. Further, creativity and innovation require openness to change and try out unconventional pathways, which can also be hindered by traditional cultural aspects (willingness and openness to change from tradition), which is not always easy among the Chinese society.

One threat of the Chinese STI system is that smaller central Chinese cities have a clear disadvantage in order to build up an STI ecosystem compared to larger and coastal cities. China's seven largest cities still attract most of the scientific and innovative talent. There is a clear mis-match in the distribution of talent and opportunities across the country. Also for international STI stakeholders coming to China, still in many cases the support and advice for working in China is much better in larger cities than in the rest of the country. Prevailing uncertainties on the right strategy to follow can be a threat and a reason not to settle in China and thus the reason to dismiss potential collaboration opportunities.

Whereas virtual meetings and, in general, online communication, offer an improved global connectivity and permit networking and collaboration in mixed teams, closing business deals still relies very much on personal contact and physical meetings.

The more interaction is happening, the more important it is to facilitate the access to visas, which was as well discussed as a hindrance. There is still a clear imbalance in visa rules among the different EU Member States, which sometimes makes the process very long and hinders people from spontaneous meetings and travels.

There are more programmes needed that support the networking of people and the creation of new partnerships between STI stakeholders from the EU and China. This current lack of programmes is a relevant threat for stimulating and cementing the STI landscape.



## 2.4 Technological factors and trends in China influencing EU-China STI collaboration

### Identified and rated technological factors:

1. EU-China Joint technological priority areas
2. University-industry links
3. Technical / R&D infrastructure in China
4. Chinese R&D performance
5. Existence of incubators and science parks
6. Big data
7. EU-Chinese R&D collaboration
8. The Great Firewall of China / National cyber security
9. Better communication through ICT advances (online / virtual meetings, etc.)
10. Higher education Joint Venture Models (with foreign universities in China): “Sino-foreign universities”
11. Chinese dependency on foreign technologies
12. Access of EU stakeholders to Chinese R&D infrastructure

### Main findings

China has a big appetite for new and innovative technologies, which is reflected in its considerable increase of STI capabilities. Its R&D spending share of the GDP is continuously rising and is even expected to outperform the USA by 2019 (UNESCO, 2015). Reforms and policy plans dictate the direction: In 2020, China should become an innovation-oriented country and in 2025 many of China’s technological products should be smart and home-made. The numbers of patent applications and R&D investments have been rising as well (Sociedade

Portuguesa de Inovação, 2014). However, the quality in R&D in China is still poor in some areas, but the overall **R&D performance has increased**. In some technology areas China is still very dependent on foreign know-how, but this has to be considered case-by-case and definitely offers room for international collaboration (UNESCO, 2015).

The UNESCO Science Report from 2015 describes how China's numbers on STI talent have been increasing as well. Next to 25.5 million undergraduates there have been over 1.85 million post-graduates in China in 2013, most of them with a degree in science and engineering, but also computer science and materials, which are traditionally the most-chosen research areas in China, as can be seen on the 350,000 engineers graduating annually from universities in China (UNESCO, 2015). On the contrary, research in social sciences has not progressed to the same extent.

Very often, the R&D performance of China is analysed and looked at on a wider and maybe less detailed level. For example, some European experts in the ENRICH workshops stated that it is not very easy from an outside perspective to understand and follow China's progress in basic research. Not much information on activities and results is available for externals on China's basic research performance. Therefore it is very difficult to receive a full and comprehensive picture on China's R&D performance covering all STI areas.

The country has heavily invested into the availability and improvement of **technical and R&D infrastructure**. Next to several existing ones, more pilot zones and innovation demonstration zones such as Zhongguancun<sup>4</sup>- the Chinese version of Silicon Valley- are planned (State Council, 2015). There are also improvements identified for virtual infrastructure:

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<sup>4</sup> <http://en.zhongguancun.gov.cn/>

### **“Internet +” Action Plan:**

The plan combines and connects mobile internet and big data with the Internet of Things (IoT) and cloud computing with modern Chinese manufacturing, to support the sustainable growth of e-commerce, industrial networks, and to push information, communication and telecommunication (ICT) companies expanding their global presence.

Companies will be supported in setting up innovation networks. The government will enforce the creation of industrial standards to enable the cooperation of internet and industries, while guaranteeing IPR protection. Besides monetary and tax benefits China aims at lowering barriers for the market penetration of Internet+-related technologies and services, improving the credit awarding system, defining a plan for implementing big data in China as well as disseminating legal services (State Council, 2015).

Moreover, in order to expand the 5G network technology China has even signed a joint declaration with the EU in 2015 (see text box at the right side):

Overall, **university-industry partnerships and links** in China have improved and can be compared to those in other BRIC countries (Uriona-Maldonado et al., 2010). In some cases an outstanding intensity in the university-industry collaboration can be reported. A couple of shining examples are the China University of Geosciences or the China University of Petroleum, who have managed to establish successful collaboration strategies with indus-

### **EU-China Joint Declaration on developing 5G networks technology:**

The EU and China declare to strengthen their cooperation on defining basic functionalities, key technologies, time plan and global standardisation for 5G. This Joint Declaration also stipulates reciprocity and openness in terms of access to 5G networks research funding, market access as well as in membership of Chinese and EU 5G associations. Therefore, EU telecoms and ICT industry in particular, are expected to have easier access to the Chinese market.

(European Commission, 2013b)

try partners. However, according to the *Asia 100 report* these extraordinary collaborations are unfortunately not representative, as most organisations analysed in the report were demonstrating much lower intensities in their collaboration with the industry in China (Barlow, 2016).

Many of the **4,000 incubators** (often located at universities and supporting technology transfer) and **science parks** (mostly designed for clustering innovative large companies) play an increasing role in the promotion of innovation clusters, technology transfer and commercialization of research results in China. Science parks are functioning in the way that they successfully attract large companies to settle there – they are even building cities around them, as they attract other service providers and the staff of these new companies has to settle nearby. Nonetheless, many of those 4000 incubators are currently runned by, in most cases, state-owned real state companies, whose main focus is not precisely to support innovation, entrepreneurship and technology transfer, but to operate as economically viable companies.

Well aware of the above mentioned situation, few years ago the Ministry of Science and Technology (MOST) has introduced a new certification process, which should help to introduce similar standards in science parks and incubators. About 400 science parks are by now certified through MOST. This remains an open issue. Currently, the goal to effectively support technology transfer and STI collaboration through the incubators model has not been met yet.

Indeed, studies state that for European companies the **access to R&D infrastructure** in China is a field where improvements are still needed. Furthermore, compared to other standards, joint R&D centres where the cooperation with companies is encouraged are not as advanced among Chinese universities yet (Sociedade Portuguesa de Inovação, 2014).

A big technological challenge and where standards between China and the EU differ widely is the handling of big data. In China **big data** is owned by large corporations or by RTD organisations in most cases. Large corporations such as Alipay

use the data to improve user experience, but also to introduce new services.<sup>5</sup> High quality domestic research data, if it falls under the category of relevant for national security, is very often owned by the government and access to it is completely forbidden (Wan, 2015). Depending on the sector big data is a relevant driver in China's STI system, however, its overall potential can only be exploited if privacy and open access issues are carefully considered. The new cybersecurity law is here very relevant for foreigners, as it finally clarifies e. g. the processing rules of data saved on Chinese servers (Wagner, 2017).

There is a global trend towards digitalisation. Both the EU and China should pay attention on the developments related to digitalisation trends in the other region. In many areas of digitalisation China is more advanced than the EU Member States.

Since 2003 China is controlling massively the traffic and content of websites in the internet, its censorship is commonly referred to as the "**Great Firewall of China**". Among these actions can be counted:

- Filtering or blocking of IP addresses and TCP ports
- DNS request filters
- Blocking of circumvention tools (e. g. VPNs)
- Blocking of social networks (e. g. Facebook, Twitter, all Google services such as Youtube...)

Unauthorised virtual private networks (VPN) to circumvent the Great Firewall tools are indeed officially illegal (Ensafi et al, 2015), but widely used nonetheless.

Moreover, since many years the EU and China are fostering **EU-Chinese R&D collaboration** on a political level. The joint EU-Chinese research collaboration is defined and agreed on a political level in the frame of the annual EU China bilateral summits, particularly within the EU-China Joint Steering Committee

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5 Alipay is using the customer's data in order to prove their financial credibility and provide credits by developing an own scoring system (Sesame), which can even facilitate in the applications for visa: [https://news.cgtn.com/news/3d-63544d7949444e/share\\_p.html](https://news.cgtn.com/news/3d-63544d7949444e/share_p.html)

on Science and Technology Cooperation or the EU-China Innovation Co-operation Dialogue (2017 was the third time it took place). Examples of such agreements are:

- 2015: Commissioner Moedas and Minister Wan signed an agreement to launch a new research initiative to facilitate young Chinese scientists supported by the National Natural Science Foundation (NSFC) to join projects funded by the European Research Council (ERC)
- 2016: Agreement on the Chinese Co-funding Mechanism for Chinese participation in EU-funded projects and its extension until the end of Horizon 2020
- 2017: Agreement on additional joint flagship initiatives in the areas of Food, Agriculture and Biotechnologies, Environment and Sustainable Urbanisation, Surface Transport, Safer and Greener aviation, Biotechnologies for Environment and Human Health (European Commission, 2017)

On the implementation level, research collaboration between the EU and China is growing, as can be seen in risen numbers of joint research centres, programmes or research networks. There is also a rising amount of FDI-supported R&D centres in China and clusters have become popular platforms for both European and Chinese researchers to establish for industry-research collaboration (Sociedade Portuguesa de Inovação, 2014).

The amount of published joint research papers among European and Chinese researchers equals the amount of those published jointly among European and US researchers. There is nevertheless a difference when comparing the numbers of articles published in high-impact papers – here, the number of joint articles of EU and Chinese researchers is lower compared to those with the USA (Sociedade Portuguesa de Inovação, 2014).

The **EU-China Joint Technological Priority Areas** are defined and set out in the Strategic Agenda. They entail:

- Food, Agriculture and Biotechnology (FAB)
- ICT
- Space
- Aviation
- Energy and energy conservation
- Health
- Transportation
- Water Resources
- Advanced Manufacturing
- New Materials
- Sustainable Urbanisation

(European Commission, 2013b)

These areas represent sectors where Chinese enterprises still **dependent on foreign core technologies** can initiate mutually beneficial cooperations with European counterparts. In the Chinese innovation system there exists a mismatch between the government's input and the companies' outputs in form of tangible results. Although intensive financial funds have been provided, the output, such as outstanding novel inventions and innovations able to receive a Nobel Prize is in some cases still missing. The number of highly innovative products able to compete at interna-

tional level and the commercialisation rate are still low, which is also due to legal circumstances, since results of public organisations are also considered as public goods. A World Bank study found out that China had a 8.4 billion EUR deficit in 2009 in its intellectual property balance of cost outflows, based on royalties and license fees (UNESCO, 2015).

Furthermore, China's internet population is growing, especially through the rising use of smart phones (Jain, 2017). In China, **ICT advances have pushed virtual and online communication** massively. The introduction of 4G mobile networks, which are used through over 90 million smart phones in China supported this trend. WeChat, a messaging service for mobile phones is used by nearly 800 million people, of those about 100 million live outside of China (EU SME Centre, 2015). New functionalities even allow using the service for payments. WeChat regularly introduces new features; some of them have even been taken over by Facebook.

Furthermore, China is rapidly developing many own cloud services and among the country's industry champions there are many high-tech IT companies, which shape China's society and are making the online communication in China to a normal part of life. Prominent companies are Alibaba, Tencent or Baidu (EU SME

Centre, 2015). Compared to most European countries, it sticks out that Chinese are much more willing to accept and use new technologies, even at the costs of privacy rights.

The number of **Sino-foreign joint venture universities** is increasing, their creation falls under the responsibility of the Chinese Ministry of Education (MoE). There are very stringent preconditions to be fulfilled in order to set-up a sino-foreign joint venture university, but nevertheless their number is steadily increasing across China. A reason for it lies in the popularity among Chinese students' to spend their studies outside of China and the common belief that studying at prestigious foreign universities in China might provide them the necessary kick-off impulse when entering the labour market. For foreign universities being present in China is an opportunity to promote their name and gain additional revenues (Chen et al, 2013). Examples are Xi'an Jiaotong-Liverpool University, University of Nottingham Ningbo or the New York University Shanghai, as well as Kean University-Wenzhou and Duke Kunshan University, which are currently under development (Chen et al, 2013).

## Trends

As already stated, the Chinese R&D performance has risen and experts agree that it will continue to do so. To the same extent as Chinese STI products and results will mature, the dependency of China on foreign technologies is expected to decrease.

The Chinese government has understood that the provision of the necessary infrastructure is a key factor for success in its goals to become an innovation-driven and knowledge-based country. Ensuring stability and equal opportunities across the country will very likely lead to further and improved R&D infrastructure across China. Smaller cities and less developed provinces will gain in importance and create new innovation hubs. Currently, what is lacking to some extent is the linkage between the industry and universities. However, since the awareness is there, it is very likely that in the near future the Chinese government will take measures to support the interplay of universities and industry players in China.



The developments on the STI performance in China have of course direct consequences for the EU-China STI collaboration. All signals demonstrate that the collaboration in STI will deepen on political and implementation level. Examples are the creation of more and more Sino-foreign universities (with European partner universities), the creation of joint labs and the growing number of joint publications, as well as investments into R&D infrastructure from Chinese in the EU and vice versa.

## **Opportunities**

The fact that China's R&D performance is steadily improving is very positive, highly relevant and important and makes the country also attractive to European STI stakeholders. Due to this development new focus cooperation areas could be identified and international collaboration has been steadily growing in the last years. Besides major improvements in its RTD infrastructure the huge market is still a main magnet for foreign STI stakeholders to come to China. A better and more transparent regulatory framework could certainly help to promote more investments and collaboration opportunities.

Chinese SMEs (companies with less than 500 employees) at private level are a great cooperation partner also for European STI stakeholders and very important R&D drivers with great performance. On the other hand, large private companies are usually less dynamic and collaboration with them has to be carefully considered.

There is a great potential for European technologies to be commercialised in China. The definition of joint priority areas is a step into the right direction and offers clear areas where opportunities for international collaboration can be seized. Dedicated funding and incentives would boost and reinforce the positive perception and underline the coherence.

A further positive signal for EU-Chinese STI collaboration is its political endorsement, which can be a key decisive factor in order to build up trustworthy relationships. The existence of joint labs, research centres and networks are valuable and useful tools for collaboration. They generate a higher level of commitment of par-

ticipating scientists. Joint collaboration can help EU stakeholders in China to get access to Chinese funding and public procurement, it is especially in areas where information is only partially available (or e. g. only in Chinese). However, some impact of the current efforts to support EU-Chinese STI collaboration might be only be visible on a long-term, as some results may need time to prosper.

Improved technical infrastructure in China is an advantage and creates high attractiveness for national and foreign stakeholders, some overseas Chinese researchers are even coming back to do their work in one of the large available facilities. The One Belt, One Road Initiative is another opportunity to allow EU stakeholders access to Chinese R&D infrastructure.

A highly important opportunity is the fact that the government has introduced tax incentives in order to attract innovative STI organisations to settle in science parks. This mechanism is working well and showing effects. However, the success of this mean varies according to priority areas, branches and regions. A right balance between a political umbrella, freedom to operate and a good complementarity of the companies is necessary for a successful operation of science parks.

## **Challenges**

There have been investments into large Chinese infrastructure with a lot of goodwill, but now in some cases the skilled personnel to implement the work or use the – sometimes – highly sophisticated devices is missing. Critical factors related to this threat and to a successful R&D facility are money, efficiency, personnel and meaningful equipment. Access to R&D infrastructure in China remains difficult for EU companies and joint R&D centres with companies are still immature in Chinese universities. For these reasons ENRICH experts have evaluated this topic as a threat. Furthermore, the interoperability of Chinese and EU infrastructure (equipment) is not necessarily given, which was as well evaluated as a potential barrier towards more integrated STI collaboration.

Too often, science parks do not fulfil their mission in facilitating collaboration, as they are not fulfilling the anticipated mission. Many are run by real-estate

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companies and are profit-oriented. There is also no standard on services and the certification process by MOST has only certified by now around 10% of science parks. It is a good approach to set-up incubators, but there is no strategy behind it. For a qualitative success, the communication at political level should improve. Also for foreigners it is not always clear what the incubators and science parks are offering and providing in terms of support services – and according to which quality standards.

When having talked about big data, ENRICH stakeholders mainly associated negative connotations to this topic. Laws for the regulation of privacy aspects in big data collection are only by now on the way. The Cybersecurity law is now about to be in place and should close the existing gaps. Open access to internet is extremely limited to foreign actors and one needs key Chinese partners to access it.

In fact, internet restrictions impose unnecessary limitations upon innovation and restrict important efficiency. All experts agreed that this is a considerable threat. The governance of virtual infrastructure and the internet in China has negative economic consequences and no advantages neither for researchers nor for companies. It is a barrier hindering collaboration at different levels. While the impact for researchers is limited, the impact for (foreign) businesses is much higher. Sharing resources is the future and open internet is needed for that. To improve this situation, better interaction at ministries and at regional level is needed in China.

Dependent on whether they are more politically relevant or not, some of the sectors which fall under the joint priorities are not yet fully opened to foreign organisations so far, which was identified as the most important threat in this regard. A success in these sectors, depends on the partner foreign organisations choose. If the partner is high-level, this can be a benefit to enter a sector. The exclusivity for Chinese companies as providers (health) is definitely a barrier.

## 2.5 Legal aspects in China with an influence on EU-China STI collaboration

### Identified and rated legal factors:

1. IPR protection & enforcement
2. Patenting and number of patent applications in China
3. Entrepreneurial climate for foreigners in China
4. Development of standards in China based on top-down approach
5. Anti-monopoly law enforcement
6. Anti-bribery / corruption measures
7. China's market protectionism
8. China's new Foreign NGO Management Law

### Main findings

In the last years China has drastically improved its **Intellectual Property Rights (IPR) protection and enforcement**. Although improving, it saw some drawbacks especially in the rising e-commerce sector – one example underlining this trend is that 70 % of Alibaba's products are infringing copyrights.

China strengthened their anti-piracy and anti-counterfeiting laws and regulations and promoted their implementation through a “Special Campaign” (Sociedade Portuguesa de Inovação, 2014). The laws have been regularly revised, new priorities set annually and international collaboration in this field is extended. Dialogue between the EU and China on intellectual property (IP) issues has taken place since 2003. The commitment to reinforce cooperation in IPR protection and enforcement is also regularly expressed during bilateral meetings, e. g. the EU-China IPR

Dialogue<sup>6</sup>, whose main objectives lie in improving the IP environment, to promote creativity, innovation and investment, deepening mutual understanding and to raise the public awareness on IP issues (European Commission, 2015a).

**Patent applications**, which can be considered the most direct indicator for the creation of new technological knowledge in China have been continuously rising since 2000, with up to 17,000 patents in 2011. While the global share of patents has therefore been decreasing for the US and the EU from 43 % to 25 % each, China's share grew up to 11 % in 2011 (Sociedade Portuguesa de Inovação, 2014). In 2013, Chinese inventors were granted some 143.000 invention patents and China had risen to fourth place worldwide for the number of citations of Chinese-authored scientific papers. Next to the increase of patent applications the share of private R&D investments has also risen steadily, an indicator for the development of new product innovations. Key areas for patent applications include Computers, Electronics and Optical Products (here esp. ICT) as well as Electrical Equipment, where China shares 12 % of all patents. China's multinational enterprises ZTE and Huawei, accounted for more than 30 % of patents in these sectors (Sociedade Portuguesa de Inovação, 2014).

Furthermore, the **entrepreneurial climate for foreigners** in China is in a constant flow and affected and influenced by laws and regulations, some of them giving a positive stimulus, while other limit the expansion and settling of foreign entrepreneurs. The 13<sup>th</sup> Five-Year Plan states that the country will open up for international collaboration, however, the undermining actions rather force Chinese companies to go abroad than improving access to China's market (indigenous innovation support, Made in China 2025, One Belt, One Road). Other challenges include intensified direct competition in some sectors or in third country markets where China hopes to establish its State Owned Enterprises (SOE) as global champions.

In the political dialogue the EU expressed the wish of China being economically more open and stable. It was articulated that market access for foreign companies in China as well as fair competition for business and investment should be equal to foreign companies entering the European market. A further challenge is the access

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6 For further information see [www.ifro.org/content/china-and-european-union-upgrade-dialogue-intellectual-property-and-sign-memorandum-understa](http://www.ifro.org/content/china-and-european-union-upgrade-dialogue-intellectual-property-and-sign-memorandum-understa)

of foreign entrepreneurs to local and regional authorities, which is necessary in different sectors (e. g. sustainable urbanisation), e. g. for registration issues and the understanding of local regulations. At regional level, the working procedures of administrations are not always transparent to foreigners.

Moreover, the Chinese **standard development** is based on a top-down approach. Decision-making in the standardisation process involves technical committees, market demand analyses and ultimately political decisions. It therefore appears that the Chinese government uses standardisation as a way to promote indigenous innovation and support the Chinese industry – while at the same time promoting Chinese standards in the international standards setting process. Setting different national standards can also be considered a market barrier, as it forces foreign companies to adapt their own products to the particular standard of a country in order to offer their products there – and ultimately affects the technology transfer to a country.

However, since China faces difficulties in competing against developed countries whose standards require the acquisition of expensive IPR, the development of its own standards represents a strategy to overcome these difficulties and compete alongside developed countries by reducing exposure to royalties. Nevertheless, not all Chinese companies accept the top-down approach and the spread of Chinese standards. Huawei, for example, demonstrates that it is essential for its success to be able to use international standards to compete internationally.

China's **Anti-Monopoly Law** (AML) was introduced in 2008, helping the country to open up for competition in different market sectors and to induce a fair market competition in principle. The AML is considered as a fruitful tool, as it includes antitrust guideline drafting, anti-trust public enforcement and anti-trust litigation. Its latest update was enforced in early 2017, which defines the procedure of anti-monopoly investigations and include an anti-trust guideline for cars, the anti-trust guideline for the abuse of intellectual property rights, the management's guarantee guideline in anti-trust cases, penalty reduction system guideline for price-fixing cases, the general condition and procedure for exemption of monopoly agreement and the guideline for illegal income and penalty. Critics on the AML

state that the law is dragging foreign companies in order to promote the domestic industry (Wei and Yin, 2017).

The SoE reform is implemented rather slowly. In some sectors, SoEs still sometimes continue to control newly opened markets. This trend can be seen especially in infrastructure-related industries, water management for example remains under municipal level control. In this way China differs from Europe, where many former SoE are privatised, but the government remains the largest shareholder (stock company) (Wang and Xiao, 2009).

An additional critical issue in China is related to **bribery and corruption**. China differentiates between official bribery (involving at least one government representative) and commercial bribery (giving a bribe, involving no government official). There are monetary thresholds for offences related to official bribery and corruption. Commercial bribery is also prohibited by the Anti-unfair Competition Law, which defines commercial bribery as business operators using money, assets, or other means to bribe counter parties to sell or purchase goods. In the past five years investigations related to bribery have drastically increased, especially in the sectors telecom, airline and security. Adopted in November 2015, the Ninth Amendment to the Chinese Criminal Code enhanced penalties for bribe-givers, extending criminal liability beyond improper payments to current and former government officials to those aimed at the relatives and close associates of both. The anti-bribery laws have been continuously improved over the years and the commercial anti-bribery law, the Anti-Unfair Competition Law effectively broadens the scope of payments (Liu, 2017).

As previously mentioned, China is often confronted with the assault to limit its **market access for foreign companies**. Especially foreign companies are challenged with special rules and regulations related to technological standards, discriminating licensing and certification requirements, unequal restraints arising from security-related legislation, uneven communication with Chinese standardisation bodies or no access at different levels to calls for proposal related to public procurement (European Commission, 2016). Further challenges arise from:

- access to finance

- restrictions for representative offices
- access to information about regulations
- difficulties in maintaining human resources
- compulsory technology transfer for those entering JVs or
- restricted openness of highly-regulated markets (banking, healthcare etc.)

All these issues are affecting mostly foreign SMEs (Sociedade Portuguesa de Inovação, 2014).

Initiatives like “Made in China 2025” or the “Internet+” plan stress this tendency (European Commission, 2016). In other sectors the import of products is highly regulated, such as for food, agriculture and biotechnological (FAB) products or high tariffs are applied (e. g. cars, luxury items). Special rules also apply for strategic sectors such as military, telecommunication or critical infrastructure, which are of relevance for the national security.

Recently, foreign companies are also affected by foreign capital outflow limitations: European companies with operations in China reported in late 2016 that due to new regulations they were not permitted to transfer dividends for China abroad. Payments were stated to need unusually long approval times or special approvals when capital outflows exceeded the sum of 1–5 million RMB. (Clover, 2016).

Not only foreign companies, but also foreign NGOs are facing a challenging (controlled) context in China. **The new Foreign Non-Government Organisation (NGO) Management Law** came into effect on January 1, 2017 forcing all non-profit, non-government overseas organisations operating in China to register their offices or activities. Organisations such as charities, think tanks, trade associations, academic institutions, sports clubs and chambers of commerce fall under this new law. NGOs which do not register or report activities under the law will not be able to legally operate or donate funds to Chinese NGOs (Lexology, 2017).



## Trends

China's complex legal system is a complex challenge to most foreigners at first sight, and it is important to get good advice when planning to do STI work in China, especially as soon as a business operation is linked to it. Very likely, the system in general will not change dramatically in the next years. Indeed, there are some identifiable trends making legal issues in China somehow easier to foreigners. The good news is that IPR protection laws have been better enforced in recent years. The same accounts for the anti-corruption laws. Very often, legal difficulties are not directly caused by Chinese laws themselves, but their weak implementation and control. Hence, a general trend goes into the direction that the awareness to enforce laws is improving in China.

Linked to the political priority of stability for the country instead of pushing above-average economic growth is the perception that China is closing its market from outside competition. ENRICH experts and other reports coincided in describing different economic and legal measures that gave the Chinese government more control over foreign activities in the country. In general, many foreign companies feel constricted in their businesses in China. The introduction of Chinese standards can be interpreted as an indirect market barrier, while the Foreign NGO Law forces organisations into an almost direct control by Chinese bodies.

## Opportunities

China's efforts to protect IPR have increased steadily. There is a changing mind-set to be observed among Chinese companies. Education campaigns on IPR protection have led to growing sensitivity on the topic. The increased legal certainty in this regard has been mentioned by ENRICH experts as a positive factor stimulating new opportunities for European STI stakeholders.

The Chinese market is opening up in sectors which have been monopoly sectors before. This gives European companies and other STI stakeholders new freedom to operate in different sectors in China. It is also good that European companies generally have more awareness and experience with sectors which are now

monopoly-free in China compared to Chinese companies, fact that actually places them in an advantageous position.

Additional positive news for European STI stakeholders in China are that the moral awareness of individuals on anti-bribery and corruption has risen and huge improvements can be seen since the enforcements of strategies in 2012. The mind shift is happening and both “tigers” (big bosses) and “flies” (small bosses) receive hard punishment due to a better enforcement of the anti-corruption laws and effectual awareness-raising campaigns.

The rising number of patents can be interpreted as a sign for a transformation of China towards a knowledge-based economy. STI activities have been focusing on industrial developments, but China’s STI work is also shifting to basic research, which can be highly relevant for international collaboration. In fact, the patent approval process in China is very tough, therefore the quality of the inventions can be considered as good. Utility models are also widely applied and once legally enforced it is very difficult to make them legally void, hence current patenting processes are at a high quality level, which can be seen as positive signal in the Chinese STI system.

## **Challenges**

China’s market protectionism can be an obstacle for potential European clients. Current intentions to open up the Chinese market rather give Chinese STI organisations incentives to operate outside of China than facilitating opportunities for foreign STI stakeholders in China. As previously stated, it is extremely difficult for foreigners to access some sectors highly regulated by the Chinese government. For foreign STI stakeholders in specific sectors (e. g. sustainable urbanisation) it is essential to have access to national / regional authorities and knowledge on regulations and standards.

The main challenge for foreign entrepreneurs is still the lack of understanding of the local markets and the Chinese mind-set. Understanding the market and mind-

set, e. g. the importance of guanxi, is much more a key factor for success than the perfect legal knowledge.

National standards are a market entry barrier for foreign products (technical barrier for trade, TBT) and some regulations in China are misused to block imports, as happening with food laws (Agreement on the Application of Sanitary and Phytosanitary Measures, SPS). For international STI providers, this is a strong threat. However, the Chinese legislation on import and IPR is very often adopted from EU and US laws and regulations. On the other side, from a Chinese position, the complexity of products and international suppliers hinders national standards, which is a relevant weakness for Chinese companies interested in competing at international level.

Although the legal framework is good, the enforcement of IPR laws is too often weak and strongly depends on regions. A further critical point is that IPR protection processes are very different to Western countries and complex, what the stakeholders stated to be the strongest threat of this factor.

It is difficult to establish NGOs and public institutions from abroad. The law means a stronger dependency and control by the Chinese government over foreign NGOs and therefore symbolises an entry barrier.

## **2.6 Environmental trends and factors with an influence on EU-China STI collaboration**

### **Identified and rated environmental factors:**

1. Air pollution
2. Water
3. Soil pollution
4. Food safety

5. Blue Economy
6. Access to environmental data
7. Health care and aging populations
8. Reduction of GHG emissions in China
9. China's international cooperation on climate change
10. Energy
11. Antibiotic resistance

## Main findings

**Air pollution** is seen as one of the biggest environmental challenges in China and it is a threat for the health of the Chinese population. Key factors are smog and the burning of coal. Both primary (e. g. through coal or biomass) and secondary pollution (e. g. aerosol) can be found in China. Since 2008, the US Embassy in Beijing is releasing data on air pollution and since 2012, PM2.5 values are published, and a huge network of monitoring stations has been created within two years.<sup>7</sup> Only 10% of Chinese cities that implement new air quality monitoring standards have reached the standard of average annual air quality (Gao, 2016)).

However, the monitoring system has been spreading so widely in China that European cities look at China in order to investigate the potential of the monitoring networks for themselves. Latest data proves that the average PM2.5 values has fallen due to increased efforts of introducing alternative energies and a general slow-down of manufacturing and production in China in the last years. However, this development is not yet to be confirmed as a trend (Fullerton, 2017). Furthermore, there is more time needed to enforce laws and measure results as well as in several regions in China people still have to better understand the potential and use of alternative energy sources and, for example, construct houses in energy-efficient manners. The uptake of innovative solutions could be faster, but social realities also have to be considered and understood.

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<sup>7</sup> <https://china.usembassy-china.org.cn/embassy-consulates/beijing/air-quality-monitor/>

An additional issue having a massive environmental impact is the unequal distribution of **water** in China. While coastal cities are regularly “flooded”, other central regions hardly get sufficient amounts of water. In many cases when a flood reaches a Chinese city the key problem is the lack of permeation systems for the water to sink into the ground (also the case in Europe). Therefore, the new Sponge City Initiative<sup>8</sup> in China is promoting more green areas, permeable sidewalks and roads in Chinese cities.

About 6.5–9.2 % of rivers and larger lakes are grouped within the highest (worst) category of water contamination according to latest evaluations (Gao, 2016). Contamination stems mostly from industry and farming. One key factor causing the contamination is the different mind-set in China – problems are often solved once they exist instead of putting efforts into prevention. Therefore, from a Chinese mind-set one would rather try to clean the water of the river instead of trying to avoid toxic liquids from factories or farms flowing into the river (prevention at factory level).

Nevertheless, the level of public awareness for drought, water scarcity and water pollution among the Chinese population has continuously risen.

One sixth of China’s soil exceeded state pollution limits in 2015, being mainly contaminated with heavy metal or other chemicals. Some experts say that this fact makes **soil pollution** actually to the most dangerous environmental problem of all (Reuters, 2016). Treatment costs for soil remediation are high and difficult to cover without private investments, which are hard to attract due to the lack of profit. The problem has become more and more critical in the last years and in many cases cleaned land is needed for reuse, especially in densely populated areas. About 100 key soil remediation projects have been initiated, adding up to 500 bn yuan. An action plan has been introduced by the central government to curb the worsening of soil pollution by 2020 and stabilise / improve soil quality by 2030 (Reuters, 2016).

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8 Further information to be found e. g. on <http://theconversation.com/chinas-sponge-cities-aim-to-re-use-70-of-rain-water-heres-how-83327> (08.09.2017)

Moreover, in 2015, 71% of the Chinese population considered **food safety** a big problem in their country, as China was hit regularly by food scandals in the past years and still authorities uncover thousands of food safety violations every month (Fu, 2016). The national food standardisation system used to cover over 5.000 safety standards, which in reality was a huge bureaucratic burden for producers. The Food Safety Law from 2015 has reduced the number of standards to 683 and simultaneously enforces enhanced supervision of the whole food supply chain (O'Brien, 2016). Further, China faces the need for environmentally-friendly agricultural systems while ensuring quality and safety of agricultural products.

In the past decades the South China Sea has been highly affected by environmental pollution and industrial fishery. This has caused environmental damage (metal / chemical pollution of water and coastal areas, plastic waste, 80% less coral reefs in the last 20 years, growth of algae) and the overexploitation of fish, reducing their decline and bringing local fishermen with small businesses into existential difficulties (Conathan and Moore, 2015). Investments have been made in order to protect the environment. Strategies towards a **blue economy** have been on the table since the 12<sup>th</sup> Five-Year Plan and some important steps to better protect marine ecosystems have been taken.

Nevertheless its primary focus has still been on economic development and a thorough protection plan for a sustainable but productive ocean ecosystem does not exist yet. Consequently, China is facing a decline of fish catch in coastal areas due to conflicting interests deriving fishing state subsidies (although said they have no influence on overexploitation of fish), claims of exclusive economic zones and mega-commercial fishing trawlers. At the same time, oil and gas production and their transport have become a significant problem for the marine environment (Borton, 2015).

Regulations on catching fish are already in place but more are needed. The 13<sup>th</sup> Five-Year Plan mentions steps towards a blue economy, as well as the 2008 National Marine Industrial Development Plan, stating the marine industry to occupy a very important strategic position within coordinated developments of both land and sea resources. Alternative and more sustainable exploitation approaches include tourism and bio-prospecting search for new organisms that might prove valuable

to the pharmaceutical or cosmetic industries, an activity which recently grew by 21 % (Conathan and Moore, 2015).

Moreover, in the past decade China managed to increase health expenses and to further develop the infrastructure for **healthcare**, which even includes a nearly universal health insurance and allowing a good access to health care for most of the population. However, this system is currently very much centred around hospitals, making it less efficient and more expensive than necessary. According to a World Bank study from 2016 the system could be improved by offering access to healthcare again much more outside of hospitals and rather in the communities. With increasing incomes there is more and more demand for proper healthcare and services in China. Since 2011 more competition is allowed on the health care market, including wholly foreign-owned entities. China can be considered thus as one of the fastest growing healthcare markets (World Bank, 2016).

Due to a growing middle class that can afford more and better health care, the living expectations in China have risen. On the other hand, although the one-child policy has loosened, birth rates are still expected to be low, as many families feel like they cannot afford a second child. Hence, the **Chinese population is aging rapidly** and is losing necessary workforce. While by now 7.6 workers come up for every retired person in China the ratio will very likely decrease to 2.5 in 2050. Accordingly, China has to cope with an increasing pension problem. One solution to tackle this problem is the national social security fund set up in 2000, which complements current pensions and is listed in the stock market in order to gain assets (Wang, 2016).

China, along with India and other emerging economies, has long insisted on the principle of 'common but differentiated responsibilities' in dealing with global climate change. Entitled as the world's largest **greenhouse gas (GHG) emitter**, China is most amenable to the climate change consequences. This is reflected mostly in agriculture, forestry, natural ecosystems, water resources and coastal areas (UNESCO, 2015). Reducing its GHG emissions has been in conflict to other development goals China is also pushing, among those industrialisation, urbanisation, employment and exports to sustainability, as well as duplicating its GDP until 2020 (UNESCO, 2015). In 2014, China's State Council unveiled an

Energy Development Strategy Action Plan (2014–2020)<sup>9</sup> which promised more efficient, self-sufficient, green and innovative energy production and consumption, limiting the yearly primary energy consumption to 4.8 bn tons until 2020 (State Council, 2014).

Indeed, China is the world's largest coal producer and consumer, in 2015 coal accounted for 64% of the country's total **energy** consumption. China's energy consumption has still been still growing, about 0.9% in 2015 (Energypost, 2016).

Nevertheless, China is also putting remarkable efforts into a better energy mix, involving new technologies related to renewable energy sources, such as wind and solar power, installing systems which lead to new record of alternative energy generation per country (Tianjie, 2017). The mix furthermore includes nuclear power and natural gas, of both the shares have risen. Overall, clean energy sources account for 18% of the energy mix (China Daily, 2017). At the same time the share of coal in the energy mix fell for 3.7% from 2015 to 2016. Pushing clean energies is a goal of the central government, stronger support for the generation of wind, solar, biomass, water and geothermal energy is planned (Gao, 2016).

Furthermore, the EU and China reinforced their **international cooperation on climate change** by supporting the development of cost-effective and low-carbon technologies (17<sup>th</sup> bilateral summit in June 2015).

They agreed to intensify the bilateral climate cooperation for example in the areas of domestic mitigation policies, carbon markets, low-carbon cities, greenhouse gas emissions from the aviation and maritime industries, and hydrofluorocarbons (Ministry of Foreign Affairs, 2015). A new collaborative research arrangement was closed between the European Commission's Joint Research Centre (JRC) and the Chinese Academy of Sciences (CAS) Institute of Remote Sensing and Digital Earth (CAS-RADI). The focus of their work will lie on sustainable development, climate action and disaster risk reduction. This furthermore covers topics such as air quality, human settlement detection and characterisation, land and soil mapping, land cover mapping, digital earth sciences and agricultural monitoring (European Commission, 2015b).

9 <https://policy.asiapacificenergy.org/node/138>



The use of antibiotics per capita in China is five times as high as in the EU and the USA, 52 % of the overall use of antibiotics are used for animals (veterinary drug use). In 2013, half of the world's use of antibiotics was accounted to China (Tang, Son, Li, Kong, Su and Xu, 2016). Increasing **resistance to antibiotics**, partly also due to misuse, is a serious problem – not only in China. Reports from 2017 describe that bacteria resistant to the “last resort” antibiotic colistin were now found in humans, carried by flies from animal farms. Hence there is a need for a reduction of the use of antibiotics in animal farming and their introduction into the food chain, e. g. through improved animal welfare and environmentally-friendly production systems. Colistin is now banned for its use as a growth stimulator of animals; however, it is still allowed to treat sick animals. It will also be used from now in hospitals for the treatment of humans due to the antibiotic resistance of some people to other antibiotics (Hancock and Keyu, 2017).

**Access to environmental data** in China is difficult and its information often hard to work with scientifically. This is caused through:

- Differences in data collection across the country
- Available data is not meaningful enough
- Accuracy not always clear
- Not sufficient number of energy-environment indicators (but the government has mentioned to increase this number in the 12<sup>th</sup> and 13<sup>th</sup> Five Year Plan)

Much of the existing environmental data is furthermore seen as national high security information and therefore not available at all, which makes it difficult do to proper research on particular topics (e. g. there is no comprehensive quantitative data on fish in Chinese coastal areas) (Hsu, Yan & Cheng, 2017).

## Trends

Still, China's environmental problems are severe in many areas and for certain problems it is difficult to predict if parts of the environment will ever recover. However, a positive trend, which has already started is that there is a growing num-

ber of laws in favour of the protection of the environment and some of the ordered actions can be considered as stricter than in Europe. A prominent example is the electric car quota for vehicle sales in China (from 8 % in 2018 and 12 % in 2020). It is one measure to improve the air quality, but also helps China at the same time to keep up with the own development of innovative technologies.

Our experts agreed that there is generally a rising awareness among the population to be seen on environmental topics, but the awareness differs from case to case and from region to region. There is more awareness on visual problems such as air pollution than on less visible problems like contaminated soil, ground or water. Furthermore, they have also mentioned that awareness does not necessarily lead to actions. The Chinese government has the potential to use its power by steering developments through top-down management here.

Although there are many laws, their enforcement is often too weak, since in some cases there is a lack of control mechanisms or even there is a lack of awareness among local officials. One of China's challenges will be to control the implementation of laws all over the country; in order to become successful here provincial and local municipality officials should have the same level of education and information in order to see the need for a proper implementation of measures.

## **Opportunities**

When looking at China's environmental situation is fair to mention that the majority of challenges faced are global problems not just limited to affect China. Indeed, to some extent many EU countries are struggling with same and similar challenges. This common situation already provides a clear baseline on the meaningfulness why the EU and China should collaborate and work together on innovative approaches to tackle their environmental challenges. STI collaboration on environmental topics is a must instead of an option for the EU and China.

All described environmental topics offer opportunities for joint STI collaboration between the EU and China. Particular opportunities can be:

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- **Air pollution:** There is still much more research needed on atmospheric chemistry and chemical pathways, green alternatives and improved monitoring technology as well as promotion of renewable energy and energy efficiency. The next assigned mayor of Beijing will be from the Ministry of Environment, hence there is a good potential that the research and activity focus is put on strategies to reduce air pollution.
  - **Water:** Water and flood management systems and the infrastructure behind are not very well designed in urban areas. There is lots of potential for innovative approaches through STI projects and collaboration with relevant stakeholders.
  - **Soil pollution:** STI efforts for efficient waste management at large scale are needed as well as more education, awareness raising and incentives on this topic, as there is need to advance on this topic scientifically.
  - **Blue Economy:** Tax incentives help to develop further approaches such as bio-prospecting in order to support sustainable alternatives in maritime exploitation
  - **Health care and aging population:** There is already now an increase in the nursing industry in China, at the same time, the retirement limits are increasing. Among the society there is a change of perceptions and values.
    - Next to technologies for the treatment of age-related illnesses remote technologies will become more and more important.
  - **Reduction of GHG emissions in China:** There is a top-down reform to reduce the energy consumption, which is an opportunity for the Chinese STI landscape, furthermore, international collaboration on this topic is planned and supported as well from the government. The Ministry of Environmental Protection is active in introducing advanced technologies from abroad in order to support the reduction of GHG emissions.
  - **Energy:** China puts remarkable efforts into a better energy mix and is trying to improve clean coal technologies, which experts identified as a very relevant opportunity for further STI work. This field offers lots of potential for STI involvement. Furthermore, developments and new technologies are currently

supported by the Chinese governments through investments into low carbon and renewable energy technologies.

- **Antibiotic resistance:** An opportunity for STI work is that pig and chicken farms are interested in available technologies, as the intensive farming involving antibiotics is also one of the biggest factors influencing the resistance against antibiotics. Antibiotic resistance offers room for new international research opportunities, however, a different mind-set and culture which appreciates the proper and not the fast treatment is necessary.

## Challenges

A key challenge not only for foreign researchers but equally to Chinese researchers is the mentioned fact that much of the environmental data is classified as national security information. STI activities in China on environmental topics are often hindered as available data is very general, gaps exist or access is only possible through government-endorsed channels. Other data, e. g. provincial data is often not accessible at all. These problems are a highly critical threat both for researchers inside and outside of China.

Experts criticised that although considered to be a must, international agreements do not influence China's behaviour in the fight against climate change that much. They explained that this is a threat for the Chinese STI landscape and its potential for international collaboration. Decisions are often taken based on national priorities. However, common actions and policy at a political level are very relevant. Therefore, the direct impact of China's international cooperation on climate change has only limited direct influence on STI developments and stakeholders in China.

Furthermore, the ENRICH experts commented on single environmental challenges as follows:

- **Air pollution:** All experts agreed that the law enforcement is too lax and environmental laws related to air pollution are not complex or far-reaching enough to currently implement a better protection. There is also still too much conflict

between competing economic and environmental goals in China. Some parties in the process have vested economic-driven interests. The public awareness on the dangers but also green alternatives is not strong enough yet.

- **Water:** Water management is happening decentralised in China, which makes its correct implementation difficult to control. At the moment, water management but also the implementation and uptake of innovative technologies is happening through a very fragmented approach. The law enforcements addressing water pollution are too lax or not applied; there are too many different interests by the different stakeholders – which causes a threat for innovative water management approaches. It was also reported that when it comes to international cooperation on water, especially Chinese SoEs prefer to apply and accept less novel technologies purely in order to prevent risks and financial losses that could occur with innovative technologies.
- **Soil pollution:** Measures taken at the local government level in order to deal with soil pollution are too often not purposeful yet. One example is that no effective measures are taken to separate garbage. There is no coherent definition for garbage separation and recycling. Very soon soil pollution can become a bigger threat than air pollution in China and the government is lacking so far a plan to cope with it. The public is also too often not aware of the severity of the problem. Innovative solutions to tackle these problems have to be applied with local government support in close collaboration in order to ensure their effectiveness.
- **Food safety:** On the one the one hand there are food safety laws and regulations in China, but they are not properly enforced, which could also fall back negatively on STI activities. As a consequence, China is quite regularly overrun with food process incidents; prominent examples are the melamine-contaminated milk powder or re-used gutter oil. Without any change of mind-set and behaviour novel STI solutions will not be able to solve the man-made problem of food safety.
  - Furthermore, technologies to improve food safety are there and the processing procedures are generally safe. Most dangers on the quality of food however stem from air, water and soil pollution (20 % of agriculturally used land are heavily polluted, in fish and seafood traces from water pollution can

also be found), where the processing technologies have little influence on. This problem needs more public awareness and social responsibility along the whole life cycle of foods. It was also criticised that although the level of awareness among citizens on food processing is high, the level of taking actions is low.

- **Blue Economy:** Parts of the available data is not accessible to researchers in order to assess the effectiveness of blue economy measures and their consequences, which causes a threat for thorough STI work on this topic.
- **Reduction of GHG emissions in China:** Experts agreed that a critical threat is that laws are not strict enough, which causes problems in their implementation.
- **Energy:** Coal still has the highest share in the energy mix, reasons for this are that coal is a very cheap energy source and easier to get compared to other (renewable) resources. To decrease the share of coal policy actions from government bodies are needed. Some alternative energy resources such as crops will hardly be pushed in China, as they stand in a usage conflict for alimentation purposes. Very likely, land will be used to grow crops for alimentation instead for resources for energy generation if there was an opportunity to choose.
- **Antibiotic resistance:** The biggest threat is the lack of awareness by the public of the risks of too much antibiotics consumption. Better and larger information campaigns, as well as awareness on alternative treatments are necessary.

### 3 Conclusions

The presented findings allowed drawing a current picture of the status and developments of the Chinese science, technology and innovation landscape and how these impact EU-China STI collaboration. This analysis of the various political, economic, social, technological, legal and environmental factors has unveiled a large variety of promising opportunities, but also some critical threats. Both can have impacting influence on the work and operations of the different STI stakeholders in China, but also on EU-Chinese STI collaboration.

This overview proves that the Chinese STI landscape is currently **benefiting from national political priorities favouring innovation** and new technological developments. Public, but also private **research expenditures have steadily risen** and the **quality of STI products and results, such as publications, patents and innovations is increasing**. In some thematic fields China belongs to a group of international leaders – which is conducting to the new situation that Chinese companies become inter-sectorial high-level competitors. Nevertheless, the framework conditions of the Chinese STI landscape strongly depend on political stability, **economic growth and financial support** and the political endorsement of the national and local governments. Researchers in China also face the **challenges of access to data** which is qualified as “top national security”, such as environmental data. These are important aspects EU STI stakeholders should keep in mind when deciding on STI collaboration with China.

An important foundation for EU-China STI collaboration are defined **common thematic priorities**, complementary and reciprocity, as well as an awareness on joint global challenges and megatrends, which have to be tackled together. Here, the majority of all discussed **environmental factors** but also the cross-thematic social factor of the “aging population” offers many collaboration opportunities – to give some examples.

According to ENRICH findings, key success factors fostering EU-China STI collaboration are:

- the existence and **knowledge on joint research and innovation funding opportunities**,
- **occasions for networking** and
- awareness and **information on existing STI infrastructure**.

ENRICH experts involved into this analysis shared the view that European STI stakeholders in China encounter difficulties related to:

- **internet censorship**,
- access to information on STI infrastructure and
- information on Chinese funding opportunities.

The current political **trend in China to close and protect the country** in order to boost national technical developments is also considered as critical.

What can we learn from these findings for EU-China STI collaboration on a micro level? EU stakeholders should be aware that STI collaboration with China is becoming a rather dynamic process. It can be compared to a “marriage” of two complementing systems, of which one is very dynamic and the other more structured. To achieve fruitful results the partners should know each other very well and good communication is a key factor for success.



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China's Science and Technology (STI) market is a very dynamic sector with rapid progress, offering considerable opportunities for potential collaboration. The European Union (EU) and China have a long track of cooperation on STI subjects. There are several points of coincidence, common trends and a political commitment to deepen existing collaboration. Many reasons bring us to take a closer look at China's STI landscape and to understand the implications of all these changes on the EU-China STI collaboration.

This report provides current insights in that direction, by analysing the core elements shaping the Chinese STI landscape, highlighting trends and by identifying key challenges as well as main opportunities for international STI collaboration. The document aims at delivering an overview on main issues to be considered by European organisations when intending to get engaged in STI collaboration with China.

A thorough documentary analysis has been performed and a set of key stakeholders has provided their views on the topics scrutinised. Indeed, whereas there is a common agreement on the strategic relevance of fomenting and reinforcing international STI collaboration between European and Chinese actors, there is also a clear view that it is a process requiring perseverance and decisive steps towards building up a relationship based on mutual trust.

The underlying study is part of the activities of EU-funded project ERICENA, which established ENRICH China, a European Network of Research and Innovation Centres and Hubs in China. ENRICH China supports and connects European research, innovation and business organisations to China.

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