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The challenge of China's rise as a science and technology powerhouse

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Executive summary

reach China outperforms the European nion in terms of expenditure on research and development as a share of its and already produces aout the same numer of scientic pulications and more hs in natural sciences and engineering than the nited tates

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but its growth model for science still involves sending out its increasingly better locally-trained scholars to the best institutes in the world and reaping the bene ts when they return in the later stages of their careers, after they have fully developed their capabilities and built their networks. e US remains the favoured destination for Chinese students, which has led to the creation of US-Chinese science and technology networks and connections that are mutually bene cial: enabling China to catch up and helping the US to keep its position at the science frontier.

to China than the US.

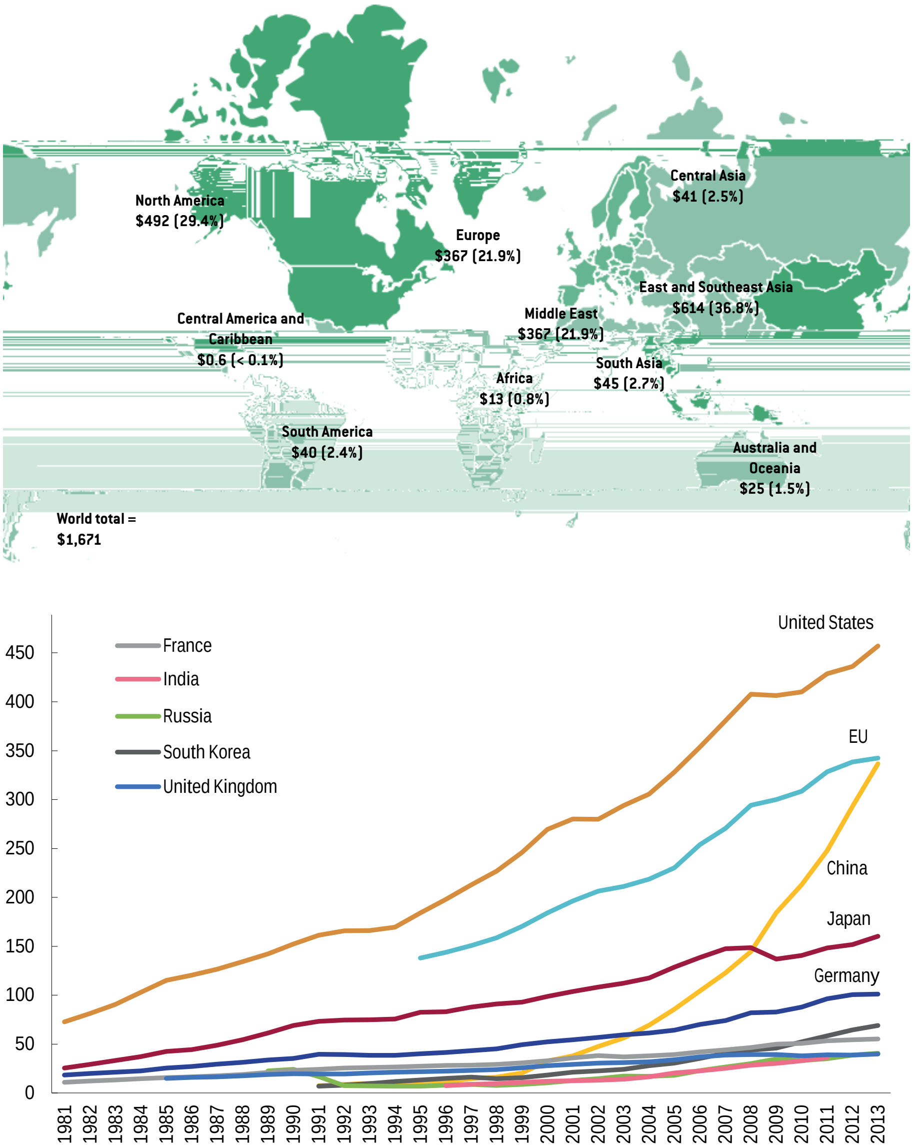
e EU should take steps to engage more with China if it is not to miss out in the future multipolar science and technology world.

1 Introduction

e creation of scienti c knowledge and its use in technology and economic and societal development has become increasingly global and multipolar. Europe and the United States have traditionally led in scienti c development, but China in particular has emerged as a new science and technology (S&T) powerhouse.

A key indicator of the rise of China in S&T is its spending on research and development (R&D). Chinese R&D investment has grown remarkably, with the rate of growth greatly exceeding those of the United States and the European Union. China is now the second-largest performer of R&D, on a country basis, and accounts for 20 percent of total world R&D (Figure 1).

Figure 1: The world R&D landscape (R&D spending in billions of current PPP)



Source: Bruegel based on NSF (2016). PPP = purchasing power parity. NOTES: Foreign currencies are converted to dollars through PPPs. Some country data are estimated. Countries are grouped according to the regions described by The World Factbook, www.cia.gov/library/publications/the-world-factbook/.

China is increasingly prominent in industries that intensively use scienti c and technological knowledge. China ranks second behind the US in terms of the share of total value added cre-

e rise of China as an S&T powerhouse is likely to a ect S&T in the US and Europe. e US S&T model has traditionally been at the frontier and very open. Because the US science and engineering workforce is highly dependent on migrants, especially from Asia, the rise of China has provoked deep concern about the sustainability of the American capacity for innovation and international competitiveness. An added concern is the more recent trend in the US to move to a more restrictive immigration policy. is comes on top of a reluctance to allocate public funding to support the building of S&T infrastructure[1].

e EU has focused on catching up in S&T terms with the US. e failure to attract and keep the best scienti c brains is also a persistent area of concern for the EU (Veugelers, 2017). However, the EU is mostly focused on building and sustaining its integrated internal market for research (the European Research Area, ERA) and removing barriers to intra-EU mobility of researchers. Although ERA is posited to be an open area, its international strategy is marked by pronounced EU-supported, intra-EU collaboration, with the risk of overlooking the US and emerging Asia as partners.

2 A multipolar science world: trends

2.1 China's increasing share of scienti c output

e US has led the world in the production of scienti c knowledge for decades, in terms of both quantity and quality. However, since 1994, the EU, considered as a bloc (including the United Kingdom), has -o.1 (U)46 (, cons (e)15 0 0 123 (d K)43 ((y anm7 (as - (e for 3 (sn4S6Str)-6.9 (uct)e)15 0

US. e EU as a bloc accounts for 30 percent of published computer sciences papers. In -
, China produces one quarter of all published papers. In , the Chinese share is 18 percent. In (biological and medical sciences), China's rise has been much less pronounced. e EU and the US retain for the moment their predominant roles in this area.

Table 2: The rise of China by scienti c eld

F e d	C a' a e f b ed a e , 2013	C e e c e c b ca a a a e (2007-2013)
A e d	18.2%	18.9%
Med ca c e ce	7.5%	15.0%
B ca c e ce	13.9%	14.4%
C e	24.5%	14.8%
P c	19.6%	14.7%
Ma e a c	18.0%	17.8%
C e c e ce	21.1%	25.1%
E ee	34.8%	22.1%

Source: Bruegel based on NSF (2016).

Quality of research is another matter. In terms of research impact, measured by the number of times scienti c papers are cited, the US's dominant position is less contested (Table 3). Proportionally, more papers produced in the US are included among the top 1 percent of most-cited papers, and the US contribution is still growing. e EU is also improving its position in the top cited segment, but still scores below the US.

China for now is making only very modest inroads into the top segment. e share of Chinese scienti c papers included in the top 1 percent cited segment is still below 1 percent, but China is progressing and is already on par with Japan.

In and in , more than 1 percent of Chinese papers are already in the top 1 percent segment for citations. And in

e Chinese programme to build-up scienti c capacity has been concentrated on a selected set of institutes. Of China's 1700 chartered institutes of higher education, 6 percent absorb 70 percent of scienti c research funding and produce about a third of all Chinese undergraduate students, two-thirds of graduate students and four- fths of doctoral students. China's top universities are Tsinghua University and Beijing University. Both are among the top 100 universities in the Shanghai Academic Ranking of World Universities[4]. e US continues to dominate this ranking. In the 2016 edition, 15 of the rst 20 places are taken by US

enough to contribute to the build-up of quality science, maintaining the US in its top position, which ensures it can keep on attracting the best foreign talent (Veugelers, 2017).

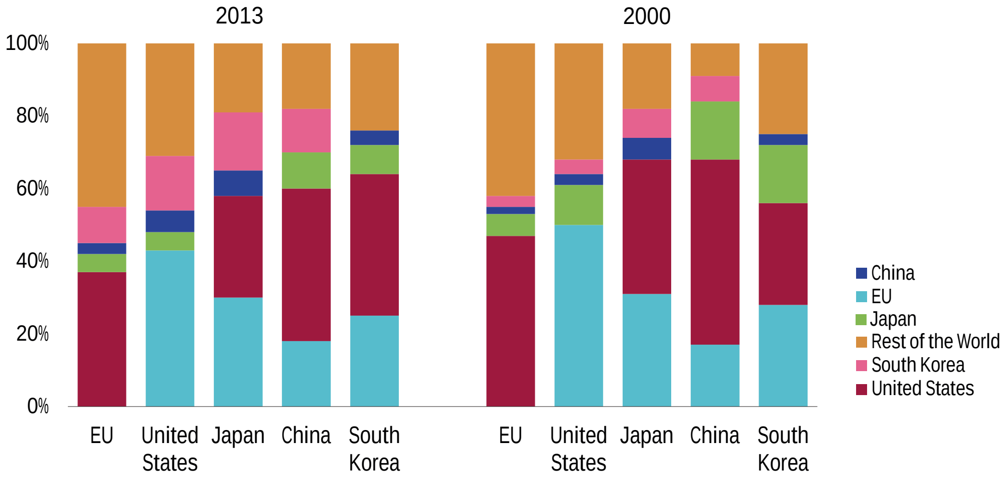
The presence of foreign PhD students in the EU, including Chinese students, is less systematically recorded. In general, the imperfect evidence shows that the PhD student populations of EU countries have fewer foreigners compared to the US, and the geographic sources of foreign PhD students are different, with geographical, cultural and political links being more important relative to the US, and a less strong Asian presence compared to the US (see for example Moguerou, 2006).

The EU introduced in 2007 a new programme to support the research ideas of individual scientists, who are selected by peer review on the basis of scientific excellence: the European Research Council (ERC) grants. So far about 7,000 grants have been granted. In addition to supporting EU scientists, the intent was to use the ERC grants to attract leading scientists from outside the EU. So far, only about 8 percent of ERC grants have been allocated to scientists from non-EU countries. Of these, the greatest amount went to US scientists (40 percent), and only 4 percent to Chinese nationals. Nevertheless, ERC grants attracted researchers to Europe (most of them PhD or post-doctoral students), not as established principal investigators, but rather as team members on ERC projects: about 17 percent of ERC team members come from a non-ERA country (ERA includes the EU countries and Switzerland, Israel and Norway), amounting to more than 9000 scientists so far. Of these non-ERA team members, the country of origin for the largest proportion is China, with 18 percent, closely followed by the US with 16 percent. The ERC case thus shows that Chinese graduates can be attracted to the EU, at least to scientific excellence hubs.

3.2 International collaboration in science

International collaboration allows scientists from different countries to partner with leading experts elsewhere. Scientists engaged in international collaboration tend to produce higher quality research (OECD, 2015b; European Commission, 2016). In the context of its increasing

Figure 4: Partners in international scienti c collaborations, measured by internationally co-authored publications (2000, 2013)



Source: Bruegel based on European Commission (2016).

In terms of the international collaboration nanced by the EU through its Seventh Framework Programme (FP7, 2007-13), Chinese involvement is marginal[8]. Although FP7 was designed to be open to non-EU countries (although non-EU parties typically cannot receivg20 e EU funding) in practice there was little support for non-EU partnerships. For all collaborative projects in the FP7 period a total of about 1.5 million pairings were supported (European Commission, 2014). Of these 89 percent involved partners from di erent EU countries. Only 0.4 percent involved a US partner and only 0.2 percent involved a Chinese partner.

4 A multipolar science world: the impact beyond science

e rise of China as a scienti c powerhouse will have an impact beyond science on the technology, innovation, entrepreneurship and economic growth potential of the west. Chinese companies will leverage China's scienti c power to increase their competitiveness on world markets, challenging their western competitors.

In the list of the rms worldwide that spend the most on R&D, tracked by the EU Industrial

Table 5: R&D spending by companies by region, from EU Industrial R&D Investment Scoreboard

- In 2013, 57 percent of foreign-born individuals in the US workforce with a science and engineering degree were from Asia. While the leading country of origin was India (20 percent), China was in second place with 8 percent, which is somewhat lower than in 2003 when it was 11 percent.
- Source countries for the 402,000 foreign-born holders of science and engineering doctorates were somewhat more concentrated, with China providing a higher proportion (22 percent) than India (14 percent).
- One quarter of engineering and technology companies founded in the US between 1995 and 2005 had a least one key founder who was foreign-born. Over half of Silicon Valley start-ups had one or more immigrants as key founders (Wadhwa, , 2007). Of all immigrant-founded companies, 26 percent have Indian founders, with Chinese (including Taiwanese) founders coming second (about 13 percent). In computers and communications, Chinese (including Taiwanese) immigrant start-ups in the US make up more than one third of foreign start-ups. Chinese (mainland- and Taiwan-born) entrepreneurs are heavily concentrated in California, with 49 percent of US companies with founders from mainland China located there.
- Foreigners are also increasingly responsible for US patents. One quarter of US patent applications led at the World Intellectual Property Organisation in 2006 were authored by a non-US national, up from seven percent in 1998. e largest group of immigrant non-citizen inventors was Chinese (mainland and Taiwan-born) (Wadhwa, , 2007).

e data shows the importance for the west's S&T system of being able to tap into global talent pools, and the importance of China within the global talent pool.

Figure 5 breaks down international co-invention partnerships. Who collaborates with whom in international co-invention partnerships is sticky and doesn't change fast. For the US, 5