May 2021

Advanced Technologies for Industry – international reports

Advanced technology landscape and related policies in China

This report was prepared by Heidi Heimberger and Maria Karaulova; Fraunhofer ISI - with support from Henning Kroll, Fraunhofer ISI and Kincsö Izsak, Technopolis Group.

EUROPEAN COMMISSION

European Innovation Council and SMEs Executive Agency (EISMEA)

Unit I.02.2 — SMP / COSME Pillar

E-mail: EISMEA-SMP-COSME-ENQUIRIES@ec.europa.eu

Directorate General for Internal Market, Industry, Entrepreneurship and SMEs

Unit D.2 — Industrial forum, alliances, clusters

E-mail: GROW-ATI@ec.europa.eu

European Commission

B-1049 Brussels

PDF ISBN978-92-9460-715-7 doi: 10.2826/573690 EA-03-21-300-EN-N

May 2021

Table of Contents

Section

Introduction

The objective of the international country reports is to explore the technology and policy landscape of selected non-European countries. Country performance in advanced technologies is presented based on patent, trade and investment data. This particular report is an update and extension of the China report published in 2020 (available at https://ati.ec.europa.eu/reports/international-reports/report-china-technological-capacities-and-key-policy-measures) and zooms into two technology ecosystems notably into Artificial Intelligence/Big Data and Advanced Manufacturing/Robotics. The reason why these fields have been selected is that they represent technologies where China has been developing particularly fast recently and important lessons can be drawn for the EU. The analysis relies on the data collected within the ATI project complemented with expert opinion.

The starting point of this analysis has been sixteen advanced technologies that are a priority for European industrial policy and that enable process, product and service innovation throughout the economy and hence foster industrial modernisation.

Advanced technologies are defined as recent or future technologies that are expected to substantially alter the business and social environment and include *Advanced Materials, Advanced Manufacturing, Artificial Intelligence, Augmented and Virtual Reality, Big Data, Blockchain, Cloud Technologies, Connectivity, Industrial Biotechnology, the Internet of Things, Micro and Nanoelectronics, Mobility, Nanotechnology, Photonics, Robotics and Security*. The full methodology behind the data calculations is available on the ATI website: https://ati.ec.europa.eu/reports/eu-reports/advanced-technologies-industry-methodological-report.

The report is structured as the following:

- The first section outlines the overall performance of China in terms of technology generation (patent applications), trade and venture capital data.
- The second section dives into the Chinese ecosystem in the field of Artificial Intelligence and Big Data.
- The third section presents the Chinese Advanced Manufacturing and Robotics ecosystem.
- The last section analyses the impact of and economic responses to the COVID-19 pandemic.

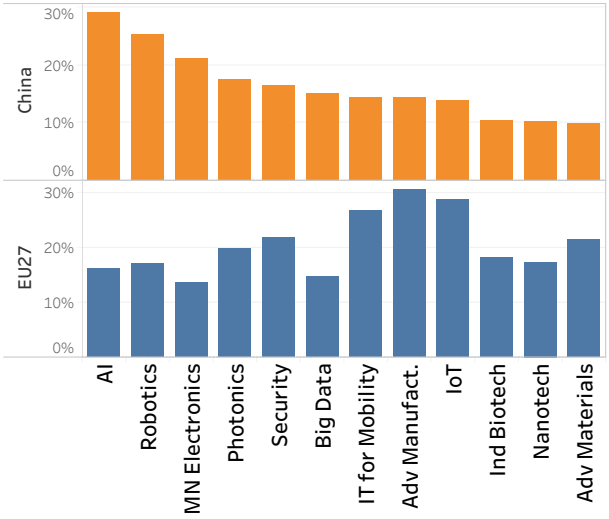
Section 1

1 Overall performance in advanced technologies

1.1 Patent applications

Over the past decade the technological performance of China has improved rapidly. An analysis of China's share in worldwide transnational patent applications helps to assess and benchmark its technological performance. Figure 1 provides an overview of the Chinese share of worldwide transnational patent applications in advanced technologies compared to that of the EU27's Member States in 2018[1].

Figure 1: Share in global transnational patent applications in advanced technologies (2018)

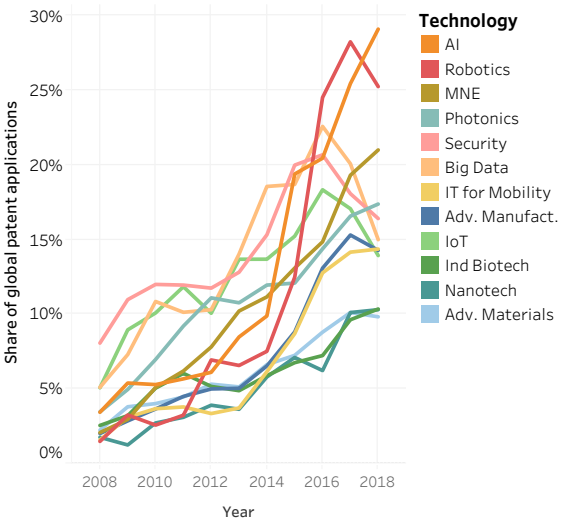


Source: Fraunhofer ISI, based on EPO PATSTAT

As seen in Figure 1, the EU27 continues to hold a higher share of global patent applications than China in many advanced technologies. However, China is not far from catching up with Europe in Photonics, Security and has done so in the advanced technology of Big Data already. Moreover, China's share in global patenting now clearly exceeds that of Europe in Micro- and nanoelectronics (MNE), Robotics, as well as Artificial Intelligence.

Patenting trends over time show the force of Chinese technology and its increasing dominance on the global patent landscape. Over the period from 2008 to 2018 patent applications filed by Chinese applicants increased most in Artificial Intelligence (see Figure 2).

Figure 2: Trends in the share in global transnational patent applications in China (2008-2018)



Source: Fraunhofer ISI, based on EPO PATSTAT

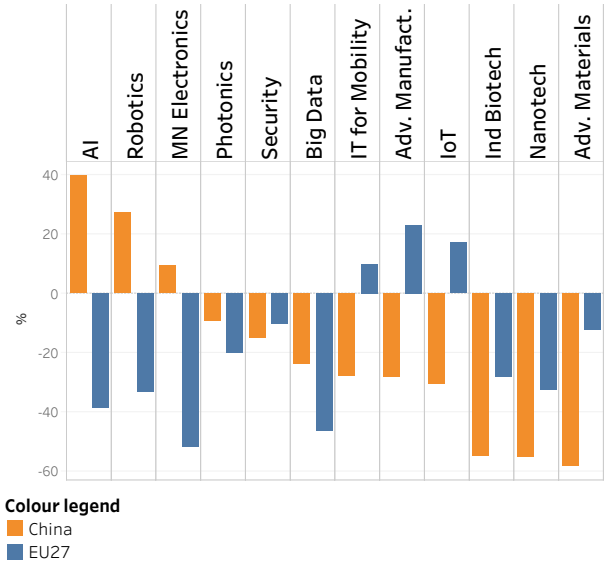
The analysis of China's technological specialisation (RPA-index[2]) as visualised in Figure 3 demonstrates China's relative focus of activity in all twelve advanced technologies, compared to that of the EU27.

The findings of the analysis confirm China's technological focus on information technologies (see also Figure 1) with outstanding specialisation in Robotics and Artificial Intelligence as well as - to a lesser extent - Micro- and nanoelectronics. The EU27, in contrast, displays a negative specialisation in all four of these fields.

[1] The patent analysis reflects the owner (applicant) of the technology, since patents have been localised based on the location of their legal owner.

[2] The RPA-Index illustrates the relative specialisation on a scale from -100 to +100, putting the share of a specific field in national applications in relation to the global average share.

Figure 3: Technological specialisation RPA-index of China and EU27 (2018)

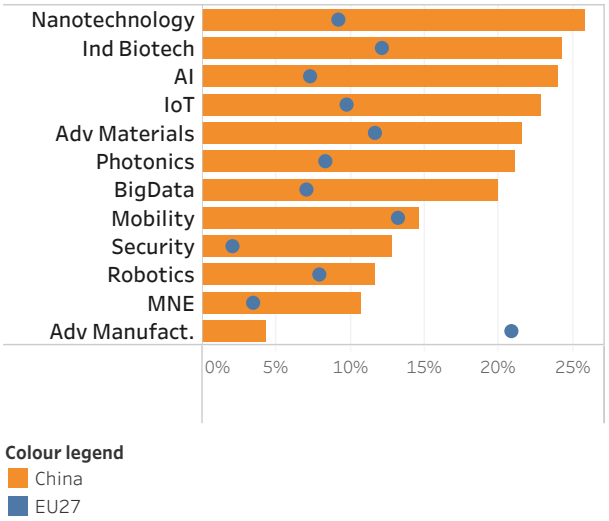


Source: Fraunhofer ISI, based on EPO PATSTAT

1.2 International competitiveness

Trade measures are a common indicator of global competitiveness, as they document the attractiveness of a country's products beyond the home market. Total exports provide evidence about a country's role as a producer, and trade balance captures its sovereignty in certain areas of production.

Figure 4: Export share in world total (2018)

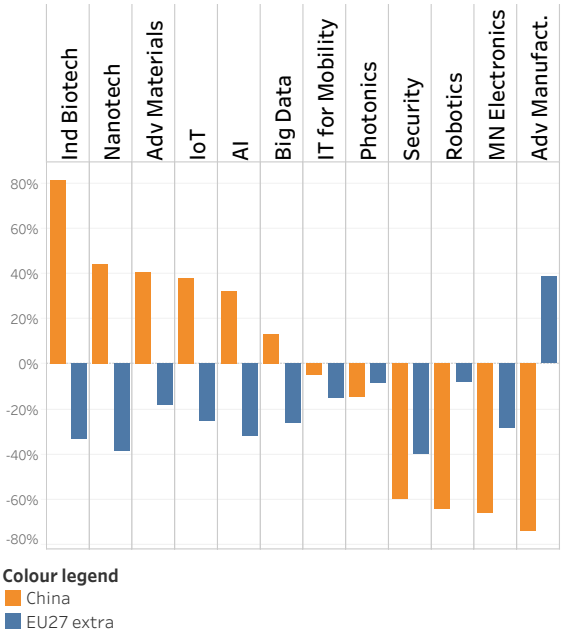


Source : Fraunhofer ISI, based on UN COMTRADE
Note: 'EU27-extra' refers to exports to non-EU countries, i.e. competitiveness-based exports outside the single market The view is filtered on China, the export shares of which range from 4.3 (AMT) to 25.8% (Nanotechnology)

Figure 4 displays the share of global technological exports in 2018. It clearly demonstrates that China exports more goods related to advanced technologies for industry than the European Union in all fields - except for Advanced Manufacturing technologies.

Figure 5 visualises the trade balance[3] in relation to the total trade volume of China and the EU27 countries in 2018.

Figure 5: Trade balance in relation to overall trade volume (exports - imports) (2018)



Source: Fraunhofer ISI, based on UN COMTRADE
Note: 'EU27-extra' refers to exports to non-EU countries, i.e. competitiveness-based exports outside the single market

China displayed a large relative trade surplus in 2018 in goods related to Industrial Biotechnology, Nanotechnology, Advanced Materials and the Internet of Things. The analysis shows, however, a rather notable trade deficit in terms of total trade volume in Micro and nanoelectronics (over 60%), Advanced Manufacturing, Security and Robotics. The European Union had significant relative trade deficits almost in all fields related to advanced technologies - with the exception of Advanced Manufacturing technology.

1.3 Startup and scaleup activity

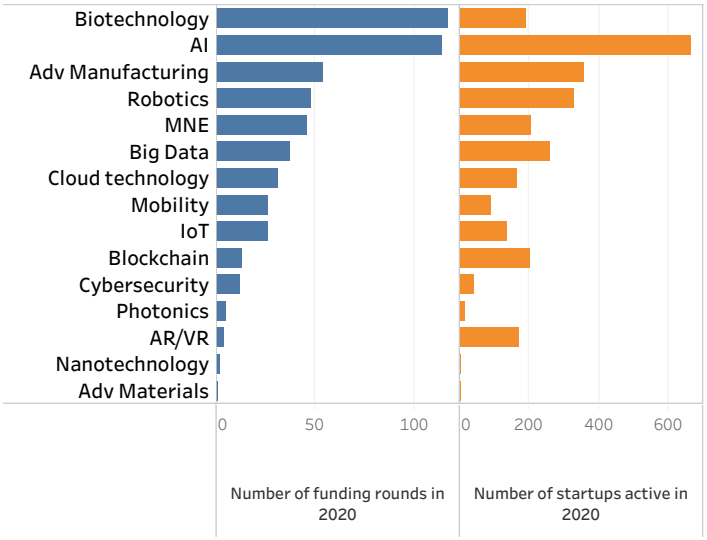
Figure 6 analyses private and venture capital (VC) investments in advanced technologies in China. It illustrates the number of investment deals concluded in 2020 in advanced technologies as well as the number of active startups[4] in 2020 in China based on Crunchbase[5] data.

The analysis suggests that the number of funding rounds was the highest in Biotechnology followed by Artificial Intelligence and Advanced

[3] Exports - Imports
[4] Startups have been defined as companies founded after 2015.
[5] Private equity, venture capital investment and related innovative start-up creation have been explored based on a merged dataset available in Crunchbase and Dealroom. Crunchbase provides information on venture capital backed innovative companies.

Manufacturing in China in 2020. Startups have been most active in the area of AI and Advanced Manufacturing, although 2020 has not seen many newly founded startups except for AI (as captured by the LinkedIn database). The data suggest that investors focused on ventures already well established and had a relatively high average investment amount per company.

Figure 6: The number of funding rounds in advanced technologies and startups, China (2020)



Source: Technopolis Group based on Crunchbase

Section 2

2 Analysis of selected technology ecosystems: Artificial Intelligence and Big Data

2.1 Major players

Table 1: Major government stakeholders in China's AI and Big Data development

Scope	Name and resulting organisations/initiatives, if applicable
Ministries	Ministry of Science and Technology (MOST) - New Generation AI Strategy Advisory Committee - National New Generation AI Governance Expert Committee
	National Development and Reform Commission (NDRC)
	Ministry of Industry and Information Technology (MIIT) - China Academy of Information and Communications Technology (CAICT)
Other institutional players	Shenzhen Research Institute of Big Data (SRIBD)
Authorities for regulation and Intellectual Property Rights	Chinese National Intellectual Property Administration (CNIPA)
	Standardisation Administration of China (SAC) - National Artificial Intelligence Standardisation General Working Group - National Artificial Intelligence Standardisation Expert Advisory Group
	China Electronics Standardisation Institute (CESI)

Source: authors.

Ministries

In China, various state organisations as well as institutions are engaged in the development of strategies and initiatives in the field of Artificial Intelligence (AI) and Big Data. Alongside the highest executive body of the Chinese state administration, the State Council, headed by Premier Li Keqiang, subordinate ministries are also actively involved. The MOST, the NDRC and the MIIT in particular appear to play leading roles for AI and Big Data. For example, the State Council, which is responsible for implementing the principles and policies of the Communist Party of China as well as the regulations and laws passed by the National People's Congress launched the mega-project called 'New Generation of AI Development Plan' as well as the 'Outline for Actions to Promote Big Data Development'.[6]

The Ministry of Science and Technology (**MOST**) was originally established in 1959 as the National Science Council but was reorganised and renamed in 2014. The ministry, which is directly subordinate to the State Council, frames guidelines and policies in addition to setting out the vision and strategies for China's national economic and technological development. The three main tasks of the ministry are to promote nationwide science and technology development, support scientific research, and develop science parks.[7] The MOST has approved eleven pilot zones for innovative AI development, e.g. Beijing, Shanghai and Shenzhen, to develop local versions of the governance principles and regulations for AI.[8] At least two committees closely related to AI have been established within the MOST.

The *New Generation AI Strategy Advisory Committee* was founded in 2017 and aims at providing input to the Chinese government on AI-related science and technology development plans as well as relevant projects.[9] Another committee related to AI, the *National New Generation AI Governance Expert Committee*, was established by the MOST in 2019, and announced eight principles for the governance of AI in 2020 to 'develop responsible AI'. These principles emphasise that AI developments should be driven by the goal of improving the general well-being of humanity. Accordingly, human rights, privacy and fairness are emphasised as well as the relevance of transparency, collaboration and agility in dealing with new risks.[10] [11]

Originally established in 1952 as the State Planning Commission, the agency was reorganised and has been operating as the National

[6] People's Daily Online 2006.
[7] MOST 2020.
[8] Jia 2020.
[9] Murphy 2020a.
[10] Roberts et al. 2020.
[11] chinainnovationfunding.eu 2020.

Development and Reform Commission (**NDRC**) since 2003.[12] The NDRC is directly subordinate to the State Council and is responsible for the formulation and implementation of strategies as well as annual and development plans for national economic and social development. It submits these development plans to the National People's Congress on behalf of the State Council.[13] In the field of Big Data and AI, the NDRC published a list of selected projects in 2017, the 'List of 2018 Internet+, AI and Digital Economy Experiments Major Projects Recipients'. It features projects in the field of natural language processing and health data exchange, for example. A study estimates the role of the companies awarded by the NDRC to be substantial for both Big Data and AI in China.[14] Additionally, the NDRC leads the development of China's national Five-Year Plans.[15][16]

Another influential player for Big Data and AI in China is the Ministry of Industry and Information Technology (**MIIT**). Established in 2008 as a department under the State Council, it is responsible for managing the industrial sectors and information technology industry in China and is considered 'the nation's top industry regulator'.[17] The State Council lists the following matters among the main tasks of MIIT: determining China's industrial planning, policies and standards; supervising the daily operation of industries; promoting the development of large-scale technological equipment and innovations in communications; leading the construction of information systems; and ensuring China's information security.[18] Given its responsibilities, the MIIT has initiated various plans and strategies in the field of AI and Big Data, including the 'Big Data Industry Development Plan' and the 'Three-Year Action Plan for Promoting Development of a New Generation AI Industry'.

Founded in 1957, the - China Academy of Information and Communications Technology (*CAICT)* is a subordinate institute to the MIIT[19], and plays an important role in telecommunications and the internet. It acts as a 'specialised think-tank for the government' as well as an 'innovation and development platform for the industry'.[20] Emerging technology issues on the agenda include AI, Big Data, 4G/5G, Cloud Computing, etc. The CAICT supports the development of policies, including industry plans (such as the Big Data Industry Development Plan), develops standards and certification, and conducts a variety of technology and industry studies.[21] A variety of innovation centres are part of the CAICT, including the New Generation AI Institute in Nanjing, the 5G and AI Research Centre in Hangzhou and the Central Big Data Research Innovation Centre in Zhengzhou.[22] The 'Cloud Computing and Big Data Research Institute', which was established in 2017, is one of the core business departments of the CAICT. It deals with the emerging technologies, business models and industries of the internet. The institute conducts research in the areas of Big Data and AI, builds various platforms, and tests and evaluates various products and services. In addition, scientific projects are carried out on a national level as well as with industry partners.[23]

Other institutional players

Although there are certainly other institutions relevant to AI and Big Data developments in China, the SRIBD stands out in particular.

In 2016, the government of Shenzhen established the Shenzhen Research Institute of Big Data (**SRIBD**). The institute is designed to lead and coordinate the research and development of Big Data innovations and focuses on basic theories, novel computing systems of the future, and intelligent application technologies in the field of Big Data. Its vision is to become a globally recognised research institute in the field of Big Data with its own Intellectual Property rights and outstanding core technologies.[24]

Authorities for regulation and IPR

With a view to intellectual property rights (IPR) and standards in China's AI and Big Data agenda, key responsibilities rest with the CNIPA and, regarding standards, the SAC and the CESI.

The Chinese National Intellectual Property Administration (**CNIPA**)**,** which is responsible for the organisation and coordination of the protection of IPR in China[25], amended the guidelines for patent examination. They now include examination rules for claims characterised by algorithmic features, with a particular focus on emerging technologies, including Big Data and AI, for which new standards are defined. The revised rules have been in force since February 2020. For AI, only inventions created with the help of AI can currently be patented, while inventions developed independently of AI are not permitted, as

[12] United Nations Economic and Social Commission for Asia and the Pacific 2012.
[13] National Development and Reform Commission 2008a.
[14] Grossman et al. 2020.
[15] China's Five-Year Plans are the most important guiding documents for the economic and social policy direction of China, and have been developed since 1953.
[16] Haacke 2014.
[17] Si 2019.
[18] State Council 2014.
[19] The MIIT operates at the same level as the MOST and is subordinate to the State Council in China.
[20] CAICT 2020.
[21] Jiang 2018.
[22] CAICT 2020.
[23] CAICT 2020.
[24] Shenzhen Research Institute of Big Data 2020.
[25] US-China Business Council 2018.

standards for their examination have yet to be established.[26] [27]

The General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ), a ministerial administrative body directly under the State Council, is responsible for the standards system in China. In turn, the AQSIQ heads the Certification and Accreditation Administration of China (CNCA) as well as the Standardisation Administration of China (**SAC**).[28] The latter represents China in various standardisation organisations at national and international level, including the International Organisation for Standardisation (ISO) and the International Electrotechnical Commission (IEC).[29]

Another important responsibility for standardisation in AI and Big Data lies with the China Electronics Standardisation Institute (**CESI**), a think-tank subordinate to the MIIT, which is specifically responsible for the standardisation of the IT and electronics industry in China. CESI manages a number of China's counterparts to IEC and ISO Technical Committees and Subcommittees. The National Information Technology Standardisation Technological Committee (SAC/TC 28) is responsible for developing AI-standards in China. It is considered the counterpart to the ISO/IEC Joint Technological Committee One. SAC/TC 28 also includes a working group on Big Data standards.[30] In April 2020, the SAC announced the establishment of an AI sub-technical committee (SAC/TC 28/SC 42), mainly reponsible for the development and revision of national standards in AI.[31] [32]

In addition to the technical committees, China has established organisational mechanisms aimed at the overall coordination of measures for AI-standardisation. For this purpose, the SAC approved two groups in 2018: The National AI Standardisation General Working Group, which is responsible for the coordination, planning and layout of a variety of AI standardisation work in China. Its office is located at CESI. Additionally, the National AI Standardisation Expert Advisory Group was established, which is an expert group of AI-experts and scientists, responsible for advice related to AI standards. The expert group leads the work of the National AI Standardisation General Working Group.[33]

Major business actors

China is home to a number of globally leading AI and Big Data companies. Next to the 'big four', Baidu, Alibaba, Tencent (collectively referred to as 'BAT'[34] [35]) and Alibaba, some interesting start-ups show a strong track record. Table 2 shows the major companies in China's AI and Big Data landscape.

Table 2: Selected list of major Chinese business actors in AI and Big Data

Company Name	Company Information
Tencent Holdings Ltd.[36]	– Established in 1998 – Headquarters: Shenzhen, Guangdong province – Leadership in speech and image recognition due to Big Data developed in its social network; expansions also into medical Research & Development (R&D) through image recognition and analysis – Focus: digital communication and social platforms, advertising, financial technologies and business services
iFlyTek Co., Ltd.[37]	– Established in 1999 – Partially state-owned – Headquarters: Hefei, Anhui province – Focus: intelligent speech and AI; including research in speech and languages, natural language understanding, machine learning, machine reasoning, adaptive learning
Baidu Co., Ltd.[38]	– Established in 2000 – Headquarters: Beijing, Hebei province – Analogous to Google – New Big Data and AI developments: 'Baidu Cloud' produces, analyses and tags data; the algorithm platform 'Baidu Brain' is open to internal use as well as third parties – Focus: platforms connect users to information and services via various channels; online marketing
Alibaba Group Holding Ltd.[39]	– Established in 2007 – Headquarters: Hangzhou, Zhejiang province

[26] Wei 2020.
[27] Quan 2020.
[28] China Electronics Standardization Institute 2020a.
[29] International Organization for Standardization 2020.
[30] China Electronics Standardization Institute 2020a.
[31] China Electronics Standardization Institute 2020b.
[32] China Electronics Standardization Institute 2020a.
[33] China Electronics Standardization Institute 2020a.
[34] Jing and Dai 2017.
[35] Jia et al. 2018.
[36] Tencent 2020.
[37] iFlyTek 2020.
[38] Baidu 2020.
[39] Alibaba Group 2020.

Company Name	Company Information
	– AI strategy based on research of the Institute of Data Science and Technologies (iDST): 'ET Brain' platform available to companies to apply AI practically; AI labs; AI in order to improve Alibaba's e-commerce and payment service – Focus: e-commerce, cloud computing, digital media and entertainment, innovation initiatives, payment services and financial services
Startups	
Megvii Technology Ltd.[40]	– Established in 2011 – Headquarters: Beijing – Large research focus; operator of the world's biggest computer vision research institute – Focus: core competence deep learning with a focus on the integration of AI and IoT for people, cities and supply chains
SenseTime Group Ltd.[41] [42]	– Established in 2014 – Headquarters: Hong Kong – World's most valuable AI startup – Various technological breakthroughs, including the development of the first AI system to achieve better detection accuracy than the human eye – Focus: development of AI technologies, provider of AI algorithms
iCarbonX Co., Ltd.[43]	– Established in 2015 – Headquarters: Shenzhen, Guangdong province – Tencent led iCarbonX series A financing – Platform that combines biological measures with experiential data from people worldwide and mines it for signals of disease, health, ageing based on advanced AI – Focus: AI-based healthcare platform
CloudWalk Technology Co., Ltd.[44] [45]	– Established in 2015 – Headquarters: Guangzhou, Guangdong province – Listed on the US Entity List due to US claims of complicity in human rights violations and abuses, restricting its access to US technology. – Focus: Integration of multidimensional recognition (visuality, language, environment), to create an intelligent decision-making system and realise the closed loop of AI technology.

Source: authors.

2.2 Underlying conditions

Looking at the general conditions for the development of AI and Big Data in China, three aspects stand out as being of special relevance: the availability of data, protection and regulation, and regional development areas.

Availability of data

Over time, a digital ecosystem for Chinese tech companies has developed in a partially protected market with a large number of internet users. China has the largest number of internet users worldwide. In June 2020, over 939 million citizens were connected to the internet, while more than 932 million used mobile internet. As the number of internet users increases, those connected make extensive use of digital technologies and mobile access, using the internet for a variety of reasons e.g. for payment, travel or communication. Consequently, China has huge amounts of constantly generated data. Access to this available data is considered one of the enablers for China's future leadership in AI.

Protection and regulation

For a long time, China did not have any law ensuring basic data processing principles. The Chinese data protection system was mainly criticised for a lack of definitions, the non-existence of the concept of individual consent, the absence of references to the rights of information, access and rectification, and the lack of a supervisory authority.[46]

The 'Cyber Security Law' has been in force since July 2017 to protect critical infrastructures and data from unauthorised access. It sets out rules for the protection of IT infrastructures and systems, data management for public services as well as compliance by economic and social actors. Due to the barriers caused by strict cyber and data

[40] Megvii 2020.
[41] SenseTime 2020.
[42] Marr 2019.
[43] iCarbonX 2020.
[44] CloudWalk 2020.
[45] U.S. Department of Commerce 2020.
[46] Hert and Papakonstantinou 2015.

security regulations, foreign companies' access to China's digital and telecommunication markets remains limited.[47] Another step towards the protection of personal information by law was unveiled in October 2020, with the draft of a 'Personal Information Protection Law' (PIPL). [48] The PIPL is considered to have similarities to the European Union's data protection law (General Data Protection Regulation).[49]

A nationwide 'Social Credit System' (SoCs) is expected to become mandatory, which will monitor companies, organisations and individuals through a big-data-based control mechanism and thus enforce compliant and conformist behaviour. The SoCs has been in planning since 2014, it was piloted in many programmes and its main framework and mechanisms were established in 2020. It is seen as a powerful instrument of control over companies and people with the help of digital technologies.[50] [51]

Pilot zones for innovative development

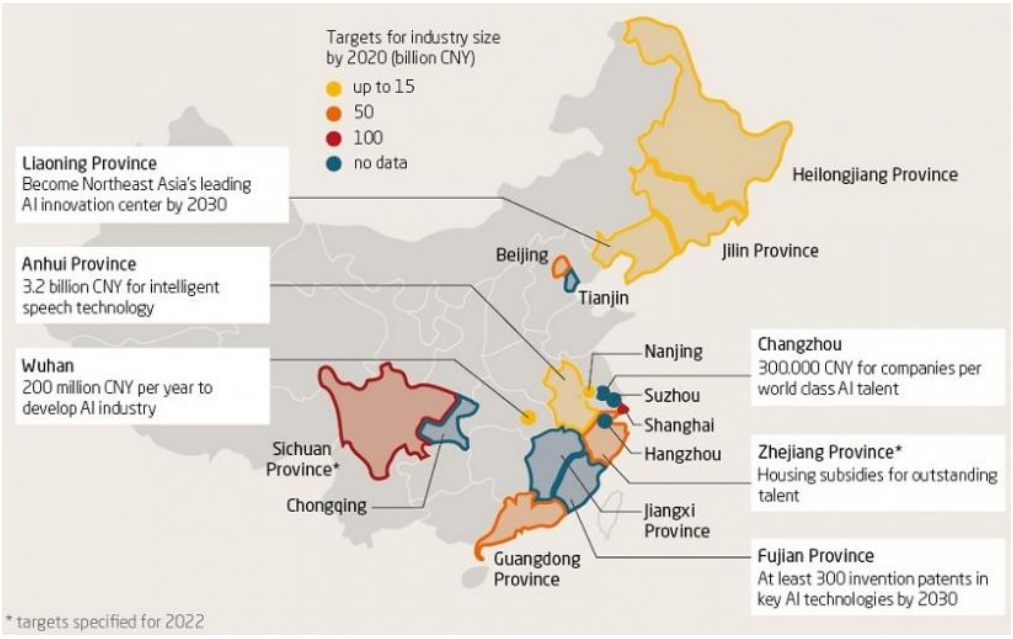
Guiyang City (in Guizhou province) has proactively promoted the integration of AI in its economy since 2014. In 2017, the city set itself a series of goals to be achieved by 2020 in order to become China's 'Big Data Valley': reach the capacity to store one exabyte of data, attract more than 10 000 Big Data companies and over 100 000 Big Data experts, and generate over ¥100 bn (€12.81 bn[52]) through Big Data companies. The first funding round was projected to reach ¥10bn (€1.28 bn[53]). To promote these ambitious plans, 28 scientific research organisations and 23 incubators as well as investment agencies have been set up in the field of Big Data in the Guizhou province.[54] [55] Since then, Guiyang has undergone rapid development and is respected worldwide, which has attracted several offices of internationally leading companies such as Alibaba, Tencent, Apple and Intel to the city.[56]

To drive the development of AI in China, in addition to national level efforts, China's government is also reaching out to individual provinces, cities and municipalities in order to promote the AI industry at the local level.[57] As of March 2020, a total of eleven 'AI Pilot Zones' had been publicly announced and established by the MOST in Beijing, Shanghai, Hangzhou, Hefei, Shenzhen, Tianjin, Deqing County, Chengdu, Chongqing, Jinan and Xi'an.[58] As part of this effort, the provinces and municipalities have developed AI plans, which set their individual, local targets. Beijing, Shanghai and Shenzhen, in particular, stand out as tech hubs and are home to some of China's largest digital pioneers (e.g. Baidu and Tencent). By 2020, Shanghai's plan aims to generate a core AI industry of ¥100 bn (€12.81 bn[59]). To achieve this, AI industrial zones and agreements between leading AI companies have been established in several parts of the city. In Beijing, the AI hub Zhongguancun stands out and, in response to Shanghai's developments, a new AI industry park was announced in 2018. In addition to these prominent AI locations, Hefei is also a solid hub for AI development, with the AI base 'China Speech Valley' providing a strong centre for speech recognition technologies in China. Beyond that, China's more reserved provinces, such as Liaoning, also have ambitious AI plans to join the regional AI developments.[60]

China also places a special focus on attracting AI talent and companies. For example, an article by the Mercator Institute for China Studies (MERICS) 61 mentions rewards offered to research institutions and companies for AI professionals settling in specific regions, or initiatives for recruiting AI professionals from abroad. A map prepared by MERICS illustrates the provincial and municipal plans for AI development in China (see Figure 7).

[47] Shi-Kupfer and Ohlberg 2019.
[48] Holzmann and Meinhardt 2020.
[49] Zhang and Chen.
[50] Shi-Kupfer and Ohlberg 2019.
[51] Sutherland 2020.
[52] The amount in euro was calculated based on the ECB's official euro foreign exchange reference rates for 2017.
[53] The amount in euro was calculated based on the ECB's official euro foreign exchange reference rates for 2017.
[54] China Daily 2017.
[55] Guiyang Government 2020.
[56] Shenggao 2019.
[57] Ives and Holzmann 2018.
[58] Center for Security and Emerging Technology 2020.
[59] The amount in euro was calculated based on the ECB's official euro foreign exchange reference rates for 2020.
[60] Ives and Holzmann 2018.
[61] Ives and Holzmann 2018.

Figure 7: Provincial and municipal plans for AI development in China



Source: Ives and Holzmann, 2018.

2.3 Policies, strategies and initiatives

In line with its general industrial policy, China is pursuing a top-down approach to promote the development of AI and Big Data in the country by investing lots of capital in the relevant areas, devoting a lot of human resources to them and setting other incentives.[62] A variety of city-level funds for AI and Big Data were identified.

Shanghai AI Investment Fund

In 2019, Shanghai launched its AI Investment Fund to support the city's transformation into an innovative AI ecosystem by 2021. This city-level fund is managed by a group of government-led firms as well as private equity enterprises, has initial funds of ¥10 bn (€1.28 bn[63]) and plans to increase this to ¥100 bn (€12.79 bn[63]). Four AI institutes were introduced at the ceremony, including the Shanghai AI Smart Algorithm Institute. A guide to Shanghai's AI development revealed plans to start 10 AI-labs between scientific institutions and firms, establish 15 Big Data labs and turn Shanghai into an AI chip hotspot. Shanghai also aims to double its AI talent pool within three years to 200 000 workers. In addition to loans guaranteed by major banks to support capital, the municipality subsidises important AI application solutions. [64]

Governance Principles for the New Generation AI - developing responsible AI

The MIIT published 'Governance Principles for the New Generation AI' in 2019, which were formulated by the National Governance Committee for the New Generation AI. This was triggered by global AI developments that have a profound impact on daily life, possess new capabilities and will bring about major changes in the future. The document lists eight principles, which are addressed to all actors involved in AI development:[65]

1. Harmony and human-friendly
2. Fairness and justice
3. Inclusion and sharing
4. Respect for privacy
5. Safety and controllability
6. Shared responsibility
7. Open and collaboration
8. Agile governance

Action Plan to Promote Big Data Development (2015)

To launch the 'startup-phase' for the national Big Data strategy development in China, the State Council issued an 'Outline for Actions to Promote Big Data Development' in 2015.[66] The call aimed to foster the development and adoption of Big Data, both for economic restructuring and to advance governance. This was triggered by the recognition of China's rich data resources, which

[62] Ives and Holzmann 2018.
[63] The amount in euro was calculated based on the ECB's official euro foreign exchange reference rates for 2019.
[64] Wei 2019.
[65] China Daily 2019.
[66] China Academy of Information and Communications Technology 2019.

harbour potential benefits for competitive advantage, economic growth and governance. However, Big Data developments remained hesitant due to a weak industrial foundation, the lack of openness and the absence of a long-term strategy. In this outline, the State Council also announced the development of a new model of social governance and the formulation of regulations to ensure social access to public data via an open platform. Moreover, the government is pushing for the integration of Big Data into new generation information technologies (e.g. Cloud Computing).[67]

Guidance on Developing Industrial Big Data

In 2019, the MIIT released a 'Guidance on Developing Industrial Big Data' as a draft to solicit opinions. This focuses on four areas of data: resources, analysis, industry and governance, and aims to establish high-quality manufacturing and a data-driven manufacturing sector in China by strengthening the link between manufacturing and the internet, AI, Big Data and the industrial internet. It conveys two highly significant messages: first, industrial Big Data is considered a factor of production and thus an economic resource, reinforcing developments to determine data ownership, market transaction mechanisms as well as valuations of data assets. Second, legislation on data governance is anticipated, underpinning improvements in legal issues around security, ownership and sharing of data. The timeline extends until 2025.[68]

2.3.1 Major projects

In addition to the initiatives, small projects and funds presented above, several large-scale projects exist in China that contribute significantly to the development of AI and Big Data. Table 3 lists these projects.

MIC 2025

MIC 2025 is a strategic masterplan of the Chinese government with the main goal of upgrading Chinese industry in a relatively short period of time and developing it into a global high-tech superpower. The plan therefore targets key high-tech industries and technologies that make a significant contribution to economic growth but at present are largely dominated by foreign companies in China. AI and Big Data play a significant role among these technologies. AI is defined as one of the core technologies being pushed by the government and there is also a strong focus on Big Data, with many industrial parks being established in China.[69]

Table 3: Major projects for China's AI and Big Data development

Project	Year
Made in China 2025 (MIC 2025)	2015-ongoing
Internet Plus	2015-ongoing
Three-Year Guidance for Internet Plus AI Development	2016-2018
Big Data Industry Development Plan	2016-2020
Three-Year Action Plan for Promoting Development of a New Generation AI Industry	2018-2020
New Generation of AI Development Plan	2020-ongoing

Source: authors.

Internet Plus

Proposed in 2015, the grand action plan 'Internet Plus' aims at the comprehensive digitalisation of the economy and society beyond the conventional internet, which is to be integrated into various areas such as e-commerce, education and manufacturing. Big Data is one of the relevant technologies promoted by Internet Plus. As part of this bottom-up initiative, internet companies are closely integrated in the development of implementation guidelines. On the government side, the NDRC is responsible for the plan.[70] [71]

Both MIC 2025 and Internet Plus were launched in 2015 with the purpose of driving industrial and digital innovation within China.[72]

Three-Year Guidance for Internet Plus AI Development

In 2016, the Chinese government published the 'Three-Year Guidance for the Development of the Internet Plus AI'. According to this plan, China aims to develop new AI industries, for example in core technology research. In addition, the statement emphasises that projects relevant to AI innovations (e.g. smart vehicles or houses) will be promoted, and the development and application of smart wearable devices as well as robots will be pushed.[73] Led by the MIIT, the plan focuses on four aspects [74]:

- AI-hardware skills
- Powerful platform-ecosystems
- AI-applications in major socio-economic fields
- Societal impact of AI

[67] State Council 2015b.
[68] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH 2020.
[69] Zenglein and Holzmann 2019.
[70] Wübbeke et al. 2016, p. 20.
[71] China Daily 2015.
[72] Shi-Kupfer and Ohlberg 2019.
[73] State Council 2016.
[74] OECD 2020b.

Big Data Industry Development Plan

The Big Data Industry Development Plan was officially issued by the MIIT at the end of 2016, marking an important phase of China's national Big Data strategy.[75] [76] It was introduced as part of the 13th Five-Year Plan with the overall goal of developing Big Data into a key strategic resource in China. China's draft of the 13th Five-Year Plan describes this plan for the development of Big Data, which is intended to speed up the openness, sharing, development and application of data resources. Big Data will thus support the transformation and improvement of industries and innovate social governance.[77] This comprehensive Big Data strategy is considered a major step towards the development of a Big Data industry in China.[78]

Three-Year Action Plan for Promoting the Development of a New Generation AI Industry

In 2017, the MIIT issued an action plan focused on integrating AI into manufacturing. This plan supports the implementation of MIC 2025 and the Next Generation AI Development Plan. Four initiatives are identified for 2020[79] [80]:

- Ensure developments and the integration of key intelligent AI-products in the economy and society, e.g. intelligent robots, smart unmanned vehicles or video image recognition systems.
- Ensure a sound hardware and software base for AI development, such as intelligent sensors, neural network semiconductors and open platforms.
- Ensure, enhance and promote the development of smart manufacturing and the integration of AI in the industrial sector.
- Ensure the development of a public AI support system for, e.g. training resources, cybersecurity and network infrastructure.

New Generation of AI Development Plan

In 2017, the State Council issued the 'New Generation of AI Development Plan' with a total budget of ¥870 m (€111.48 m[81]). It is part of sixteen '2030 Innovation Mega Projects' listed by the State Council, which are intended to address important bottlenecks in technology.[82] [83] The plan defines 16 research tasks including, e.g. new generation neural network models or game decision under incomplete information conditions.[84] It is set to seize the great strategic opportunities of AI developments, further expand China's AI advantage as a first mover, and accelerate the establishment of China as an innovative and globally advanced country in science and technology.[85]

Four strategic goals are presented, aimed at making China a global AI leader by 2030[86]:

- China evolves as a centre for basic AI research and the development of AI theories.
- China leads applied research and development of innovative AI products and services.
- China creates a domestic AI industry and leads global AI markets.
- China utilises AI to improve the efficiency of traditional sectors and to move up the global value chain.

2.4 Lessons for Europe

Compared to the European Union (EU), the analysis of China's AI and Big Data landscape reveals a number of points of lessons the EU can learn from.

Number one is that Europe needs to ascertain a broad availability of data to train and further develop AI applications. Due to China's large population and the near absence of any privacy related regulation, China is in a unique position to collect, process and analyse unprecedented amounts of data. Compared to the EU it has thus more options to train AI models and accelerate the development of its application to numerous contexts, from everyday life to strategic considerations. While it cannot be the ambition of Europe to remodel the regulatory environment of China, the question remains how sufficient access to suitable data sources and respositories could be ascertained.

The EU should seek to actively promote and enable the diffusion of AI and Big Data. Today, China demonstrates a much wider commercialisation of AI and Big Data applications. Due to numerous government initiatives, a large AI and Big Data ecosystem has developed in China, between private companies, government institutions and other relevant actors. As a result, the adoption, diffusion and commercialisation of AI into all areas of daily life as well as the industrial economy has progressed further in China. To match these developments European companies

[75] China Academy of Information and Communications Technology 2019.
[76] China Academy of Information and Communications Technology 2019.
[77] Central Compilation & Translation Press 2016.
[78] China Academy of Information and Communications Technology 2019.
[79] Triolo et al. 2018.
[80] United States Information Technology Office.
[81] The amount in euro was calculated based on the ECB's official euro foreign exchange reference rates for 2017.
[82] Colvin et al. 2020.
[83] DEVELOPMENT Solutions Europe Ltd. 2018.
[84] Colvin et al. 2020.
[85] Ministry of Science and Technology 2017.
[86] Carter and Crumpler 2019.

have to increase their readiness for the integration of these technologies.

The EU should seek to improve citizens and businesses openness for AI and Big Data. Another reason for the commercialisation in China is the **prevalent positive image** of AI and Big Data. Compared to China, where digital technologies are often associated with progress, technological advances and national strength, Europeans tend to be more sceptical. AI in particular is often associated with job risk, lack of privacy and fear in European countries. This mistrust hinders a greater diffusion and unbiased attitude towards such promising technologies.

Transnational clusters could strengthen European development in AI and Big Data. China shows excellent initiatives in promoting startups, technologies and ideas related to AI and Big Data. As a result, a number of clusters and regions have emerged that are specifically driving these developments and have succeeded in developing as hotspots for AI and Big Data. Due to the sheer size of China's market, such initially local initiatives can scale easily and feed into what has become a diverse national AI and Big Data landscape. The Chinese government provides targeted funding and other incentives to AI and Big Data companies, to enable them on their growth trajectory. To develop similar momentum, Europe will have to join forces in both the funding of initiatives and subsequent market development.

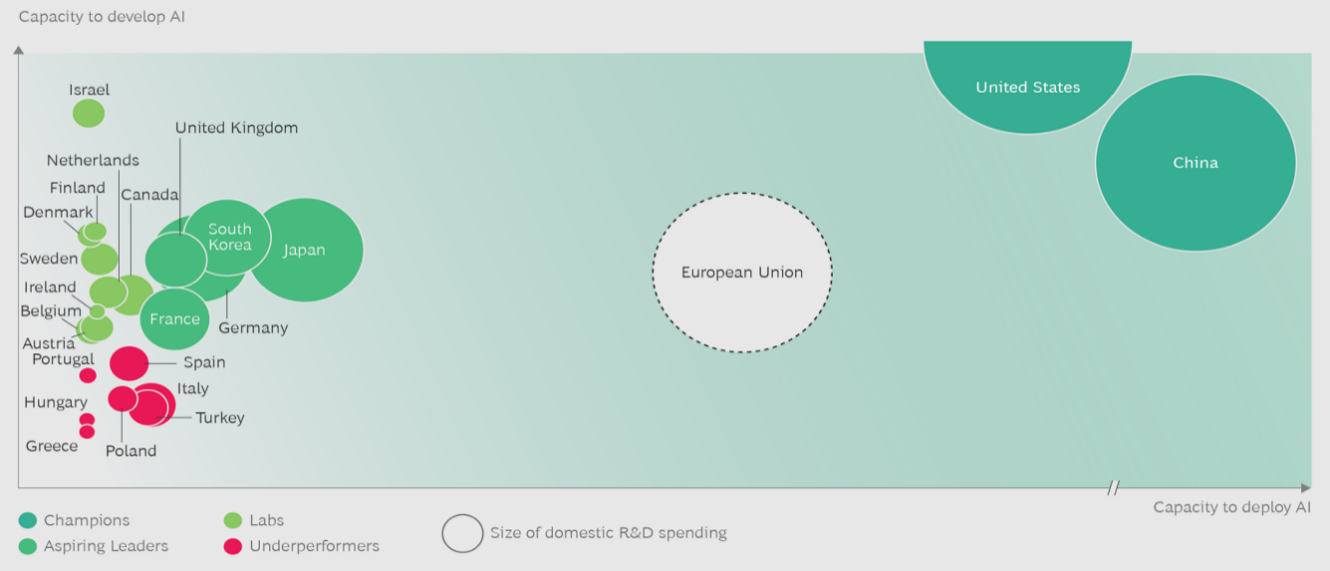
A study by the Boston Consulting Group estimates the AI competitiveness of countries based on their capacity to develop AI (in terms of available talent and funding), and capacity to deploy AI (in terms of commercialisation and implementation). According to the study, China is considered an AI champion alongside the United States while the EU is lagging behind. Reasons for China's strong role include the extensive use and commercialisation of AI, the availability of data and readiness of its companies.[87]

While the EU will - in different areas - hardly want to imitate Chinese policies directly, the below overview shows that falling further behind is one of the real threats of technological development. Given the substantial head-start of both the United States and China in various areas, Europe may face a double challenge. First, it must leverage its remaining strengths in e.g. AI related to industrial applications and seek to connect and integrate those with the existing dynamism in the United States and China.

Secondly, it must carefully consider which of the abovementioned success factors could be replicated in a specific European way, e.g. how large datasets can be collected and rendered accessible without compromising existing data protection regulations - that will most likely not fundamentally change in the foreseeable future.

Figure 8 visualises China's position in the AI-competitiveness map. In addition to the categorised countries (champions, emerging leaders, labs and underperformers), the current AI competitiveness of the European Union is visualised by the white circle with dotted lines. The volume of the dots refers to the level of domestic R&D spending.

Figure 8: AI-competitiveness map



Source: Candelon et al. 2020a, p. 3.

[87] Candelon et al. 2020a.

Section 3

3 Advanced Manufacturing and Robotics

3.1 Major players

Table 4: Major government stakeholders in China's Advanced Manufacturing and Robotics development

Scope	Name and resulting organisations/initiatives, if applicable
Ministries	Ministry of Industry and Information Technology (MIIT) - National Manufacturing Strategy Advisory Committee (NMSAC)
	National Development and Reform Commission (NDRC)
Other institutional players	Institute of Advanced Manufacturing Technology (IAMT)
	Shenyang Institute of Automation, Chinese Academy of Sciences (SIACAS)
Authorities for regulation and IPR	Standardisation Administration of China (SAC)
	China Electronics Standardisation Institute (CESI)
	China Robot Industry Alliance (CRIA)

Source: authors.

Ministries / central government bodies

The analysis of Advanced Manufacturing and Robotics reveals that similar political bodies play an essential role in their development in China. Among other related projects, the State Council initiated MIC 2025 in 2015 and therefore placed a clear focus on the national promotion of manufacturing.[88] Regarding the ministries, the MIIT and NDRC seem to be the dominant players for Advanced Manufacturing and Robotics in China. Although other ministries (such as the MOST) certainly play an important role as well, insufficient availability of information hindered the analysis of corresponding programmes or initiatives.

The Ministry of Industry and Information Technology (**MIIT**) is perhaps the most influential player in the field of Advanced Manufacturing and Robotics in China. It has established various related committees and associations and strongly influences current developments at both national and provincial level. It has launched a variety of projects on Advanced Manufacturing and Robotics, such as the 'Smart Manufacturing Plan' or the 'Robotics Industry Development Plan'. In addition, the MIIT is responsible for establishing many related innovation centres and guidelines in China. Even though the State Council is responsible for the coordination of MIC 2025, the MIIT is in direct charge of this big national strategic plan.[89]

The National Manufacturing Strategy Advisory Committee (**NMSAC**) was founded in August 2015 under the administration of the MIIT. It acts as a think-tank and is responsible for studies, assessments and proposals on the future prospects of the manufacturing industry as well as identifying key issues and measures related to the strategy. The NMSAC also assists in setting up additional think-tanks (including private and corporate think-tanks) to provide knowledge-based support for the process of China becoming a manufacturing power.[90]

As outlined above, the National Development and Reform Commission (**NDRC**) is an important policy actor directly subordinated to the State Council, which provides centralised guidance to most ministries whose remit falls into or is closely related to the economic domain. In this capacity, it supported the MIIT in developing the Robotics Industry Development Plan and, earlier on, the Ministry of Science and Technology (**MOST**) in developing the Made in China 2025 inititiave. More generally, it plays a central role in developing the economic section of the Five-Year Plan - in which Advanced Manufacturing plays an increasingly central role. Furthermore, it triggers more concrete actions, e.g. addressing advanced manufacturing at regional level by releasing a blueprint for the reform and development of the 'Pearl River Delta' in 2008.[91] Today, the Pearl River Delta plays a significant role in China's Advanced Manufacturing landscape, which will be discussed later.

Other institutional players

In addition to the ministries presented, other institutions play an important role in the development of Advanced Manufacturing and

[88] State Council 2015a.
[89] Frietsch 2020.
[90] Ning 2018.
[91] National Development and Reform Commission 2008b.

Robotics in China. In this context, the IAMT and the SIACAS stand out in particular.

Based in Jiangsu Province, Institute of Advanced Manufacturing Technology (**IAMT**) is a sub-unit of the Hefei Institute of Physical Science, Chinese Academy of Sciences (CASHIPS), conducting research on Robotics and smart devices. Established in January 2007, the IAMT has since undergone several mergers and affiliations with other institutes. It is one of the first members of the Jiangsu Industrial Technology Research Institute (JITRI). IAMT's research focus includes Robotics, intelligent vehicles and intelligent equipment, for which three research centres (Intelligent Robotics Centre, Intelligent Vehicle Centre and Intelligent Equipment Centre) have been established to provide technical support for innovations in the intelligent equipment industry. The institute is now emerging as a training hub for experts in the field of Advanced Manufacturing in China.[92]

The Shenyang Institute of Automation, Chinese Academy of Sciences (**SIACAS**) was established in 1958 and is regarded as the national leading institute in the development of automation science and technology in China. Considered the 'cradle of China's Robotics technology', the institute is a key institution for industrial and high-tech development in China. It focuses on the three fields of Robotics, intelligent manufacturing and opto-electronic information technology. The research centre supports more than 10 national and provincial central laboratories and technical centres, as well as an educational facility for master's degree programmes, doctoral programm*es and postdoctoral programs. SIACAS operates various exchange and cooperation programmes with research institutions and high-tech companies, at the international level as well.[93]

Authorities for regulation and IPR

Looking at the stakeholders responsible for regulation and IPR for Advanced Manufacturing and Robotics, the China Robot Industry Alliance (CRIA) contributes to current developments alongside the SAC and CESI in China.

New efforts via patents are designed to help enhance China's role as a globally successful Robotics manufacturer. In 2016, the Industrial Robot Patent Alliance established a patent pool for industrial robot technologies to improve the availability of critical, high-quality patents in China. In addition, China is pursuing a strategy to increase collaborations and acquisitions to strengthen robotics developments, for example of Chinese research teams with leading manufacturing companies outside China.[94]

There are several technical committees for standardisation in Advanced Manufacturing and Robotics. The China National Technical Committee for Automation Systems and Integration Standardisation (SAC/TC 159) includes a 'Robotics Devices Technical Subcommittee', which is mainly responsible for the development of standards for industrial robots, system interfaces as well as parts and controls. In addition, the National Information Security Standardisation Technical Committee (SAC/TC 260) is responsible for the development of security-related standardisation, for example in the areas of smart manufacturing and biometric facial recognition. The National Technical Committee 268 on Intelligent Transport Systems (SAC/TC 268) develops standards specifically for intelligent transportation. These three subcommittees were also listed in CESI's AI Standardisation White Paper.[95] In its 'Main Points of National Standardisation Work in 2020', the SAC also draws attention to the need to carry out 'pilot work on standard research, supply and standardisation in the field of integration of Advanced Manufacturing and modern service industries' with the overall goal of improving the standardisation system and the capacity of highly skilled development in China.[96]

Another prominent player in China's industrial policy landscape is the China Robot Industry Alliance (**CRIA**), a non-profit organisation consisting of companies, manufacturers, universities, institutions as well as other organisations in China that work together voluntarily. Established in 2013, the CRIA pursues various tasks, such as the implementation of national industrial policies and measures or strengthening the dialogue between members on technologies, the market and intellectual property rights regarding Robotics standards. The CRIA represents China in the International Federation of Robotics (IFR) as a national association member.[97]

Major business actors

In addition to the stakeholders presented, a number of companies play a significant role in China's developments in both Advanced Manufacturing and Robotics.

Table 5 summarises the largest business players as well as four promising start-ups in Advanced Manufacturing and Robotics in China.

[92] Institute of Advanced Manufacturing Technology 2020.
[93] Shenyang Institute of Automation, Chinese Academy of Sciences 2020.
[94] Nan 2016.
[95] China Electronics Standardization Institute 2020a.
[96] Seconded European Standardization Expert for China 2020.
[97] China Robot Industry Alliance 2020.

Table 5: Selected list of major Chinese business actors in Advanced Manufacturing and Robotics

Company name	Company information
Midea Group Co., Ltd.[98]	– Established in 1968 – Headquarters: Beijao, Shunde District, Foshan, Guangdong province – German Robotics company KUKA was acquired by the Midea group in 2016 – Focus: Robotics, international automation, heating, ventilation and air conditioning (HVAC) systems, consumer appliances, smart logistics
Estun Automation Co., Ltd.[99]	– Established in 1993 – Headquarters: Nanjing, Jiangsu province – Major manufacturing company conducting national R&D projects for the MIIT and running several technology centres in China – Focus: Leading high-tech enterprise in manufacturing core controlling parts for high-end equipment and industrial Robotics in China
SIASUN Robot & Automation Co., Ltd.[100]	– Established in 2000 – Belongs to (owned by) the Chinese Academy of Sciences – Group Headquarters: Shenyang, Liaoning province – International Headquarters: Shanghai – Focus: Robot technology, provision of intelligent products and services
Da-Jiang Innovations Science and Technology Co., Ltd. (DJI)[101]	– Established in 2006 – Headquarters: Shenzhen, Guangdong province – Focus: World's leading manufacturer of unmanned aerial vehicles for private and business use.
Startups	
UBTech Robotics Inc.[102]	– Established in 2012 – Headquarters: Shenzhen, Guangdong province – Robotics company supplying robots to consumers (humanoid robots, education robots) and businesses (service robots) – Focus: AI and humanoid Robotics
Intelligent Steward Co., Ltd. (ROOBO)[103]	– Established in 2014 – Headquarters: Beijing – Variety of products, including an AI platform, a voice chip for processing speech and intelligent robots – Focus: AI system solutions for the household, automotive, Robotics and other sectors
CloudMinds Technology Inc.[104]	– Established in 2015 – Headquarters: Beijing – Provider of cloud robots and services – Focus: Smart robots for people, e.g. service, patrol, hospitality, vending
Geekplus Technology Co., Ltd.[105]	– Established in 2015 – Headquarters: Beijing – Robots for picking, sorting, moving, lifting; software system; algorithm research & development – Focus: Smart logistics by applying advanced Robotics and AI to new factory or warehouse operation solutions

Source: Following Lin, 2018

3.2 Underlying conditions

In order to achieve constant development in the fields of Advanced Manufacturing and Robotics, certain underlying framework conditions as well as driving developments can be identified in these advanced technologies in China. As both areas often go hand in hand, they are also discussed jointly here. In addition to China's historical developments in Robotics and Advanced Manufacturing, regional specification measures are discussed.

Industry development

China's manufacturing industry has made great progress in recent decades. According to Si (2019), industry in China now consists of 41 industrial divisions, 207 groups and 666 classes of products and services. Nevertheless, challenges still exist in some areas (e.g. strong import dependency in semiconductors, which are

[98] SIASUN 2020.
[99] Estun Automation 2020.
[100] Midea Group 2020.
[101] DJI 2020.
[102] UBTech 2020.
[103] ROOBO 2020.
[104] CloudMinds 2020.
[105] Geek+ 2020.

necessary for Robotics and some important industrial materials). From a Robotics perspective, China has developed very positively within the last years. Although global robot installations fell by 12% in 2019 (for the first time after six years of growth), China has remained the world's largest market for industrial robots since 2013. The decline in global robot installations has been triggered by various factors, such as difficulties in the main user sectors (automotive and electronics) as well as the trade conflict between China and the US.[106]

Historically, China's initial success story as the **'factory of the world'** was particularly due to its low-cost production workers. Over the last few years, however, labour costs in China have been rising combined with a shrinking working-age population. According to Cheng et al. (2019), this has increased economic pressure as well as political support for the Robotics industry in China. The Chinese government has been promoting the production and use of robots aggressively in recent years, especially by subsidising the industry. Compared to the image of Robotics in other countries, the Chinese perception of robot use as well as automation in general, has been positive. Government documents rarely mention job losses in this context; instead, the adoption of robots is described as a tool for overcoming challenges. One reason this opinion is widely shared is that scientific and technological advances are seen as ways for China to rise as a world power. Additionally, the government's initiatives pursue the ambition of leading a new wave of industrial revolution.[107]

Reports of a meeting between Chinese Premier Li Keqiang and members of the International Advisory Committee on Advanced Manufacturing in October 2019 suggest that leaders of major manufacturing companies met with the Premier to discuss developments in Advanced Manufacturing in China. According to the statement, the Chinese government is trying to create a favourable environment for the development of Advanced Manufacturing by reducing taxes and fees, facilitating market access, ensuring fair and equitable supervision and strengthening the protection of intellectual property rights.[108]

Regional specialisation

In order to target specific clusters, China is pursuing strategies for regional specialisation, a recognised trend in innovation- and growth-related policymaking. Using this strategy, companies, research and development institutions as well as universities are brought together in the same city or region to specifically promote a particular innovation. Regional clusters bring greater employment, consumption and economic growth to local industries, while on the strategic side, they increase the country's know-how and competitiveness. Of the current 19 city clusters in China, three stand out in particular and have also been selected to become world-leading clusters by 2020: the Pearl River Delta, Yangtze River Delta and Beijing-Tianjin-Hebei (also referred to as Jing-Jin-Ji)[109]. According to an article by the Economist[110], not all of the 19 clusters have published detailed information on their development plans to date. Since many of the defined regions are much smaller, accounting for less GDP than the three major regional clusters in China, they will not be discussed in detail below.[111]

Also referred to as the 'factory of the world', the **Pearl River Delta** is a major regional hub focused on Advanced Manufacturing. This region is one of China's strongest and includes Hong-Kong as China's financial centre as well as Shenzhen, known as the Chinese 'silicon valley' due to its start-up-culture and focus on innovation. Another relevant city in this region is Guangzhou, famous for its manufacturing industry and its role as a logistics hub.[112]

Driven by Shanghai, the **Yangtze River Delta** is also dedicated to Advanced Manufacturing as well as modern services, technology and innovation. Additionally, the region serves as the 'gateway to the Asia-Pacific market'.[113] According to Xiaoming (2019), the Yangtze River Delta is the leading region of China's Advanced Manufacturing industry, home to over 30 percent of the top 500 companies. This region is also home to a significant number of Robotics companies, which is why it is considered the strongest foundation for the development of Robotics in China.[114]

The **Beijing-Tianjin-Hebei** region, also referred to as Jing-Jin-Ji, is empowered by Beijing and commonly known as the centre for politics, education, culture and R&D in China. It includes Tianjin, China's northern logistics hub with one of the busiest ports worldwide as well as Hebei and its heavy industry and industrial steel production.[115] Figure 9 shows a map of the 19 Chinese city clusters.

[106] International Federation of Robotics 2020a.
[107] Cheng et al. 2019.
[108] State Council 2019.
[109] clustercollaboration.eu 2018.
[110] The Economist 2018.
[111] clustercollaboration.eu 2018.
[112] clustercollaboration.eu 2018.
[113] clustercollaboration.eu 2018.
[114] Lin 2018.
[115] clustercollaboration.eu 2018.

Figure 9: 19 City clusters in China

Source: The Economist, 2018.

3.3 Policies, strategies and initiatives

The development of advanced technologies in the fields of Advanced Manufacturing and Robotics in China is promoted by various funds, strategies and initiatives, which are outlined in this chapter.

National Advanced Manufacturing Investment Fund

The first phase of the National Advanced Manufacturing Investment Fund was launched in 2016, valued at ¥20 bn (€2.56 bn[116]). This fund was primarily targeted at enterprises focusing on railroad equipment, industrial robots, new energy vehicles, etc. Estimated at ¥50 bn (€6.39 bn[117]), the second phase of the fund was initiated in 2019 with the strategic aim of boosting industrial restructuring and helping to achieve growth. Leveraging technological advances to boost industrial production, AI and 5G are set to complement each other to guide the modernisation of manufacturing. The fund is likely to be focused on companies promoting the integration of virtual and real economies, such as manufacturers of industrial robots or smart manufacturing companies.[118]

National Manufacturing Transformation and Upgrade Fund

Another fund aimed at pushing industrial upgrading was set up in 2019 and valued at ¥147.2 bn (€18.82 bn[119]). It was established by approximately 20 Chinese companies, with the Ministry of Finance (MOF) holding the largest stake of roughly 15%. The purpose of this high-end manufacturing fund is to support and upgrade the Chinese manufacturing industry, focusing on investments in areas such as new materials, electric equipment and new generation information technology (IT).[120]

Guideline for Shared Manufacturing Platforms

In 2019, the MIIT issued a guideline aimed at building 20 innovative shared manufacturing platforms by 2022. By applying the concept of the sharing economy, the use and coordination of resources from different areas such as production or R&D will be optimised by matching available and desired resources. A small company, for example, may not be able to afford expensive equipment, but with the help of the platform, it can utilise the available resources of another company. The objective is to enable an efficient use of capacities as well as new sources of revenue in manufacturing.[121]

Guidelines for the 'Key Special Programme on Intelligent Robots'

The MIIT announced a guideline (for the 'Key Special Programme on Intelligent Robots') in 2019, according to the International Federation of Robotics (2020b), budgeted at ¥400 m (€51.15 m[122]). This programme is aimed at

[116] The amount in euro was calculated based on the ECB's official euro foreign exchange reference rates for 2017.
[117] The amount in euro was calculated based on the ECB's official euro foreign exchange reference rates for 2019.
[118] Si 2019.
[119] The amount in euro was calculated based on the ECB's official euro foreign exchange reference rates for 2019.
[120] Jun 2019.
[121] Jun 2019.
[122] The amount in euro was calculated based on the ECB's official Euro foreign exchange reference rates for 2019.

speeding up the development of intelligent robot technologies and industries in China.

National innovation centres

Within the framework of the national strategic plan MIC 2025, one of the measures for improving the development of manufacturing processes is the establishment of 40 national manufacturing innovation centres. These centres are expected to facilitate company partnerships and innovations. Since the implementation of MIC 2025, numerous centres have been established in order to create core technologies, many of which can also be attributed to the fields of Advanced Manufacturing and Robotics.[123] [124] As not all information about the currently existing innovation centres is publicly available in a structured way, we base our analyses on the research of the National Institute of Standards and Technology (NIST)[125], make updates where necessary and try to present the most comprehensive coverage of 12 national innovation centres.

Table 6: National innovation centres established in China

Name	Since	Location	Focus
National Power Battery Innovation Centre[126]	2016	Beijing	Strategic research on power batteries; improvement of China's competitiveness; support the development of a new e-automotive industry
National Innovation Institute of Additive Manufacturing[127] [128]	2016	Xi'an	Innovating and accelerating the development of additive manufacturing in China
National Information Optoelectronics Innovation Centre[129]	2017	Wuhan	Promotion of the development of Chinese optoelectronic chips and devices in various fields, e.g. 5G communications, high-end materials
National Robot Innovation Centre[130] [131]	2017	Shenyang	Creation of major technological breakthroughs in Robotics; enhancement of China's global competence; support China in becoming a qualitative power in Advanced Manufacturing
National Printing and Flexible Display Innovation Centre[132]	2017	Guangdong	Strengthening China's industrial power in printing technology for displays
National Innovation Centre for Integrated Circuit[133]	2018	Shanghai	Researching and developing integrated circuits sized five nanometres or less as well as advanced technologies (such as advanced simulation)
National Intelligent Sensor Innovation Centre[134]	2018	Shanghai	Researching, developing and piloting key smart sensor technologies involved in all areas of smart manufacturing; focus, e.g. on new processes, devices, IoT application solutions
National New Energy Vehicle Technology Innovation Centre[135]	2018	Beijing	Creation of a source of innovation and new developments in new energy automotive technology
Digital Design and Manufacturing Innovation Centre[136]	2018	Wuhan	Provision of support (technical and professional) for digital and intelligent manufacturing across China
National Advanced Rail Transit Equipment Innovation Centre[137] [138]	2019	Zhuzhou	Investigation of trends in high-speed, heavy-duty, green and smart rail equipment, as well as new energy storage systems and multi-energy systems
National Innovation Centre of Intelligent and Connected Vehicles[139]	2019	Beijing	Building a strong R&D platform; bringing intelligent connected vehicle companies together; enabling breakthroughs in key technologies
National Agriculture Machinery Equipment Innovation Centre[140]	2019	Luoyang	Basic research, technology development, transfer and application in the field of agricultural engineering

Source: Copan, 2019.

[123] Si 2019.
[124] Institute for Security & Development Policy 2018.
[125] Copan 2019.
[126] China Automotive Battery Research Institute CABRI 2020.
[127] Linkedin 2020.
[128] People's Daily Online 2016.
[129] Wuhan East Lake High-tech Development Zone 2018b.
[130] HIT Robot Group 2020.
[131] Casanova 2019.
[132] Jie 2020.
[133] China (Shanghai) Pilot Free Trade Zone 2018.
[134] Lingzhi Technology 2018.
[135] Beijing Motor Corporation 2020.
[136] Wuhan East Lake High-tech Development Zone 2018a.
[137] Hunan Government 2020.
[138] Teller Report 2020.
[139] China Intelligent and Connected Vehicles (Beijing) Research Institute 2020.
[140] Li 2019.

3.3.1 Major projects

Four major projects stand out as having a big impact on recent developments in Advanced Manufacturing and Robotics in China. They are listed in Table 7 and described in detail below.

Table 7: Major projects for China's Advanced Manufacturing and Robotics development

Project	Year
MIC 2025	2015-ongoing
Robotics Industry Development Plan	2016-2020
Smart Manufacturing Development Plan	2016-2020
14th Five-Year Plan	2021-ongoing

Source: authors.

MIC 2025

The strategic industrial policy plan MIC 2025, as already discussed in Heimberger et al. (2020) and presented above, was introduced in 2015, seeking to boost China's global manufacturing power. The key industries addressed in this initiative include various fields in Advanced Manufacturing as well as Robotics.[141] As we have already discussed this programme in detail in the analysis of AI and Big Data, we will not discuss it further here, but it must be mentioned as it represents a major project for the advanced technologies analysed.

Robotics Industry Development Plan

The MIIT, the NDRC and the MOF jointly released this plan targeting the development of China's Robotics industry in April 2016. In order to achieve advances in industrial and service robots, the plan includes both government strategies and ambitious goals for 2020 [142] [143] [144]:

- Production of 100 000 industrial robots as well as 50 000 robots with six or more axes per year by Chinese brands
- Sales of service robots to exceed ¥30bn (€3.84 bn[145]) per year
- At least three globally competitive Robotics companies and at least 5 AI-related industry clusters in China
- Mean Time Before Failure (MTBF) in the production of industrial robots by Chinese companies to reach 80 000 hours
- Quality of Chinese service robots and core components for robots produced by Chinese companies to reach comparable quality levels to players in the world market
- Robot density for industries with high automation to reach 150 per 100 000 employees

Smart Manufacturing Development Plan

This five-year plan was presented by the MIIT and the MOF in 2016 and embodies the first general national policy on Smart Manufacturing. The plan aims at encouraging the industry to adopt information and communications technology (ICT) and to enhance the manufacturing process. According to Chengjin[146], the plan outlines four general tasks:

1. Development and technology know-how: the industry must be able to develop the necessary technologies and have a general understanding plus know-how for the essential smart manufacturing technologies.
2. Capabilities: High relevance for cybersecurity, crosscutting standards, and the Industrial Internet of Things (IIoT).
3. Adoption: Develop an ecosystem that provides system solutions and encourages companies to willingly adopt smart manufacturing (especially small and medium-sized enterprises (SMEs)).
4. Workforce: Invest in education and training to prepare the workforce with the necessary knowledge and skills for smart manufacturing.

14th Five-Year Plan

Advanced Manufacturing is specifically and prominently listed in the outline for the 14th Five-Year Plan, which is to be approved in spring 2021. In this outline, a transformation of the industrial supply chain is recognised as necessary to increase domestic demand and develop China's innovation capacity. In addition, the outline mentions new developments in the direction of high quality, intelligent and green technologies in a post-COVID-19 era for the manufacturing industry. Policy measures for these developments include, for instance, integrating 5G, Big Data as well as AI in Advanced Manufacturing; improving the quality of the national infrastructure as well as the digital development of industrialisation. Although enhancing the manufacturing industry also featured in the 13th Five-Year Plan (2016-2020), new measures for Advanced Manufacturing are expected in the 14th plan.[147]

3.4 Lessons for Europe

The developments outlined in the field of Advanced Manufacturing and Robotics in China also offer some lessons for Europe.

The EU needs to work further towards a unified, overarching strategy for the development of Advanced Manufacturing and Robotics on an international level. Although individual countries (e.g. Germany with the High-

[141] Sutter 2020.
[142] He and Bowser 2017.
[143] Ray et al. 2016.
[144] Estolatan et al. 2018.
[145] The amount in euro was calculated based on the ECB's official Euro foreign exchange reference rates for 2017.
[146] Chengjin 2020.
[147] Wong 2020b.

Tech Initiative Industry 4.0) have been pursuing similar initiatives to China (e.g. with MIC 2025), various Member States still need to better integrate their efforts geared at the development and uptake of advanced technologies for industry. Against this background, Europe should seek to add to these efforts, work towards improving their coordination and consistently pursue an integrated strategy for industrial modernisation.

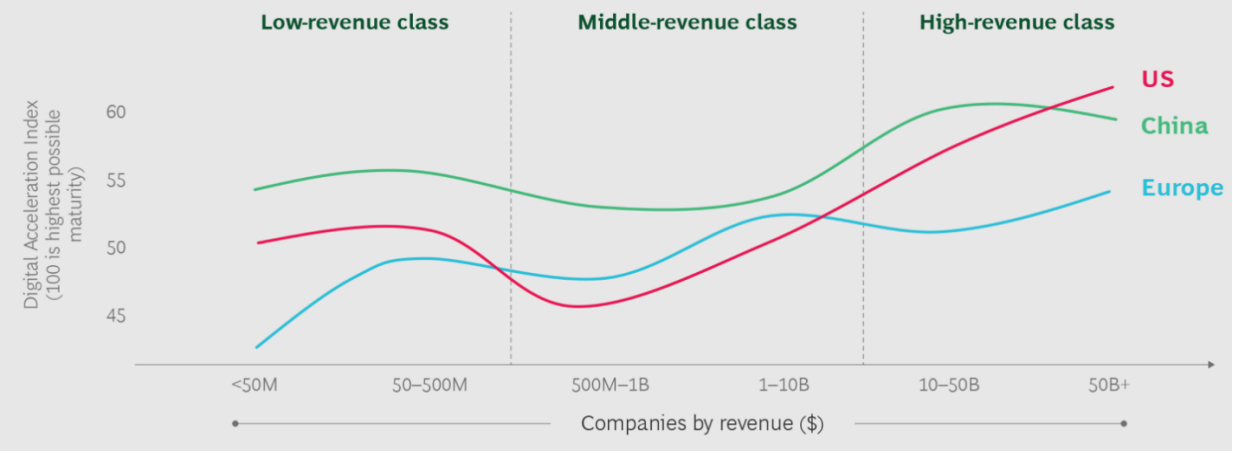
European clusters should facilitate and coordinate technological development across national borders to gain international visibility and relevance. Lessons similar to those on AI and Big Data can also be identified in terms of regional specialisation. The Chinese government has specifically promoted regional hubs for the further development of technological innovations such as advanced manufacturing and robotics, and thus it has been possible to create globally recognised and leading regions in these areas. Similar clusters certainly exist in individual European countries, but these can still be strengthened at the European level, across countries.

The digital maturity of European firms has to be increased on a broad basis. Both China and Europe are facing the continued challenges that many, in particular smaller, companies have not yet achieved sufficient digital maturity for the increased use of Robotics and Advanced Manufacturing. With the anchoring of robotics and automatisation in MIC 2025 and, more importantly, the high priority assigned to it in the upcoming 14th-Five Year Plan, China will continue to invest substantially in upgrading digital readiness in the business sector on an as broad basis as possible. At this critical moment, Europe has to avoid being left behind.

The EU needs to work on improving the image and openness for automation and robotics. Although the difference may not be quite as pronounced as in the field of AI, the attitude towards automation and robotics remains more open and positive in China than in the EU. While many Chinese decision makers are acutely aware of potential job market implications as well, this will not hinder the advancement of centrally directed, high priority government initiatives in the field of robotics.

Figure 10 reinforces this argument. The chart visualises the digital maturity of Advanced Robotics in the United States, China and Europe in different revenue categories of companies. The chart confirms the restrained digital maturity of European companies. While the EU has a higher level of digital maturity than the US in the mid-tier revenue class, China still outperforms the EU in all revenue classes.

Figure 10: Digital Maturity of countries ordered by company revenue



Source: Klicken oder tippen Sie hier, um Text einzugeben.Candelon et al. 2020b, p. 2.

Section 4

4 COVID-19 in China: Impact, response and recovery

4.1 Impact of COVID-19 in China

4.1.1 COVID-19 in China

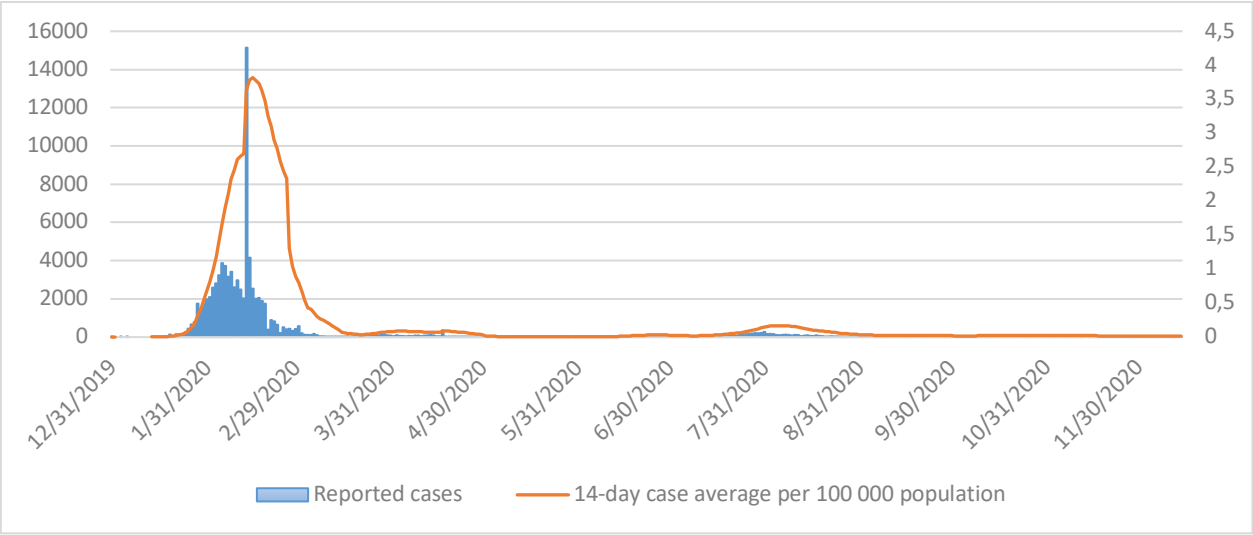
The novel coronavirus was first detected in a wet market in Hubei province in China in December 2019. China became the first country to be severely affected by the COVID-19 pandemic. Although COVID-19 rapidly spread to most other provinces in the months since it was first identified, Hubei remained the worst affected province.

The government implemented a 76-day lockdown in Wuhan city from the 23rd of January 2020 and initiated the first-level public health emergency mechanism in another 30 provinces on the 26th of January to control and prevent the spread of the virus.[148] The virus was largely contained by the end of February 2020. China passed the peak of the pandemic on the 12th of March 2020.[149] Although China is overall regarded as a 'successful case' of managing the pandemic, some analysts criticised the authorities for not reacting quickly enough. A more rapid response could have significantly reduced the scale of the outbreak.[150]

Later in the year, China managed to avoid a nationwide 'second wave' spike of infections. After the major first wave was put under control, China only implemented localised restrictions to control outbreaks in new hotspots in Jilin, Heilongjiang, Beijing, Shanghai and Hebei. These subsequent outbreaks were probably caused mostly by imported cases.[151] The spread of the virus was prevented largely thanks to the coordinated strategy and wide-scale testing and contact tracing.[152]

In total 96 000 confirmed cases of COVID-19 were reported in China by January 2021, with 4 782 confirmed deaths.[153] Hubei remains the worst affected province with over 68,000 confirmed cases, around 76% of all confirmed cases and 97% of all reported deaths.

Figure 11 COVID-19 infection rates in China in 2020



Source: authors based on the data from the European Centre for Disease Prevention and control, 2020.

As China emerged as one of the most successful cases among the global pandemic response, far surpassed in both case load and mortality rate by the US and Europe, the Chinese government called this success a proof the government handles important matters effectively, supported by traditional Chinese values.[154] It is likely that in China, the handling of the pandemic will remain the source of national pride, despite the initial

[148] Zhang et al. 2020.
[149] Xinhua.net 2020a.
[150] Global Times 2020.
[151] Yang and Li 2021.
[152] Burki 2020.
[153] Statista.com.
[154] economist.com 2020.

misgivings, especially because the economy managed to bounce back (see section 4.2).

China's successful recovery from the pandemic will likely have lasting geopolitical consequences. China has championed the global pandemic response, both in terms of international relief aid, international cooperation and vaccine geopolitics. Table 8 shows the list of Chinese vaccines in the advanced clinical trial phase at the time of writing. SinoVac and SinoPharm vaccines have been approved for innoculation of high risk groups in China. By the end of January 2021 over 24 million people were vaccinated. These vaccines show promising results and offer attractive alternatives to Pfizer and AstraZeneca / Oxford vaccines. Some experts suggest that if China successfully participates in vaccine geopolitics, it will be able to boost its influence in Asia and beyond.[155]

Table 8 Chinese COVID-19 vaccines in phase 3 clinical trials, January 2021

Company	Method
Sinovac Research and Development Co., Ltd	Inactivated virus
Sinopharm + China National Biotec Group Co + Wuhan Institute of Biological Products	Inactivated virus
CanSino Biological Inc./Beijing Institute of Biotechnology	Viral vector (Non-replicating)
Anhui Zhifei Longcom Biopharmaceutical + Institute of Microbiology, Chinese Academy of Sciences	Protein sub-unit
Institute of Medical Biology + Chinese Academy of Medical Sciences	Inactivated virus
Inovio Pharmaceuticals + International Vaccine Institute + Advaccine (Suzhou) Biopharmaceutical Co., Ltd	DNA based vaccine

Source: WHO, 2021.

4.1.2 Overall economic impact

The closure of all but essential businesses and international borders in the effort to contain the spread of COVID-19 has led to an unprecedented worldwide economic crisis. Like many other countries, China was significantly affected by the shock in the first two quarters of 2020: the economy contracted by 16% in the 1st quarter alone. In contrast to many other countries, China recovered fairly quickly, reaching 6.5% growth by the 4th quarter.[156] Overall, China's GDP is expected to grow by around 2% in 2020.[157] The World Bank expects China's GDP to grow up to 7.9% in 2021, compared to 6.1% in 2019, under the assumption that the spread of COVID-19 is properly contained. CEBR expects that China will be able to further improve its economic performance relative to the leading EU countries such as Germany or France thanks to its management of the pandemic.[158]

Table 9 China's selected economic indicators, 2018-2022

China selected indicators	2018	2019	2020f	2021f	2022f
Real GDP growth, at constant market prices	6.6	6.1	2.0	7.9	5.2
Private consumption	9.5	6.8	-1.0	11.0	6.0
Government consumption	10.4	8.4	9.7	7.2	8.0
Gross fixed capital formation	4.8	4.5	1.1	6.5	3.6
Exports, goods and services	4.0	2.5	0.8	2.5	2.0
Imports, goods and services	7.9	1.0	-1.7	4.0	2.0
Real GDP growth, at constant factor prices	6.6	6.1	2.0	7.9	5.2
Agriculture	3.5	3.3	3.0	3.4	3.3
Industry	5.8	5.5	2.3	6.5	4.7
Services	7.6	7.0	1.6	9.7	5.9
Inflation (Private Consumption deflator)	2.1	2.9	2.5	1.8	2.0
Current account balance (% of GDP)	0.4	1.1	1.8	1.3	1.1
Financial Account Balance, excl. reserves (% of GDP)	1.0	0.9	0.2	0.6	0.7
Net foreign direct investment (% of GDP)	0.8	0.9	0.5	0.7	0.8
Public finance budget balance (% of GDP)	-3.4	-2.8	-3.6	-3.0	-2.8
Augmented fiscal balance (% of GDP) [a]	-4.6	-6.4	-11.8	-7.8	-6.4
Primary balance (% of GDP) [a]	-3.6	-5.1	-10.7	-6.5	-5.0
Government debt (% of GDP)	38.5	41.9	52.2	55.3	57.9

Source: World Bank.
Notes: f = forecast (baseline).
(a) World Bank staff calculations. The augmented fiscal balance (narrow definition) adds up the public finance budget, the government fund budget, the state capital management fund budget, and the social security fund budget. The primary balance is the difference between revenue and non-interest expenditures.

Source: The World Bank, 2020a.

[155] wsj.com.
[156] Zenglein et al. 2021.
[157] The World Bank 2020a.
[158] Cebr 2020.

The significant short-term decline in economic activity was caused by the demand and supply suppression due to restrictions. China succeded in controlling the infection and many businesses stayed open for a large part of 2020. The industrial production and investment led the recovery.[159] China also benefited from continued lockdowns around the world that drove its exports growth in the second half of the year, especially by strong demand for medical goods and electronics.[160] Various other factors contributed to the **supply-led recovery**, for example, weak energy prices.

The industrial production growth rate started to rise in the second quarter of 2020 and reached 6.9% by September, however, there were differences in terms of the scale of impact for various sectors.[161] The secondary industry benefited the most from public support during the pandemic. Industrial value-added growth expanded across the manufacturing sectors, especially in auto, machinery equipment, computer and electronics.[162] In terms of the type of firm, private companies may have suffered more than state-owned enterprises in the pandemic, with small businesses facing biggest negative effects.[163] Services sector was hit hardest by the pandemic and has been one of the slowest to recover, held back by the remaining contact restrictions. One exception here is the e-commerce and e-payments sector, which boomed in China during the pandemic with the adoption driven by the implementation of social distancing and exit restrictions. According to the OECD, the number of e-commerce users in China is projected to increase by 71 million over 2020, driving e-commerce market penetration by 5 percentage points to 64%.[164]

The biggest consequence of the pandemic is in **exacerbating existing economic imbalances**. Although the supply side of the economy was able to bounce back thanks to the extensive public support, concerns remain about domestic demand and especially private consumption.[165] Retail sales growth was at -7.2% in the first three quarters of 2020.[166] Private consumption improved in the second half of the year, demonstrated by retail sales growth, the rebound of automobile and real estate sales.[167] However, concerns remain that pandemic conditions may lead to long-term behavioral effects in Chinese society, such as increased saving and reduced consumption. These may reflect on future economic growth.

There are also regional and social imbalances: eastern coastal regions recovered faster because of the strong presence of the manufacturing sector, while labour market conditions in the western and rural areas are lagging. Therefore, although on the national level it is unlikely that **unemployment** will significantly increase in 2020[168], there will likely be regional variation. An analysis by the European Central Bank suggests that the relatively minor increase in unemployment in 2020 may not reflect the actual situation, because businesses were urged to keep their employees on payroll.[169]

Social protection to mitigate job and income losses has been limited. The World Bank estimates that the three major social assistance programmes, Dibao, Tekun and temporary assistance, covered around 4.1% of the population registered as beneficiaries.[170] The losses of income and the unstable labour market conditions may **halt poverty reduction**, or even lead to the rise of poverty among certain social groups, e.g. among migrant workers and in urban areas.

An important consequence of the pandemic is the further **buildup of debt**, which contributes to financial sector vulnerabilities. Total deblt increased from 262% of GDP in the first quarter of 2020 to 288% in the third quarter, driven mainly by the accelerated credit growth.[171] The increase has largely been in household and government debt.

Finally, China will likely be affected by the **economic uncertainty** as the rest of the world is still dealing with the COVID-19 pandemic. Foggy prospects of global recovery create challenges for foreign direct investment and international policy coordination. Disruptions may arise from new outbreaks and restrictions that will follow. The extent of the global economic crisis and its consequences remain uncertain, which creates risks for China. These are further exacerbated by increasingly more confrontational geopolitical stand-offs with the US and Europe. This will likely bring about challenges for trade and exports, especially in high tech sectors, and affect investors' confidence.

4.2 China's COVID-19 related government restrictions

The initial set of government restrictions on domestic and international travel, the closure of businesses and schools was in place in January and February 2020. During the 76-day quarantine in Wuhan, all businesses were closed with only a few exceptions, people were ordered to stay at home and all public transport was shut down. The measures were strictly enforced. The Lunar New

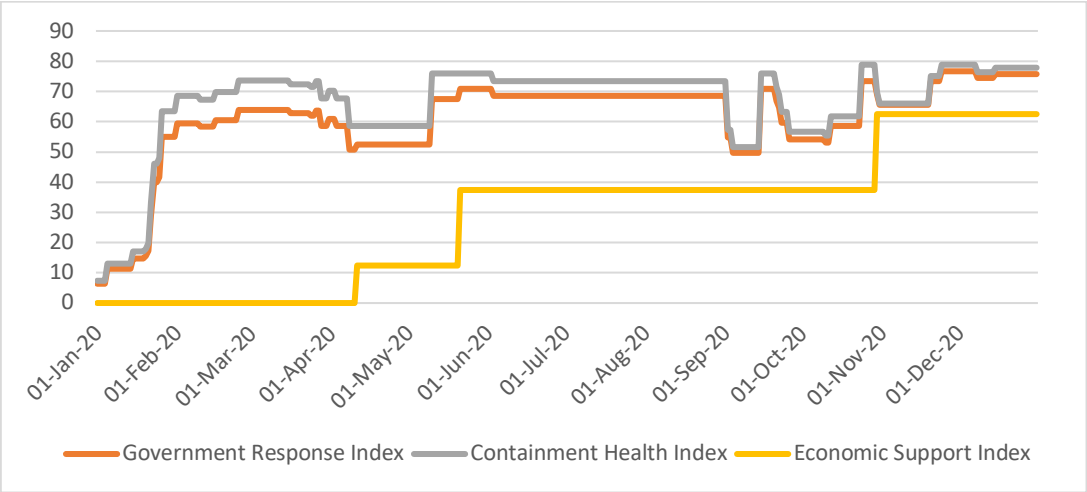
[159] Al-Haschimi et al. 2020; The World Bank 2020a; OECD 2020a.
[160] Cebr 2020; The World Bank 2020a; Zenglein et al. 2021.
[161] OECD 2020a.
[162] OECD 2020a; The World Bank 2020a.
[163] Gu et al. 2020, based on the analysis of electricity usage in Suzhou
[164] OECD 2020a.
[165] The World Bank 2020a.
[166] OECD 2020a.
[167] Al-Haschimi et al. 2020.
[168] OECD 2020a.
[169] Al-Haschimi et al. 2020.
[170] The World Bank 2020b.
[171] The World Bank 2020a.

Year holidays were extended to prevent workers from travelling.[172]

After the case load was significantly reduced, the government gradually lifted the restrictions and re-opened the economy from mid-Februrary onwards, prioritising the essential sectors. Since March, a tiered response system has been implemented. If a new hotspot was identified, restrictions were put into place in that area locally. Health checks and social distancing rules remained in place nationwide throughout 2020. Foreign entry also continues to be restricted.[173]

According to the Oxford COVID-19 government response tracker, the Chinese government focused its resources on developing a sophisticated system of health-related measures relative to other types of response. Public information campaign was a lage part of this: the government was issuing daily announcements about current cases and was informing the citizens about why it is important to stay indoors and comply with the sanitary norms, like disinfecting, social distancing, wearing masks and washing hands. Public health requirements were strictly enforced. A special package of policies helped increase the production of medical essentials, like face masks, to satisfy the increasing demand.[174] Three temporary Fangcang hospitals with 13 000 beds operated in February 2020 to accommodate COVID-19 patients.[175] Around 426 000 doctors and nurses were moved to Hubei province by the beginning of March, including 19 000 Intensive Care Unit (ICU)-related staff.[176]

Figure 12: COVID-19 related government responses in China in 2020



Source: authors based on the data from Oxford Government Response Tracker. The overall government response includes closure, health and economic measures. Health and containment indicator traces, in particular, public information campaigns, the scale of COVID-19 testing and contact tracing. The economic support index includes measures on income support and debt relief.

4.3 Economic measures

China's economic response to the pandemic was delayed. For example, by May 2020 Germany spent around 34% of its GDP on COVID-19 support measures while China spent only around 2.5%.[177] However, China ramped up its economic support later in the year. According to the Asian Development Bank's Policy Database[178], by the end of 2020 China spent over **€1.9 bn, in excess of 17% of its GDP**, to support its economy during the COVID-19 crisis. However, it is still lower than the US with 37% of GDP spent and Germany with 54%.

Table 10 lists China's key economic support and recovery measures. A substantial amount of the recovery package was spent on fiscal measures, estimated at around 5.4% of GDP. These measures supported mainly firms and banks.[179] Direct financial support tools were made available to businesses from various sources, e.g. the reduction of interest rates, increasing renewal loans and providing more credit.[180] Firms involved in essential activities, in healthcare and medical fields received substantial assistance. Micro, small and medium enterprises (SMEs) also received direct support via low or zero-interest lending, Value Added Tax (VAT) and Corporate Income Tax (CIT) exemptions, delay of payments and other

[172] Al-Haschimi et al. 2020.
[173] ADB 2021.
[174] Huang et al. 2020.
[175] Burki 2020.
[176] Huang et al. 2020.
[177] weforum.com 2020.
[178] ADB 2021.
[179] The World Bank 2020a.
[180] Huang et al. 2020.

credit support measures. SME recovery is expected to further benefit from new public digitalisation programmes, the adoption of e-commerce and fintech tools.[181] By August tax and fee cuts totalled ¥1.5tn (€191 bn).[182] Local governments spent around ¥509.7 bn (€64.9 bn) by September. People's Bank of China (PBOC) focused on injecting liquidity into the banking system.[183] Other measures aimed to stabilise international trade and foreign direct investment.

The biggest headline policy is the **fiscal stimulus package of around ¥3.6tn (€331.1 bn)** announced by premier Li Keqiang at the National People's Congress in May. The package identified six priority areas that would drive China's post-pandemic recovery: employment, basic livelihood, companies, food and energy security, stable supply chains and the smooth operation of government.[184] ¥1tn (€127.3 bn) of the announced package were issued as special government treasury bonds. The other ¥1.6 tn (€203.8 bn) were put to increase the local government special bond quota in order to stimulate infrastructure funding.

The majority of measures that were announced over the course of the year were extended until 2021.

Table 10 Economic support measures

Type of Measure	Description
Monetary	(i) liquidity injection into the banking system via open market operations (reverse repos and medium-term lending facilities) totaling RMB 1 tn (ii) expansion of re-lending and re-discounting facilities by RMB 1.8 tn to support manufacturers of medical supplies and daily necessities, SMEs and the agricultural sector; reduction of their interest rates (iii) reduction of the 7-day and 14-day reverse repo rates by 30 bps, as well as the 1-year medium-term lending facility (MLF) rate and targeted MLF rate by 30 and 20 bps, respectively (iv) targeted RRR cuts by 50-100 bps for large- and medium-sized banks that meet inclusive financing criteria which benefit SMEs, an additional 100 bps for eligible joint-stock banks, and 100 bps for small- and medium-sized banks to support SMEs (v) reduction of the interest on excess reserves from 72 to 35 bps
Fiscal	(i) VAT exemption on a wide range of customer services (medical services, catering, accommodation, public transport, delivery services, some personal services) for an unlimited period (ii) CIT and VAT incentives for companies producing medical supplies, used in relation with COVID-19; CIT deferral for SMEs to the first filing period in 2021 (iii) longer tax loss carry-forward period (from five to eight years) for severely affected companies (iv) enterprises may make catch-up employer social security contributions within a period of three months following containment of COVID-19 outbreak without adversely affecting employee rights to social security benefits (v) some local authorities have introduced policies to support local enterprises during the outbreak, including deferring adjustments to social security contribution base, adjusting employer contribution rate for social security plans, extending payment of employer social security contributions and relaxing the restrictions on applying for refunds of unemployment insurance (vi) an individual income tax exemption on receipt of the following types of income: (1) temporary subsidy and bonus received by medical and epidemic prevention staff engaged in prevention and control activities, (2) medicines, medical supplies, protective equipment and other benefit-in-kind provided by employers to their employees for prevention of COVID-19 (vii) full tax deductibility of (1) donations made by individuals through non-profit social organisations or governmental authorities; (2) donations in kind, made directly by individuals to designated hospitals undertaking the tasks of the prevention and treatment of COVID-19

[181] Huang et al. 2020.
[182] Xinhua.net 2020b.
[183] Haasbroek 2020.
[184] weforum.com 2020.

Type of Measure	Description
Subsidies	(i) consumer vouchers (government-subsidised coupons or discounts) that can be spent at designated venues, over RMB 6.5 bn by May (ii) 'temporary assistance allowance': lump sum to jobless rural workers, migrant workers and other unemployed groups not covered by unemployment insurance who apply to local authorities
Lending	(i) expansion of policy banks' credit line to private firms and SMEs; bond issuance by financial institutions to support SME lending (ii) introduction of new instruments to support lending to SMEs, including a zero-interest 'funding-for-lending' scheme by RMB 400 billion to finance 40 percent of local banks' new unsecured loans and incentivising them to further extend payment holidays for eligible loans by subsidising 1 percent of loan principles (iii) delay of loan payments, with the deadline extended to the end of March 2021 or later, and easing loan size restrictions for online loans for eligible SMEs and households (iv) tolerance for higher Non Performing Loans (NPL) and reduced NPL provision coverage requirements (v) additional financing support for corporates via increased bond issuance by corporates, including relaxing rules on insurers for bond investments (vi) increased fiscal support for credit guarantees (vii) flexibility in the implementation of the asset management reform
Stock market, exchange rate and balance of payments	(i) the stock market reopened on the 2nd of February 2020 (ii) the exchange rate has been allowed to adjust flexibly. A ceiling on cross-border financing under the macroprudential assessment framework for financial institutions and enterprises was raised by 25 percent in March, but lowered to the original level for financial institutions in December and for enterprises in January 2021 (iii) The counter-cyclical adjustment factor in the daily trading band's central parity formation was phased out. The reserve requirement on FX forward was reduced to zero (iv) Restrictions on the investment quota of foreign institutional investors (QFII and RQFII) were removed and new quota for domestic institutional investors were granted. The macroprudential adjustment coefficient for overseas lending by domestic enterprises was increased by two-thirds in January 2021
Employment	(i) social insurance payments were cut by RMB 1 tn to incentivise companies to retain employees. Daily stipends for infected medical workers (ii) companies in major cities that are in temporary difficulties owing to the coronavirus outbreak and do not lay off employees or minimise the layoffs can get a refund of unemployment insurance premiums
Industrial	(i) inftrastructure investment projects financed by special local government bonds (ii) commitment to provid more credit to core companies in key industries

Sources: ADB, 2021; IMF, 2021; KPMG International, 2021; Lu et al., 2020; Cheng et al., 2020.

4.4 Pandemic Technology Policy

China's government used the challenge of COVID-19 to exensively integrate new technologies in various areas and sectors. These efforts were supported by several key policies.

On the 18th of February 2020, the MIIT announced the strategy '**Applying information technology services to tackle COVID-19**' with three stated objectives:

1. to fully support scientific epidemic prevention and control
2. to accelerate the resumption of work and production
3. to strengthen service guarantees.[185]

The strategy itself was a declaration to support the use of new technologies (big data, cloud computing, 5G, artificial intelligence) to address various aspects of the pandemic where possible. Concrete measures included, among others, the commitment to promote cooperation between

[185] OECD STIP Compass 2020.

manufacturing and IT companies to deepen applications of industrial internet and industrial software, AI, augmented reality, unmanned production, remote operation, online services, and other new models and new formats. The strategy declared support for enterprises, especially SMEs, to adopt digital tools. Support was also announced for the overall improvement of online services, financing methods such as online rapid lending, and for all efforts to strengthen digital infrastructure and data integration.

A separate **Action plan to digitalise micro, small and medium enterprises**[186] focuses on promoting digital management and operation, on exploring new business models such as service-oriented manufacturing, on using digital platforms to guarantee supply chains, and on strengthening data sharing and development.

The role of technological innovation received attention as a part of the government's policy package towards the resumption of work and restarting of the economic activity in February and March 2020. On the 6th of February the MOST issued a **`Notice on Further Providing Facilitation Services for Various Technology Enterprises during the Period of Epidemic Prevention and Control'**[187], which acknowledged the importance of technology companies in responding to the pandemic and offered several measures to reduce red tape by implementing digital technologies. Companies with technology contracts were offered the opportunity to register them online on a special platform and conduct related operations in a paperless form thereafter. Local authorities were to identify high technology companies and assist them in handling their operations online as much as possible. Rent for companies in incubators and science parks was reduced or removed. Provinces were obliged to provide assistance, including tax reduction and other concessions, to pharmaceutical companies, manufacturers of medical and protective equipment, and to companies located in National High Tech Economic Zones.

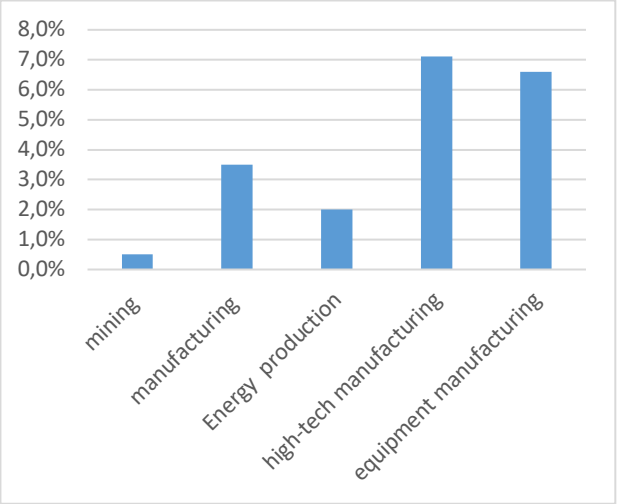
On the 21st of March, **Several Measures on Supporting Resumption of Work and Production and Stable Economic Operation through Scientific and Technological Innovation**[188] by the MOST outlined specific support for S&T actors in returning to normal life. **'Technology Boosts Economy 2020'** initiative would fund several technological R&D projects. The directive also instructed the local authorities to support the return to work of high tech innovative SMEs and companies working in National High Tech Zones via various means of support, including advice, implementation of online tools and health monitoring. The policy increased the funding of the National Science and Technology Achievement Transformation Guidance Fund for high tech SMEs. Special commitments were made to support key core technology areas, including AI, 5G, quantum computing, industrial internet, major new drugs, high end medical equipment and new energy. Support of Science and Technology (S&T) talent was also announced, including the creation of new types of positions in companies and research organisations, and new internship opportunities in National High Tech Economic Zones.

4.5 The impact of COVID-19 on Advanced Technologies in China

4.5.1 Overall impact on Advanced Technologies

Advanced Technology (AT) sectors did not suffer as much as they could have during the pandemic due to two key factors: first, the government made significant effort to keep high tech enterprises and high priority sectors afloat; and second, some of the advanced technologies were put at the heart of the response and recovery measures, giving them an impetus for growth. As the result high tech manufacturing became the fastest growing industrial production sector of the economy, with the growth of 7.1% in 2020.[189] High tech industries were also outliers in terms of investment received in the first three quarters of the year, which grew by 9.1% while overall investment in manufacturing industry decreased by 6.5%.[190]

Figure 13: Growth of industrial production sectors in China in 2020



Source: NBSC, 2021

[186] OECD 2020a.
[187] MOST 2020.
[188] MOST 2020.
[189] NBSC 2021.
[190] Grieger 2020.

4.5.2 Use of Advanced Technologies to combat the pandemic

Digital technologies spearheaded China's response to the pandemic. According to MERICS, Chinese authorities worked closely with technology companies to develop the pandemic response and prioritised the rebuilding of the economy by 'putting digitalisation first'.[191] According to Accenture, this was done in four distinctive ways: to contain the spread of the virus, to keep people informed, to ensure the quality of life and to re-ignite productivity.[192] These are summarised in Table 11.

Figure 14 (next page) depicts the distribution of the applications of the various digital tools. The rapid and widespread use of digital technologies was enabled in part by the prioritisation of security concerns over citizen privacy.

Table 11: China's use of Advanced Technologies to manage the COVID-19 pandemic

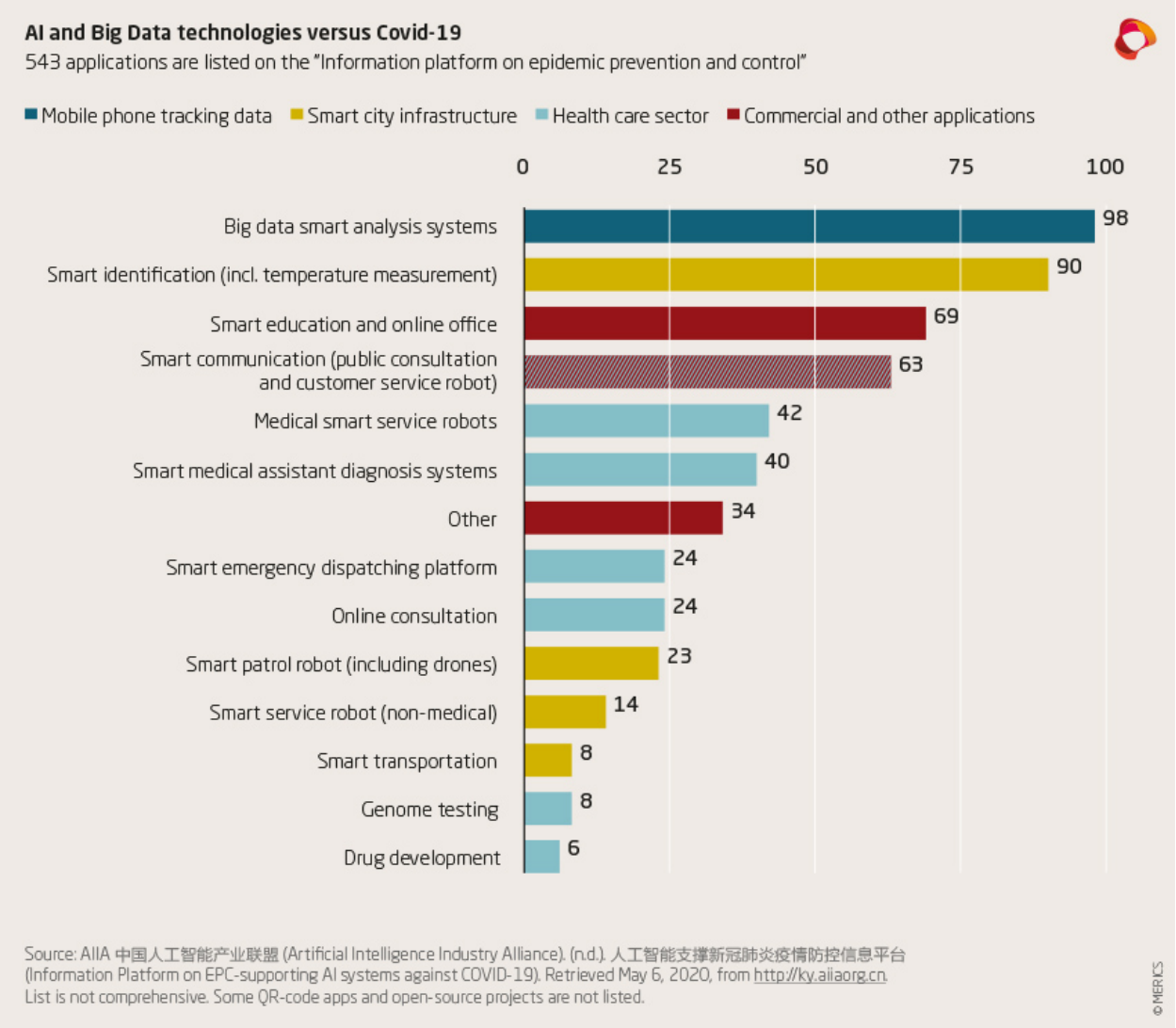
Strategy	Tools
Containing the spread of the virus	(i) use of location-based services and big data analytics to identify new cases (ii) 'Close contact detector' mini-app for WeChat developed by the Chinese Electronics Technology Corporation to self-check risk levels (iii) QR code health passports to monitor contacts and limit movements, compulsory to show at checkpoints when entering public areas (iv) use of robotics to perform 'human-touch' tasks - including patrolling robots to test body temperature, community drones to disperse gatherings, and others (v) use of 5G-enabled cloud systems developed by a startup CloudMinds Technology in Wuhan hospitals to perform jobs like nursing, body temperature taking, vitals measurement, medication delivery, disinfection and cleaning
Keeping people informed	(i) setting up sites to aggregate and share information, e.g. WeChat mini-app developed by DXY that provides real-time updates for China and globally; information on restrictions and points of interest by e.g. dianping.com and mafengwo.cn (ii) use of mobile channels and apps to alert users about potential cases nearby such as AIA Connect
Ensure the quality of life	(i) wide adoption of online-to-offline business models that range from grocery shopping to online medical consultations by a wide range of enterprises. E-commerce and e-medicine expanded especially significantly (ii) Adoption of augmented and virtual reality tools to enhance quality of life, e.g. virtual gyms, virtual exhibitions, virtual cinemas with social experience
Re-ignite productivity	(i) wide range of experimentation with online platforms by traditionally offline businesses (ii) use of 5G and IoT and robotics technologies to enable intelligent manufacturing in order to resume production with limited workforce (iii) wide adoption of remote work tools by businesses, e.g. DingTalk (iv) mobilisation of digital tools by local authorities, including fintech platforms, especially to ease paperwork load and reduce operational volatility of SMEs

Sources: Accenture, 2020; cnet.com, 2020; OECD, 2020a; Huang et al., 2020.

[191] Huotari et al. 2020.

[192] Accenture 2020.

Figure 14: AI and Big Data Technologies versus COVID-19 in China, January-May 2020



Source: Carnap et al., 2020.

As the result of the widespread mobilisation of new and digital technologies, AT sectors grew significantly in 2020. The **IT and software sector** grew by 16.9% in 2020.[193] China was already the global leader in the installation of **industrial robots** in 2019.[194] In 2020, the production of robots expanded by 19.1%, reflecting the increase in demand boosted by policy incentives, capacity additions during the crisis and the tendency of firms to upgrade their manufacturing.[195] Online giants such as Alibaba and Tencent also greatly benefited from the boost in e-commerce during the pandemic and from the digitalisation policies.

One area where China's adoption of digital tools has not been so high is online edication, because the school closure was not as prolonged as in many other countries. Therefore, Chinese education providers made less use of online platforms and tools.[196]

Certain ATs that were not in the focus of the dedicated COVID-19 recovery policies experienced shocks and had to face the consequences of the halted manufacturing in the first two quarters of 2020. Among them is, for example, certain **advanced manufacturing** industries, where not only the production but also the international supply chains were significantly negatively affected by the pandemic, creating cascading effects.[197]

It is reasonable to expect that the digital transformation will remain China's major policy focus. Pandemic conditions eased one of the biggest hurdles in technology diffusion - the adoption of new technologies by traditional

[193] NBSC 2021.
[194] OECD 2020a.
[195] Zenglein et al. 2021.
[196] OECD 2020a.
[197] Zhao and Liu 2020.

industries. Although digitisation in certain traditional industries is still lagging, the adoption trend is expected to continue beyond 2020.[198]

4.5.3 New Infrastructure, Supply Chains and Tech Transfer

The Chinese government used pandemic conditions to accelerate the development of self-reliant infrastructure for new technologies. The MOST identified seven key areas for infrastructure development: 5G networks, industrial internet, inter-city transportation and rail system, data centers, AI, ultra-high voltage power transmission and new-energy vehicle charging stations. Around ¥1.4tn (€178.3 bn) will be spent on these 'new infrastucture' projects, increasing to ¥16.2 tn (€2.06 tn) by 2025.[199] Besides providing employment and stimulating the economy, these projects work in concert with other initiatives that aim to propel China in the leaderboards of the most innovative nations. The target for **5G infrastructure**, for example, is to build 600 000 base stations by the end of 2020 and around 5 million by 2025. The **AI chip market** is expected to particularly benefit from the infrastructure investment. Experts estimate rapid development of related technologies and the growth of new investment up to €11.9 bn by 2025.

Technologies in the focus of the new infrastructure projects are expected to attract significant extra investment, as illustrated by the sharp rise of the stocks related to 5G, industrial internet, inter-city transit systems, vehicle charging stations and data centres shortly after the announcement of the support. The leading telecom operator, China Unicom, announced plans to accelerate 5G base stations construction to 250 000 units by the end of the third quarter of 2020.[200] Plans are also underway for the government to provide more credit to core companies involved in the seven key areas and to strengthen international cooperation, including by attracting foreign investment.[201] However, the government limited foreign participation in strategic priority projects, e.g. internet data centres and industrial internet.

The new infrastructure projects were announced among the growing concerns about the consequences of China's geopolitical conflicts for its high tech industries. As Chinese national political agendas re-iterate the new slogans about technological self-reliance[202], the COVID-19 pandemic may have significantly accelerated the process of disengaging China from global supply chains. China's access to foreign technologies in the areas where it still has gaps is also expected to become subject to increasingly stricter controls.[203] This may lead to adverse consequences for some of the related industries, including intelligent manufacturing. Semiconductors is one of the biggest examples: only 8% are produced in China by Chinese companies, and the country is completely reliant on foreign suppliers for the advanced chips.[204]

[198] Huotari et al. 2020.
[199] Wong 2020a.
[200] china.org.cn 2020.
[201] Chipman Koty 2020.
[202] Blanchette and Polk 2020.
[203] Capri 2020; Grieger 2020.
[204] Lewis 2019.

Bibliography

Accenture (2020): COVID-19: China's Use of Digital & New Technologies | Accenture.

ADB (2021): ADB Covid-19 Policy Database: People's Republic of China. ADB. Available online at https://covid19policy.adb.org/policy-measures/PRC, checked on 2/23/2021.

Al-Haschimi, Alexander; Apostolou, Apostolos; Ricci, Martino (2020): China's path to normalisation in the aftermath of the COVID-19 pandemic. European Central Bank. Available online at https://www.ecb.europa.eu/pub/economic-bulletin/articles/2020/html/ecb.ebart202006_01~853248c2d2.en.html, checked on 2/23/2021.

Alibaba Group (Ed.) (2020): About us. Available online at https://www.alibabagroup.com/en/global/home?spm=a2700.8293689.0.0.678367afBTxd1Z&tracelog=footer_alibabagroup, checked on 1/12/2021.

Baidu (Ed.) (2020): Company overview. Available online at https://ir.baidu.com/company-overview/, checked on 1/12/2021.

Beijing Motor Corporation (Ed.) (2020): Building the First National New Energy Vehicle Technology Innovation Center with Five Principles. BAIC Company News - BAIC International. Available online at http://www.baicintl.com/html/2018/company_news_0411/33.html, updated on 1/13/2021, checked on 1/14/2021.

Blanchette, Jude; Polk, Andrew (2020): Dual Circulation and China's New Hedged Integration Strategy. CSIS. Available online at https://www.csis.org/analysis/dual-circulation-and-chinas-new-hedged-integration-strategy, checked on 2/23/2021.

Burki, Talha (2020): China's successful control of COVID-19. In *The Lancet Infectious Diseases* 20 (11), pp. 1240–1241. DOI: 10.1016/S1473-3099(20)30800-8.

CAICT (Ed.) (2020): CAICT - ABOUT US. Available online at http://www.caict.ac.cn/english/about/202004/t20200413_279063.html, updated on 1/14/2021, checked on 1/18/2021.

Candelon, Francois; Bürkner, Hans-Paul; Duranton, Sylvain; Lang, Nikolaus; Di Charme Carlo, Rodolphe; Bondt, Midas de (2020a): Europe Can Catch Up in AI, But Must Act—Today. Edited by Boston Consulting Group. Available online at https://web-assets.bcg.com/96/57/f970ece243989575e343165eb4e6/bcg-europe-can-catch-up-in-ai-but-must-act-today-jun-2020.pdf, updated on 1/25/2021, checked on 8/2/2021.

Candelon, Francois; Bürkner, Hans-Paul; Grebe, Michael; Di Charme Carlo, Rodolphe; Bont, Midas de (2020b): As the COVID-19 Crisis Reveals, Europe Urgently Needs to Digitize Its Industry. Edited by Boston Consulting Group. Available online at https://image-src.bcg.com/Images/BCG-As-the-COVID-19-Crisis-Reveals-Europe-Urgently-Needs-to-Digitize-Its-Industry-Jun-2020-rev_tcm9-251451.pdf, updated on 1/8/2021, checked on 9/2/2021.

Capri, Alex (2020): Strategic US-China decoupling in the tech sector. Hinrich Foundation. Available online at https://www.hinrichfoundation.com/research/wp/tech/us-china-decoupling-tech/, checked on 2/23/2021.

Carnap, Kai von; Drinhausen, Katja; Shi-Kupfer, Kristin (2020): Tracing. Testing. Tweaking. Approaches to data-driven Covid-19 management in China. MERICS. Available online at https://merics.org/en/report/tracing-testing-tweaking, checked on 2/23/2021.

Carter, William A.; Crumpler, William D. (2019): Smart Money on Chinese Advances in AI.

Casanova, Robert (2019): The Industrial Robotics Industry in China: Demand and Domestic Innovation. In *Executive Briefing on Trade*. Available online at https://www.usitc.gov/publications/332/executive_briefings/chinese_industrial_robots.pdf, checked on 1/14/2021.

Cebr (2020): World Economic League Table 2021. Cebr, checked on 2/3/2021.

Center for Security and Emerging Technology (Ed.) (2020): China Creates National New Generation Artificial Intelligence Innovation and Development Pilot Zones. Translation. Available online at

https://cset.georgetown.edu/research/china-creates-national-new-generation-artificial-intelligence-innovation-and-development-pilot-zones/, checked on 1/19/2021.

Central Compilation & Translation Press (Ed.) (2016): The 13th-Five-Year Plan. For Economic and Social Development of The People's Republic of China (2016-2020). Beijing. Available online at https://policy.asiapacificenergy.org/sites/default/files/The%2013th%20Five-Year%20Plan%20For%20economic%20and%20social%20development%20of%20the%20People%27s%20Republic%20of%20China.pdf, checked on 1/21/2021.

Cheng, Cindy; Barceló, Joan; Hartnett, Allison Spencer; Kubinec, Robert; Messerschmidt, Luca (2020): COVID-19 Government Response Event Dataset (CoronaNet v.1.0). In *Nature human behaviour* 4 (7), pp. 756–768. DOI: 10.1038/s41562-020-0909-7.

Cheng, Hong; Jia, Ruixue; Li, Dandan; Li, Hongbin (2019): The Rise of Robots in China. In *Journal of Economic Perspectives* 33 (2), pp. 71–88. DOI: 10.1257/jep.33.2.71.

Chengjin, Xu (2020): Chinese Government's Approach to Smart Manufacturing. Edited by Center for International Economic and Technological Cooperation, MIIT. Available online at https://www.miti.gov.my/miti/resources/Industry4Point0/Chinese_Governments_Approach_to_Smart_Manufacturing.pdf, checked on 1/18/2021.

China (Shanghai) Pilot Free Trade Zone (Ed.) (2018): Shanghai unveils plans for new manufacturing centers. Available online at http://en.china-shftz.gov.cn/2018-06/06/c_256972.htm, updated on 1/5/2021, checked on 5/1/2021.

China Academy of Information and Communications Technology (Ed.) (2019): Big Data White Paper (2019). Available online at http://www.caict.ac.cn/english/research/whitepapers/202003/P020200327550643303469.pdf, checked on 1/21/2021.

China Automotive Battery Research Institute CABRI (Ed.) (2020): About CABRI. Available online at http://www.glabat.com/class/view?id=54, updated on 1/5/2021, checked on 5/1/2021.

China Daily (Ed.) (2015): China unveils 'Internet Plus' action plan to fuel growth - Business. Available online at https://www.chinadaily.com.cn/business/tech/2015-07/04/content_21181256.htm, checked on 1/20/2021.

China Daily (Ed.) (2017): Guiyang ambitious to shape China's 'Big Data Valley'. Available online at https://www.chinadaily.com.cn/m/guizhou/guiyang/2017-12/01/content_36078640.htm, checked on 1/22/2021.

China Daily (Ed.) (2019): Governance Principles for the New Generation Artificial Intelligence--Developing Responsible Artificial Intelligence. Available online at https://www.chinadaily.com.cn/a/201906/17/WS5d07486ba3103dbf14328ab7.html, updated on 6/17/2019, checked on 1/22/2021.

China Electronics Standardization Institute (Ed.) (2020a): Original CSET Translation of "Artificial Intelligence Standardization White Paper" [人工智能标准化白皮书（2018版)]. Translation. Available online at https://cset.georgetown.edu/research/artificial-intelligence-standardization-white-paper/, checked on 1/28/2021.

China Electronics Standardization Institute (Ed.) (2020b): 全国信息技术标准化技术委员会人工智能分技术委员会获批成立. Available online at http://www.cesi.cn/202004/6294.html, checked on 1/28/2021.

China Intelligent and Connected Vehicles (Beijing) Research Institute (Ed.) (2020): About CICV Intelligent and Connected Vehicles (Beijing) Research Institute Co.,Ltd. Available online at http://www.china-icv.cn/en/about, checked on 1/5/2021.

China Robot Industry Alliance (Ed.) (2020): About CRIA. Available online at http://cria.mei.net.cn/English/AboutCRIA.asp, checked on 1/29/2021.

china.org.cn (2020): China speeds up 'new infrastructure' investment to combat economic pressure. Available online at http://www.china.org.cn/business/2020-03/05/content_75777877.htm, checked on 2/23/2021.

chinainnovationfunding.eu (Ed.) (2020): Publication of the "New Generation AI Governance Principles – Developing Responsible AI" - China Innovation Funding. Available online at http://chinainnovationfunding.eu/dt_testimonials/publication-of-the-new-generation-ai-governance-principles-developing-responsible-ai/, updated on 12/11/2020, checked on 1/18/2021.

Chipman Koty, Alexander (2020): China's Two Sessions 2020: What Have We Learnt So Far, 2020. Available online at https://www.china-briefing.com/news/chinas-two-sessions-2020-learnt-far/, checked on 2/23/2021.

CloudMinds (Ed.) (2020): About CloudMinds Technology | We Make Robots Smarter. Available online at https://www.en.cloudminds.com/about-cloudminds/, checked on 1/27/2021.

CloudWalk (Ed.) (2020): Business Scope. Available online at https://www.cloudwalk.com/en/About, updated on 1/27/2021, checked on 1/27/2021.

clustercollaboration.eu (Ed.) (2018): China city-clusters policy: clusters to boost regional development. Available online at https://www.clustercollaboration.eu/news/china-city-clusters-policy-clusters-boost-regional-development, updated on 8/31/2018, checked on 1/13/2021.

cnet.com (2020): Coronavirus care at one hospital got totally taken over by robots. cnet.com. Available online at https://www.cnet.com/news/coronavirus-care-at-one-hospital-got-taken-over-by-robots/, checked on 2/23/2021.

Colvin, Thomas J.; Liu, Irina; Babou, Talla F.; Wong, Gifford J. (2020): A brief examination of Chinese Government Expenditures on Artificial Intelligence R&D. Available online at https://www.ida.org/-/media/feature/publications/a/ab/a-brief-examination-of-chinese-government-expenditures-on-artificial-intelligence-r-and-d/d-12068.ashx, checked on 18.01.21.

Copan, Walter G. (2019): NIST Update Visiting Committee on Advanced Technology. Available online at https://www.nist.gov/system/files/documents/2019/10/28/1.copan-v2_1.pdf, checked on 1/5/2021.

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (Ed.) (2020): Policy Update. Industrial Big Data. Available online at https://www.plattform-i40.de/PI40/Redaktion/EN/Downloads/Publikation/China/industrial_big_data_i4.0_project.pdf?__blob=publicationFile&v=5, checked on 1/22/2021.

DEVELOPMENT Solutions Europe Ltd. (Ed.) (2018): Advance EU Access to Financial Incentives for Innovation in China. Guide for EU Stakeholders onChinese national STI funding programmes. European Union (FWC FPI/PSF/2015 Lot 4). Available online at https://ec.europa.eu/research/iscp/pdf/201801_guide_cn_sti_programmes.pdf, checked on 1/21/2021.

DJI (Ed.) (2020): Über uns - DJI. Available online at https://www.dji.com/de/company, checked on 1/8/2021.

economist.com (2020): China calls its "heroic" handling of covid-19 proof of its wisdom. In *The Economist*, 2020. Available online at https://www.economist.com/china/2020/10/17/china-calls-its-heroic-handling-of-covid-19-proof-of-its-wisdom, checked on 2/23/2021.

Estolatan, Eric; Geuna, Aldo; Guerzoni, Marco; Nuccio, Massimiliano (2018): MAPPING THE EVOLUTION OF THE ROBOTICS INDUSTRY: A CROSS COUNTRY COMPARISON. Munk School of Global Affairs & Public Policy; University of Toronto (Innovation Policy White Paper Series, 2), checked on 1/8/2021.

Estun Automation (Ed.) (2020): Company Profile. Available online at http://en.estun.com/AboutUs.aspx?id=479, checked on 1/8/2021.

European Centre for Disease Prevention and control (2020): Covid-19. Available online at https://www.ecdc.europa.eu/en/covid-19, checked on 2/22/2021.

Frietsch, Rainer (2020): Current R&I policy: The future development of China´s R&I system. In *Fraunhofer ISI Discussion Papers Innovation Systems and Policy Analysis* (63). Available online at https://www.isi.fraunhofer.de/content/dam/isi/dokumente/cci/innovation-systems-policy-analysis/2020/discussionpaper_63_2020.pdf, checked on 1/5/2021.

ft.com (2020): Xi Jinping faces China's Chernobyl moment. In *Financial Times*, 2020. Available online at https://www.ft.com/content/6f7fdbae-4b3b-11ea-95a0-43d18ec715f5, checked on 2/23/2021.

Geek+ (Ed.) (2020): About Us. Available online at https://www.geekplus.com.cn/company/, checked on 1/27/2021.

Global Times (2020): COVID-19 infections would be much fewer if strict Covid-19 infections would be much fewer if strict measures implemented in early December: Zhong Nanshan. In *Global Times*. Available online at https://www.globaltimes.cn/content/1180946.shtml, checked on 2/23/2021.

Grieger, Gisela (2020): China's economic recovery and dual circulation model. European Parliament Think Tank. Available online at https://www.europarl.europa.eu/thinktank/en/document.html?reference=EPRS_BRI(2020)659407, checked on 2/23/2021.

Grossman, Derek; Curriden, Christian; Ma, Logan; Polley, Lindsey; Williams, J. D.; Cooper III, Cortez A. (2020): Chinese Views of Big Data Analytics. Edited by RAND Corporation. Available online at https://www.rand.org/content/dam/rand/pubs/research_reports/RRA100/RRA176-1/RAND_RRA176-1.pdf, checked on 1/26/2021.

Gu, Xin; Ying, Shan; Zhang, Weiqiang; Tao, Yewei (2020): How Do Firms Respond to COVID-19? First Evidence from Suzhou, China. In *Emerging Markets Finance and Trade* 56 (10), pp. 2181–2197. DOI: 10.1080/1540496X.2020.1789455.

Guiyang Government (Ed.) (2020): Big data industry. Available online at http://english.guiyang.gov.cn/2020-05/12/c_365595.htm, checked on 1/22/2021.

Haacke, Owen (2014): NDRC Prepares for Next Five-Year Plan, Focuses on Quality over Quantity. Edited by The US-China Business Council. Available online at https://www.uschina.org/ndrc-prepares-next-five-year-plan-focuses-quality-over-quantity, updated on 5/1/2014, checked on 1/26/2021.

Haasbroek, Michiel (2020): Stimulus package reveals China’s financial constraints. MERICS. Available online at https://merics.org/en/analysis/stimulus-package-reveals-chinas-financial-constraints, checked on 2/23/2021.

He, Yujia; Bowser, Anne (2017): How China is preparing for an AI-powered Future (Wilson Briefs). Available online at https://www.researchgate.net/profile/Yujia_He/publication/317881261_How_China_is_Preparing_for_an_AI-powered_Future/links/595a6b43a6fdcc36b4d7b3fb/How-China-is-Preparing-for-an-AI-powered-Future.pdf, checked on 1/14/2021.

Heimberger, Heidi; Horvat, Djerdj; Kroll, Henning; Shauchuk, Palina (2020): Advanced technologies for industry. International reports: report on China: technological capacities and key policy measures. Edited by European Commission. Brussels.

Hert, Paul de; Papakonstantinou, Vagelis (2015): The data protection regime in China. In-depth Analysis for the LIBE Committee. European Parliament. Brussels. Available online at https://www.europarl.europa.eu/RegData/etudes/IDAN/2015/536472/IPOL_IDA(2015)536472_EN.pdf, checked on 1/20/2021.

HIT Robot Group (Ed.) (2020): HIT Robot Group Index. National Robot Innovation Center. Available online at http://www.hrgrobotics.cn/en/innovation_platform/index, checked on 1/5/2021.

Holzmann, Anna; Meinhardt, Caroline (2020): MERICS China Industries Briefing - October 2020. Available online at https://merics.org/en/briefing/merics-china-industries-briefing-october-2020, updated on 1/20/2021, checked on 1/20/2021.

Huang, Yi; Wang, Pengfei; Xu, Zhiwei (2020): Saving China from the coronavirus and economic meltdown: Experiences and lessons. CEPR. Available online at https://voxeu.org/article/saving-china-coronavirus-and-economic-meltdown-experiences-and-lessons, checked on 2/23/2021.

Hunan Government (Ed.) (2020): National Advanced Rail Transit Equipment Innovation Center Opens-Hunan Government Website International-enghunan.gov.cn. Available online at http://www.enghunan.gov.cn/hneng/News/Localnews/202011/t20201105_13951366.html, updated on 1/15/2021, checked on 1/15/2021.

Huotari, Mikko; Weidenfeld, Jan; Wessling, Claudia (2020): Towards a "Principles First Approach" in Euope's China Policy. Drawing lessons from the Covid-19 crisis. MERICS. Available online at https://merics.org/sites/default/files/2020-09/200910_MPOC_EU-China_final_0.pdf, checked on 2/23/2021.

iCarbonX (2020): Our Difference - iCarbonX. Available online at https://www.icarbonx.com/en/about.html, checked on 1/27/2021.

iFlyTek (Ed.) (2020): about us. Available online at https://www.iflytek.com/en/about-us.html, checked on 1/12/2021.

IMF (2021): Policy responses to Covid-19. IMF. Available online at https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19, checked on 2/23/2021.

Institute for Security & Development Policy (2018): Made-in-China-Backgrounder. Available online at https://isdp.eu/content/uploads/2018/06/Made-in-China-Backgrounder.pdf, checked on 1/5/2021.

Institute of Advanced Manufacturing Technology (Ed.) (2020): Brief Introduction. Available online at http://english.cime.cas.cn/au/, updated on 10/24/2014, checked on 1/5/2021.

International Federation of Robotics (Ed.) (2020a): Executive Summary World Robotics 2020 Industrial Robots. Available online at https://ifr.org/img/worldrobotics/Executive_Summary_WR_2020_Industrial_Robots_1.pdf, checked on 1/12/2021.

International Federation of Robotics (Ed.) (2020b): World Robotics R&D Programs. Frankfurt (Information paper). Available online at https://ifr.org/downloads/hidden/200601_World_Robotics_RD_Program_v01.pdf, checked on 1/14/2021.

International Organization for Standardization (Ed.) (2020): SAC. Available online at https://www.iso.org/member/1635.html, checked on 1/28/2021.

Ives, Jaqueline; Holzmann, Anna (2018): Local governments power up to advance China's national AI agenda. Edited by merics.org. Available online at https://merics.org/en/analysis/local-governments-power-advance-chinas-national-ai-agenda, updated on 1/19/2021, checked on 1/19/2021.

Jia, Hepeng (2020): Yi Zeng: promoting good governance of artificial intelligence. In *National Science Review* 7 (12), pp. 1954–1956. DOI: 10.1093/nsr/nwaa255.

Jia, Kai; Kenney, Martin; Mattila, Juri; Seppälä, Timo (2018): The Application of Artificial Intelligence at Chinese Digital Platform Giants: Baidu, Alibaba and Tencent (BRIE Working Paper, 2). Available online at https://brie.berkeley.edu/sites/default/files/brie_working_paper_2018-2.pdf, checked on 1/18/2021.

Jiang, Chunyu (2018): Big Data Industry in China. Edited by China Academy of Information and Communications Technology (CAICT). Available online at https://www.itu.int/en/ITU-D/Regional-Presence/CIS/Documents/Events/2018/06_Tashkent/Presentations/ITU%20Workshop%2019%20June%202018%20-%20Chunyu%20Jiang.pdf, checked on 1/18/2021.

Jie, Wen (2020): National printing flexible display a breakthrough innovation center construction. Edited by Shenzhen When Jie. Available online at https://www.wenjie-printing.com/national-printing-flexible-display-a-breakthrough-innovation-center-construction, updated on 10/20/2020, checked on 5/1/2021.

Jing, Meng; Dai, Sarah (2017): China recruits Baidu, Alibaba and Tencent to AI 'national team'. In *South China Morning Post*, 11/21/2017. Available online at https://www.scmp.com/tech/china-tech/article/2120913/china-recruits-baidu-alibaba-and-tencent-ai-national-team, checked on 1/18/2021.

Jun, Xi (2019): China establishes government-led, SOE-backed fund worth $21b to push industrial upgrading - Global Times. Edited by Global Times. Available online at https://www.globaltimes.cn/content/1170551.shtml, updated on 11/21/2019, checked on 1/7/2021.

KPMG International (2021): China - Government and institution Measures in response to Covid-19. KPMG International. Available online at https://home.kpmg/xx/en/home/insights/2020/04/china-government-and-institution-measures-in-response-to-covid.html, checked on 2/23/2021.

Lewis, James Andrew (2019): China's Pursuit of Semiconductor Independence. CSIS. Available online at https://www.csis.org/analysis/chinas-pursuit-semiconductor-independence, checked on 2/23/2021.

Li, Baozhong (2019): Development of power swap system based on unmanned electric tractor. Available online at http://www.nttzzc.com/pdf/27.pdf, checked on 1/5/2021.

Lin, I-Ting Shelly (2018): The Robotics Industry in China - China Briefing News. Edited by China Briefing. Available online at https://www.china-briefing.com/news/chinas-robot-industry/, updated on 12/9/2019, checked on 1/8/2021.

Lingzhi Technology (Ed.) (2018): The National Intelligent Sensor Innovation Center settled in Shanghai, Lingzhi won new opportunities for development – Shanghai LINGZHI Technology Co., Ltd. Available online at http://en.lingzhitech.com/698.html, updated on 8/17/2018, checked on 1/5/2021.

Linkedin (Ed.) (2020): National Innovation Institute of Additive Manufacturing (NIIAM). Available online at https://de.linkedin.com/company/national-innovation-institute-of-additive-manufacturing%EF%BC%88niiam%EF%BC%89, updated on 1/5/2021, checked on 5/1/2021.

Lu, Quan; Cai, Zehao; Chen, Bin; Liu, Tao (2020): Social Policy Responses to the Covid-19 Crisis in China in 2020. In *International Journal of Environmental Research and Public Health* 17 (16). DOI: 10.3390/ijerph17165896.

Marr, Bernard (2019): Meet The World's Most Valuable AI Startup: China's SenseTime. Edited by Forbes. Available online at https://www.forbes.com/sites/bernardmarr/2019/06/17/meet-the-worlds-most-valuable-ai-startup-chinas-sensetime/, updated on 6/17/2019, checked on 1/27/2021.

Megvii (Ed.) (2020): https://en.megvii.com/about_megvii. Available online at https://en.megvii.com/about_megvii, checked on 1/27/2021.

Midea Group (Ed.) (2020): About us. Available online at https://www.midea-group.com/About-Us, checked on 1/11/2021.

Ministry of Science and Technology (Ed.) (2017): Next Generation Artificial Intelligence Development Plan Issued by State Council. China's Strengths Creates Innovation Miracles. Department of International Cooperation Ministry of Science and Technology (MOST) (China Science & Technology Newsletter, 17). Available online at http://fi.china-embassy.org/eng/kxjs/P020171025789108009001.pdf, checked on 1/21/2021.

MOST (2020): Ministry of Science and Technology Introduction. Available online at https://www.most.gov.tw/most/attachments/4cfb868e-6946-4395-b5b1-ebcd7b5151d1?, checked on 18.01.21.

Murphy, Ben (2020a): Profiles of Members of China's New Generation Artificial Intelligence Strategic Advisory Committee. Translation. Edited by Center for Security and Emerging Technology. Available online at https://cset.georgetown.edu/wp-content/uploads/t0122_AI_advisory_committee_EN.pdf, checked on 1/18/2021.

Murphy, Flynn (2020b): Inside China's response to COVID. In *Nature* 588 (7836), S49-S51. DOI: 10.1038/d41586-020-03361-7.

Nan, Hao (2016): Country developing new age of robotics with patent efforts. Edited by China Daily. Available online at http://www.chinadaily.com.cn/kindle/2016-02/03/content_23375544.htm, checked on 1/2/2021.

National Development and Reform Commission (Ed.) (2008a): Main Functions of the NDRC. Available online at https://en.ndrc.gov.cn/mfndrc_8237/200812/t20081217_1193980.html, updated on 12/17/2008, checked on 1/26/2021.

National Development and Reform Commission (Ed.) (2008b): The Outline of the Plan for the Reform and Development of the Pearl River Delta (2008-2020). Available online at https://en.ndrc.gov.cn/policyrelease_8233/200901/P020191101482240854534.doc, checked on 1/26/2021.

NBSC (2021): National Economy Recovered Steadily in 2020 with Main Goals Accomplished Better Than Expectation. NBSC. Available online at http://www.stats.gov.cn/english/PressRelease/202101/t20210118_1812432.html, checked on 2/23/2021.

Ning, Lai (2018): Continually Evolving "World Factory" : Manufacturing Power Strategy on Show in "Made in China 2025" : Hitachi Review. In *Hitachi Review* 67 (2), pp. 172–179. Available online at

https://www.hitachi.com/rev/archive/2018/r2018_02/pdf/P034_041_R2-9_GIR.pdf, checked on 1/8/2021.

OECD (2020a): Economic Outlook for Southeast Asia, China and India 2021. Reallocating resources for digitalisation. OECD.

OECD (Ed.) (2020b): Three-year Guidance for Internet Plus Artificial Intelligence Plan. Available online at https://www.oecd.ai/dashboards/policy-initiatives/2019-data-policyInitiatives-24471, updated on 7/28/2020, checked on 1/22/2021.

OECD STIP Compass (2020): Applying information technology services to tackle COVID-19. Available online at https://stip.oecd.org/covid/policy-initiatives/covid%2Fdata%2FpolicyInitiatives%2F1229, checked on 2/23/2021.

OxCGRT (2021): Oxford Coronavirus Government Response Tracker. University of Oxford. Available online at https://www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker, checked on 2/23/2021.

People's Daily Online (Ed.) (2006): The State Council. Available online at http://en.people.cn/data/organs/statecouncil.shtml, updated on 3/17/2006, checked on 1/26/2021.

People's Daily Online (Ed.) (2016): National Institute Corporation of Additive Manufacturing Xi'an is inaugurated. Available online at http://en.people.cn/n3/2016/1019/c209361-9129565.html, updated on 10/19/2016, checked on 5/1/2021.

NBSC (2021): Preliminary Accounting Results of GDP for the Fourth Quarter and the Whole Year of 2020. Available online at http://www.stats.gov.cn/english/PressRelease/202101/t20210120_1812680.html, checked on 2/23/2021.

Quan, Kang (2020): What are the Chinese examination standards for AI-related inventions? Edited by managingip.com. Available online at https://www.managingip.com/article/b1n06p9symf6mt/what-are-the-chinese-examination-standards-for-ai-related-inventions, checked on 1/26/2021.

Ray, Jonathan; Atha, Katie; Francis, Edward; Dependahl, Caleb; Mulvenon, James; Alderman, Daniel; Ragland-Lucie, Leigh Ann (2016): China's Industrial and Military Robotics Development. Edited by U.S.-China Economic and Security Review Commission. Center for Intelligence Research and Analysis. Available online at https://www.uscc.gov/sites/default/files/Research/DGI_China's%20Industrial%20and%20Military%20Robotics%20Development.pdf, checked on 1/14/2021.

Roberts, Huw; Cowls, Josh; Morley, Jessica; Taddeo, Mariarosaria; Wang, Vincent; Floridi, Luciano (2020): The Chinese approach to artificial intelligence: an analysis of policy, ethics, and regulation. In *AI & Soc*. DOI: 10.1007/s00146-020-00992-2.

ROOBO (Ed.) (2020): About Us - Globally Oriented AI Solution Provider. Available online at https://www.roobo.com/en/aboutUs.html, checked on 1/27/2021.

Seconded European Standardization Expert for China (Ed.) (2020): Main Points of National Standardisation Work in 2020 (SAC Issue, 8). Available online at https://www.sesec.eu/app/uploads/2020/04/Main-Points-of-National-Standardisation-Work-in-2020.pdf, checked on 1/29/2021.

SenseTime (Ed.) (2020): About Us. Available online at https://www.sensetime.com/en/about-index#1, checked on 1/27/2021.

Shenggao, Yuan (2019): Guiyang grows its global influence via big data. Edited by China Daily. Available online at http://global.chinadaily.com.cn/a/201905/24/WS5ce754c2a3104842260bd94b_1.html, updated on 5/24/2019, checked on 1/22/2021.

Shenyang Institute of Automation, Chinese Academy of Sciences (Ed.) (2020): Brief Introduction of SIACAS. Available online at http://english.sia.cas.cn/au/bi/202011/t20201111_249067.html, updated on 11/11/2020, checked on 1/8/2021.

Shenzhen Research Institute of Big Data (Ed.) (2020): About us. Available online at http://www.sribd.cn/index.php/en/about-us.html, checked on 1/12/2021.

Shi-Kupfer, Kristin; Ohlberg, Mareike (2019): China's digital rise. Challenges for Europe. Mercator Institute for China Studies (Merics Papers on China, 7), checked on 2/12/2020.

Si, Ma (2019): Fund to boost industrial restructuring. Edited by State Council. Available online at http://english.www.gov.cn/policies/policywatch/201911/13/content_WS5dcb3dfcc6d0bcf8c4c16fc2.html, updated on 11/13/2019, checked on 1/4/2020.

SIASUN (Ed.) (2020): About us. Available online at http://www.siasun.com/index.php?m=content&c=index&a=lists&catid=78, checked on 1/8/2021.

State Council (Ed.) (2014): Ministry of Industry and Information Technology. Available online at http://english.www.gov.cn/state_council/2014/08/23/content_281474983035940.htm, updated on 7/18/2019, checked on 1/8/2021.

State Council (Ed.) (2015a): 'Made in China 2025' plan issued. Available online at http://english.www.gov.cn/policies/latest_releases/2015/05/19/content_281475110703534.htm, updated on 5/19/2015, checked on 1/26/2021.

State Council (Ed.) (2015b): China seeks to promote big data. Available online at http://english.www.gov.cn/policies/latest_releases/2015/09/05/content_281475183253390.htm, updated on 7/18/2019, checked on 1/22/2021.

State Council (Ed.) (2016): China releases 3-year guidance for Internet plus AI development. Available online at http://english.www.gov.cn/news/video/2016/05/24/content_281475356234629.htm, updated on 11/5/2019, checked on 1/22/2021.

State Council (Ed.) (2019): Premier: China welcomes advanced manufacturing. Available online at http://english.www.gov.cn/premier/news/201910/18/content_WS5da9c13bc6d0bcf8c4c15652.html, updated on 10/18/2019, checked on 1/5/2021.

Statista.com: Coronavirus COVID-19 in China - statistics & facts. Available online at https://www.statista.com/topics/5898/novel-coronavirus-covid-19-in-china/.

Sutherland, Michael D. (2020): China's Corporate Social Credit System. Edited by Congressional Research Service (CRS) (IF11342). Available online at https://crsreports.congress.gov/product/pdf/IF/IF11342, checked on 1/20/2021.

Sutter, Karen M. (2020): "Made in China 2025" Industrial Policies: Issues for Congress. Edited by Congressional Research Service (CRS) (IF10964). Available online at https://fas.org/sgp/crs/row/IF10964.pdf, checked on 1/5/2021.

Teller Report (Ed.) (2020): National Advanced Rail Transit Equipment Innovation Center was unveiled in Zhuzhou, Hunan. Available online at https://www.tellerreport.com/business/2020-11-04-national-advanced-rail-transit-equipment-innovation-center-was-unveiled-in-zhuzhou--hunan.S1_WpYpJKw.html, checked on 1/15/2021.

Tencent (Ed.) (2020): about us. Available online at https://www.tencent.com/en-us/about.html, checked on 1/12/2021.

The Economist (2018): A tale of 19 mega-cities - China is trying to turn itself into a country of 19 super-regions. In *The Economist*, 6/23/2018. Available online at https://www.economist.com/china/2018/06/23/china-is-trying-to-turn-itself-into-a-country-of-19-super-regions, checked on 1/13/2021.

The World Bank (2020a): From Recovery to Rebalancing: China's Economy in 2021. The World Bank. Available online at http://documents1.worldbank.org/curated/en/297421610599411896/pdf/From-Recovery-to-Rebalancing-China-s-Economy-in-2021.pdf, checked on 2/23/2021.

The World Bank (2020b): Leaning Forward: Covid-19 and China's Reform Agenda. The World Bank (China Economic Update). Available online at http://pubdocs.worldbank.org/en/438251594293079547/ceu-July-2020-en.pdf, checked on 2/23/2021.

Triolo, Paul; Kania, Esa; Webster, Graham (2018): Translation: Chinese government outlines AI ambitions through 2020. Edited by New America. Available online at https://www.newamerica.org/cybersecurity-initiative/digichina/blog/translation-chinese-government-outlines-ai-ambitions-through-2020/, checked on 1/22/2021.

U.S. Department of Commerce (Ed.) (2020): Commerce Department to Add Nine Chinese Entities Related to Human Rights Abuses in the Xinjiang Uighur Autonomous Region to the Entity List. Available online at https://www.commerce.gov/news/press-releases/2020/05/commerce-department-add-nine-chinese-entities-related-human-rights, updated on 5/22/2020, checked on 1/27/2021.

UBTech (Ed.) (2020): About UBTECH Robotics. Available online at https://www.ubtrobot.com/pages/about-ubtech?ls=en, checked on 1/27/2021.

United Nations Economic and Social Commission for Asia and the Pacific (Ed.) (2012): Guiding the shift to a new economic system China's National Development and Reform Commission (Low Carbon Green Growth Roadmap for Asia and the Pacific). Available online at https://www.unescap.org/sites/default/files/12.%20CS-China-National-Development-and-Reform-Commission.pdf, checked on 1/26/2021.

United States Information Technology Office (Ed.): Three Year Action Plan Focuses on Next Generation Artificial Intelligence. Available online at http://www.usito.org/news/three-year-action-plan-focuses-next-generation-artificial-intelligence, checked on 1/22/2021.

US-China Business Council (Ed.) (2018): China National Intellectual Property Administration (CNIPA). Available online at https://www.uschina.org/sites/default/files/2018.12.18_cnipa_0.pdf, checked on 1/27/2021.

weforum.com (2020): China's 'six priorities' and fiscal stimulus will spearhead its COVID-19 recovery. In *World Economic Forum*, 2020. Available online at https://www.weforum.org/agenda/2020/06/china-stimulus-covid19-economic-recovery/, checked on 2/23/2021.

Wei, He (2019): Shanghai launches AI investment fund. Edited by China Daily. Available online at http://www.chinadaily.com.cn/a/201908/31/WS5d6a6bd3a310cf3e35568fc9.html, updated on 8/31/2019, checked on 1/22/2021.

Wei, Jun (2020): Newly Amended China Patent Examination Guidelines Effective February 1, 2020. Edited by National Law Review. Available online at https://www.natlawreview.com/article/newly-amended-china-patent-examination-guidelines-effective-february-1-2020, updated on 1/26/2021, checked on 1/26/2021.

WHO (2021): Draft landscape and tracker of COVID-19 candidate vaccines. Available online at https://www.who.int/publications/m/item/draft-landscape-of-covid-19-candidate-vaccines, checked on 2/22/2021.

Wong, Dorcas (2020a): How Can Foreign Technology Investors Benefit from China's New Infrastructure Plan? In *China Briefing*, 2020. Available online at https://www.china-briefing.com/news/how-foreign-technology-investors-benefit-from-chinas-new-infrastructure-plan/, checked on 2/23/2021.

Wong, Dorcas (2020b): What to Expect in China's 14th Five Year Plan After the Fifth Plenum? Edited by China Briefing. Available online at https://www.china-briefing.com/news/what-to-expect-in-chinas-14th-five-year-plan-decoding-the-fifth-plenum-communique/, updated on 12/29/2020, checked on 1/15/2021.

wsj.com: China's Covid-19 Vaccine Diplomacy Boosts Its Influence in Europe. In *The Wall Street Journal*. Available online at https://www.wsj.com/articles/chinas-covid-19-vaccine-diplomacy-boosts-its-influence-in-europe-11613221201, checked on 02/23.2021.

Wübbeke, Jost; Meissner, Mirjam; Zenglein, Max J.; Ives, Jaqueline; Conrad, Björn (2016): Made in China 2025. The making of a high-tech superpower and consequences for industrial countries. Available online at https://merics.org/de/studie/made-china-2025, checked on 18.01.21.

Wuhan East Lake High-tech Development Zone (Ed.) (2018a): National digital design innovation center unveiled. Available online at http://subsites.chinadaily.com.cn/eastlakehightechzone/2018-10/26/c_286026.htm, updated on 10/26/2018, checked on 1/5/2021.

Wuhan East Lake High-tech Development Zone (Ed.) (2018b): National optoelectronics center set up in OVC. Available online at http://www.chinaopticsvalley.com/2018-04/27/c_223351.htm, updated on 4/27/2018, checked on 1/5/2021.

Xiaoming, Yu (2019): Yangtze River Delta leads in advanced manufacturing - Chinadaily.com.cn. With assistance of China Daily. Available online at https://www.chinadaily.com.cn/a/201909/18/WS5d81a268a310cf3e3556c25a.html, updated on 9/18/2019, checked on 1/13/2021.

Xinhua.net (2020a): China says its COVID-19 peak is over. Available online at http://www.xinhuanet.com/english/2020-03/12/c_138870547.htm.

Xinhua.net (2020b): China's tax, fee cuts top 1.5 trillion yuan in H1. In *Xinhua*, 2020. Available online at http://www.xinhuanet.com/english/2020-08/08/c_139275745.htm, checked on 2/2/2021.

Yang, Zhaowei; Li, Jing (2021): Letter from China: Response after the first wave of COVID-19. In *Respirology (Carlton, Vic.)*. DOI: 10.1111/resp.13998.

Zarocostas, John (2021): WHO team begins COVID-19 origin investigation. In *The Lancet* 397 (10273), p. 459. DOI: 10.1016/S0140-6736(21)00295-6.

Zenglein, Max J.; Holzmann, Anna (2019): Evolving Made in China 2025. China's industrial policy in the quest for global tech leadership. Mercator Institute for China Studies. Available online at https://www.merics.org/sites/default/files/2019-07/MPOC_8_MadeinChina_2025_final_3.pdf, checked on 2/12/2020.

Zenglein, Max J.; Kaernfelt, Maximilian; Chimits, Francois (2021): MERICS Economic indicators - Economic recovery picks up over last quarter. MERICS. Available online at https://merics.org/en/tracker/economic-recovery-picks-over-last-quarter, checked on 2/23/2021.

Zhang, Longmei; Chen, Sally: China's Digital Economy. Opportunities and Risks. IMF (IMF Working Paper, WP/19/16). Available online at https://www.imf.org/~/media/Files/Publications/WP/2019/wp1916.ashx, checked on 2/12/2020.

Zhang, Shuxian; Wang, Zezhou; Chang, Ruijie; Wang, Huwen; Xu, Chen; Yu, Xiaoyue et al. (2020): COVID-19 containment: China provides important lessons for global response. In *Frontiers of medicine* 14 (2), pp. 215–219. DOI: 10.1007/s11684-020-0766-9.

Zhao, Bruno; Liu, Helen (2020): China's Supply Chains and Coronavirus: What's Next? Bain & Company. Available online at https://www.bain.com/insights/chinas-supply-chains-and-coronavirus-snap-chart/, checked on 2/23/2021.

MOST (2020): 多措并举 科技创新破解复工复产痛点——解读《关于科技创新支撑复工复产和经济平稳运行的若干措施》. Available online at http://www.most.gov.cn/kjzc/zdkjzcjd/202003/t20200323_152516.htm, checked on 2/23/2021.

MOST (2020): 科技部火炬中心印发《关于疫情防控期间进一步为各类科技企业提供便利化服务的通知》. Available online at http://www.most.gov.cn/tztg/202002/t20200206_151447.htm, checked on 2/23/2021.

About the 'Advanced Technologies for Industry' Project

The EU's industrial policy strategy promotes the creation of a competitive European industry. In order to properly support the implementation of policies and initiatives, a systematic monitoring of technological trends and reliable, up-to-date data on advanced technologies are needed. To this end, the Advanced Technologies for Industry (ATI) project has been set up. The project provides policymakers, industry representatives and academia with:

- Statistical data on the production and use of advanced technologies, including enabling conditions such as skills, investment and entrepreneurship
- Analytical reports, such as on technology trends, sector-based insights and products
- Analyses of policy measures and policy tools related to the uptake of advanced technologies
- Analysis of technology trends in competing economies, such as in the US, China and Japan
- Access to technology centres and innovation hubs across EU countries

You may find more information about the 16 technologies here: https://ati.ec.europa.eu.

The project has been undertaken on behalf of the European Commission – the Directorate General for Internal Market, Industry, Entrepreneurship, and SMEs and the European Innovation Council and Small and Medium-Sized Enterprises Executive Agency (EISMEA) – by IDC, Technopolis Group, Capgemini, Fraunhofer, IDEA Consult and NESTA.

EA-03-21-300-EN-N

Publications Office
of the European Union