POWERING CHINA'S DIGITAL FUTURE: STRATEGIES AND CHALLENGES

Erik BAARK

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Executive Summary

1. The Chinese leadership has prioritised establishing new advanced digital infrastructure in the 2018 central policy statements. Accordingly, Chinese mobile telecommunications operators had expanded the network to include 1.4 million 5G base stations by end 2021, or more than 60% of the world's 5G base stations.

2. China still faces a shortage of new and exciting 5G applications to drive consumer uptake of new services and profitable industrial applications, reflecting a typical Chinese top-down policy failure and a "infrastructure first" syndrome, similar to building highways before knowing their car usage.

3. Nevertheless, a successful experience in adopting 5G based networks was edge computing by the electric power grid operators in China. As a result, seven of the top 10 organisations with the most patent filings for edge computing in 2021 were grid operators based in China.

4. Provinces in the east coast are the main beneficiaries of the expansion of digital infrastructure with the higher improvement in total factor productivity. Cloud computing is another example of an uneven distribution of digital infrastructure, which in 2020 led to the "Eastern Data, Western Computing" plan to distribute data centre resources more equally in the country.

5. Internationally, concerns about national security in the United States and allied countries have reduced the extent to which leading Chinese telecommunications equipment producers such as Huawei and ZTE can export to these countries. The approaches of European nations have reflected the same concerns, but each country has chosen its own way to securitise networks.

6. The supply of a digital infrastructure such as 5G, data centres and surveillance equipment has also been an important component of the Digital Silk Road. In general, the reception of Chinese suppliers has been very positive in Central Asia

and Africa, but countries in Southeast Asia have shown different approaches to the import of Chinese systems.

7. US-China geopolitical conflict has dampened Chinese efforts to achieve domestic and international digital transitions. The placement of 468 Chinese persons or firms on the Entity List, restricting the export of products, components or software by US firms, has reduced China's access to vital integrated circuits and equipment for upgrading microchip production.

8. In response, the Chinese has intensified policy measures and direct support to boost technological capabilities and production facilities in the sanctioned high technology sectors. While China has also created its own "Unreliable Entity List" (UEL) in September 2020 and adopted an Anti-Foreign Sanctions Law in June 2021, it has not implemented them against any US firms.

9. While a decoupling between the United States and China for telecommunications, semiconductors and other advanced technology sectors presents challenges to China's plans for rapid expansion of its digital infrastructure, it is unlikely that a major decoupling will dampen China's ambitions – rather, it would amplify them.

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Erik BAARK*

A Key Political Commitment by Xi Jinping

1.1 In a January 2022 paper in *Qiushi*, the official journal of the Chinese Communist party (CCP), President Xi Jinping provided details of his personal commitment to promoting the digital economy:

> "I myself have been paying close attention to the development of digital technologies and the digital economy for a long time now. In 2000 when I was working in Fujian Province, I put forward the "Digital Fujian" initiative, and I also proposed the development of a "Digital Zhejiang" in 2003 when I worked in Zhejiang Province…"[1]

1.2 The paper enumerates the emphasis on promoting the digital economy in Xi's speeches and multiple leadership decisions since the CCP's 18th National Congress in 2012, and outlines the role of a digital transition in China's current and future development. However, Xi also notes the challenges: "We should, however, also be aware that when compared with the world's major digital players and powerhouses, China's digital economy, while large in size, is not yet strong enough, and though growing quickly, is not yet competitive enough".

1.3 A strategy to promote a digital economy encompasses a wide range of technologies and policy issues. China's policies seek to enhance the development and production of core information and communication technologies (ICT), including the production of advanced semiconductor microchips and creation of successful 5G mobile communication networks. China has already established advanced capabilities in most sectors of ICT hardware manufacture and systems applications,

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* Erik Baark is Professor Emeritus at the Hong Kong University of Science and Technology.

[1] Xi Jinping, "Building Up the Strength, Quality, and Size of China's Digital Economy" *Qiushi,* no 2, 2022. http://en.qstheory.cn/2022-03/03/c_721608.htm (accessed 13 April 2022).

but is still dependent on foreign suppliers for essential components. The strategy to promote a digital economy also seeks to promote the creation of advanced capabilities in artificial intelligence (AI) and cloud computing facilities for service providers to offer sophisticated services to consumers and industries.

1.4 As part of the priority to establish new advanced digital infrastructure in China as set out in central policy statements in 2018, Chinese mobile telecommunications operators have expanded the mobile communications network to include 1.4 million 5G base stations by the end of 2021, accounting for more than 60% of the world's 5G base stations. The 5G network has thus been described as nation-wide, covering all prefecture-level cities, more than 98% of county cities and 80% of townships. Although this represents an impressive achievement, the number of 5G base stations per 10,000 people in China has so far only reached 10.1.[2]

1.5 In fact, policymakers in China face new challenges in their efforts to make the digital transition a cornerstone in their economic strategies. First, the progress achieved in the domestic economy depends on the willingness and ability of private entrepreneurs to create efficient and cost-effective applications that will significantly raise productivity in industry and/or entertainment value for private consumers. Second, issues relating to unequal access to digital facilities in eastern or western regions of China and other forms of digital divide, will need to be addressed. Third, China's new capabilities in production and application of advanced digital systems have encountered international reactions that threaten to undermine the leadership's aims in the short run, but might increase the country's capabilities in the long run.

The "Infrastructure First" Syndrome and Industry Applications

2.1 On the domestic front, China still faces a shortage of new and exciting 5G applications to drive consumer uptake of new services as well as profitable industrial applications. For example, Huawei Executive Director Ding Yun made an unusual comment in 2020, stating that China's 5G services were criticised by many

[2] https://www.tzbotautomation.com/news/hot-words-of-the-two-sessions-5g-helping-inte-55299498.html (accessed 25 April 2022).

customers as "fake, dumb and poor".[3] A year later Wang Jianzhou, a former chairman of China Mobile, argued that only "massive consumer-level applications" could take full advantage of the coverage and huge capacity of 5G networks. Although some industrial use systems had already been tested and put into practice, new consumer 5G applications were rare.[4]

2.2 The difficulties experienced in developing commercially profitable applications for consumers using 5G services reflects a typical Chinese top-down policy failure, what one Chinese expert has called the "infrastructure first" syndrome.[5] Simply put, it is similar to "building a road and waiting for the cars to arrive"; the telecommunications operators have been encouraged to invest heavily in 5G infrastructure in the hope that commercially viable consumer and industry applications would emerge.

2.3 The 5G equipment producers and service operators have been particularly eager to develop IoT applications for industry, mining and services, and have adopted new alliances to promote R&D and testing for such software. The Ministry of Industry and Information Technology has announced that China's 5G application cases have exceeded 10,000, covering key industries such as steel, electric power and mining.[6] A report titled *5G Use Cases for Verticals China 2021* describes 21 5G-empowered applications for verticals, ranging from industrial manufacturing, ports/mines, transportation, electric power, health care to content creation.[7]

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[3] https://www.lightreading.com/5g/fake-dumb-and-poor-huawei-exec-unloads-on-china-5g-/d/d-id/764654 (accessed 2 March 2022).

[4] https://www.lightreading.com/5g/we-need-new-kinds-of-5g-devices-says-ex-china-mobile-chief/d/d-id/769640? (accessed 2 March 2022).

[5] "5G yingyong guanjian shike: Taotai shu qian "yangban jian" xiangmu hou, naxie changjing zhengzai da guimo tuiguang? (The critical moment of 5G application: after eliminating thousands of "model room" projects, which scenarios are being promoted on a large scale?)" https://finance.sina.com.cn/tech/2021-10-17/doc-iktzqtyu1881651.shtml (accessed 5 March 2022).

[6] "Chinese firms push forward 5G application in industries, epidemic control" https://www.globaltimes.cn/page/202109/1233080.shtml (accessed 4 March 2022).

[7] https://www.gsma.com/greater-china/wp-content/uploads/2021/02/5G-Use-Cases-for-Vertical-China-2021-EN.pdf (accessed 4 March 2022).

2.4 Nevertheless, the paucity of ready-made 5G value-added applications for many industries is likely to reduce their enthusiasm for switching to 5G devices and networks. A 2021 survey among 600 automotive and electronic manufacturers undertaken by ABI Research identified an absence of clear business cases for industrial applications and the perceived high upfront investment need as the main barriers to deployment.[8]

2.5 So far, most of the applications that mobile vendors have installed have generally been "showroom-only" systems that have little commercial potential in the Chinese economy. Therefore, some vendors have dramatically reduced the number of new projects, retaining only those that implement a set of standardised solutions that can be customised for specific enterprise clients.[9]

2.6 For example, teleservice operators had developed a dedicated network for the transmission of a popular concert using 5G, but realised that it required dozens of people to run the network, while the organisers sold only a few more tickets. Similarly, a pilot project demonstrating telesurgery with 5G support also turned out to be too costly and was later dropped as a commercial product. Companies have concentrated new pilot projects on sectors such as the chemical industry and coal mining that are dominated by large groups and a large market, which are suitable for standardisation of customer packages that allow for large-scale replication from point to point.

2.7 Another issue that leading equipment vendors like Huawei or operators such as China Mobile have encountered in practice is their deficiencies in terms of domain knowledge and specialised technical competence for specific industrial or service sectors. For instance, coal mining companies may require unmanned mining trucks that can be remotely controlled by a system provider that engages people who are very familiar with navigation in mines. Huawei reportedly established a joint "Intelligent Mine Innovation Laboratory" in China's coal-producing province

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[8] "5G manufacturing in China – where the Industry 4.0 dream is becoming reality (Analyst Angle)" https://enterpriseiotinsights.com/20210913/channels/analyst-angle/5g-manufacturing-in-china-where-the-industry-4-0-dream-is-becoming-reality-analyst-angle (accessed 5 March 2022).

[9] https://www.lightreading.com/asia/china-culls-unprofitable-5g-use-cases-as-it-narrows-focus/d/d-id/772855 (accessed 5 March 2022).

Shanxi with 220 experts in 2021, of which 53 were experts in electronic technology from Huawei and more than 150 were coal mining experts.[10]

2.8 Service operators have also discovered that their conventional approaches to delivering and charging products may have to be adapted to the specific sector or industry segment. Previously, operators have been accustomed to charging customers on the basis of the amount of data traffic utilised by the customer, but have found that this approach does not work well in traditional enterprises. Small and medium-sized firms, for instance, have often preferred to make a one-off purchase of the necessary equipment and service in order to keep tight budgets under control, and are unaccustomed to variable costs for data services.

A Successful 5G Network: Electric Power and Edge Computing

3.1 Nevertheless, an early and successful experience in the adoption of 5G based networks was gained by the electric power grid operators in China. The electricity grid has expanded very fast in China during the last decade as the demand for energy grew by leaps and bounds; the network had to be enlarged and upgraded to tap new sources of renewable energy such as power generated by wind turbines in remote areas of China.

3.2 Therefore, the Chinese government is encouraging the convergence of digital development for the electric power and telecom sectors by allowing telecom operators to use the grid operators' resources for base station deployment and operation (a 5G base station uses four times the electricity consumed by 4G stations), while telecom operators assist grid operators with 5G services.[11] Reducing the costs of the rapid expansion of 5G and electric power supply networks through sharing of resources makes a lot of sense and could help upgrade homes with smart metering and other facilities.

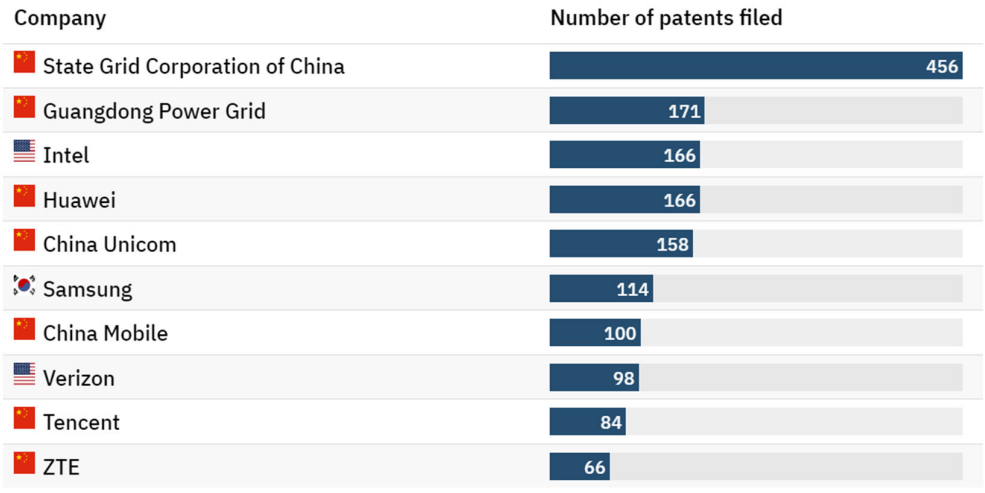
[10] "Ren Zhengfei announces that Huawei has established a "Coal Corps" to enter the coal industry" https://www.codetd.com/en/article/12626931 (accessed 6 March 2022).

[11] "China pushes for 5G and power network convergence" https://www.asiafinancial.com/china-pushes-for-5g-and-power-network-convergence (accessed 24 April 2022).

3.3 The accident handling and maintenance of lines, transformers and distribution equipment have traditionally been carried out by emergency maintenance staff. They are now increasingly being replaced by automatic monitors, sensors and other equipment linked by a new 5G and cloud computing network. For example, China Southern Power Grid, one of the country's two major power grid operators, will invest more than RMB26 billion (US$4.1 billion) in the construction of a digital power transmission network as the core of a new power system during the 14th Five-Year Plan period (2021-25).[12]

3.4 An important component of the digital transition of the electric power networks is edge computing, that is, distributed computing that brings computation and data storage closer to the sources of data. This has placed the Chinese power sector at the forefront of innovation and implementation of dedicated edge computing systems. As shown in Figure 1, seven out of the top 10 organisations with the most patent filings for edge computing in 2021 were based in China. The State Grid Corporation of China filed the most patents, with 456 in total, followed by the Guangdong Power Grid Corporation and US chipmaker Intel.[13]

FIGURE 1 EDGE COMPUTING PATENTS FILED IN 2021



Source: GrayB, https://techmonitor.ai/technology/networks/what-chinas-lead-in-edge-computing-means-for-the-world (accessed 25 April 2022).

[12] "Billions Invested in Grid's Modernization" http://en.sasac.gov.cn/2022/04/21/c_13334.htm (accessed 24 April 2022).

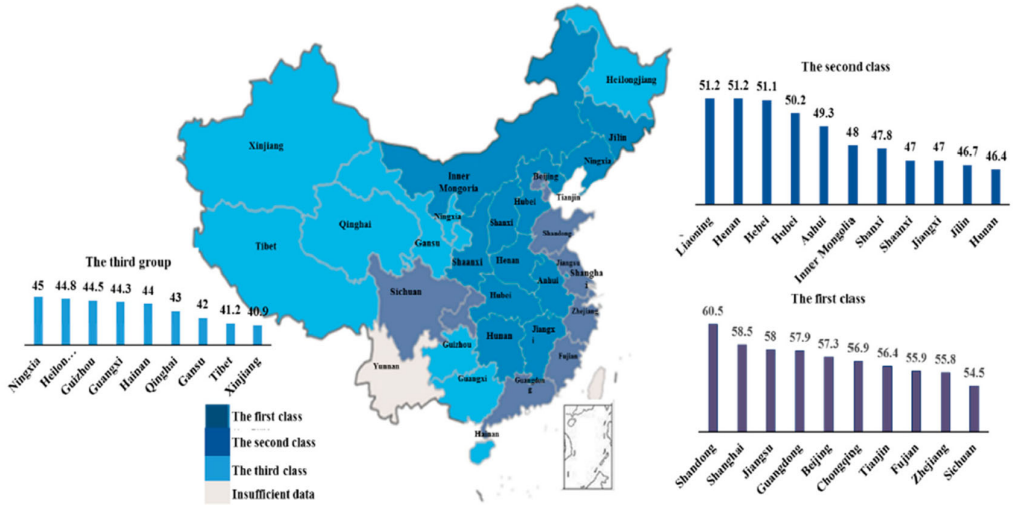
[13] Afiq Fitri, "What China's lead in edge computing means for the world" https://techmonitor.ai/technology/networks/what-chinas-lead-in-edge-computing-means-for-the-world (accessed 24 April 2022).

3.5 These types of innovative capability spin-offs and practical experience in developing advanced industrial applications may provide China with competitive advantages in the global markets. The Chinese leadership is quite explicit about encouraging Chinese companies in moving to the frontiers, and for many international observers – especially from the United States – this phenomenon is often perceived as a threat to their own country's competitiveness in the field. However, it is in many ways a natural extension of any country's position as a pioneer in the development of new technology applications.

Uneven Digital Development and the Digital Divide

4.1 The expansion of digital infrastructure has primarily taken place in China's most industrialised and advanced provinces, that is, in the provinces on the east coast. By 2021, Beijing had already deployed a total of 44,000 5G base stations, while Shanghai had built a total of 31,400 5G outdoor base stations and 49,800 indoor 5G small stations. Figure 2 provides a geographic presentation of the differences between provinces that are most advanced in digital transformation (first class), those of medium digital transformation (second class) and the least digitally transformed.[14]

FIGURE 2 DATA MAP OF CHINA'S REGIONAL DIGITAL TRANSFORMATION



Source: https://www.mdpi.com/2079-9292/10/11/1301/htm (accessed 20 April 2022).

[14] Li, J, Dou, K, Wen, S, and Li, Q, "Monitoring Index System for Sectors' Digital Transformation and Its Application in China", *Electronics* 2021, 10, 1301. https://doi.org/10.3390/electronics10111301 (accessed 20 April 2022).

4.2 The uneven distribution of digital resources also results in uneven conditions for growth. A recent econometric analysis shows that in eastern China, the impact of digital economic development on the improvement of total factor productivity is more significant than that in non-eastern regions.[15] The analysis also argues that the mediating effect of technological progress, namely extension of the digital infrastructure, has a more significant marginal effect on high-quality economic development and therefore should be a priority for the Chinese government in the future.

4.3 Another study published in 2021 uses data from 2004 to 2019 for digital economy activities of 30 Chinese provinces to analyse the spatial linkages between the 30 provinces and the developmental differences between northern and southern China.[16] It finds that the development level of the digital economy in the southern region is higher than that in the northern region, and that there are beneficial spillover effects of the digital economy development between provinces on the provision that the future development of the digital economy focuses on the balanced development of the whole country.

Cloud Computing and Data Centres: "Eastern Data and Western Computing"

5.1 The uneven distribution of digital infrastructure and resources is also evident in the availability of resources for cloud computing, that is, the on-demand availability of computer system resources, especially data storage and computing power in China. The early Chinese pioneers of cloud computing, such as Alibaba and Tencent, initially operated from large data centres in Hangzhou and Shenzhen respectively, to meet the demands of most of their clients in the coastal provinces. Gradually, Alibaba Cloud has set up additional data centres in the north and west of the country.

5.2 This move of data centre facilities to western provinces is now getting additional impetus with official support. In 2020 the National Development and Research

[15] Wei Zhang, Siqi Zhao, Xiaoyu Wan and Yuan Yao, "Study on the effect of digital economy on high quality economic development in China", *PLoS ONE* 16(9) (2021): e0257365.

[16] Luyang Tang, Bangke Lu and Tianhai Tian, "Spatial Correlation Network and Regional Differences for the Development of Digital Economy in China", *Entropy* (2021), 23, 1575.

Commission (NDRC) launched an initiative known as the "Eastern Data, Western Computing" plan to distribute data centre resources in both eastern and western regions. In July 2021, the plan was further developed when the Ministry of Industry and Information Technology released the "Three-year action plan for the development of new data centres (2021 – 2023)".

5.3 The action plan called for accelerating the construction of four new data centre clusters in the eastern and coastal regions and improving the service quality and efficiency of computing power of the new regional hubs in inland provinces of Guizhou, Inner Mongolia, Gansu and Ningxia to form a base of guaranteeing computing power for non-real-time purposes (such as data storage and backup) for the whole of China.[17] One of the rationales for this plan is that while the majority of China's data centres are located in the east, they are becoming increasingly costly and difficult to maintain, given new requirements for lowering CO_2 emissions. China's remote western regions, in contrast, have ample access to land and are less costly, and have renewable energy from wind, solar and hydroelectric power, but less access to digital infrastructure.

International Challenges for China's Digital Endeavour: Huawei 5G Export

6.1 On the international front, China has encountered several setbacks that challenge both the domestic and international expansion of the digital economy. First, the worries about national security in the United States and allied countries have reduced the extent to which leading Chinese telecommunications equipment producers such as Huawei and ZTE can export to these countries. Second, Chinese efforts to use the Digital Silk Road project to enhance digital infrastructure internationally and, in particular, for African countries have been criticised and occasionally encountered resistance locally. Third, US-China competition has reduced Chinese access to semiconductor microchips essential for the expansion of 5G infrastructure and AI systems.

[17] "'Eastern Data, Western Computing' – China's Big Plan to Boost Data Center Computing Power Across Regions". https://www.china-briefing.com/news/china-data-centers-new-cross-regional-plan-to-boost-computing-power-across-regions/ (accessed 6 May 2020).

6.2 The literature discussing national security risks related to the use of Chinese digital equipment has been expanding rapidly during the last five years. Apparently, these security concerns originated from an incident in Australia in 2012 concerning a software update provided by Huawei that included malicious codes that were able to monitor and capture data from the Australian network and ship it to China.[18] This event was accompanied by a number of other incidents, such as the uploading of data every night by Huawei installed equipment from the Headquarters of the African Union in Ethiopia to servers in China.

6.3 In the end, US governments, intelligence agencies and private actors have worked to address the risks posed by Huawei equipment, and in May 2019, the White House issued an Executive Order that banned Huawei from US 5G networks and the Department of Commerce added Huawei and 68 subsidiaries to the Entity List, thereby preventing US firms from exporting goods or services to them without a licence. US actions were accompanied by similar initiatives of allies – especially the Five Eyes network comprising the UK, Australia, Canada and New Zealand – to ban Huawei from 5G networks in their countries.[19]

6.4 The campaign against Huawei became part and parcel of a period where a confluence of geopolitical rivalry, advanced technological innovation and concern with data security came to occupy a central position in the political landscape. According to one observer, "[t]here is an emerging consensus among scholarly and security policymaking circles that there is a growing centrality of technology competition in the rivalry between the U.S. and China. The ongoing U.S.-China trade war is actually a disguised 'Tech Cold War' between the two big powers, who struggle for global technological leadership and therefore economic supremacy".[20]

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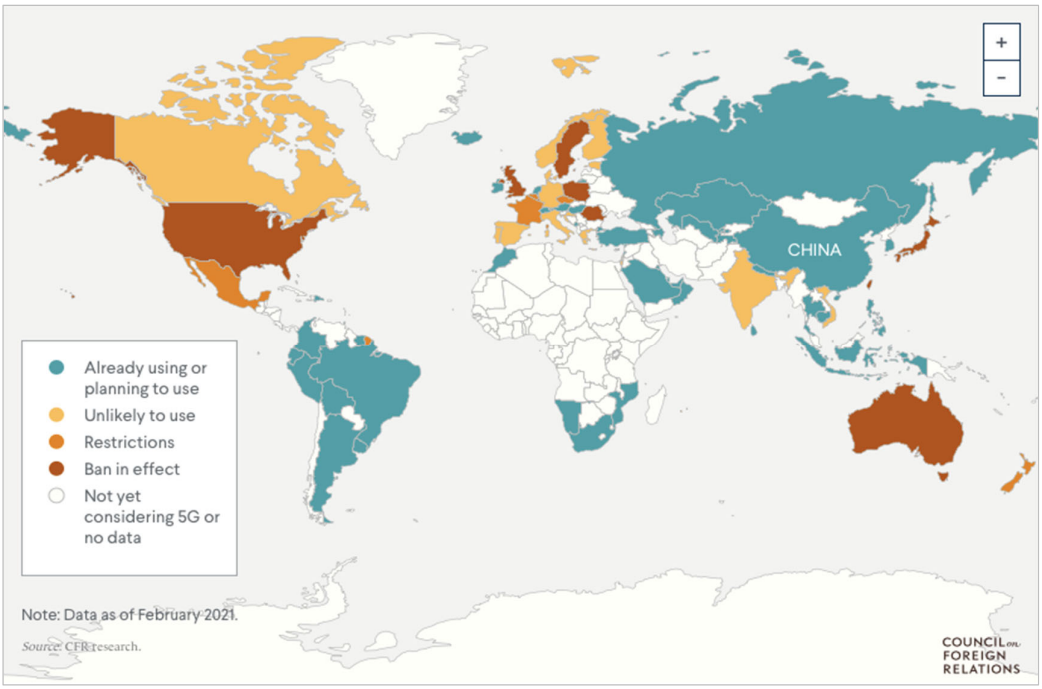
18 "US' Campaign Against Huawei As Security Risk Proves Correct" https://www.ndtv.com/world-news/how-china-used-huawei-in-secret-australia-telecom-hack-report-2656051 (accessed 10 May 2022).

19 Ashley Dutta and Jonathon Marek, *A Concise Guide to Huawei's Cybersecurity Risks and the Global Responses*, The National Bureau of Asian Research, October 2019. https://www.nbr.org/publication/a-concise-guide-to-huaweis-cybersecurity-risks-and-the-global-responses/ (accessed 10 May 2022).

20 Pak Nung Wong, *Techno-Geopolitics: U.S.-China Tech War and the Practice of Digital Statecraft*, (Abingdon, Oxon: Routledge 2022), p. 19.

6.5 Although the United States and Europe were concerned with some of the same security issues arising from the emerging 5G networks, their approaches to securitisation were different in significant respects. The technical features of 5G are such that it remains difficult to ensure that any threats to national security by espionage and sabotage via software are avoided; therefore, many countries have decided that 5G security cannot be achieved merely through technical screening, and calls for action at the political level. However, while the United States and allies opted for a general approach to securing 5G networks through an explicit ban on Chinese vendors, some European countries have sought to achieve similar security for their 5G networks by means of legal-political regulation that made it unlikely that they would use Chinese companies.[21] Figure 3 shows an overview of the different approaches to Huawei across the world.

FIGURE 3 COUNTRIES THAT HAVE BANNED OR RESTRICTED HUAWEI FROM THEIR 5G NETWORKS



Source: https://www.reddit.com/r/neoliberal/comments/r4dvtw/countries_which_have_banned_or_restricted_huawei/ (accessed 10 May 2022).

6.6 In the case of India, Huawei and ZTE had delivered much of the telecommunications equipment that served the country's 4G network operators. However, after clashes

[21] Karsten Friis and Olav Lysne, "Huawei, 5G and Security: Technological Limitations and Political Responses", *Development and Change* 52(5) (2021): 1174–1195.

between Indian and Chinese forces in Galvan Valley in 2020, the Indian government changed the regulations for investments from neighbouring countries, and in effect barred Chinese vendors from participating in 5G trials.[22] This has opened opportunities for other global and domestic companies to engage in the Indian 5G rollout, with the government encouraging domestic actors to develop a new, low-cost technical 5Gi standard that is likely to enter the 3GPP portfolio of standards.[23]

A Digital Transition Along the Digital Silk Road

7.1 The supply of digital infrastructure such as 5G, data centres and surveillance equipment has been an important component of the Digital Silk Road (DSR). However, even before the DSR was formally launched as a key foreign policy initiative in 2015, telecommunication vendors such as Huawei and ZTE had already become major suppliers for countries in Central Asia and Africa. The support of the DSR further amplified these activities and extended efforts to promote a digital transition further in Southeast Asia and Latin America.

7.2 In Central Asia, China's 5G investments in Uzbekistan, Kazakhstan and Tajikistan are turning into a major digital infrastructure engagement, led by Huawei. The Chinese telecoms company has been chosen by the Kazakh authorities to launch a 5G trial network in the capital Nur-Sultan from 2021 in cooperation with Beeline, the biggest independent mobile phone operator in the country. The deployment of the Huawei 5G network in other large cities will take place in 2022, first in Shymkent and then in Almaty, the former capital and largest city.[24]

7.3 The DSR is likely to take very different shapes in different countries, with a mix of infrastructures, hardware, software and services that will reflect pre-existing ecosystems and regional preferences. At the level of digital services such as e-commerce, the typical strategy of Chinese companies is to form local partnerships

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22 https://www.fiercewireless.com/tech/india-conducts-income-tax-raids-huawei-offices-continues-act-tough-chinese-vendors (accessed 10 May 2022).

23 https://www.thehindubusinessline.com/news/national/made-in-india-5g-technology-to-be-incorporated-in-global-standard/article37927968.ece (accessed 10 May 2022).

24 https://novastan.org/en/kazakhstan/kazakhstan-huawei-to-launch-5g-network-in-2021/ (accessed 15 May 2022).

and leverage the existing digital ecosystem to enter a market and then establish their own presence; AliExpress is an example of such flexible nature of the Chinese digital industry's outward expansion.[25]

7.4 Central Asia is also developing its surveillance capacity by cooperating with Chinese ICT companies to create "Safe City projects". Safe City projects use facial recognition cameras, data management systems and control centres to monitor the activity of citizens and levy fines. Kazakhstan, Kyrgyzstan, Uzbekistan and Tajikistan all developed different Safe City projects within the past few years, employing facial recognition technology, biometric registries and data management centres. In terms of regulation legislation, countries in the region have adopted data protection legislation, but in some countries, incidents have shown that they are insufficient to guarantee protection of privacy for citizens, or ensuring its own data sovereignty from foreign interference. See Table 1.

7.5 The DSR is also following up on extensive Chinese assistance to countries in Africa for developing digital infrastructure since the turn of the century. A study of Chinese ICT aid to Africa identified projects across 44 countries between 2000 and 2014. Half of them were in Nigeria, Ethiopia and Zimbabwe.[26] By 2019, Huawei had built about 70% of the continent's 4G networks[27] and the company has continued to develop 5G infrastructure, data centres and "smart city" surveillance systems, partly as a consequence of helping African countries control the COVID-19 pandemic.

7.6 Reports on the Chinese role in digitalisation in Africa tend to fall into two contrasting categories. On the one hand, the progress achieved by African countries has been reviewed by local and international agencies, pointing to the extent to which the infrastructure has enabled Africa to push forward the individual countries'

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[25] Nargis Kassenova and Brendan Duprey, (eds), *Digital Silk Road in Central Asia: Present and Future* (Davis Centre for Russian and Eurasian Studies, Harvard university, 2021) https://daviscenter.fas.harvard.edu/digital-silk-road (accessed 15 May 2021).

[26] Rebecca Arcesati, "China's Evolving Role in Africa's Digitalisation: From Building Infrastructure to Shaping Ecosystems" Italian Institute for International Political Studies, 29 July 2021. https://www.ispionline.it/en/pubblicazione/chinas-evolving-role-africas-digitalisation-building-infrastructure-shaping-ecosystems-31247 (accessed 15 May 2022).

[27] https://foreignpolicy.com/2019/03/19/for-africa-chinese-built-internet-is-better-than-no-internet-at-all/ (accessed 15 May 2022).

economic development.[28] On the other hand, a considerable number of reports have been published that emphasise the risks that African nations may face if they remain dependent on Chinese information technology. Most of these reports focus on US-inspired worries about national security and data sovereignty or privacy.[29]

TABLE 1 REGIONAL OVERVIEW OF DIGITAL TECHNOLOGIES, COMPANIES AND REGULATION IN CENTRAL ASIA

	Kazakhstan	Kyrgyzstan	Tajikistan	Uzbekistan
Technology	• Internet • Biometric Database • Safe City Projects • Facial Recognition • Data Centers	• Internet • Biometric Database • Safe City Projects • Facial Recognition • Data Centers	• Internet • Biometric Database • Safe City Projects • Facial Recognition	• Internet • Biometric Database • Safe City Projects • Facial Recognition
Foreign Companies Involved	• Huawei • HikVision • Dahua • CETC	• CEIEC • Huawei • IZP Group • Shenzhen Sunwin Intelligent • Vega (Russian)	• Huawei	• Huawei • CITIC • COSTAR • ZTE
Domestic Companies Involved	• IPAY • Sergek	• Government	• Government	• Government
Data Privacy Legislation	Yes	Yes	Yes	Yes
Known Data Privacy Scandals	Yes	Yes	No	No

Source: Nargis Kassenova and Brendan Duprey, (eds), *Digital Silk Road in Central Asia: Present and Future* (2021), p. 18.

[28] See, for example, OECD's *Africa's Development Dynamics Report* 2022 https://www.oecd.org/development/africa-s-development-dynamics-3290877b-en.htm (accessed 15 May 2022) and "China Cooperates with Africa to Encourage Digital Transformation" https://opengovasia.com/ china-cooperates-with-africa-to-encourage-digital-transformation/ (accessed 15 May 2022).

[29] See "Analysts: China Expanding Influence in Africa Via Telecom Network Deals" https://www.voanews.com/a/economy-business_analysts-china-expanding-influence-africa-telecom-network-deals/6209516.html (accessed 15 May 2022), "Chinese tech, ignored by the West, is taking over Africa's cyberspace" https://www.rfi.fr/en/science-and-technology/20210722-chinese-tech-ignored-by-the-west-is-taking-over-africa-s-cyberspace (accessed 15 May 2022), or Daria Impiombato, *Chinese Telecommunications Giants and Africa's Emerging Digital Infrastructure* NBR. https://www.nbr.org/publication/chinese-telecommunications-giants-and-africas-emerging-digital-infrastructure/ (accessed 15 May 2022).

7.7 Even if Chinese projects have been successful in the past decades, China's engagement will still encounter challenges. For instance, several countries in North Africa have been among the earliest to embrace the potential supply of Chinese telecommunications systems. Huawei opened its first African factory in Algeria, employing Algerians to assemble products for and beyond the Algerian market. It also launched an OpenLab for conducting research and development (R&D) activities in Egypt and established partnerships with several universities in the region to train local students. However, Huawei's localisation in both Algeria and Egypt improved the company's brand image without engaging in meaningful capacity building.[30]

7.8 Similarly, Chinese digital expansion in Southeast Asia has encountered mixed experiences. Thailand has been one of the enthusiastic recipients of advanced 5G systems from Huawei and aims to be among the first countries in the region to establish 5G networks and cloud computing data centres.[31] Huawei has been engaged in the design of large-scale tests of 5G-driven networks in 158 hospitals in Bangkok and major cities across Southeast Asia's second largest economy. The Ministry of Digital Economy and Society (MDES) has mobilised Huawei to pilot 5G technology in a total of nine projects in multiple sectors including agriculture, health, industry, education, transportation and Smart City nationwide.[32]

7.9 Singapore has developed its mobile networks and a broad range of digital services together with Chinese companies, and has been engaged in digital development projects in China too. Therefore, it came as somewhat of a surprise when it was announced that major operators Singtel and a joint venture between Starhub and M1 had been assigned spectrum resources to develop two nationwide 5G networks in cooperation with Ericsson and Nokia respectively. A third company TPG Telecom, which works with Huawei systems, was assigned spectrum for localised 5G

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30 Tin Hinane El Kadi, *How Huawei's Localization in North Africa Delivered Mixed Returns* Carnegie Endowment for International Peace, 2022.

31 "Thailand leads ASEAN in 5G rollout due to pandemic" https://asia.nikkei.com/Spotlight/5G-networks/Thailand-leads-ASEAN-in-5G-rollout-due-to-pandemic (accessed 16 May 2022).

32 "5G innovation center aims to speed up Thailand 4.0" https://disruptive.asia/5g-innovation-center-aims-to-speed-up-thailand-4-0/ (accessed 16 May 2022).

networks.[33] Some analysts saw this as evidence that Singapore had been influenced by the US campaign against Huawei, but others pointed out that Singaporean priorities are more likely driven by the need to diversify suppliers.[34]

7.10 Indonesia and Cambodia have decided to rely on Chinese suppliers of 5G networks, while Vietnam and the Philippines have avoided Huawei for a variety of reasons.[35] Simply put, attitudes have been mixed in Southeast Asia towards telecommunication supply from Huawei and other Chinese companies, as Figure 4 shows. Clearly, many prefer Samsung even though it is not among leading 5G systems vendors.[36]

FIGURE 4 SOUTHEAST ASIA'S PREFERRED 5G DEVELOPERS

Source: *The State of Southeast Asia: 2020*, ISEAS – Yusof Ishak Institute.

[33] "Singapore finalizes 5G network operators in building up infrastructure" http://www.xinhuanet.com/english/2020-06/24/c_139164580.htm (accessed 16 May 2022)

[34] "Singapore Decides on 5G Networks: Is Huawei Banned?" *The Diplomat*. https://thediplomat.com/2020/07/singapore-decides-on-5g-networks-is-huawei-banned/ (accessed 16 My 2022).

[35] Sofia Cuyegkeng, "5G Geopolitics and the Philippines: The Huawei Controversy" https://www.asiapacific.ca/publication/5g-geopolitics-and-philippines-huawei-controversy (accessed 15 May 2022).

[36] Melinda Martinus, "The Intricacies of 5G Development in Southeast Asia". https://www.iseas.edu.sg/wp-content/uploads/2020/11/ISEAS_Perspective_2020_130.pdf (accessed 15 May 2022.

7.11 Many reports have emphasised the perceived geopolitical consequences and security issues that the DSR and China's digital technology exports entail.[37] The political reaction from the United States was the development of The Clean Network programme in 2020 – an initiative that represented the Trump administration's approach to safeguarding US and allies' networks "from aggressive intrusions by malign actors, such as the Chinese Communist Party". This approach alerted many nations and firms to these risks, but does not appear to have substantially held back the Chinese progress under the DSR.

International Restrictions for China's Access to Digital Core Technologies

8.1 No doubt the most serious challenge to China's efforts to promote a digital transition has been the US-China geopolitical conflict that has affected technology significantly. This has been the case, in particular, with sanctions against technology companies such as Huawei and ZTE as discussed earlier. Moreover, the restrictions imposed by the United States on exports of advanced technologies, such as semiconductor components and equipment or biotechnology, to China have become important "choke points" for Chinese plans to catch up in high technology sectors.

8.2 There is a long tradition of export restrictions by the United States such as the International Traffic in Arms Regulations (ITAR) from 1976 for dual-use products and technologies, goods and technology that may have both civilian and military uses.[38] Under US government export control system, three different agencies have the authority to issue export licences: The Departments of State, Commerce and the Treasury.[39] Moreover, The Export Control Reform Act of 2018 (ECRA) (PL 115-

[37] For example, Clayton Cheney, *China's Digital Silk Road: Strategic Technological Competition and Exporting Political Illiberalism*, Pacific Forum, *Issues & Insights,* Vol. 19, WP8, July 2019; and Pointe Bello, *The Digital Silk Road Initiative: Wiring Global IT and Telecommunications to Advance Beijing's Global Ambitions*. January 2019. https://a.storyblok.com/f/58650/x/bb4f38245b/pointe-bello-digital-silk-road-2019.pdf (accessed 3 July 2021).

[38] For details of ITAR, see https://www.govinfo.gov/content/pkg/CFR-2016-title22-vol1/xml/CFR-2016-title22-vol1-chapI-subchapM.xml (accessed 27 May 2022).

[39] For more information, see https://2009-2017.state.gov/strategictrade/overview/index.htm (accessed 26 May 2022).

232) re-established authority for the president to control dual-use exports for national security and foreign policy reasons.[40]

8.3 The Entity List is used by the US Department of Commerce Bureau of Industry and Security (BIS) to restrict the export, re-export and in-country transfer of items to entities – individuals, organisations and/or companies – believed to be involved in activities contrary to the national security or foreign policy interests of the United States, mostly as prompted by Executive Orders of the president. Currently, 468 Chinese firms are listed on the BIS Entity List, with Huawei and its affiliates in China listed 57 times, together with a large number of overseas affiliates.[41]

8.4 During an early period since 1997, the Entity List mostly targeted the aerospace sector, but after 2014, technology firms and especially telecommunications became subject to US export restrictions, as Figure 5 shows. In particular, 2019 and 2020 had seen the entry of many firms in surveillance and technology, primarily companies that specialise in artificial intelligence, facial recognition and integrated circuits.[42]

8.5 Increasingly, the semiconductor industries have been subject to sanctions, and various instruments have been expanded from list-based controls to end-use and end-user controls.[43] For instance, in December 2020 one of the leading producers of integrated circuits in China, the Semiconductor Manufacturing International Corporation Incorporated (SMIC) and 10 affiliated units were placed on the Entity List. These actions have reduced China's access to vital integrated circuits and the equipment required to upgrade microchip production in China, putting up new

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40 Congressional research Service, *U.S. Export Controls and China*, 24 March 2022.

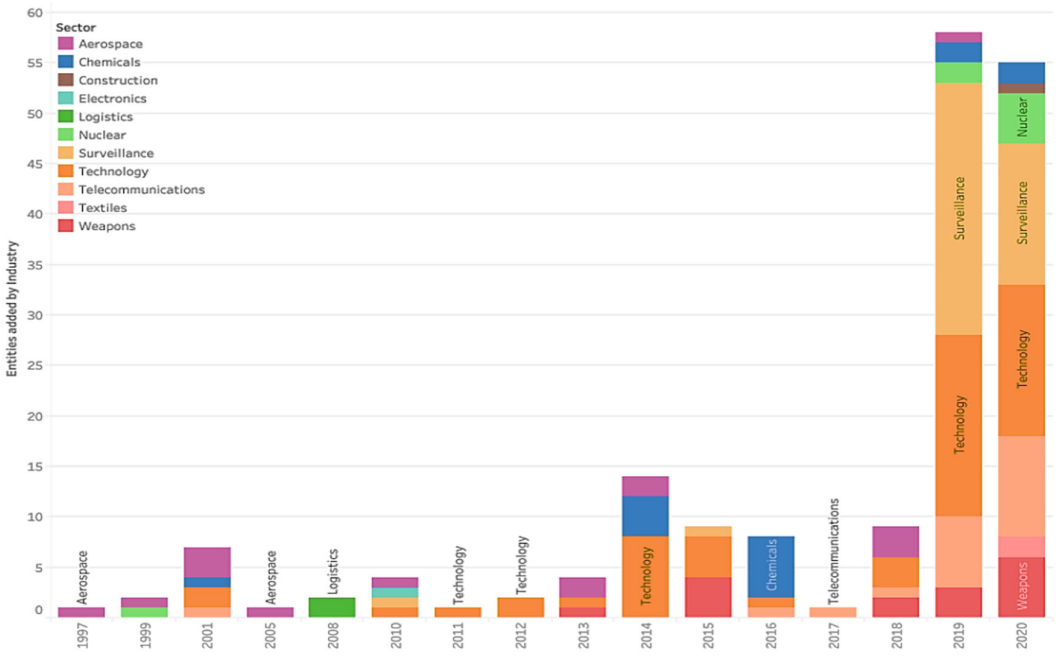
41 https://www.bis.doc.gov/index.php/documents/regulations-docs/2326-supplement-no-4-to-part-744-entity-list-4/file (accessed 27 May 2022).

42 Jeremy Ney, *United States Entity List: Limits on American Exports*, Belfer Centre for Science and International Affairs, February 2021. https://www.belfercenter.org/publication/united-states-entity-list-limits-american-exports (accessed 27 May 2022).

43 Saif M Khan, *U.S. Semiconductor Exports to China: Current Policies and Trends*, CSET Issue Brief, October 2020. https://cset.georgetown.edu/publication/u-s-semiconductor-exports-to-china-current-policies-and-trends/ (accessed 27 May 2022).

barriers for China to reduce its dependency on foreign supplies of advanced semiconductors.[44]

FIGURE 5 CHINESE ENTITY ADDED BY INDUSTRY, 1997-2020



Source: https://www.belfercenter.org/publication/united-states-entity-list-limits-american-exports (accessed 27 May 2022).

US-China Geopolitical Tensions

9.1 Chinese reaction to the aforementioned geopolitical challenges has predictably been to intensify policy measures and direct support to the establishment of technological capabilities and production facilities in the sanctioned high technology sectors.[45] In addition, China has created its own "Unreliable Entity List" (UEL) in September 2020, administered by the Ministry of Commerce and based on principles enshrined primarily in Anti-Monopoly Law and the National Security Law.[46] This was followed in June 2021 by an Anti-Foreign Sanctions Law (AFSL) that provides legal

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44 Fergus Ryan, Audrey Fritz and Daria Impiombato, *Reining in China's technology giants*, Australian Strategic Policy Institute, Issues paper, Report No. 46/2021. https://www.aspi.org.au/report/mapping-chinas-technology-giants-reining-chinas-technology-giants (accessed 27 May 2022).

45 Douglas B Fuller, "China's Counter-Strategy to American Export Controls in Integrated Circuits", *China Leadership Monitor*, Spring 2021 Issue 67, Monday, 1 March 2021. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3798291 (accessed 27 May 2022).

46 See http://english.mofcom.gov.cn/article/policyrelease/questions/202009/20200903002580.shtml (accessed 27 May 2022) and Qingxiu Bu, "China's blocking mechanism: the unreliable entity list" *Journal of International Trade Law and Policy*, Vol. 19 No. 3, 2020, pp. 159-180.

grounds for Chinese government authorities and private individuals and entities to take countermeasures against "discriminatory restrictive" foreign sanctions.[47] However, so far no announcement of the listing of foreign firms under UEL or the ASFL has been made.

9.2 While Chinese actions have prepared the ground for extensive "tit-for-tat" reciprocal sanctions on US multinational firms and high technology sectors such as semiconductors, they have not been implemented on a major scale. Interestingly, a number of US organisations and researchers have expressed various reservations about the effectiveness of US government's sanctions against Chinese high-tech firms and, in particular, the effects of export restrictions in semiconductors. A report from the Peterson Institute for International Economics described how a reluctant US semiconductor industry was forced into implementing export restrictions targeting the semiconductor supply chain in order to constrain Huawei.[48]

9.3 Another report from the Boston Consulting Group estimated that, by 2025, US semiconductor related companies could lose eight percentage points of global share and 16% of their revenues in 2020, given the restrictions enacted with the current Entity List.[49] Scenarios in the report envisaged that South Korea would take over the leading role of the United States in the sector for the short term, while China would become a world leader in the long term. Yet another report raised the question of whether ongoing developments would eventually snowball into a full-fledged US-China semiconductor decoupling that could carry immense economic and innovative costs.[50]

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47 See Zhonghua renmin gongheguo fan waiguo zhicai fa (Anti-Foreign Sanctions Law of the People's Republic of China). http://www.npc.gov.cn/npc/c30834/202106/d4a714d5813c4ad2ac54a5f0f78a5270.shtml (accessed 27 May 2022).

48 Chad P Bown, "How the United States marched the semiconductor industry into its trade war with China" Peterson Institute for International Economics Working Paper 20-16, December 2020. https://www.piie.com/publications/working-papers/how-united-states-marched-semiconductor-industry-its-trade-war-china (accessed 28 May 2022).

49 Antonio Varas and Raj Varadarajan, "How Restricting Trade with China Could End US Semiconductor Leadership" BCG, March 2020. https://www.bcg.com/publications/2020/restricting-trade-with-china-could-end-united-states-semiconductor-leadership (accessed 28 May 2022).

50 Justin Feng, "The Costs of U.S.-China Semiconductor Decoupling" CSIS, May 2022. The Costs of U.S.-China Semiconductor Decoupling | Center for Strategic and International Studies (csis.org) (accessed 28 May 2022).

9.4 A decoupling between the United States and China for telecommunications, semiconductors and other advanced technology sectors would therefore present great challenges to China's plans for rapid expansion of 5G infrastructure. In the meantime, it is likely that a major decoupling will not dampen China's ambitions – rather, it would amplify them – while breaking up the current interconnected technology supply chains between the two countries could have negative effects for US technological leadership.

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