Chapter 9

China—A Rising Tech Power?

National Ambitions and Local Realities

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In the battle for global tech dominance, China is rapidly surpassing its Western competitors (Olsen, 2020).[1] The country is quickly reaching global leadership in many areas of science and technology, including facial recognition, certain fields of AI and e-mobility. In this chapter, I argue that the rise is both fueled and constrained by the specific institutions of the party-state. The 'fuel' is the party-state's capacity and will to lead China up the value chain thanks to massive investments. The 'constraints' have to do with the downside of decentralised and fragmented authoritarianism.

This chapter begins by analysing China's growing technological power by juxtaposing national ambitions with local realities. Despite Beijing's impressive efforts to devise industrial policies for technology upgrading (Naughton 2021), there is a substantial high-tech policy implementation gap. The term 'implementation gap' refers here to differences between Beijing's high-tech ambitions and local policy outcomes. The reason for the gap may be that many elements of Beijing's tech agenda fall to local governments for delivery. As local governments' pre-existing industrial structures, interests, and capabilities differ widely, national plans and investment funds are often not (or only partially) implemented, poorly executed, or significantly delayed.

The analysis further shows that China's national technology policies and plans have been implemented unevenly across regions. By focusing on three provinces (i.e., Sichuan, Anhui, and Zhejiang), this analysis highlights how different institutional structures have shaped the provinces' technological development trajectories. A historical comparison sheds light on the diverse state–business relations in the high-tech industry: While Sichuan's tech industry has, to a large extent, been dictated by government and defence projects, tech companies in Zhejiang have benefitted from more freedom to develop. In Anhui, the tech industry has formed particularly close relationships with local research institutes and labs located in Hefei. The historical institutional perspective offered here helps to explain why the high-tech industry in Sichuan is largely focused on civil–military industry production, while in Anhui and Zhejiang there is a stronger focus on AI technology and speech recognition.

NATIONAL AMBITIONS

China has seen astonishing technological advances in the past few decades. It has the largest 5G network and the most extensive optical fibre cable network in the world, and it is producing self-driving cars. It is already leading in many AI technologies, including AI-based emotion recognition and facial recognition technologies (Kharpal 2019). Two of the world's largest supercomputers—Tianhe-2 and Sunway TaihuLight—are also located in the country (Abbany 2017). Rapid advances have also been made in high-speed quantum computing. In 2016, China successfully launched its quantum satellite, Micius (or QUESS), the first in the world (Disha 2021). Researchers at the University of Science and Technology of China in Hefei recently announced a new quantum computing breakthrough that allegedly surpassed Google's achievements, making it the world's leader in quantum technology (Corbett and Singer 2022). On the Global Innovative Index, China climbed from twenty-ninth place in 2015 to twelfth in 2021 (World Intellectual Property Organisation 2022). These are impressive achievements, and there is no question that China is becoming a leader in global science and technology innovation.

However, China's industrial technology capabilities should not be overstated, and for many digital technologies, China is still catching up. Particular vulnerabilities are in the integrated circuit and basic software industries. In 1999, then Minister of Science and Technology Xu Guanhua famously said, 'The Chinese ICT industry lacks a core (chips) and souls (basic software)' (*Zhongguo xinxi chanye 'que xin shao hun*') (Bu 2020). Since then, China has invested massive sums in the semiconductor and software industries to increase domestic capacity, but it still relies largely on imports for high-end chips, which state media often describe as being 'wedged by the neck' (*Ka bozi*).

No matter how one assesses China's technological capabilities, there is general agreement that technological progress has been at the core of the political agenda for a very long time. The period following the global financial crisis in 2009 was especially significant as policymakers shifted from an indicative planning approach to new industrial policies in which the state plans to invest unprecedented amounts of money to leapfrog other nations in technology (Naughton 2021). The 2015 release of both *Made in China 2025* and *Internet Plus Strategies* marked a new stage in the state's efforts to lead the tech industry up the value chain. Other relevant policy initiatives that support China's tech rise include the *Action Outline for Promoting the Development of Big Data* (2015), *the Outline of National Informatisation Development Strategy* (2016) and *the Development Plan on the New Generation of Artificial Intelligence (AI)* (2017). In the *Plan on the Next Generation of AI*, the Chinese government outlines its road map to become the primary AI 'innovation centre' by 2030 (Webster et al. 2017). Between 2014 and 2020 alone, China's Industrial Guidance Funds (IGFs) raised a staggering US$1.6 trillion for the targeted sectors (Naughton 2021: 106),[2] thereby underlining the Chinese party-state's commitment to leaping ahead in strategically important technologies.

China's recent five-year plans (FYPs) also reflect the growing emphasis on tech primacy. The 13th FYP (2016–2020) called for the expansion of strategic emerging industries (SEIs) and opens its chapter on the National Big Data Strategy with a statement that the government 'will make big data a fundamental strategic resource . . . to help transform and upgrade industries and bring about innovation in social governance' (NDRC 2016). The 14th FYP (2021–2025) dedicated an entire section (section 5) exclusively to facilitating digitalisation and establishing a digital China, and it picked seven key emerging technologies to be further promoted to speed up the country's ambitious tech advancement, as well as ten sectors where the technologies are encouraged to be applied (NDRC 2021).[3]

Statements by national leaders further underline the political will of China's party-state to win the global race for technological leadership. At the Fourth Plenary Session of the 19th Central Committee of the Communist Party of China in 2019, leading cadres listed data as one of the seven major factors of production, along with labour, capital, land, knowledge, technology, and management. Xi Jinping also stressed China's national tech ambitions in the thirty-fourth collective study of the Political Bureau of the 19th Central Committee in 2021 when he stated: 'In today's era, digital technology and digital economy are the opportunities for the world's technological revolution and industrial transformation, and they are the key areas of a new round of international competition. We must seize the opportunities and seize the commanding heights of future development' (Xi 2022).

In addition to having comprehensive top-down planning and using massive funds to support homegrown tech companies, China has also developed a large-scale domestic talent promotion programme. In May 2020, the Ministry of Education launched the 'School of Future Technology' programme to upgrade technological and innovation capabilities through educational investments (Li 2021). A stated programme goal was to move Chinese innovation power from 'Made in China' (*Zhongguo zhizao*) to 'Created in China' (*Zhongguo chuangzao*) (Huang 2016). In the first batch, twelve universities were selected with strengths in critical technologies such as aerospace, AI, quantum information science, marine technology, and life and health science. The plan is to expand this to another twenty to thirty 'Schools of Future Technology' in the future. Table 1 lists the twelve higher-education institutions selected to implement the programme (Zhongguo Jiaoyu Zaixian 2021).

Table 9.1: Twelve Universities Selected for the School of Future Technology Programme

	Higher-Education Institution	*Technologies*
1	Peking University, Beijing	Big Data and Biomedical Artificial Intelligence Department: biomedical imaging, molecular medical sciences, biomedical engineering, big data, and biomedical artificial intelligence
2	Tsinghua University, Beijing	Advanced chips, new materials, software, AI, intelligent manufacturing, and national security
3	Beihang University (BUAA), Beijing	Aerospace/aviation
4	Tianjin University (TJU), Tianjin	Smart/intelligent machines and systems, storage science and engineering, smart city, etc.
5	Northeastern University (NEU), Shenyang, Liaoning, in cooperation with Huawei	Control science and engineering, computer science and technology, software engineering, robotics
6	Harbin Institute of Technology (HIT), Harbin	AI, intelligent manufacturing, life and health sciences
7	Shanghai Jiao Tong University (SJTU), Shanghai	Energy and environment, health and medicine
8	Southeast University (SEU), Nanjing	Chip design, information materials, future communication, intelligent perception and sensing (*zhineng ganzhi* 智能感知)
9	University of Science and Technology of China (USTC), Hefei, Anhui	Quantum technology
10	Huazhong University of Science and Technology (HUST), Wuhan	Advanced intelligent manufacturing, biomedical imaging, photoelectron chips and system, AI
11	South China University of Technology, Guangzhou	intelligent perception and sensing, big data, AI+ technologies
12	Xi'an Jiaotong University (XJTU), Xi'an	AI, energy storage sciences and engineering, intelligent manufacturing, biomedical engineering, smart city

Sources: Zou 2021; Li 2021; Zhongguo Jiaoyu Zaixian (eol.cn) 2021

Despite all the planning and investment, turning these tech ambitions into reality is a challenge. It is well known that in China's highly decentralised authoritarian structures (Landry 2008), local governments play a key role in shaping implementation outcomes, which often results in the 'selective' implementation of national policy (Li and O'Brien 1999). Often it is the local governments that have to create an attractive investment environment for innovation and research. For instance, many local governments have created special development zones and high-tech industrial parks, but not all of them were successful in creating the necessary conditions for high-tech industrial cluster growth (Kania and Laskai 2021). Many examples are known where local governments simply picked the wrong tech companies as a 'local champion' or where they overinvested in certain industries (Segal 2018), resulting in a duplication of efforts. In other words, Beijing strongly depends on provincial governments to support its tech agenda with the right means and tools.

The next section highlights how technological trajectories vary across regions. At the provincial level, the trajectory of tech advancement is often shaped by multiple pre-existing economic, social, and political factors. By looking at local governments' technical, financial, and political capacities to push for tech leadership in their locally grown tech industries, the final section will explain why national tech ambitions are often only partially implemented at the local level.

HIGH-TECH SECTOR DEVELOPMENT AND REGIONAL PATH DEPENDENCY

China's national technology policies and plans have been implemented unevenly across regions. This is partly the result of local governments adjusting and repurposing national policies to make them fit the local context. Additionally, local trajectories for innovation and technological advancement depend heavily on pre-existing infrastructures and conditions. Therefore, the growth of regional tech hubs is very path-dependent in that new outcomes are firmly tied to previous outcomes rather than the current conditions alone (Isaksen 2015). Below, the focus will be on three provinces (i.e., Sichuan, Anhui, and Zhejiang) to illustrate how different existing institutional structures shaped their provincial trajectories in high-tech sector development.

Sichuan

Located in Western China, Sichuan province is home to many car manufacturing plants and major high-tech suppliers of critical car manufacturing components, such as lithium batteries for Tesla and integrated circuit assembly for foreign companies like Intel, Texas Instruments, and Onsemi. Sichuan is also home to a large military and defence sector, with many research institutions and factories for military-use aircraft, rockets, and components for nuclear weapons headquartered there. Some of the high-tech products produced in Sichuan are dual-use technologies, that is, they partly or fully originate in the defence industry, which has made use of AI and other advanced technologies (Chen 2022).

Sichuan showcases how a national security movement in the 1960s set the stage for a strong linkage between a local defence industrial base and a growing civilian, high-tech economy. The origin of Sichuan's high-tech industrial sector is often linked to China's Western Development Strategy (*Xibu dakaifa*) in 2001. However, this explanation gives insufficient credit to industrial policies that can be traced back further—specifically, to the Mao era. In the early 1960s, during the Cold War, Mao proposed a geo-military industrial grand plan called the Third Front Movement (*Sanxian jianshe*), which started in 1964 and targeted mountain regions in southwestern and western parts of China for key military production. The isolated mountain areas were chosen as they would be the hardest for foreign forces to invade.

As a result of Mao's plan, large-scale investments were made in national defence complexes in the remote and mountainous areas of Sichuan. The new provincial military and defence sector included defence-related technology research, the transport sector, and other basic supporting industries such as manufacturing, mining, metal, and electricity supply. Table 2 provides an overview of key sectors developed during the Third Front Movement in Sichuan.

Although many Third Front plants went bankrupt after the 1980s because of bad planning, hasty implementation, and the geographical inaccessibility of supplies and markets, these areas retained a certain level of industrial infrastructure into the era of reform and opening. In the early 1980s, many companies and factories moved out of the mountainous areas to gain better access to the market and reinvented themselves to produce civilian goods rather than military supplies (Butterfield 1980). The purpose of this 'defence conversion' was to 'pull the military into the process of national macro-economic adjustment' (Lee 2011: 3). By 1996, almost all former military sectors, including the aviation and electronic industries, which formed industry clusters in Sichuan, were producing more than 80 percent of their total output on civilian products (Lee 2011: 4). Thus, the early industrial structures built during the Third Front provided fertile ground to grow a local electronic manufacturing sector in Sichuan province. In subsequent years, many of Sichuan's military firms diversified into the manufacturing sectors and even established joint ventures with foreign firms.

Table 9.2: Industrial Sectors Developed During the Third Front Movement in Sichuan

Sector	*Location*
Industrial manufacturing	Chongqing*, Chengdu
Arms industry, including research institutions on defence, midsize to large enterprises specialising in the defence industry and civil–military enterprises	Chongqing* (production of conventional weapons such as rifles, tanks, trucks, and conventional powered submarines), Chengdu, Mianyang, Guangyuan, Leshan, Xichang, Daxian (now Dazhou)
Coal mining	Dukou (now Panzhihua; Panzhihua Iron and Steel), Guang'an Huaying (Lushuidong coal mine)
Petrochemical industry	Nanchong
Metallurgical industry	Dukou (Panzhihua), Daxian (Dazhou), Leshan, E'mei, Zigong, Jiangyou
Hydropower stations	Chengdu, Deyang, Gongzui, Zigong, Chongqing*
Machinery and electronic plants	Chengdu, Deyang, Mianyang, Jiangyou, Guangyuan, Leshan, Xichang, Zigong, Neijiang, Luzhou, Ya'an, Fuling Dist. (Chongqing)*, Wanxian (Chongqing)*, Guang'an Huaying
Aviation and aerospace industry	Chengdu and satellite cities such as Deyang/ Guang'han (Civil Aviation Flight University of China), Ya'an, Mianyang, Xichang and Daxian (Dazhou)
Nuclear industry	Mianyang (research, the Chinese Academy of Engineering Physics), Yibin (components, Plant 812), Guangyuan (plutonium production complex, Plant 821), Leshan
Textile industry	Daxian (now Dazhou), Neijiang, Suining, Nanchong

* Although Chongqing is not counted as part of Sichuan in terms of the administrative level, it is listed here due to its geographic proximity.

Source: Gu et al. (1999: 185), Xu and Xiao (2009), Jencks (1980) and the Federation of American Scientists (FAS) (2010).

Sichuan's repurposed industrial firms later provided the necessary basis for today's local high-tech sector to flourish. In the early 2000s, with maturing electronic manufacturing capacity and skills, provincial policies started pushing for an upgrade from traditional mechanical manufacturing to a 'digital military industry/informatisation (*jungong xinxihua*)' with a focus on reforming the defence industry to adapt to information warfare, including digital security systems, AI-equipment, and combat technologies (People's Daily Online 2004). Sichuan's digital innovation industry has grown substantially, and by 2022, the high-tech industry was contributing significantly to the local GDP (Tian 2022).

The historical trajectory of Sichuan's military and defence sector helps to explain why Sichuan's high-tech industry is spread out across the province. Today, the high-tech industry clusters are not only concentrated in the provincial capital city, Chengdu, but they are also spread around in the Sichuan Basin (e.g., Chengdu, Miangyang, Meishan) as well as in mountainous areas (e.g., Guangyuan, Yibin, Ya'an, Ganzi). Many of these remote prefectures are less developed than larger urban cities in the province, but they benefitted from industrial development during the Third Front Movement (Chen 2011, 40). One leading prefecture in industrial and technological development is Mianyang prefecture, which is frequently dubbed the 'China Science and Technology City.' The prefecture is leading not only in high-tech military technologies such as AI for hypersonic weapon design but also in the commercial electronic and high-tech industries (Chen 2022).

When tracking local digital initiatives in Sichuan from 2015 to 2022 (Digital Index Database 2022), one also notices that prefecture-level digital initiatives are widely spread across the province.[4] Of the 222 initiatives tracked, in the Sichuan Basin, Mianyang prefecture topped the chart by leading 28 local digital initiatives. Chengdu city (the provincial capital) and Neijiang prefecture followed closely in second place with 27 digital initiatives. Mianyang, Chendu, and Neijiang are all prefectures that benefitted from machinery and electronic plants during the Third Front Movement (see Table 2). Guang'an prefecture is also home to many digital initiatives, likely because it is in Chongqing's spill-over zone. Overall, in Sichuan, the setup of a military defence sector during the Mao period helps to explain the regional layout and character of this province's high-tech sector.

Zhejiang

The growth of the high-tech sector in Zhejiang has a very different origin than Sichuan's state-led development of the military complex. In this coastal province, developments have been shaped by the active role of the private sector and the relatively laissez-faire style of local governance. Today, Zhejiang is home to some of the biggest tech companies and start-ups in China. Hangzhou's Alibaba is the province's most famous tech firm, but other prominent players include Hikvision, Dataqin, Geely, NetEase, and Kuaidi Dache. In this region, the relationship between the provincial government and local private tech entrepreneurs has historically been very cooperative. Early on in their development, the provincial government became a major customer of the bigger private tech companies and provided high-tech start-ups with a certain level of freedom essential for private entrepreneurship to flourish (Breslin 2012).

Historical path dependencies play a key role in explaining the growth of Zhejiang's high-tech industry and the close public–private cooperation. Wenzhou, a prefecture in southeast Zhejiang, has long been famous as a cradle of private micro-entrepreneurs. The prefecture also played a key role in shaping the province's economic path (Tsai 2002). During the early 1980s, Wenzhou's high population density and lack of arable land pushed local government officials to promote private entrepreneurship instead of agriculture. This was very risky at the time, as private entrepreneurship in the early post-Mao period was still a political taboo and framed as the 'tail end of capitalism.' Zhejiang's local governments allowed private enterprises to formally register as public or collective enterprises, giving rise to so-called red-hat (*Hong maozi*) enterprises. These red-hat private enterprises had better access to capital and other favourable policies and, as a result, were able to grow quickly in the 1980s and early 1990s (Tsai 2002). Terms such as 'Zhejiang business culture' and the 'Wenzhou (economic) model' are still very widely used in China to describe the active bottom-up business activities that originated in Zhejiang province.

The provincial legacy of strong local entrepreneurship and its freer market environment eventually became a growth platform for the high-tech industry. Here developments were based on win-win bargains between the state and industry. Provincial leaders benefitted from a rapidly growing high-tech industry, which helped them to meet their economic growth targets in the cadre evaluation process. At the same time, the development of private tech enterprises was helped by a nurturing environment largely free of big-data technology regulation (Lv and Luo 2018). Zhejiang's provincial government also served as the main customer of tech enterprises to improve the provincial e-government services. For instance, Zhejiang was one of the first provinces to start a 'Maximum one visit for administrative procedures' digital project to showcase more efficient e-government services (Gao and Tan 2020; Kostka 2022).

Another example of close state–business cooperation is Zhejiang's 'City Brain' project. The project took shape in 2016 when Alibaba's then Chief Technology Officer Wang Jian proposed the concept to integrate different Hangzhou city administrative services in order to solve urgent city governance issues. Alibaba's City Brain project began in Hangzhou and has spread to cities throughout Zhejiang province (Chen 2021) and even abroad (Szewcow and Andrews 2020). The cooperation with Alibaba helped Zhejiang's government to position itself as the frontrunner and provincial role model for smart technologies for other provinces (14th Five-Year Plan of Zhejiang). The success of City Brain helped to deepen the provincial government's cooperation with the high-tech sector, creating new forms of mixed ownership and interdependence (Kostka 2022). In 2020, the government initiated the Zhejiang City Brain Industry Alliance, a local 'non-profit organisation,' (Zhejiang University Holding Group 2021) that comprises 331 members (as of May 2021) across the public sector, private sectors, civil organisations, and research institutions to further promote and develop

Zhejiang's flagship programme City Brain (Zhong Tuo Bang 2021). In short, for Zhejiang, the provincial hardship in the 1970s and '80s provided fertile ground for local private sector growth (Kostka 2012), which, in turn, eventually helped to produce high-tech entrepreneurs such as Jack Ma.

Zhejiang province's capital, Hangzhou, played a key role in local digital initiatives between 2015 and 2022 by offering positive spillovers to its neighbouring prefectures. The prefectures with the highest number of digital initiatives include Jinhua (53), Shaoxing (52), Huzhou (43), and Hangzhou (42), while Quzhou (16) and Taizhou (14) were significantly left behind.[5] Jinhua prefecture, the locality with the most digital initiatives, is home to dozens of industrial parks and start-up incubators and has a unique development trajectory. Jinhua's local innovation and high-tech sector was strengthened in 2015, when the Jinhua Peking University Science Park Branch was established with the help of the Jinhua Municipal Party Committee Organisation Department and Peking University (China Cultural Chamber of Commerce for the Private Sector 2017). The park's close cooperation with the prefecture's Party Committee Organisation Department and Peking University, in particular, helped to recruit top local talents from within the government and outside the park (China Cultural Chamber of Commerce for the Private Sector 2017). Shaoxing and Huzhou prefectures are geographically close to Hangzhou and benefit from positive spillover effects from Hangzhou. Alibaba's headquarters are in Hangzhou, and City Brain has been an important trademark for the entire Zhejiang province. The 'Hangzhou City Brain Experience' was repeatedly used as the benchmark for the whole province's digital initiatives work (Zhejiang Digital Economic Development Administration and Zhejiang Governance Digitalisation Promotion Committee 2020). Prefectures with the lowest number of initiatives are located farther away from Hangzhou and did not benefit from positive spillovers.

Anhui

The agricultural province of Anhui in central China has a surprisingly large and thriving high-tech industry. In 2017, Anhui set up a fund of US$1.6 billion to support construction of the world's biggest quantum research facility (Shi-Kupfer and Ohlberg 2019, 32). The high-tech industry in Anhui is heavily concentrated in and around the provincial capital, Hefei City. Hefei is home to the Gaoxin industrial complex, which encompasses dozens of high-tech industrial parks. One of them is China Speech Valley (*Zhongguo shenggu*), which focuses on AI-powered voice recognition technologies (Hefei STIP Co. Ltd 2022). Hefei's high-tech start-ups and companies focus on integrated circuits, biomedicine, and high-end medical equipment. Within the Gaoxin industrial complex, the different industrial parks work closely together. For instance, the Gaoxin industrial complex's flagship company, iFlyTek, cooperated with another private enterprise in the Gaoxin industrial complex, ListenAI, to produce their 'AI chips' products (Su 2021).

The history of iFlyTek is the epitome of Anhui's provincial development of a local high-tech industry. In 1999, iFlytek Co., Ltd was founded in Hefei by Liu Qingfeng, then a student at the University of Science and Technology of China (USTC) in Hefei, and eighteen of his classmates. Since then, iFlytek has gradually grown into a large company that is the 'One Core (*Yi he*)' of Anhui's smart development. Among the more than one thousand companies in China Speech Valley, iFlyTek is now the largest. It has more than 14,300 employees (Market Screener 2022) and is the only intelligent speech recognition technology company listed on the Shanghai Stock Exchange (Zhu 2019: 68).

As the case of iFlyTek indicates, university linkages were key to the early start-up phases and have played an important role in attracting talent to the region. Anhui is home to USTC, a prestigious university in China that is directly managed by the Chinese Academy of Sciences. Founded in 1958 during the early years of the PRC, USTC set up many science and tech departments that are particularly relevant to emerging sciences, such as nuclear physics and space technology. The university founders include Guo Moruo, the first president of the Chinese Academy of Sciences of the PRC, who also became the first principal of USTC. Besides USTC, the Hefei University of Technology (HFUT) and Anhui University also provide a skilled labour force for the many start-up companies that have settled in China Speech Valley in Hefei.

Aside from the talent incubation and close linkages with university research institutes, Anhui's tech trajectory is also greatly influenced by its proximity to prosperous coastal neighbours. Anhui's southern prefectures enjoyed various spillover benefits on digital implementation and technological innovation from its technologically advanced neighbours. Situated along the Yangtze River, Anhui was naturally connected to the downstream cities, especially those in Jiangsu and Zhejiang. In 2014, the State Council positioned Hefei as a sub-centre city of the Yangtze River Delta city-region, which meant Hefei would be included, along with eastern coastal cities, such as Nanjing and Hangzhou, in the Yangtze River Delta's national strategy (Zhao and Zou 2018). These connections facilitated the flow of tech know-how, capital, and entrepreneurs (Kostka 2009). Table 3 summarises the ten strategic emerging industries and their regional distribution outlined in Anhui province's 14th FYP (2021–2025).

In Anhui, digital initiatives are more heavily concentrated in Southern Anhui, which is more developed than the prefectures in Northern Anhui. By tracking 205 local digital initiatives in Anhui from 2014 to 2021,[6] we find that

Table 9.3: Anhui's strategic emerging industries in the 14th Anhui provincial FYP.

District	*Strategic Emerging Industry Clusters*	*Industry Sectors*
Hefei	New energy vehicles, biomedicine and high-end medical equipment, culture and creative industry, and cyber security	Smart technology/electronic appliances, AI ICTs, Green food
Ma'anshan	High-end computer numerical control machine tools, railway transport equipment	
Suzhou	Cloud computing	
Huainan	Big data	
Chizhou	Semiconductors	
Wuhu	Robots, new energy vehicles, modern agricultural machines, general aviation	
Chuzhou	Smart household electronic appliances	
Bengbu	Silicon-based new materials	Six new materials: bronze-based, iron-based, aluminium-based, magnesium-based, silicon-based, and bio-based
Tongling	Bronze-based new materials	
Anqing	New materials for chemical engineering	
Huaibei	Aluminium-based metal materials, high-end macromolecule material	
Huangshan	Cultural tourism	Digital culture and creative industry
Bozhou	Modern traditional Chinese medicine	Life and health industry
Fuyang	Modern medicine	
Xuancheng	Core basic assembly units and parts (production)	Units and parts production for machine manufacturing
Lu'an	High-end equipment assembly units and parts (production)	

Source: Anhui Province 14th FYP (2021).

the leading prefectures in the south include Ma'anshan (18), Wuhu (14), and Hefei (13), while many poorer prefectures were left behind. Hefei, the provincial capital city, became the new focal point for Anhui's tech industry thanks to its industrial parks and the location of many research institutes. Ma'anshan and Wuhu are located close to both Nanjing, the capital of the prosperous Jiangsu province, and Hefei, the capital of Anhui. With more than thirty-three digital initiatives, Bozhou is an interesting exception. It is in Northern Anhui and economically in the middle among the sixteen prefecture-level cities of Anhui (Zhang 2022), but the city's economic development relies predominantly on a specific sector: traditional Chinese medicine. 'Bozhou medicine' is famous throughout China. The importance of the traditional Chinese medicine industry in Bozhou gives its digital initiatives a distinct character: the City Brain project in Bozhou, for example, was tasked with tracing and controlling the quality of traditional Chinese medicine ingredients and monitoring online vendors, along with other general functions in the area of traffic and pollution (Inspur 2022).

In summary, the high-tech industries in Sichuan, Zhejiang, and Anhui have developed differently because they have distinct historical trajectories and different levels of support for the tech sector. The historical institutional perspective offered here helps to explain why the high-tech industry in Sichuan is largely focused on civil–military industry production, while in both Anhui and Zhejiang there is a stronger focus on AI technology and speech recognition. The comparison also sheds light on the diverse state–business relations in the high-tech industry across regions: while Sichuan's tech industry has, to a large degree, been dictated by government and defence projects, Zhejiang allows more space for the tech industry to develop, albeit with tighter controls, and in Anhui, the tech industry has formed close relationships with local research institutes and labs in Hefei. Support from local governments has had a major impact on tech development in all three provinces, and historical conditions have played a formative role in shaping the outcomes.

LOCAL REALITIES: THE LOCAL IMPLEMENTATION GAP IN HIGH-TECH POLICIES

Despite Beijing's impressive efforts to devise industrial policies for technology upgrading (Naughton 2021), there is a substantial *high-tech policy implementation gap*. The term *implementation gap* refers here to differences between Beijing's high-tech ambitions and local policy outcomes. There can be a gap because many elements of Beijing's tech agenda fall to local governments for delivery. As local governments' interests, capabilities, and pre-existing industrial structures differ widely, national plans and investment funds are often not or only partially implemented, poorly executed, or significantly delayed.

Examples of such 'gaps' include overinvestment in physical infrastructures, which causes a waste of public resources, insufficient long-term financial investments, ill-functioning digital platforms, and flawed digital services for the public. For instance, despite being home to more than 500 of the roughly 1,000 smart cities in the world (Deloitte 2018), probably less than 10 percent of the smart city projects in China were fully functional, according to a report by a Chinese think tank (Liu and Zhang 2020). Many smart cities do not offer complete services or have set up too many fragmented 'service brains' that overlap with each other, causing a waste of resources (Liu and Zhang 2020). Many digital projects face delays due to data integration and standardisation issues and fail to integrate and analyse data for predictive policies (Große-Bley and Kostka 2021). For instance, some of the widely reported local social credit pilots have so far failed to develop a functioning scoring or assessment system, while others engage only a small percentage of the entire population (Li and Kostka 2022).

One sector where high-tech failures at the local level are most apparent is the many failed cases of local government investment in the chip industry. In 2020 and 2021 alone, six Chinese multibillion-dollar chip projects filed for insolvency. Owing to the high costs and high risks involved, the semiconductor industry has become the prime example of 'an industry that is flush with state cash but still scarce on expertise' (Feng 2021).

As the next sections argue, many of the failed outcomes in local high-tech industries can partly be traced back to the insufficient financial, political, and technical capacities of the local agencies in charge of high-tech policy implementation.

Insufficient Financial Capacities and Mismanagement of Funds

Many local high-tech projects depend on initial funding from China's Industrial Guidance Funds (IGFs). The local governments control the majority of IGFs (Naughton 2021: 109) and an estimated total sum of RMB 3.7 trillion (US$508 billion) is in the hands of prefecture governments, who are also the main implementers of the high-tech policies. In the second place are provincial governments, who control RMB 3.3 trillion (US$454 billion), while the central government controls about RMB 1.96 trillion (US$270 billion) of IGFs (Naughton 2021, 109).

At the national level, China has increased funding for technological and innovative projects (National Bureau of Statistics of China 2022) and has been planning major future investments. Local provinces have also set aside significant amounts in funding for smart city and big data projects. For instance, Guangdong province has invested RMB 10 billion in the next-generation ICT industry in Guangzhou (Liu 2017). The Guizhou provincial government has invested RMB 1 billion in a special fund for big data development that supports enterprises specialising in data collection and storage, data sharing, and information security (Wu 2021). Typically, more advanced localities in coastal provinces spend proportionally more on digital projects than less advanced localities in central and western provinces.

Despite the significant increase in funding for local IGFs, most of these tech funds are assigned to specific programmes. Local governments, whose responsibilities and tasks have skyrocketed over the past decade, tend to be seriously underfunded (Wong, 2021). As a result, costly high-tech projects are sometimes not prioritised because there are more pressing local priorities to fund. To overcome funding shortages, local governments can apply for project funding and staff expansion from the municipal, provincial, and

Table 9.4: Examples of failed semiconductor projects

City, Province	*Local Semiconductor Company/Project*	*Type of Local Gov't Involvement*	*Year and Type of Failure*	*Reason for Failure*
Nanjing, Jiangsu	Tacoma/image sensor chip	In June 2016, the Nanjing Municipal Government, Nanjing Tacoma and Tal Corporation announced cooperation to build a wafer factory	July 2020, insolvency	Lack of money and dependence on foreign technology
Gui'an New Area, Guizhou	Huaxintong (HXT)/developing server chips based on ARM architecture	A joint venture between Qualcomm and the provincial government of Guizhou	May 2019, shut down by the government	Qualcomm headquarters shuts down server business and loses technology source
Haui'an, Jiangsu	Dehuai/12-inch CIS)	The Huai'an government initially attracted Joseph Lee, the chairman of Tacoma, to set up a wafer factory. After falling out with Lee, Dehuai bribed a Party member in charge of the Huai'an high-tech zone to gain project approval and construction, tax rebates and further government investment	2020, incomplete production line construction	Other partners did not fulfil their investment obligation

Chengdu, Sichuan	GlobalFoundries (GF)/0.18 micron/22nm chip manufacturing process	In 2016, GF and the Chongqing municipality formed a joint venture to set up a local plant	Notice of closure in May 2020	GF cancelled investment
Wuhan, Hubei	Hongxin/7nm and 14nm chips	A joint venture between Wuhan's Dongxihu district (municipal) government and Beijing Guangliang Lantu Technology	2020, insolvency	Capital chain rupture
Fengxi Xincheng, Xixian New Area, Shaanxi	Incoflex/flexible semiconductor	Major funding: Fengxi district development funds	2020, insolvency	Capital shortage. Senior executives departed, leaving employees unpaid.

Sources: Reuters (2016), Feng (2021), Chinese Semiconductor Chart/*Xin Bang* (2020), Yang (2020), Geng (2020), Li and Shi (2020).

national governments, but these funding applications are often lengthy and require sustained effort by local leadership over several years (Lo and Tang 2006; Kostka 2014).

The shortage of funding was also very clear in local governments' efforts to create a local semiconductor industry. Many of the projects described in Table 5 failed due to insufficient financial capacities. The case of Nanjing Tacoma is a vivid illustration of the local governments' limited capacity to support this costly sector. Taiwanese businessman Joseph Lee established the semiconductor company Tacoma in Taiwan in 2003. He later moved part of the business to China. In 2015, the Nanjing government invited Tacoma to the Nanjing Economic and Technological Development Zone and Tacoma signed a contract with the Israeli semiconductor giant Tower Semiconductor to buy technology know-how and IP rights from Tower for US$60 million. In 2016, Nanjing Tacoma Semiconductor Technology was officially founded. This took place against the backdrop of the 'chip rush' created by the publication of the 2014 *Guidelines to Promote National Integrated Circuit Industry Development* issued by the central government. The local government was said to have invested US$billion in Nanjing Tacoma (Zha 2016). Nanjing Tacoma was a comprehensive project that aimed to cover

Table 9.5: Largest Local Industrial Guidance Funds

Fund Name	*Level*	*Scale (in billions of RMB)*	*Key Fund Priorities*
Optical Valley Fund (Wuhan)	Prefecture	10	Optoelectronic information industry, new energy and environmental protection, high-end equipment manufacturing, high-tech services
Kunpeng Fund (Shenzhen)	Prefecture	50	The upstream and downstream of the new generation of information technology industry chain
Shanxi Taihang Fund	Provincial	20	Investment in the fields of mixed ownership reform of state-owned enterprises, development zone construction, strategic emerging industries, cultural tourism industries and civil–military integration industries
Jiangxi Development and Upgrading Fund	Provincial	100	‘2+6+N’ industries: 2 means non-ferrous metals and electronic information; 6 means equipment, petrochemicals, building materials, textiles, food, automobiles; N means aviation, traditional Chinese medicine, mobile Internet of Things, semiconductor lighting (LED), virtual reality, energy saving, and environmental protection
Zhejiang Jinhua Science and Technology Park	Prefecture	11	Fourteen projects in the first stage. Facilities are the main priority, including necessary infrastructure for high-end education and several large industrial and innovation parks that focus on digital economy innovation and urban planning (Seetao 2021)

Big Data Development Fund of Guizhou	Provincial	1	Financially supporting the BIG DATA EXPO in Guiyang (64 million RMB), building the smart airport in the Guiyang Longdongbao International Airport, and supporting hundreds of enterprises, especially focusing on ICT
Guangzhou Next-Generation ICT Industry Fund	Prefecture	10	Building an ICT ecosystem and developing a self-sufficient ICT industry supply chain in Guangzhou city

Sources: Naughton (2021: 109); Optical Valley Industrial Investment (2022), Shenzhen City Kunpeng Equity Investment Co., Ltd. (2022), Chin (2017), Liu (2022), Liu (2017), Wu (2021).

the whole semiconductor production chain: the plan was to set up IC design studios, R&D centres, facilities reproduction factories, assembly, testing, and packaging factories, as well as the downstream daily applications product centres. Nanjing Tacoma also promised to deliver a mass production capacity of 8-inch chips in June 2018.

It all turned out to be a big disappointment. Following a government investigation, Lee was found not to have invested any money in the project and to have relied solely on local government funds. However, according to Lee, the local government had promised him substantial support from China Invest Century Shareholding Investment Group Limited (Li and Shi 2020, 11). The park also failed to provide a credential financing guarantee company for Tacoma to lend money. Ultimately, the funding was unsustainable and far below the mark for semiconductor investments. On 19 April 2019, Lee announced that Tacoma would cease production, and eventually, the half-finished Nanjing Tacoma factory buildings were completely abandoned.

While the local government has tried to frame Tacoma's failure as the result of Lee's non-investment, the lack of sustainable government investment in the project is hard to ignore. As Tacoma's case highlights, initial state investments may be huge, but sustaining funding is a major problem. Similarly, other start-ups like Hongxin, Incoflex and Dehuai (another project started by Joseph Lee) were regarded as 'scams,' but they all followed the same pattern of starting as a high-profile project with large local government investments and high hopes from the local governments, leading to failure. The national strategic focus on semiconductor technology development developed by the central government generated an uncontrollable and wasteful 'chip rush' in the process of implementation at local levels.

Insufficient Technical Capacities

Technical capacity constraints can further hinder the implementation of national high-tech mandates. Two pertinent technical constraints that are commonly cited in the literature are a lack of technical know-how and insufficiently trained local staff in the public sector (Segal, 2003; Fuller 2016). China's local bureaucracy is in chronic need of well-trained staff to set up and manage complex high-tech projects, which typically require tight management of outsourced subcontracts with private or state-owned enterprises. Project management for IT and high-tech initiatives can become incredibly complex. Zhang and Bao (2018) highlight the need to further enhance the high-tech literacy of leaders in key government departments and provide training to improve leaders' skills and knowledge.

China's state-owned companies generally face difficulty attracting and retaining bureaucrats with a deep understanding of technology. For example, a Chinese article that delved into the problem of a brain drain to the United States complained that young, highly trained personnel often work at state-affiliated institutions or SOEs purely for the sake of earning better *Hukou* and polishing their résumés. The article notes that one or two years after government officials get what they needed, they move to the private sector as a step toward working abroad (Lian 2022). The shortage of human capital in the tech sector also helps to explain why digital projects in China sometimes get stuck in Phase 1 (data collection), while Phases 2 (data analysis) and 3 (using data for predictive purposes) remain locked in the distant future (Große-Bley and Kostka, 2021).

Insufficient Political and Coordination Capacities

Local governments work under certain political capacity constraints that influence policy outcomes. Political capacity constraints can result from coordination difficulties because of various factors. First, the implementation and enforcement of high-tech mandates and plans at the local level are partly hindered by bureaucratic fragmentation, as responsibilities are allocated among many different government agencies (Große-Bley and Kostka, 2021). Numerous government agencies are usually responsible for the implementation of a high-tech project but often without a clear division of labour, which in practice leads to a lack of accountability. For example, more than fifteen departments have a role to play in the implementation of digital governance platforms at sub national levels. Usually, the provincial or municipal government office and the local Big Data Administration (BDA) bureau take the lead, followed by police/legal bureaus, economic/commerce bureaus and social security/housing bureaus (Kostka, 2022). Similarly, when looking at the implementation of the City Brain projects at the local level, a lead project manager noted that there are 'way too many brains' involved (Liu and Zhang 2020). A city can have an environmental protection brain, a traffic brain, a medical care brain, and so forth—all on top of a city brain. The CEO of Hangzhou H3C City Digital Brain Research Institute, Peng Yue explained, "It might be due to the fact that many government bureaus build their own data warehouses and all call them 'brains'" (Liu and Zhang 2020). With responsibilities spread across many fragmented bureaucracies, it can be cumbersome to coordinate high-tech projects. For instance, it is often not possible for a low-ranking bureaucratic office to access relevant data from another bureau higher up the hierarchy. The same happens with bureaus at the same level. Many data systems and platforms are often only for internal use and not open to external users, even those within the government.

The implementation capacity of local departments in charge of complex high-tech projects is further constrained by competing demands and heavy workloads in implementing local agencies. High-tech projects also fall into the realm of local Development and Reform Commissions (DRCs), which are powerful but often take on too many tasks and are, therefore, sometimes understaffed. In addition, many local DRC officials lack the digital expertise to push or coordinate complex local high-tech projects. For a project to be successful, it often requires the local leadership taking it on as a pet project; only such high-priority initiatives can secure sufficient long-term start-up funding. For instance, in Zhejiang, some local digital projects have succeeded because local politicians kept pushing for them. In particular, the fast development of the 'Maximum one visit for administrative procedures' digital project would not have been successful without significant attention from Party Secretary Yuan Jiajun (Yuan, 2021).

In summary, local leaders in charge of high-tech projects receive mixed signals: they are asked to fully implement high-tech projects, but these demands by upper-level governments are not always matched by a corresponding increase in political power and financial resources. The following quotation summarises the challenge quite well: 'In a word, Big Data bureaus are a paradise for innovators, but hell for those who follow prescribed routines. Work in Big Data bureaus can be summarised with the following key words: endless tasks, limited budget compared with other departments, glory, outstanding performance, bright future' (Zhang, 2020).

CONCLUSION

This chapter argued that China's technological rise is both fueled and constrained by the specific institutions of the party-state. The 'fuel' is the party-state's capacity and will to lead China up the value chain thanks to massive investments. China's policymakers have shifted from an indicative planning approach to new industrial policies in which the state plans to invest unprecedented sums to leapfrog in technology—thereby helping Chinese tech firms to advance rapidly in the global tech war.

The 'constraints' involve the downside of decentralised and fragmented authoritarianism. As illustrated with the cases of Anhui, Sichuan, and Zhejiang provinces, at the provincial level, the trajectory of technology industrial growth differs across regions and is often shaped by multiple pre-existing economic, social, and political factors. Furthermore, many national tech ambitions are often only partially implemented at the local level due to local governments' insufficient technical, financial, and political capacities to push for tech leadership in their locally grown tech industries. In particular, the lack of long-term finances has been the main hurdle to the development of viable high-tech industries at the local level.

NOTES

1. The author gratefully acknowledges funding the European Research Council (ERC Starting Grant No: 852169). The author is also very grateful for excellent research support from Jingshin (Anita) Lin.

2. Despite strong ambition, the funds ultimately raised only about US$672 billion in total (Luong et al. 2021, 4).

3. The seven industries are: cloud computing, Big Data, Internet of Things, Industrial Internet, Blockchain, artificial intelligence and virtual and augmented reality. The ten sectors are: smart transport, smart energy, smart manufacturing, smart agriculture and irrigation, smart education, smart health, smart culture and tourism, smart community, smart household, and smart government.

4. The spread of the 222 digital initiatives in Sichuan is as follows: Mianyang (28), Chengdu (27), Neijiang (27), Guang'an (22), Meishan (13), Ganzi (12), Dazhou (12), Bazhong (10), Suining (9), Nanchong (9), Ya'an (8), Luzhou (8), Guangyuan (7), Deyang (7), Ziyang (6), Aba (5), Leshan (3), Panzhihua (3), Yibin (3), Zigong (2) and Liangshan (1).

5. The spread of the 365 digital initiatives in Zhejiang is as follows: Jinhua (53), Shaoxing (52), Huzhou (43), Hangzhou (42), Lishui (32), Ningbo (30), Jiaxing (23), Zhoushan (21), Wenzhou (20), Quzhou (16), Taizhou (14).

6. The distribution of the 205 digital initiatives in Anhui is as follows: Bozhou (33), Chizhou (22), Maanshan (18), Huangshan (18), Wuhu (14), Lu'an (13), Hefei (13), Chuzhou (11), Fuyang (10), Huaibei (10), Xuancheng (9), Benggu (8), Tongling (8), Anqing (8), Suzhou (6) and Huainan (4).

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