

CHINA'S QUEST FOR INNOVATION: PROGRESS AND BOTTLENECKS

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As the Chinese economy continues to decelerate, the central government is investing heavily in innovation, doubling down on research and development (R&D) spending and STEM-oriented human capital. In this paper, we assess China's progress so far, looking at the inputs to innovation (R&D and human capital) as well as intermediate targets, such as scientific research and patents. We then evaluate how China has fared with respect to the ultimate goal of commercialising this progress, by looking at the value-added of Chinese exports and the overall productivity of the economy. We identify three potential bottlenecks that might be hindering the translation of China's innovation efforts into productivity growth.

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Key findings:

- China has increased R&D expenditure and improved human capital. It has made significant progress with respect to the quantity and quality of both scientific publications and patent grants. However, this huge innovation effort has not fully translated into economic gains. While the value added of Chinese exports has clearly increased, China's total factor productivity (TFP) has decelerated faster than was the case for economies in similar circumstances as those of China.
- We identify three potential bottlenecks constraining the translation of innovation into improved total factor productivity. First, China's reform process has waned during the last ten years when compared to previous years which were officially dubbed as the 'Reform and Opening Up' period. At the central level, the institutional framework has become more complex with several new regulatory bodies, such as the Cyberspace Agency of China (CAC), with sweeping powers on businesses and a web of new laws to enhance national security. At the local level, the reliance of firms on connections to the government render it hard for China's 'mass of entrepreneurs' to enter a level-playing field with incumbent enterprises.
- A second bottleneck comes from China's changing society, which for a long period has been very supportive of innovation and very positive about the country's economic future. At this juncture, youth unemployment stands at over 20 percent even after the full reopening of the economy. As a result, China's youth have changed their career preferences towards security, ie civil servant jobs, indicating a reduced interest in entrepreneurship and private sector careers. This runs counter to the central government's official aims of keeping China's economic dynamism.
- A third potential bottleneck comes from the United States' push to contain China technologically, which is having a negative bearing on China's ability to move up the ladder in certain key sectors, most notably semiconductors. China's drive to spend a huge amount of funds to reduce the gap with the US and advanced economies, which started in 2015 with 'Made in China 2025' has, so far, not been successful. However, only time will tell whether China will be able to catch up with the most advanced semiconductors and what the consequences are of these two scenarios.

1 Introduction

The Chinese economy is at a crossroads. The investment-driven growth model which the government relied upon for the last four decades is running out of steam, fiscal deficits are widening and public debt is rising. Furthermore, population aging is becoming more visible and the pandemic had some scarring effects which have taken a toll on both consumer and business confidence. The very rapid rise in wages since the global financial crisis is pushing China to move up the ladder in its production capabilities so it can be productive enough to continue to raise wages and avoid the middle-income trap. Pressure on the economy is further intensified by the recent increase in geopolitical tensions and fears of decoupling between the US and China.

Against such a challenging backdrop, the central leadership is doubling down on its push towards a new type of development philosophy, one in which consumer demand and indigenous innovation serve as the two pillars for further economic progress. China's leadership is aware that only an innovation-centred economy can mitigate its structural deceleration, or, using the terms of our previous article on China's long-term growth prospects defy gravity (García-Herrero, 2023).

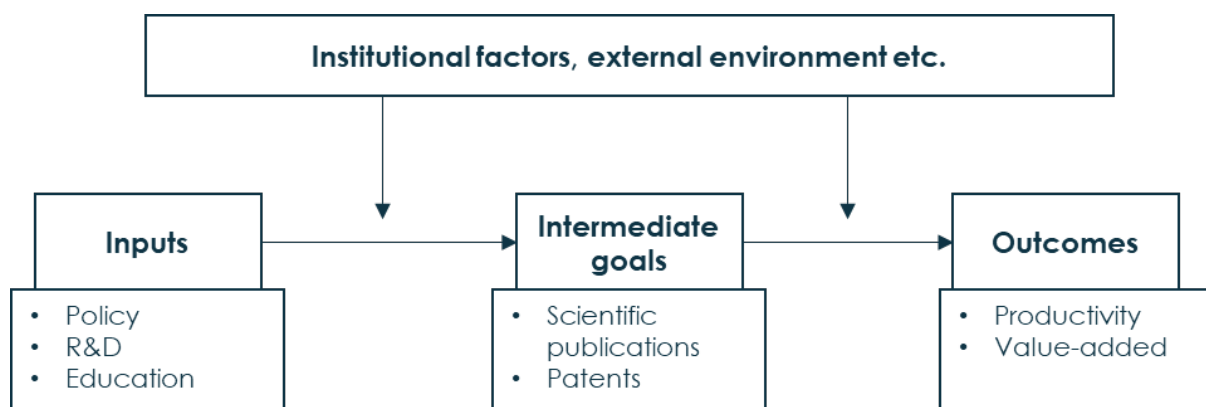
The vision of the central government was best summarised in an article by Chen Jin *et al* (2018) from Tsinghua University, in which the authors proposed a new innovation paradigm for China, dubbed as "*Holistic innovation*". Holistic innovation combines previous approaches to innovation, often embedded in a specific cultural context and implemented by isolated actors within the entirety of the ecosystem. In this new paradigm, under the umbrella of a strategic vision set by the Chinese state, actors engaging in innovation (research institutions, firms, government agencies) should seek synergies between internal and external resources for innovation, align every department of their organisation with the overall strategic goal of innovation and collaborate with all relevant institutions in the ecosystem. In other words, the central state aims to rally the entire country behind the goal of reaching the technology frontier, particularly for strategically important sectors.

So far, however, this goal has not materialised yet, as China is still dependent on foreign technology in a number of crucial sectors, including semiconductors. More importantly, the massive amount of resources in research and development (R&D) have not yet resulted in an increase in total factor productivity, even though progress can be seen in less overarching – but also abstract – indicators, such as the value added embedded in exports as well as the amount and quality of scientific research and patents. This paper seeks to provide an overview of the status of China's innovation strategy and where the potential bottlenecks are.

2 Measuring China's innovation efforts and outputs: what do we know?

Innovation describes the development and application of ideas and technologies that improve goods and services or make their production more efficient. In a standard growth model, innovation is captured by a technology factor which determines the attainable level of output from a given combination of different inputs (labour, capital etc) (Solow, 1965). Economists have long acknowledged that technological change is endogenous, meaning that it arises from intentional investment decisions made by rational agents in the economy (Romer, 1990). These technology investments serve as the **input** within the process of innovation and come from different sources. They describe the resources devoted to research and development, whether that is basic, applied, or experimental research, as well as policy support. Human capital describes the capacity for the labour force to participate in such technology efforts. These inputs then translate into outputs – **intermediate goals** – which are commonly measured by the quantity and quality of scientific publications and patents. However, the economy only prospers when these intermediate goals are translated into actual **outcomes** such as productivity increases and net-gains in industry value-added. Finally, each step of this process is subject to a variety of **influencing factors** that can accelerate or impede progress in innovation. These include the institutions that provide the incentives for the search for and commercialisation of technological improvements and cover factors such as patent and bankruptcy laws, as well the bureaucratic quality of the government and the external environment through which the country navigates (including access to foreign technology). Eventually the system should sustain itself through a virtuous cycle in which innovation, productivity and per capita income jointly reinforce each other and lead countries to long-term sustained growth rates (Rouvinen, 2002; Acemoglu, 2012). We move along this framework in our analysis (Figure 1).

Figure 1: Efficiency-effectiveness framework for the analysis of a national innovation system



Source: Mandl *et al* (2008).

2.1. Inputs

2.1.1 The party's push for innovation

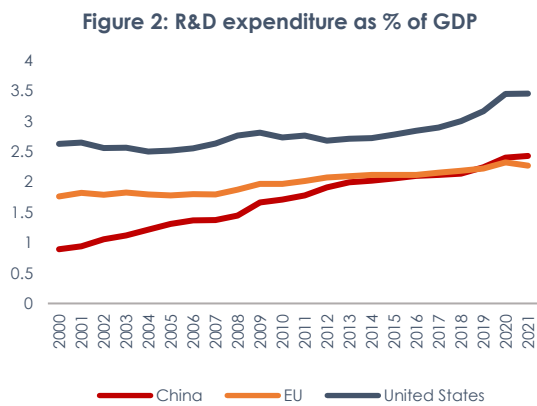
After the horrors of the Cultural Revolution and its anti-intellectual flavour, Deng Xiaoping came to power in 1978, and declared Science and Technology to be one of the four pillars of China's path to modernisation. Over the course of the next three decades, several National Science and Technology Conferences were held. At these conferences, central guidelines and directives were issued, indicating the centrality of innovation policy in the government's plan for economic development. Under President Hu Jintao, 'The National Medium- and Long-Term Programme for Science and Technology Development' was announced for the period 2006-2020¹. The programme identified key technological breakthroughs which China needed to carry out during that period. When President Xi came to power in 2013, the emphasis on innovation was not only for developmental reasons, but also to rebalance the economy away from credit-led growth to 'high-quality' growth. One of the key instruments for Xi Jinping's vision was industrial policy, as reflected in the strategy 'Made in China 2025' (中国制造2025), published in 2015. This focused on ten specific fields in which China should build up world-class technological capacity. It also included outright subsidies for indigenous innovation, and easier financial conditions (such as lower interest rates or a lower tax effective ratio) as well as China's large Government Industrial Guidance Funds for state-led investment.

2.1.2 Efforts in R&D

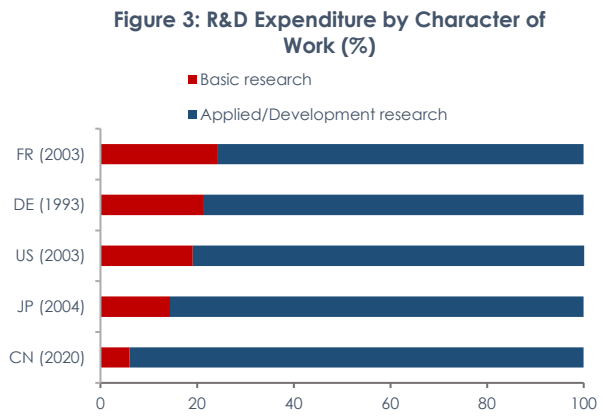
China's R&D spending as a share of GDP has ballooned during the last two decades. It has already caught up with the R&D of the EU but still remains far from that of the US (**Figure 2**). However, how much a country invests in R&D needs to be qualified by several factors, so as to gauge the effectiveness of such investment. In the case of China, several issues cast doubts on the quality of R&D, like the predominant role of the state in R&D investment and the dependence on firm-level subsidies for indigenous innovation. The latter accounted for about a quarter of total R&D spending in 2015 (Fang *et al*, 2022). Research is also highly biased towards applied research as opposed to basic research, the latter of which is usually associated with breakthrough and general-purpose technologies. While many developed nations hold a share of basic research to total R&D spending of well above 20 percent, basic research in China accounted for merely 6.01 percent of total R&D spending in 2020 (**Figure 3**). A revision of the law on Science and Technology Advancement was put

¹ Accessible via: https://www.itu.int/en/ITU-D/Cybersecurity/Documents/National_Strategies_Repository/China_2006.pdf.

into effect on 1 January, 2022 which posits a gradual increase in the proportion of basic research as part of R&D expenditure.



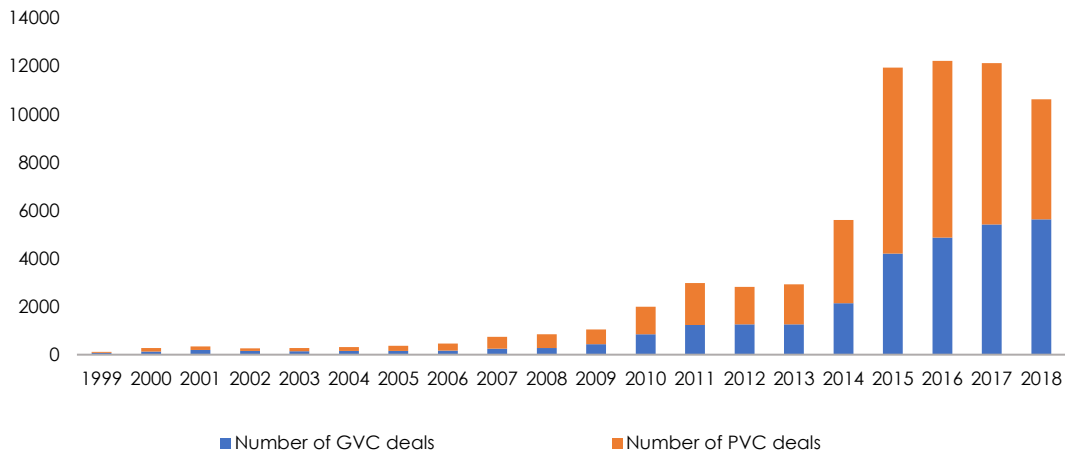
Source: World Bank, Eurostat



N.B. Numbers in parentheses stand for Fiscal Year.
Source: Natixis, MEXT, NBS

Increases in R&D expenditures are complemented by other policy instruments. Tax incentives are accessible for firms that can acquire a high and new technology enterprise (HNTE) status (15 percent corporate income tax as opposed to 25 percent generally). While banking remains the largest source of funding for most sectors in China, tech sectors are finding their way through specific channels whether it is ad-hoc stock markets or through private equity. For example, in 2009, ChiNext was launched as a subsidiary of the Shenzhen Stock Exchange aiming at attracting innovative and high-tech firms. In 2019, the Shanghai Stock Exchange STAR Market, was created allowing start-ups to maintain a dual class share structure after their IPO for more flexibility. Beyond public markets, a strong increase in venture capital activity has taken place since the 2010s, much of it was driven by government involvement (**Figure 4**). These government venture capital (GVC) funds aim to invest more in early-stage business development compared to their private counterparts and focus on sectors that the Chinese government deems strategically important (Li, 2021).

Figure 4: Number of VC deals by funding source

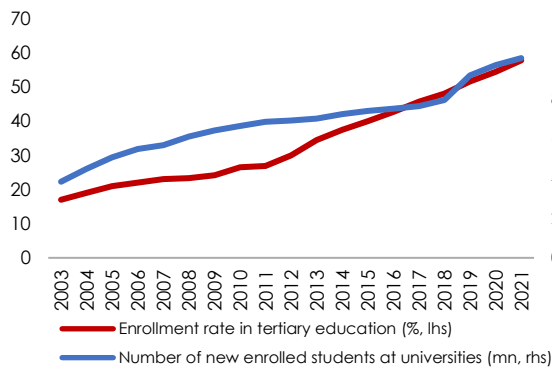


Source: Li (2021)

2.1.3 Human capital

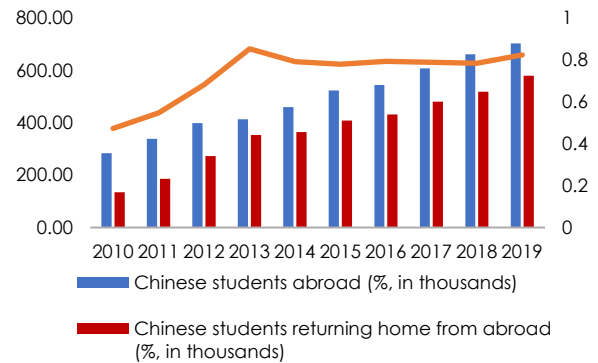
Concerning the third input, the educational attainment of the Chinese workforce has risen significantly with a larger proportion of students enrolling into tertiary education. According to the Chinese Ministry of Education, from 2003 to 2021, the annual number of newly enrolled students in higher education rose from around four million to almost ten million, while the gross admission rate gradually increased to close to 60 percent (**Figure 5**). Still, there are counterarguments as to the quality, and even coverage of Chinese education, such as those offered by Rozelle and Hell (2022) where the authors point to the still very limited coverage of secondary education, especially in the rural areas. In any event, what is undisputable is that China has been sending a very large number of students overseas, mainly to study Science Technology Engineering or Math (STEM). More specifically, since 2000, China has sent an estimated 5.2 million students and scholars to study abroad, most of whom are in STEM sectors. Many of these students have remained overseas but an increasing number return to China to work in well-resourced laboratories and high-tech companies (**Figure 6**). For the highest end of this echelon, as part of the 17th National Congress of the Chinese Communist Party in 2007, China launched the so-called 100 talent programme to recruit experts in science and technology from abroad, principally but not exclusively from overseas Chinese communities. This programme has so far been quite successful in attracting talent and has accelerated China's efforts *reverse the brain drain* (the term coined by Zweig, 2006).

Figure 5: Newly enrolled students and gross admission rate



Source: Chinese Ministry of Education

Figure 6: The return of Chinese students from abroad



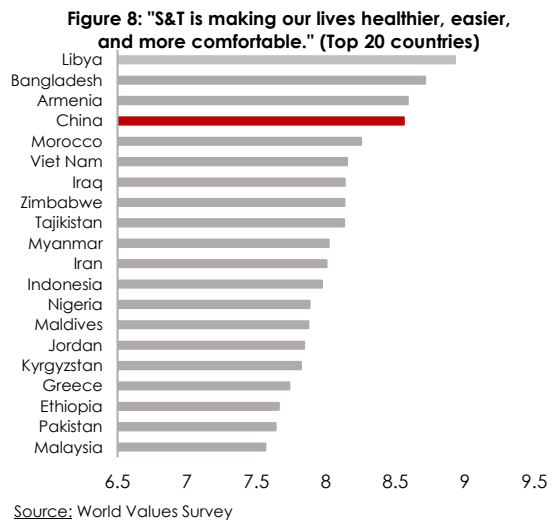
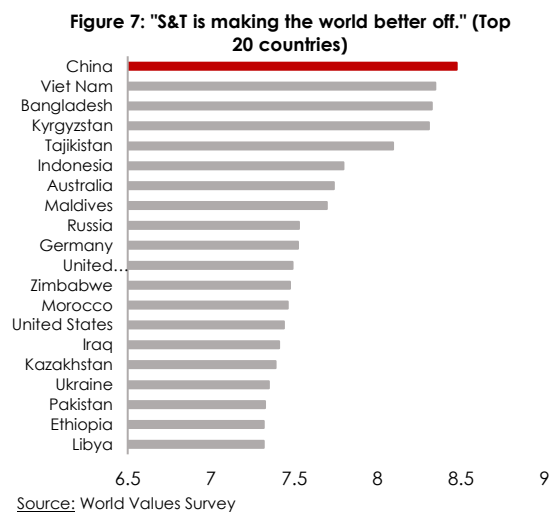
Source: National Bureau of Statistics of China

2.1.4 Societal support for innovation

When considering innovation, the focus is generally on businesses and research institutions that invest in innovation for the sake of profits. However, innovation is a complicated creative process that requires an enormous dedication to technological inventions. In this area, China can draw on a significant advantage. According to the World Value Survey, the world's most comprehensive regular survey on values and culture, China is one of the most appreciative countries when it comes to Science and Technology. **Figure 7** and **Figure 8** depict two S&T related questions from the 2017-2022 release of the survey. Of the 64 participant countries, China ranked first and fourth, respectively, indicating strong technology affinity. National identity at least partially explains this. The eventual downfall of Imperial China in the early twentieth century after more than two millennia of persistence was to a significant extent triggered by European technological superiority, and the reluctance of the ruling Qing dynasty to modernise its armed forces (Rowe, 2009). 'The Century of Humiliation' (百年国耻) that followed marked a painful and steady decline into widespread economic impoverishment and a seemingly endless series of military defeats. Japan's success in upgrading its technology and joining the imperial powers added to the bitterness of the experience. This period – starting with China's defeat during the Opium war in 1842 and only ending with the victory of the CCP in the civil war from 1945 to 1949 – is as an essential part of the PRC's founding myth². After the reform and opening era started in 1978, the continuous imitation of key technologies from overseas fuelled the 31-fold increase in GDP per capita from 1990 to 2019. Technology became not only a symbol of national security, but equally one of individual prosperity, which was embraced with enormous enthusiasm.

² Matt Schiavenza, 'How Humiliation Drove Modern Chinese History', *The Atlantic*, 25 October 2013, <https://www.theatlantic.com/china/archive/2013/10/how-humiliation-drove-modern-chinese-history/280878/>.

For instance, internet and mobile payment adoption in China has been faster than in countries that started from a comparable level of development (Dychtwald, 2021). According to the European Chamber of Commerce, Chinese consumers are demanding new products and product features at a much faster rate than European consumers, which renders the Chinese market akin to a ‘fitness club’ for European customers³, driving their need to innovate.



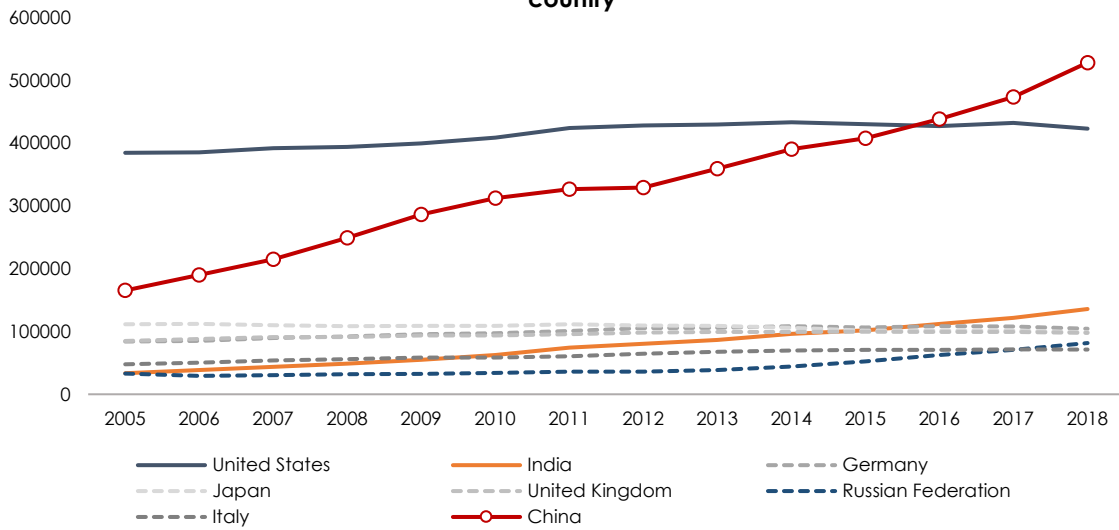
2.2 China fairing very well on intermediate goals: Scientific publications and patents

2.2.1 Scientific publications

In the field of scientific publications, Chinese efforts in closing the gap with the West are paying off. Starting with quantity, China already publishes more scientific papers than the US (Figure 9). To assess the quality of such scientific publications, the number of citations can help, especially influential citations. In fact, according to Japan’s National Institute of Science and Technology Policy (NISTEP), China tallied the top 1 percent papers in terms of citations (Tollefson, 2018).

³ *Global Times*, ‘China is akin to a fitness club for European companies that drives us to be faster, better: president of the EU Chamber of Commerce’, 17 September 2022, <https://www.globaltimes.cn/page/202209/1275450.shtml>.

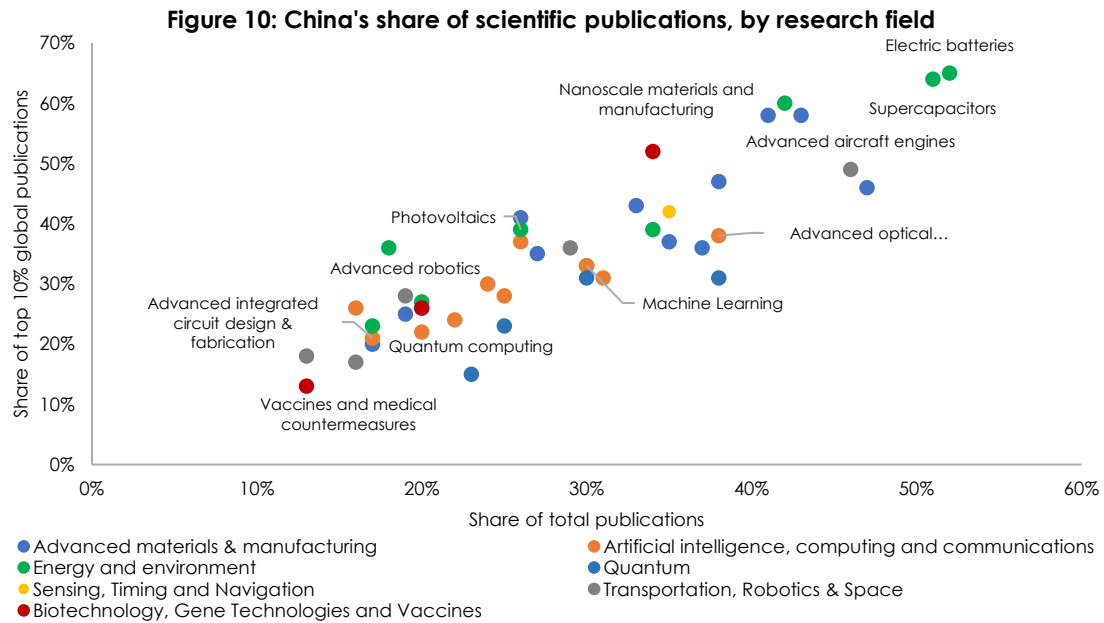
Figure 9: Number of articles published in scientific and technical journals, by country



Source: World Bank, National Science Foundation

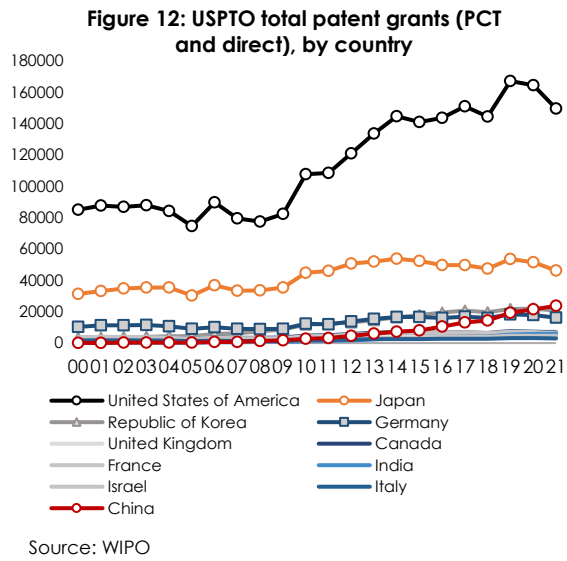
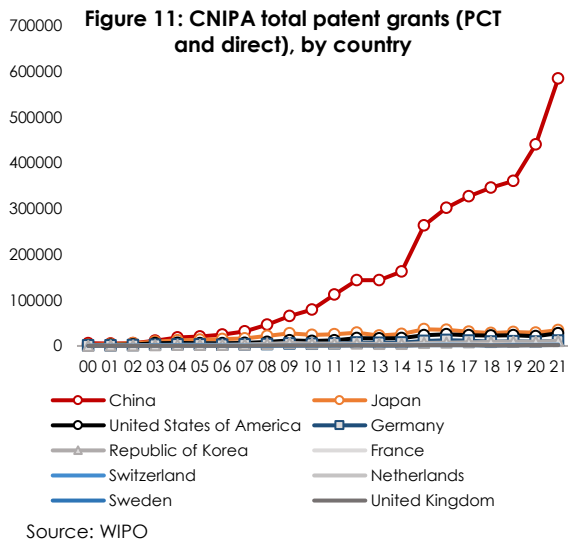
In different areas of scientific publications, according to the Australian Strategic Policy Institute, China dominates now 37 of 44 key research fields, both in terms of share of total publications (quantity) and share of publications in the top 10 percent of highly cited publications (quality). The sample of publications includes only English-language articles and covers the period 2018 to 2022. As illustrated in **Figure 10**, China's dominance is especially apparent for electric batteries, aircraft engines and nanoscale materials and manufacturing, where Chinese researchers take up a share of over 40 percent of total publications, including in the world's top 10 percent highly cited papers. In other crucial fields including photovoltaics, advanced robotics and machine learning, China holds a strong position as well, with a share along both the quantity and quality dimensions of well over 20 percent. Nevertheless, note that the analysis is not without criticism due to insufficient weighting of journal and author influences in research, and to the inclusion of self-citations. For the case of China, both factors might bias the quality indicator of the ASPI upwards by a significant margin⁴.

⁴ Marina Yue Zhang, 'Chinese tech dominance more myth than reality', *East Asia Forum*, 21 April 2023, <https://www.eastasiaforum.org/2023/04/21/chinese-tech-dominance-more-myth-than-reality/>.



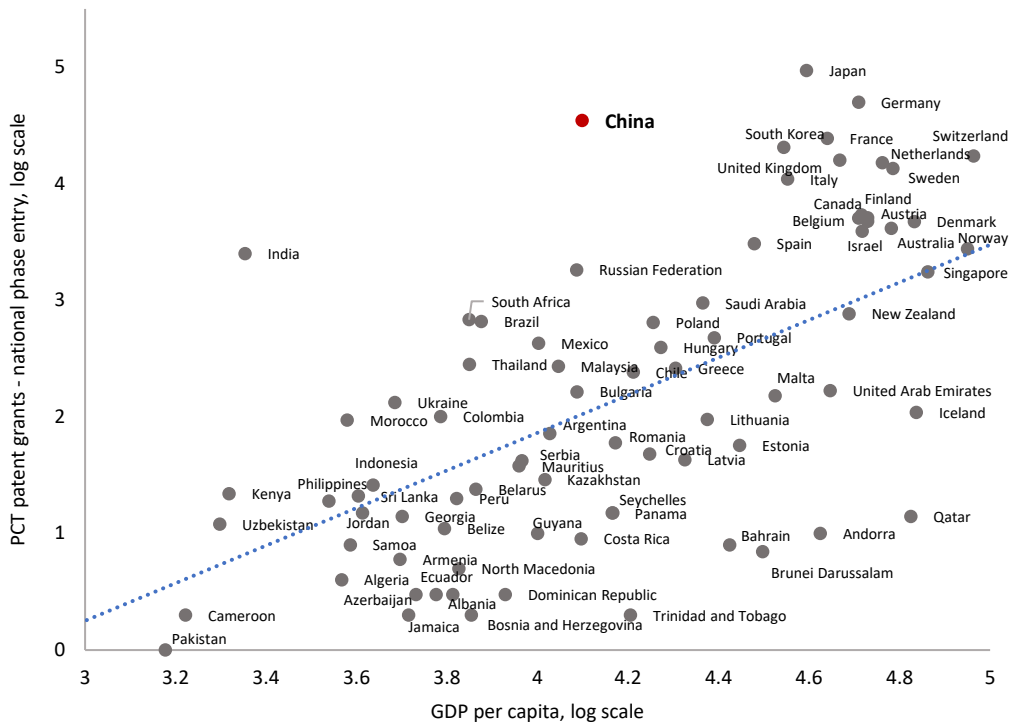
2.2.2 Patents

As another intermediate indicator of innovation, patent data is widely used. **Figure 11** shows an explosion of patent grants at the China National Intellectual Property Administration (CNIPA), for both direct patents grants and patents granted under the PCT regime. However, the number of granted patents depends on the quality standards of the responsible government agency, and thus is by construction policy driven. Furthermore, local governments in China pay patent subsidies to firms to cover their cost of filing and aid with patent application. In fact, research suggests that the average quality of PCT patents is significantly lower in China than in the rest of the world (Boeing and Mueller, 2019). To some extent, these concerns can be circumvented by looking at patents of Chinese origin granted by the United States Patent and Trademark Office (USPTO), where Chinese applicants are competing directly with applicants from other countries. **Figure 12** shows that USPTO patents of Chinese origin have increased since 2009 meaning that China has managed to reach the level of Germany and South Korea but remains below US and Japanese patent quantity.



We can further compare China’s increase in patent grants with other countries by correlating it with GDP *per capita* (Figure 13). Here we see that China is a relative outlier. Compared to countries at a similar level of GDP, China has an excess number of patent grants. This might again reflect the policy-driven nature of patents but could also indicate that the country is still relatively behind in terms of translating the achievements in intermediate goals into tangible economic benefits.

Figure 13: Patents and economic development, by country (2019)



Source: World Bank, WIPO

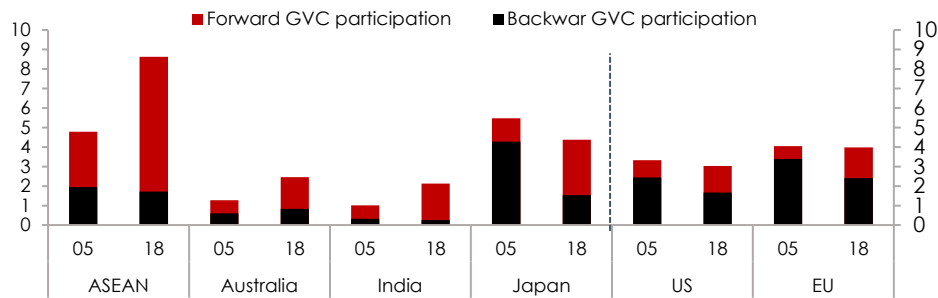
2.3 Outcomes: Value-added of exports and productivity

China has made rapid advancements in research and development and more generally, the ability to innovate. It is safe to conclude that both the quantity and quality of China's research and patent activity have gone up, even if the level of advancement is debatable. Besides, China has a government that prioritises innovation and technology and brings citizens together towards adopting new technologies. The question then is whether such innovation brings the expected economic outcomes. The most obvious outcome is economic growth and through it, higher income per capita and standard of living. The most obvious channel through which a country lifts its standard of living is productivity, but this is indeed not easy to measure.

A more measurable goal, although not so comprehensive, is the value-added embedded in the production of goods and services. **Figure 14** shows how China's domestic value-added in foreign exports (so-called forward participation in the jargon of global value chains) has significantly increased from 2005 to 2018 for most of the geographies China trades with. This is less the case for China's exports to developed economies, like the US or the EU, but very much so for its exports to neighbouring countries, such as ASEAN and even Japan. This suggests that, overall, China has moved up the value chain and that part of the outputs from its R&D efforts have made it to the stage of commercialisation. However, it also shows that China has still not fully reached the technology frontier

in the production of tradable goods as GVC participation with the EU and the US remains stagnant. In addition, part of this initial success was driven by the transfer of foreign technologies instead of indigenous innovation.

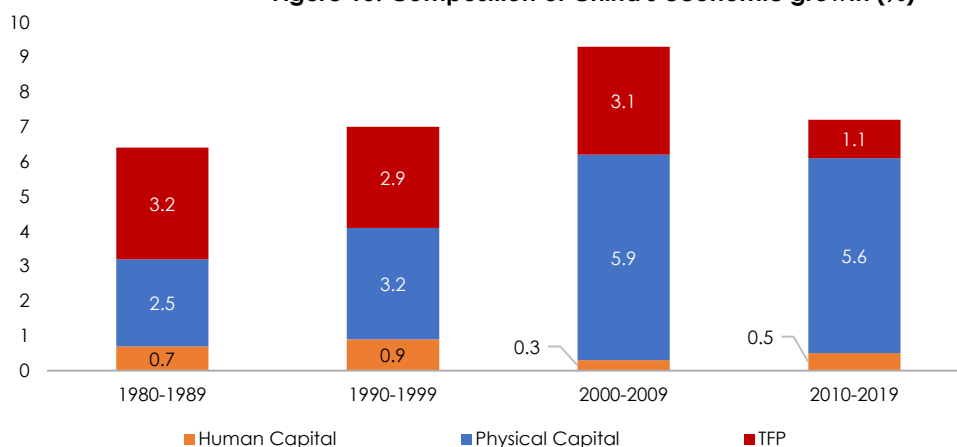
Figure 14: GVC Participation of China, by Partner and Type (% of gross exports)



ASEAN = Association of Southeast Asian Nations, EU = European Union, GVC = global value chain, US = United States.
 Notes: See Box 1 for the definition of GVC participation. Forward participation means domestic value-added in foreign exports. Backward participation means foreign value-added in domestic exports. ASEAN refers to eight of its 10 Member States: Brunei Darussalam, Cambodia, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam (no data were available for the Lao PDR and Myanmar). EU refers to the member countries as of 2013–2019.
 Source: OECD (2022).

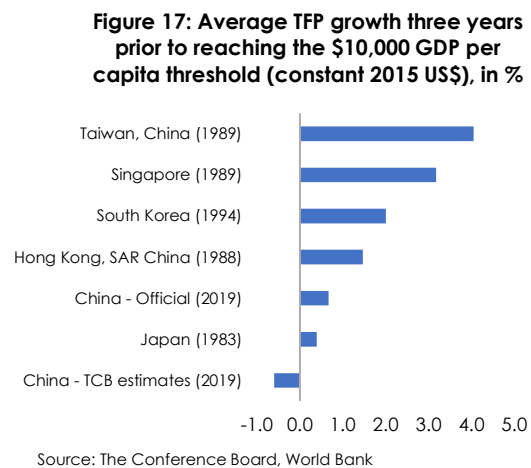
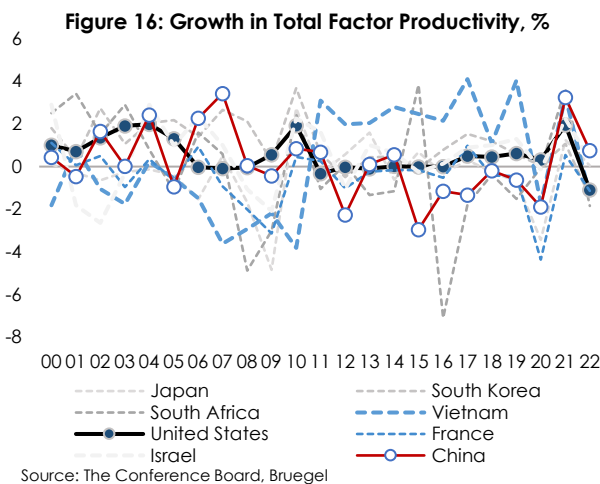
To assess whether China will eventually defy the gravity that pulls its economy down, gains in total factor productivity (TFP) need to be considered. TFP is commonly used as a measure of the efficiency with which an economy uses its inputs to produce outputs. Indeed, until the great financial crisis the removal of entry barriers to private entrepreneurship and the closure of the least productive SOEs led to substantial productivity increases (Curtis, 2016). However, since then the picture has been less rosy. China’s TFP has been stagnant or even declining since the late 2000s. Estimates by Brandt *et al* (2022) indicate that the share of TFP in overall growth dropped significantly from 3.1 percent between 2000 and 2009 to 1.1 percent between 2010 and 2019 (Figure 15).

Figure 15: Composition of China's economic growth (%)



Source: Brandt *et al* (2022)

Estimates by The Conference Board even point to an average negative TFP growth between 2010 and 2019 (Figure 16) and one that is much lower than official estimates by the Chinese government. This slowdown is partially driven by a general deceleration in global productivity since the 2010s, caused by an aging population, slowing global trade integration, and declining returns on ICT-related technologies. However, even when measured against this benchmark, China's drop in TFP growth has been particularly strong (Raiser and Soh, 2019)⁵. Remarkably, no matter whether one relies on the official or the TCB estimates, China's average TFP growth three years prior to reaching a GDP per capita of 10,000 in constant 2015 dollars is significantly less than for the four Asian tigers after reaching the same level (Figure 17). The call for innovation to deliver the promised path out of the structural deceleration of China's economy has so far been unanswered. It has undoubtedly become more innovative, but this has not been reflected in the GDP figures.



3 Potential bottlenecks to productivity growth

Given China's huge efforts and the still limited ultimate outcome, at least as far as productivity is concerned, it seems important to analyse the bottlenecks constraining the efficacy of China's innovation policies. The section below reviews such bottlenecks.

⁵ While it has been noted in the literature that the immediate post-GFC decline in TFP has been caused by a drop in new firms entering the market (see Brandt *et al*, 2017), no studies so far have done a similar composition of China's TFP after 2013.

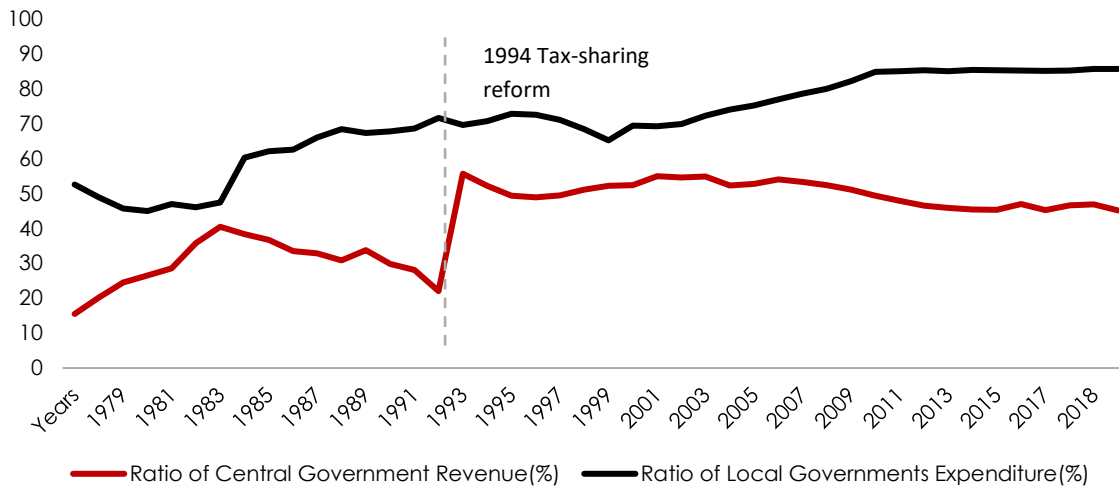
3.3 Institutional reform

China is still in the midst of defining how a modern version of its once prosperous empire should look like, and institutional reform has been a crucial component of this. With the end of credit-driven growth as a success model and so far, modest success in the rebalancing the economy, deepening reform is becoming a major challenge for the leadership. Three issues remain unsolved.

3.1.1 Readjustment of local government incentives

One essential aspect of institutional change is the struggle for an appropriate balance between central and local government responsibilities. In fact, this point is hard to overemphasise and is much older than the People's Republic itself. An old Chinese proverb states *shan gao, huang di yuan* (山高皇帝远), which roughly translates into 'the mountains are high, and the emperor is far away'. The modern equivalent to that is *shang you zheng ce, xia you dui ce* (上有政策,下有对策), roughly meaning 'policies are initiated at the top, counter policies follow from below'. Both indicate the difficulties the central government faced and still faces in making local governments comply with its directives. Given the fact that over 80 percent of public expenditure in China comes from the local levels, this might not be surprising (**Figure 18**). To illustrate the issue at hand, we need to acknowledge that the central government and the local governments in China act on quite different incentives. The central government is keen to maintain regime legitimacy and continuation, while local officials aspire to be promoted to a higher administrative position (Xu, 2011). In practice, this means that national policy directives are often centred around long-term goals such as technological upgrading and the competitiveness of the economy, while local governments favour short-term GDP figures and stable employment, often at odds with the institutional adjustments necessary for resilient growth. Although already widely recognised, a closer elaboration of the underlying mechanism is useful in the context of innovation.

Figure 18: Central-local share of revenue and expenditure, (%)



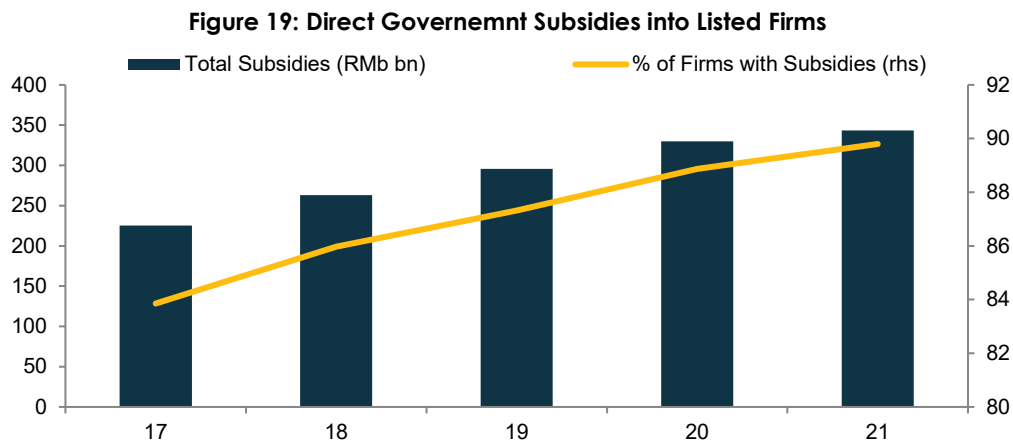
One reason explaining local government’s short-termism is the fact that local officials get rotated across provinces after just five years of tenure, if not before the end of these five years. Whether growth is sustained after the departure from their post is generally not of their concern. Another reason is China’s tax structure. As part of the reform of the tax sharing scheme in 1994, the central government started to retain a large proportion of collected taxes for itself. Local governments share of national tax revenue fell from 78 percent in 1993 to 44.3 percent in 1994 (Figure 18). Each year the central government redistributes part of the retained revenue back to the local governments. However, this is done in often nebulous negotiations between each individual province and the central authorities, with relatively more funds going to prosperous Eastern provinces. Simultaneously, localities were burdened with increasing social security responsibilities. The result was that local governments could not rely on a continuous stream of income and increasingly turned to non-tax revenues to fill budgetary gaps. These off-budget funds included land-transfer fees which localities pocketed from real estate developers in exchange for the rights to use the usufruct land for housing construction. This collusion between local officials and real estate tycoons led to increased revenue for the locality, favourable GDP figures and employment. But it also led to ‘unproductive’ investment, and the result of that: public debt. Furthermore, it instigated misallocation of capital and labour, as workers moved from relatively more productive sectors to the state-supported construction sector, which partially explains why growth has been biased towards physical capital at the expense of TFP, especially since the GFC. In some localities, competitive private firms prospered, but often with close ties to and strong support from the local authorities, stifling competition. To make matters worse for the localities, excessively high national tax rates triggered widespread tax evasion of firms, an issue which the under-institutionalised local tax authorities were unable to cope with. Designated tax officers were

hired to monitor tax-liable firms in their jurisdictions, but these tax officers often turned a blind eye to firms in exchange for bribes or imposed arbitrary fines on local businesses for their own individual profit. As a result, large and profitable firms with political connections to the government prospered while those without struggled for their very survival (Zhang, 2021).

3.1.2 Market distortions due to excessive state intervention

The collusion between local officials and business tycoons deserves a separate elaboration in specifically one area: finance. Innovators are often constrained in their access to finance as innovative activities involve enormous technical and commercial uncertainties. Plus, firms cannot fully exclude competitors from using their ideas and inventions. Consequently, they underinvest in R&D as the return on their investment cannot be fully appropriated by themselves. Economic theory therefore gives a justification for the government to correct this so-called “market failure”. But local corruption and the dominant role of the public sector once again prevent a level-playing field. Private firms are less likely to receive approval for loans at local banks than comparable state-owned enterprises (SOEs), if they do not have a personal connection to the government (Cheng, 2018). Furthermore, a high share of R&D spending in China comes in the form of government subsidies, with over 90 percent of listed firms receiving one or the other type of subsidy (**Figure 19**). These subsidy programmes are part of a national strategy to boost the innovativeness of strategically important sectors and are implemented both at the national and the local level. Research suggests that R&D subsidies are often allocated to larger, less productive and politically connected firms, but fail to achieve their purpose, namely, to fuel productivity growth (Branstetter *et al*, 2022). The reason might be that as firms receive government subsidies, they reduce their private expenditure on R&D or misappropriate these funds for non-R&D purposes (Böing *et al*, 2022; Böing and Peters, 2022). While venture capital has become relevant as an alternative source of financing for innovative start-ups, much of it is again driven by the public sector. Government VC funds make up 50 percent of total VC funds (refer to **Figure 3** in Section 2.1.2.), 84 percent of which comes from the local governments. These funds – even if managed by private VC firms – are subject to local regulatory constraints and favour industries that the government deems strategically relevant. While investing significantly more in early-stage businesses these funds underperform their private counterparts by more than 50 percent, as measured by the probability of exit through an IPO (Li, 2021). Whether the benefits of boosting strategically relevant industries outweigh the loss of efficiency caused by misallocation of scarce resources remains an open question. What is certain is that the channelling of funds into the innovative economy remains at the discretion of local officials, who frequently allocate much of their resources to their cronies. The long-

term effect is now becoming visible in decreasing returns to assets across the economy and heavily indebted local authorities (García-Herrero, 2023).



N.B. Listed firms in both onshore and offshore markets included.
Source: Natixis, Financial Statements, Bloomberg

The central government is aware of the unfavourable collusion between local officials and business elites. President Xi’s continuing anti-corruption campaign with the official aim of breaking these ties has so far had mixed effects. On one hand, it has imposed discipline on around four million bureaucrats and 500 cadres (Ang, 2020), increasing the cost of collusion from the perspective of local officials. On the other hand, it has rendered bureaucrats and private businesses more risk averse, and less ready to take initiative. This has temporarily led to the emergence of a new phenomenon, namely bureaucratic paralysis, also dubbed “*lazy government*” (懒政) (Zhang, 2017). In the long run, the disciplining hand of the central state might guide the transition to a healthier and more dynamic local economy, but it could well be that the focus on state intervention and regulation stifles innovation and thereby, growth. More specifically, the general atmosphere of anti-corruption and over-regulation is taking a toll on business confidence, hindering widespread creation of innovative tech-driven start-ups. Plus, there is also the risk that state-led innovation promotion could prolong, instead of curb, local governments’ addiction to investment. Innovation parks are built with public funds in addition to the infrastructure around them, further enshrining the symbiotic relationship between local officials and their cronies⁶.

⁶ Zhuoran Li, ‘The future of the China-US chip war’, *The Diplomat*, 2 March 2023, <https://thediplomat.com/2023/03/the-future-of-the-china-us-chip-war/>.

3.1.3 The primacy of national security

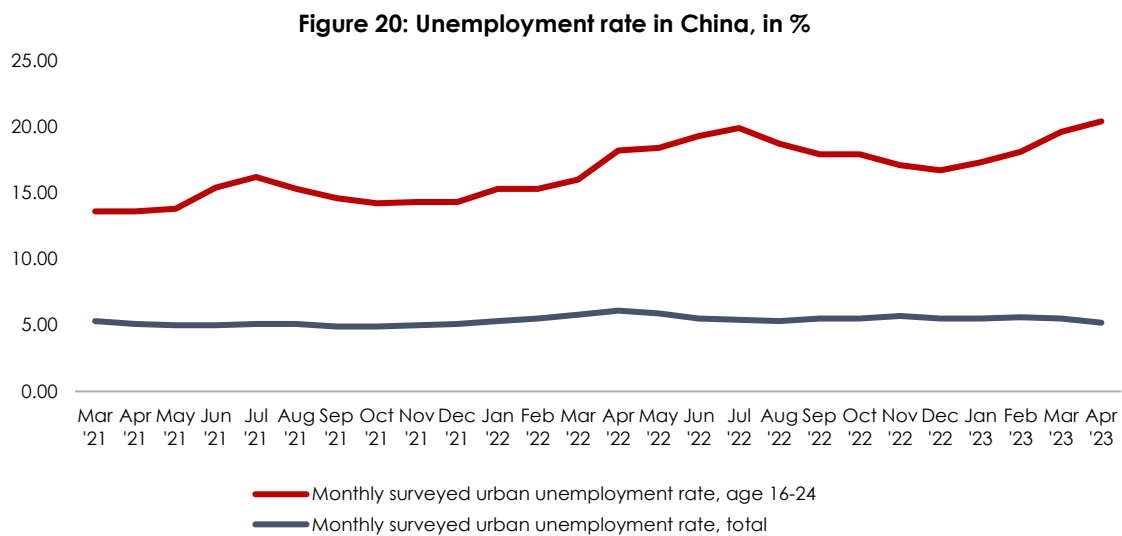
While the central government has recently stepped up its efforts to discipline local authorities, it has also promoted a comprehensive reform of administrative units responsible for cybersecurity. Over the years, the Cybersecurity Administration of China (CAC) has become the dominant organ to enact and oversee laws and regulations in this field. Milestone laws in China's cybersecurity architecture have been the Cybersecurity Law (2016), the Data Security Law (2021), and the Personal Information Protection Law (2021). Data is a crucial element in today's tech-heavy economies, ranging from supply chain analytics to analyses of consumer preferences and R&D activities in general. It is thus ever more critical for the central government to provide clear and transparent regulations and enforce them in a non-arbitrary way. However, China's data regulations appear vague compared to the European GDPR, leaving it to the companies to interpret to which extent consumer data might be exploited. Given the prevalence of local corruption and the importance of political connections, the vague language might end up harming competition rather than benefiting it, which could lead to less risky behaviour as firms are unable to anticipate regulatory responses to their data-related activities. On the enforcement side, the information available on the internal organisation of the CAC itself is quite scarce. The CAC is a state organ but stands under the authority of the Central Cyberspace Affairs Commission, a party organisation. Both organisations are chaired by the same person, Zhuang Rongwen, indicating that it is accountable not to the state, but to the party. As such it lacks the usual accountability mechanisms to which other ministries are subject (Horsley, 2022). The CAC caught widespread attention in 2020, when it cracked down on Ant Group's IPO, and later the same year, on China's major ride hailing service Didi Chuxing. While the official goal behind the crackdown of big tech is to curb the monopoly powers exerted by these companies, it might come with adverse side effects to business dynamism.

3.2 Societal and demographic challenges

Business-driven innovation not only depends on the country's institutional and external environment but also on a stable and adventuresome society. Although China is known for having one of the most optimistic citizens due to forty years of continuously improving well-being⁷, sentiment can shift quickly when challenges lie ahead. Draconian competition and a lack of social mobility might become a problem for innovation. One of the major issues at hand is that China is churning out university graduates at a faster pace than the economy can absorb. This has led to a ballooning youth

⁷ Chris Weller, 'China is the only country that's remotely optimistic about the future', *Insider*, 5 July 2016, <https://www.insider.com/china-is-the-only-country-thats-remotely-optimistic-about-the-future-2016-7>.

unemployment in the cities, reaching 20 percent in 2022 and still not dropping despite the full reopening of the economy (**Figure 20**).

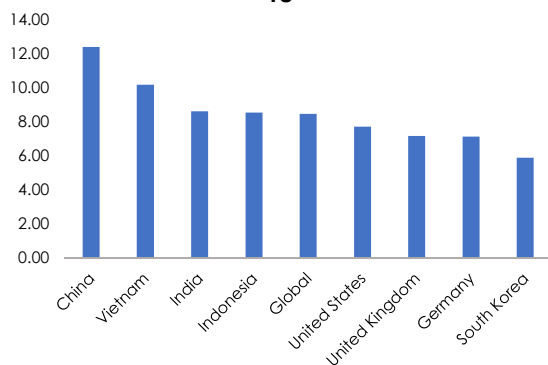


Source: National Bureau of Statistics of China

This group of unemployed or low-paid university graduates is referred to as ‘ant tribes’ (蚁族). They have high expectations about their future and are unwilling to take the blue-collar jobs their parents used to do⁸. When institutional constraints prevent young people from entering the economy as innovators or employees in higher-skilled jobs, discouragement can become a bottleneck to innovation by itself. China’s problem with video game addiction has been widely noted (**Figure 21**), so much that the government restricted the usage of online games to 90 minutes on weekdays for minors in late 2021. Video game consumption has adverse effects on labour market outcomes (Aguiar *et al*, 2021), not conducive to entrepreneurship. Another sign of this youth fatigue has been the ‘lying flat’ movement of 2021 in which Chinese netizens celebrated sloth and disinclination to exertion (Bandurski, 2021). The harsh conditions of the Covid lockdowns and the ballooning youth unemployment rate have contributed to a worsening of this trend. In 2022, the Chinese government increased the vacancies for the annual intake of civil service sector jobs to a new record. Most remarkably, this has been met by an even stronger rise in applicants, from 1.5 to 2.5 million (**Figure 22**), indicative of Chinese graduates increasingly searching for security instead of adventure.

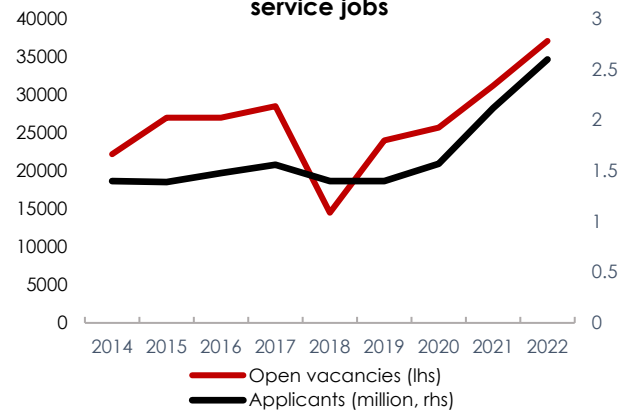
⁸ Shuli Ren, ‘The College Graduates Too Precious to Work in a Factory’, *Bloomberg*, 23 June 2022, <https://www.bloomberg.com/opinion/articles/2022-06-22/china-s-labor-and-competition-problems-stem-from-its-education-system#xj4y7vzkg>.

Figure 21: Average weekly hours spent playing computer games (2021), age 18+



Source: Limelight Networks

Figure 22: Rise in the demand for civil service jobs



Source: South China Morning Post

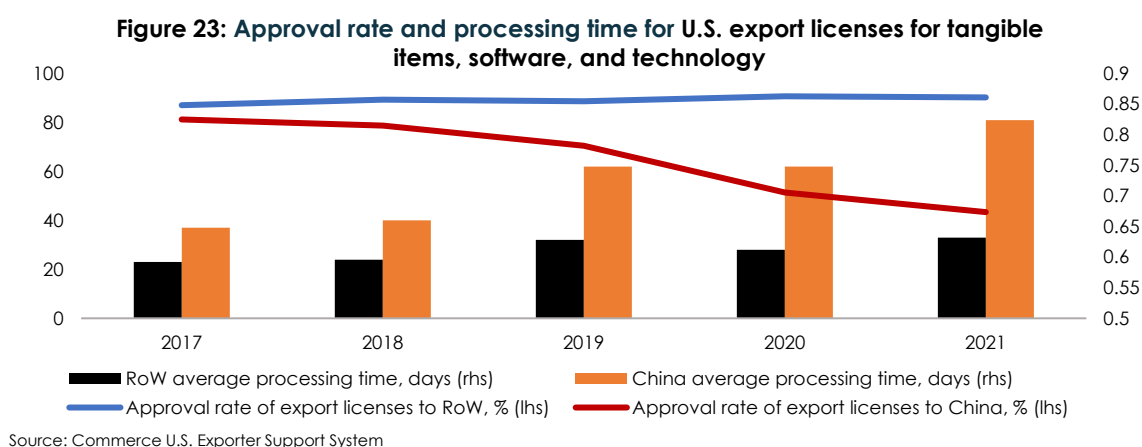
In addition to the above, China's population is rapidly aging. An aging population not only affects growth negatively due to the reduction of the labour force, but also provokes societal changes. Japan is a good example in terms of the society's changing preference due to aging population. Elderly workers are on average less risk-loving across the board, which leads to a lower rate of entrepreneurship. Furthermore, elderly workers are less familiar with current technology methods than young university graduates with state-of-the-art education. Although elderly workers individually are not less productive than younger workers, a higher share of elderly people predicts a lower firm productivity [Ozimek *et al*, 2018]. On the other hand, countries with a higher dependency-ratio are found to have a higher adoption rate of industrial robots. As labour scarcity increases, the relative price of labour in relation to physical capital rises as well. In other words, firms tend to substitute their reduction in available labour with capital [Acemoglu and Restrepo, 2018]. In the case of China this effect is particularly pronounced in SOEs which have been overstaffed with older workers [Tan *et al*, 2021]. Hence, if capital substitution is finally allowed at SOEs, it could lead to a higher demand of high-tech products and a stronger push for process innovation. Depending on the strength of this process, population aging might even contribute positively to growth, with the negative impact of a reduced labour supply being overshadowed by the innovation-inducing effect of capital substitution.

3.3 US technological containment

Finally, US containment of China is rendering access to critical technologies harder for Chinese firms. Trade tensions between the US and China started with Trump in early 2018 but soon moved into a conflict around technology which has continued, and even strengthened further, with the Biden administration. Since 2018, the approval rate of export licenses to China for tangible items, software, and technology has dropped significantly from over 83 percent to below 70 percent, while increased scrutiny is visible by a sharp increase in average processing time (**Figure 23**). In the long run,

President Xi has a strong interest in reducing dependence on the US on critical technologies, which means that indigenous innovation champions need to be supported at any cost. This support starts with allowing them to dominate the domestic market, thereby reshaping the profits from their oligopolistic position to become global champions. Fostering China’s global competitiveness is clearly essential for Xi Jinping in a world of strategic rivalry with the US.

However, China remains reliant on global trade and investment networks to gain access to key technologies that it cannot yet produce domestically. In that regard, the main difficulties for China lie on the catch up of existing technologies, such as pharmaceuticals, semiconductors, software, and smartphones, and less so new technologies such as neural networks, cloud computing and self-driving cars for which China has a higher ability to leapfrog (Han *et al*, 2020). This is because, for existing technologies, Chinese firms do not possess the accumulated knowledge capital that multinational incumbent firms have. It is these traditional fields that pose the highest risks for China’s technological rise in the light of US technological containment.

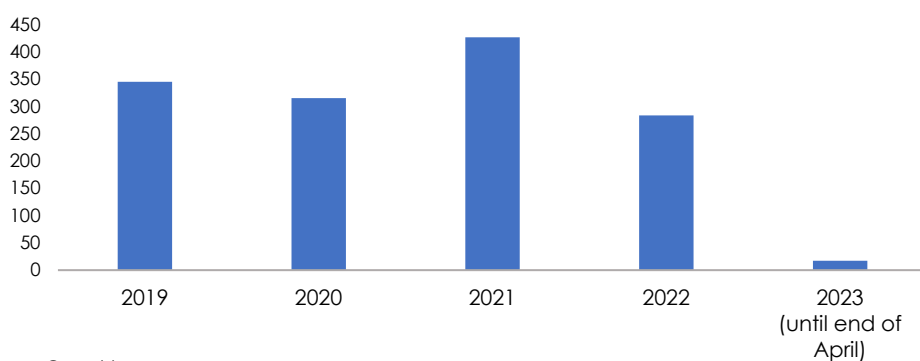


A very important traditional sector is that of semiconductors as it constitutes the backbone for nearly every new technology, including artificial intelligence and quantum computing, as well as for advanced military equipment. Since 2021, the Biden Administration has introduced a series of export restrictions to China that touch into ever deeper layers of the supply chain⁹. The most important escalation happened in October 2022, with the implementation of export controls targeting semiconductor manufacturing equipment to the PRC. This was pushed even further by a trilateral agreement of export restrictions with Japan and the Netherlands, both of which are home to firms providing crucial equipment for the advanced chip manufacturing process. As of lately, the Biden

⁹ Matt Sheehan, 'Biden's Unprecedented Semiconductor Bet', *Commentary*, 27 October, Carnegie Endowment for International Peace, <https://carnegieendowment.org/2022/10/27/biden-s-unprecedented-semiconductor-bet-pub-88270>.

administration has announced its intentions to curb US outbound investment to China. In anticipation, US-based investment in Chinese start-ups has plummeted in 2023 (**Figure 24**). The uncertainty about the success surrounding this strategy has triggered a lively debate. Proponents of President Biden’s policy claim that it will delay China’s technological rise for several years or even decades as Chinese companies are stripped of the world’s most critical technology (Miller, 2022). Each step in the semiconductor supply chain is highly specialised. Some of the technologies have decades of embedded know-how and remain in the hands of a few, if not a single firm. Replicating the entire global chip ecosystem within a few years domestically is a nearly impossible undertaking. On the other hand, critics state that the squeeze on semiconductors will merely induce China to speed up its striving for technological independence in the sector, while Chinese firms can circumvent the restriction by sourcing from third parties¹⁰. Indeed, the Chinese government has injected a large amount of financial resources (around \$81 billion) through large investment funds into the chip industry, with varying degree of government involvement. Notwithstanding the massive financial endeavour, the success of this major policy campaign has been modest, at least as far as the design and production of advanced semiconductors is concerned. One should acknowledge that part of the reason for the lack of success, at least on the design front, are US restrictions, especially in Huawei’s case (García-Herrero and Weil, 2022). There is no doubt that the semiconductor squeeze is creating a headache for the Chinese leadership and might delay China’s technological catch-up but China’s ability to mitigate this impact and ride on its own technology should not be underestimated.

Figure 24: Number of deals in China-based start-ups by US investors



Source: Crunchbase

¹⁰ Liza Lin and Dan Strumpf, ‘China’s Top Nuclear-Weapons Lab Used American Computer Chips Decades After Ban’, *Wall Street Journal*, 29 January 2023, <https://www.wsj.com/articles/chinas-top-nuclear-weapons-lab-used-american-computer-chips-decades-after-ban-11674990320>.

4 Concluding remarks

China's medium term economic outlook will be determined by whether China's efforts in innovation are providing enough tailwind to mitigate the structural deceleration of its economy. In this paper we review China's success in increasing the inputs to innovation, namely R&D and the quality of human capital. Two key intermediate outputs for innovation, the quantity and quality of scientific publications and patents, have also evolved very positively. The question is whether this innovation will mitigate and eventually reverse the deceleration of China's total factor productivity (TFP). While the deceleration of TFP reflects a global trend, China's TFP performance has recently been worse than that of emerging market economies of similar income per capita.

Beyond potential measurement error for TFP, one can think of at least three potential bottlenecks for the reduced impact of innovation in productivity, and thereby, growth. The first is related to the role of institutions in the economy, including in the innovation process. To this end, the collusion between government officials and those receiving support for innovation points to China's long-standing problem of misallocation, both of capital and labour. The current anti-corruption campaign should help, on paper, but it also has the unintended consequence of stifling the vitality of the private sector, especially as far as risk taking is concerned. The stalled reform process and the more complex institutional setting geared towards national security is another potential factor for lower entrepreneurship and reduced impact of innovation. Secondly, China's young cohorts, generally very keen about Science and Technology, are increasingly favouring security over adventure in the light of increased unemployment and institutional barriers. Beyond these societal changes, very rapid aging might also stifle innovation similar the experience of Japan, although no consensus exists in the economic literature as to whether this will be the same. Finally, US containment on China's moving up the tech ladder, with is particularly strong for semiconductors, is making it difficult for Chinese firms to access critical technologies.

References

- Acemoglu, D. and P. Restrepo (2018) 'The Race between Man and Machine: Implications of Technology for Growth, Factor Shares, and Employment', *American Economic Review* 108(6): 1488-1542
- Aguiar, M., M. Bils, K.K. Charles and E. Hurst (2021) 'Leisure Luxuries and the Labor Supply of Young Men', *Journal of Political Economy* 129(2): 337–82

- Ang, Y.Y. (2020) *China's Gilded Age: The Paradox of Economic Boom and Vast Corruption*, Cambridge University Press
- Bandurski, D. (2021) 'The "lying flat" movement standing in the way of China's innovation drive', *TechStream*, 8 July, Brookings
- Böing, P. (2016) 'Measuring patent quality in cross-country comparison', *Economic Letters* 149(C): 145-147
- Böing, P. and B. Peters (2021) 'Misappropriation of R&D Subsidies: Estimating Treatment Effects with One-Sided Noncompliance', *Discussion Paper No. 21-081*, ZEW - Centre for European Economic Research
- Böing, P., J. Eberle and A. Howell (2022) 'The impact of China's R&D subsidies on R&D investment, technological upgrading and economic growth', *Technological Forecast and Social Change* 174
- Brandt, L., L. Wang and Y. Zhang (2017b) *Productivity in Chinese Industry, 1998-2013: (Very) Preliminary Findings*, report prepared for the World Bank-Development Research Centre Project 'New Drivers of Economics Growth in China'
- Brandt, L., J. Litwack, E. Mileva, L. Wang and Y. Zhang (2022) 'Recent Productivity Trends in China: Evidence from Macro and Firm-Level Data', *China: An International Journal* 20(1): 93-133
- Branstetter, L., G. Li and M. Ren (2022) 'Picking Winners? Government Subsidies and Firm Productivity in China', *ShanghaiTech SEM Working Paper No. 2022-088*, available at <https://ssrn.com/abstract=4252843>
- Chen, J., X. Yin and L. Mei (2018) 'Holistic Innovation: An Emerging Innovation Paradigm', *International Journal of Innovation Studies* 2(1): 1-13
- Cheng, L. (2018) 'Estimating the value of political connections in China: Evidence from sudden deaths of politically connected independent directors', *Journal of Comparative Economics* 46(2): 495–514
- Curtis, C.C. (2016) 'Economic reforms and the evolution of China's total factor productivity', *Review of Economic Dynamics* 21: 225-245
- Dychtwald, Z. (2021) 'China's New Innovation Advantage', *Harvard Business Review*, May

- Fang, L., J. Lerner, C. Wu and Q. Zhang (2022) 'Anticorruption, Government Subsidies, and Innovation: Evidence from China', *Management Science*, forthcoming
- García-Herrero, A. and P. Weil (2022) 'Lessons for Europe from China's quest for semiconductor self-reliance', *Policy Contribution* 20/2022, Bruegel
- Garcia-Herrero, A. (2023) 'Can Chinese growth defy gravity?' *Policy Brief* 14/2023, Bruegel
- Li, J. (2022) 'Government as an Equity Investor: Evidence from Chinese Government Venture Capital through Cycles', mimeo, available at <https://ssrn.com/abstract=4221937>
- Han, P., W. Jiang and D. Mei (2020) 'Mapping U.S.-China Technology Decoupling: Policies, Innovation, and Firm Performance', Columbia Business School Research Paper, available at <https://ssrn.com/abstract=3779452>
- Horsley, J.P. (2022) 'Behind the Facade of China's Cyber Super-Regulator', *DigiChina*, Stanford University, available at <https://digichina.stanford.edu/work/behind-the-facade-of-chinas-cyber-super-regulator/>
- Miller, C. (2022) *Chip War: The Fight for the World's Most Critical Technology*, Scribner, New York
- Ozimek, A., D. DeAntonio and M. Zandi (2018) 'Aging and the Productivity Puzzle', Moody's Cooperation
- Raiser, M. and S.S. Hoon (2019) 'To sustain growth, China can learn from previous transitions to high income', *Future Development*, 18 October, Brookings
- Rowe, W.T. (2009) *China's Last Empire: The Great Qing*, Harvard University Press
- Rozelle, S. and N. Hell (2022) *Invisible China: How the Urban-Rural Divide Threatens China's Rise*, University of Chicago Press
- Tan, Y., X. Liu, H. Sun and C. Zeng (2022) 'Population ageing, labour market rigidity and corporate innovation: Evidence from China', *Research Policy* 51(2)
- Tollefson, J. (2018) 'China declared world's largest producer of scientific articles', *Nature* 553, 390
- Xu, C. (2011) 'The Fundamental Institutions of China's Reforms and Development', *Journal of Economic Literature* 49(4): 1076-1151

Zhang, X. (2017) 'Implementation of Pollution Control Targets in China: Has a Centralized Enforcement Approach Worked?', *The China Quarterly* 231: 1–26

Zweig, D. (2006) 'Competing for talent: China's strategies to reverse the brain drain', *International Labour Review* 145(1–2): 65–90



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