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Whole-of-Nation Innovation: Does China's Socialist System Give it an Edge in Science and Technology?

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Summary

China wants to become a science, technology, and manufacturing superpower by upgrading and modernizing its industrial base and concentrating the nation's innovation resources around strategic priorities. However, it is difficult for the state to integrate innovation resources because of the gap separating universities and research organizations from industry, which impedes the translation of scientific output into technological prowess. By contrast, Beijing has been much more successful at directing industrial development. As a result, achieving a modernized industrial base is now the dominant framework for Chinese policymakers as they pursue technological self-reliance.

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Key Findings

- Official calls for a new-style whole-of-nation effort in China are primarily aimed at directing Chinese researchers and business to tackle key techno-industrial bottlenecks. This sense of urgency is necessary to overcome barriers between academia and industry.
- Public information does not support the idea that Beijing has a shortlist of top priorities that it is concentrating the nation's resources on.
- By refusing to outsource and preferring to maintain a large share of its economy in manufacturing as opposed to services, China is pursuing a different development path than most developed countries. This will impact trade relations with other nations.
- Beijing's fixation on national sovereignty and self-reliance complicates interaction with foreign stakeholders. Its long-term vision for China's industrial and innovation policy envisions a limited role for foreign technology firms in the Chinese market.

Introduction

On October 17, 2023, the United States issued its second batch of export controls on advanced computing and semiconductor manufacturing items to China, expanding its "small yard, high fence" approach to include more technologies and impact more countries.[1] The European Commission has similar concerns about technology leakage but is more circumspect in its response. Its economic security strategy calls for partnering with allies, promoting competitiveness, and protecting interests "in a proportionate and precise way that limits any negative unintended spillover effects on the European and global economy."[2] The Commission intends to complete a security review of four critical technologies in 2024.[3]

China is a major catalyst of the global trend of scientific and technological nationalism, with its party and state leader Xi Jinping doubling down on national security ever since he came to power in 2012.[4] For instance, in 2016 Xi called for national self-reliance and self-empowerment (自立自强) in key and core digital technologies at the inaugural Work Conference for Cybersecurity and Informatization, predating U.S. sanctions by several years.[5] Science, technology, and innovation (STI) have become the main arena of global strategic competition, Xi announced in 2022, adding that the contest over the scientific and technological commanding heights of the global economy has never been more intense.[6]

Diverse geopolitical actors across the United States, European Union, and China have different interests, priorities, and approaches in securing key technologies. But the net result is that science, technology, and innovation have become increasingly political. Policy is now driven by national security concerns, which creates friction in international networks. Joint publications between U.S. and Chinese researchers are already declining.[7]

Chinese and Western firms face questions about their loyalty at home and abroad, as well as complex regulations for exporting data and goods involving strategic or critical technologies.

To understand this trend, this brief offers a thorough analysis of Beijing's vision for its innovation and industrial systems based on close readings of high-level policy documents and commentaries.

Collectivizing Industrial Efforts

The Communist Party of China has a long history of directing industrial development, combining domestic goals of providing basic goods, jobs, and economic growth with notions of self-reliance and national security that emphasize international competition. The notion of the "new-style whole-of-nation" system (NSWN, 新型举国体制) takes inspiration from this history. It has gained prominence since the fourth plenum of the 19th Central Committee in 2019 as Beijing seeks to capitalize on the socialist system's unique ability to "concentrate power to do great things (集中力量办大事)." The 14th Five-Year Plan of 2021-2025 presented the NWNS sysstem as a key component of "the battle for key and core technologies."

The NSWN concept refers back to the whole-of-nation approach of the late 1960s and early 1970s, which enabled China to develop nuclear weapons and ballistic missiles in the space of just a few years, despite being cut off from its major source of technological knowhow through the Sino-Soviet split. Under Chairman Mao, the effort had been overseen by the Central Special Commission (中央专委), which was discontinued in the 1970s. Similarly, President Xi set up a Central Science and Technology Commission (中央科技委员会) in March 2023 to oversee the NSWN approach and reform the Ministry of Science and Technology into its supporting agency.

By centralizing control of STI in China, these changes go against the central tenets of the "reform and opening up" (改革开放) policy that began in the late 1970s.[8] These included the depoliticization of science and technology, as well as the devolution of power over resource allocation to markets and local actors. Still, the presence of a large and vibrant private sector distinguishes the NSWN approach from its 1960s predecessor. Acknowledging the importance of entrepreneurship to innovation, Beijing looks to enlist the private sector through a mixture of incentives, regulations, and political steering. This structural tension in China's socialist market economy is summarized by the ideal of "an efficient market and an effective government (有效市场和有为政府)."[9]

A Network of Fitness Centers to Break Local Barriers

To understand how China's mixed economic system works for innovation and industrial policy, it helps to see the NSWN system as a variation of the country's national Olympic program. Sports programs in China are discussed in terms of a whole-of-nation system. Both China's highly successful Olympic programs and its current effort to break foreign technological bottlenecks combine training and grassroots competitions with a multi-tiered national selection program focused on outperforming international competitors. In this approach, the state delegates the day-to-day organization and refereeing of the program to trusted partners.

In the NSWN system, objective external indicators measure the program's effectiveness. Absent medal tallies, export volumes and values have become the benchmark for industrial innovation. Success in overseas markets makes a firm more worthy of government support. Domestically, Beijing allows foreign firms like Apple and Tesla to sell products in a controlled setting while monitoring the market share of domestic frontrunners to assess their competitiveness.

These mechanisms compensate for a lack of trust in local data on the fitness of Chinese businesses, and this "export discipline" targets firms as well as local officials.[10] In a previous phase of China's state-led development model, local officials had wide room for policy experimentation, including by launching industrial and innovation zones, creating pilot and demonstration projects, and allocating investments. However, this sometimes led to local protectionism. The NSWN system is part of a larger trend to restrict local discretion in how these programs are implemented.

Too Many Stakeholders to Concentrate

The whole-of-nation approach enables other actors to vie for central government attention. Following previous mission-oriented programs, it stands to reason that the NSWN system would appoint issue owners in a handful of technology areas who would each bring together various stakeholders, formulate benchmarks, allocate resources, assess progress, and lobby Beijing for funding and favorable policies.[11]

The NSWN system aligns with recommendations by professors Yutao Sun and Cong Cao, who point to more recent precedents, such as the National Integrated Circuit Industry Investment Fund, China's development of high-speed rail, or the 16 science and technology megaprojects for the 2006 to 2020 period.[12,13] The latter successfully spearheaded BeiDou's satellite navigation, Huawei's 5G next-generation mobile Internet, and the C919 commercial aircraft, which were supervised respectively under a military research organization, a state-affiliated think tank, or a state-owned enterprise (SOE).

These organizations are almost certainly lobbying for state support in Beijing. It has become hard for outsiders to read the outcome of these negotiations.

For instance, a new batch of 15 science and technology (S&T) megaprojects was announced in the S&T Five-Year Plan for 2016-2020, to which new-generation artificial intelligence was added in 2017. Details on these megaprojects and their relative centrality in the innovation chain would be in the Science and Technology Mid- to Long-Term Plan for the 2021-2035 period, but that plan was never published. Using these limited resources, Barry Naughton, Siwen Xiao, and Yaosheng Xu do a remarkable job of puzzling together what the NSWN system might look like.[14]

However, there is no public evidence to suggest that this approach has become dominant. Chinese commentators rarely discuss which technologies should be prioritized on what grounds, how many technologies China could realistically concentrate resources on, or who should bring the nation together in a specific technology area. As a result, there is no current authoritative list of key and core technologies—the best proxy is a list of 35 "stranglehold" technologies such as lithography machines, operating systems, and aircraft engines issued by a state-affiliated newspaper in 2016. There is also no matching list of topic owners or even institutional platforms for "national teams."[15]

Instead, China's innovation and industrial policy is still fragmented across many partially overlapping platforms and initiatives. Naughton, Xiao, and Xu identify around 50 bottleneck and competitive-advantage technologies. But this number is too large and the technology areas are too big for this to amount to an effective concentration of resources. Analysis of research funding, investment data, publications, and patents also does not show a clear prioritization.

Instead of focusing on specific technologies and sectors, public discussion on the NSWN focuses on improving synergies between industry, universities, and public research institutes (产学研融合).

The Slow Process of Mending Weak Links in the Innovation Chain

Next to providing a benchmark for competitiveness, the West has been a major source of science, technology, and innovation that is fueling China's catching up. Now that China's access to Western STI is less secure and China is getting closer to the global cutting edge, Beijing has repeatedly stated that it wants to improve the domestic research and development (R&D) pipeline from early-stage research to mass production. The primary contribution of the NSWN system is in making the innovation chain more prominent.

Although China produces a growing portion of the world's top-cited research papers and patents, this is not matched by a corresponding growth in total factor productivity, indicating that much of this research output is not influenced by downstream industrial demand.[16] Because China has been very successful at scaling up proven technologies and creatively adapting or re-inventing products that were pioneered elsewhere, China's issues with technology diffusion primarily involve domestic inventions. Most of the successes China can point to have some degree of foreign inspiration.[17,18] Digital giants in search, e-commerce, ride hailing, and social networking started by translating U.S. models to Chinese contexts. In hardware sectors like solar panels, batteries, electric vehicles, smart phones, and commercial drones, Chinese overseas returnees and local entrepreneurs gained global market share by building on ideas and components pioneered elsewhere.[19]

If inventing something new is going from zero to one and scaling up is going from one to 100, China's main successes are either early—close to zero—or near the end—close to 100. The largest challenge resides around the one, where invention is slowly brought to scale. This structural gap demonstrates the so-called "two-layers" (两张皮) problem of a mismatch between academy and industry. Although Beijing wants firms to lead, Chinese firms typically avoid investing in risky basic research, seeing this as a task for the state, especially if the sector is of national strategic importance. As a result, the gap between the two layers remains wide. The National People's Congress noted this when it reviewed the Science and Technology Progress Law in October 2023, adding that many in knowledge institutions do not sufficiently recognize the urgency of closing this gap.[20]

Beijing has a range of instruments to address this long-standing two-layers problem. Many of these overlap with the NSWN system as they seek to break silos in the interest of national development. Together with industry, the state formulates and funds open challenges for knowledge institutions in a process known as "unveiling the list" (揭榜挂帅). Further, local governments organize "innovation associations" (创新联合体) where companies are paired with universities and labs to tackle technological needs. In addition, a new type of more market-oriented, state-sponsored research institute is emerging to facilitate technology transfer (New R&D Institutes, 新型研发机构), while legacy institutes are pressured to serve industrial and strategic needs. Finally, reforms are being initiated to grant inventors more ownership over patents, to encourage state-employed researchers to become more entrepreneurial.

This multifaceted approach to connecting the innovation chain is piecemeal and slow because the state is simultaneously seeking to centralize control. As this plays out, public debates have embedded the pursuit of technological self-reliance into the larger question of the future of China's industrial development. These debates are now considering a larger group of industries than those involving high-end technology.

Xi Wants a Complete, Advanced, and Secure Industrial Base

The 14th Five-Year Plan (2021-2025) calls for building a modern industrial base (现代产业体系), linking the project to China's goal of becoming a manufacturing powerhouse (制造强国).[21] Similar terms have been used since at least the 17th Party Congress of 2007. In May 2023, President Xi elaborated on the closely related term of a "modernized industrial base" (现代化产业体系). To build a modernized industrial base that is complete, advanced, and secure, President Xi told the Central Commission for Financial and Economic Affairs (CCFEA) that China should make use of scientific and technological revolutions, capitalize on its industrial prowess, and promote global innovation. Xi also argued that China should not simply push out low-grade industries but instead work to upgrade them.

This last remark is consistent with the leadership's emphasis on the "real economy." President Xi repeatedly warns against Chinese modernization "losing touch with reality" (脱实向虚), for instance, during his trip to Guangzhou in April 2023. Zheng Shanjie, the director of China's chief planning agency, the National Development and Reform Commission, elaborated on this in Qiushi, the party's main theoretical journal.[22]

> Today's modernized economies rely on the real economy to generate growth and remain resilient. One of the main reasons some countries lost their lead or fell into the so called "middle income trap" and experienced long periods of stagnation is their neglect of the real economy, their failure to modernize their industrial system. … Traditional industries make up most of China's manufacturing prowess. We can't simply push "low-grade industries" out. Instead, we should guide and support firms in traditional sectors to upgrade. … The emerging industries are the pillars of future development, but we shouldn't blindly pursue foreign novelty.

China should not let its manufacturing base be hollowed out like the United States', adds Cui Fan, a professor at China's University of International Business and Economics and the director of the research unit of the China Institute for WTO Studies.[23] Cui argues for including financial and digital services that support industrial activity into the definition of the "real economy" and excluding only those activities that "directly create money with money." This is consistent with recent government clampdowns on "the disorderly expansion of capital," particularly real estate speculation.

The insistence on including traditional industries like steel, coal, and shipbuilding—as well as the SOEs that dominate them—follows Communist orthodoxy. It also seeks to hedge against an escalating trade conflict with the West. Industrial bases are important in times of crisis, as COVID-19 was a stark reminder. They are especially important to China as global technological competition intensifies, because China's leverage is based less on the uniqueness of its technologies and more on its ability to produce large volumes quickly and cheaply. Replacing China's global role in critical raw materials, solar panels, active pharmaceutical ingredients, and telecommunications equipment would be an economic challenge for the West rather than a technological one. To keep the cost of decoupling high for foreign governments and multinationals, China needs to retain its central position in global supply chains.

However, due to rising labor costs, the contribution of manufacturing to China's gross domestic product (GDP) declined 6 percent between 2008 and 2020 to 26.3 percent, calculates Professor Cui. After, Beijing was able to arrest the decline but only slightly, growing the figure 1.1 percent in 2021 and 0.3 percent in 2022, which inadvertently caused China's debts to balloon.[24] Beijing's insistence on boosting industrial production also demotes other national goals, such as making China less reliant on export markets, reducing carbon emissions, and raising consumption and quality of life under the rubrics of "common prosperity" (共同富裕).

Policy Implications

The new-style whole-of-nation system and the modernized industrial base represent two partially overlapping responses to the risk of foreign technological containment. Whereas the former focuses on generating intellectual property through strengthening the innovation chain, the latter seeks to upgrade the Chinese manufacturing sector to climb up the global value chain. The two policies side-by-side expose the contradictions of China's two goals of technological self-reliance and economic de-risking.

The relative importance of the modernized industrial base in the Chinese-language debate is clear by the recent flurry of publications, including by leading ministries and think tanks. These writings consistently call for consolidating leads, upgrading traditional industry, and accelerating innovation through the NSWN system, in that order. The tensions between these goals are rarely discussed. This paper highlights some of the more obvious contradictions, such as concentrating resources on all technologies of possible importance. The program also creates changing state-market relations, which is leading to tasking the most conservative stakeholders—such as military organizations, legacy research labs, state-owned enterprises, and public financial institutions—with organizing innovation and nurturing a start-up scene. China's policies encounter further contradictions in their attempts to upgrade manufacturing capacity without outsourcing polluting and labor-intensive industry segments to other countries and in promoting exports, international collaboration, and in-bound investments as a means to reduce foreign reliance.

Some degree of ambiguity may work in Beijing's favor, as it provides flexibility and cover in achieving its de-risking and self-reliance aims. However, implicit restrictions on the public debate also blunt the recommendations of policy advisors. A glaring absence in the emerging vision is that of large private and foreign companies. Despite the large contributions of tech giants and multinational corporations to China's past innovation and productivity gains, as well as the importance of overseas returnees in China's innovation landscape, the outside world features either as a source of risk—through the technological strangleholds—or as an export market whose absorption of more and more Chinese goods validates the country's progress.

Foreign firms may be able to convince local Chinese interlocuters that their contributions should be recognized and accommodated, especially if their branches are well integrated in local value and innovation chains. This approach is likely to succeed some of the time, and in some places and sectors. But the overarching long-term vision for innovation and industrial policy that currently dominates in Chinese policy circles follows the logic of China's dual circulation strategy (双循环), which primarily aims to compartmentalize and reduce China's exposure to external shocks.[25] Even though China may never realize this vision in full, it is wise for Western stakeholders to take it seriously and formulate their own de-risking strategies.

Conclusion

Based on China's track record, the NSWN approach will be most successful in areas where there is an established technology that China can emulate—such as atomic bombs, navigation satellites, space stations, or high-speed rail. Lithography equipment may also fit this mold. By contrast, China's successes in solar panels, electric vehicles, telecommunication equipment, and various digital platforms have relied much more on private entrepreneurship. Looking forward, the first policy by the Central Science and Technology Commission focuses on "future industries," many of which require corporate initiative, not least artificial intelligence.[26] The key metric for success of the NSWN approach will be in whether it can spur innovation by tech entrepreneurs. So far, that looks unlikely.

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