IGCC UC INSTITUTE ON GLOBAL CONFLICT AND COOPERATION

WORKING PAPER NO. 6
JUNE 2023

The Trajectory of China's Industrial Policies

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Abstract

China's industrial policy does not fit well into traditional concepts of industrial policy, and even clear definitions of China's industrial policy are rare. Everybody seems to agree that China has an aggressive industrial policy, but there is surprisingly little discussion about what that industrial policy is. To some extent, this is because China's industrial and technology policies have been in a constant state of flux since the mid-2000s. In this short piece, we situate Chinese industrial policy and then argue that most of the process of restless change can be incorporated into a trajectory of two dimensions: first, the build out of a policy/planning mechanism; and second a shift in the ultimate objective of technology and industry polices from economics to security. We argue that these two simple features are robust enough to bear the weight of most characteristics of Chinese industrial policy. We then discuss the most recent phase of China's industrial policy, characterized by a focus on security and new implementing instruments such as the "new-style national team" and the strengthening of the "national strategic science and technology force" (NSS&TF). These are clearly the culmination of the trends described earlier. Since there is still much we do not know about these very recent innovations, longer-run trends are invaluable in suggesting a hypothetical framework for current institutions.

Keywords: industrial policy; China; science, technology, and innovation; national security

Paper prepared for the conference "China's Industrial Policy: Sectors and Resources" from September 30 – October 2, 2022. Revised Version, May 31, 2023.

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Suggested Citation

Naughton, Barry, Siwen Xiao, and Yaosheng Xu. 2023. *The Trajectory of China's Industrial Policies*. IGCC Working Paper No 6.
escholarship.org/uc/item/28f568zv

1. Traditional Conceptions of Industrial Policy and China

There are a number of plausible definitions of industrial policy. While an argument can be made for broader definitions, the issues are so complex that discussions based on broad definitions almost always end up at intellectual dead-ends: Every country has an industrial policy; therefore we shouldn't demonize anybody, but we can't actually say anything beyond that. Narrower definitions of industrial policy hold more promise, including this one: "Systematic selective government interventions into key sectors." Within this narrow definition, there is a common understanding of what is involved. A government

1. Targets specific industrial sectors for support and indigenization.
2. Nurtures "infant industries" and helps them to scale up rapidly, especially through exporting.
3. Fosters the spread of technology and other capabilities through the domestic economy, in an effort to share more broadly the gains enjoyed by initial beneficiaries.

This seems straightforward, and the simplicity of it explains some of the appeal of industrial policy.[1] But note that there is typically a "man behind the curtain." In the first place, there must be some coherent theory of economic development that guides planners in the selection of priority sectors. In Japan in the 1970s, this was a systematic study of structural change in the growth process, so that certain sectors were seen to typically grow quickly at the current development stage (alternately stated, the income elasticity of that sector was high at comparable levels of GDP per capita). That theory meant that Japanese planners were essentially trying to accelerate the process of "catch-up," implying there was a leader (the United States) and they were following the leader.[2] Moreover, adequate information is implicitly available to planners, who understand the development process or at least have some effective proxies. In Robert Wade's detailed account of Taiwan, he describes planners poring over product-specific trade balances and input-output tables, identifying missing domestic links supplied by imports. These then become candidates for successful industrial policy interventions.[3]

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[1] Canonical works include Chalmers Johnson; Alice Amsden and many others. See Richard Samuels, *The Business of the Japanese State: Energy Markets in Comparative and Historical Perspective.* Ithaca: Cornell University Press, 1987.

[2] A different approach would be to start from an examination of technology and making judgments about which technologies have the largest potential spillovers, indicating potential productivity returns to accelerating their adoption and diffusion.

[3] Robert Wade, *Governing the Market: Economic Theory and the Role of Government in East Asian Industrialization.* Princeton University Press, 2003.

This is important, because the traditional emphasis on *targeting* sometimes misses the essential prerequisites for targeting effectively.

However, this description of industrial policy doesn't seem to fit China very well. China seems to be trying to do everything at once, fostering an implausibly large number of top priorities.[4] To be sure, we can find specific examples that do fit the traditional conception. However, they seem to be individual success cases, rather than systemic features. Often they reflect the voluntary choice of local actors, rather than the strategic vision of national planners. How can we understand what actually happens in China and differentiate it from decades-old conceptions of industrial policy based on the experiences of earlier developing East Asian economies? Can we make sense of such a dynamic, seemingly ever-expanding process?

In this paper, we use two simple concepts to organize our discussion. First, we show that China gradually built out a planning and industrial policy process, starting in 2006. That is, they started with ideas and policies that were tentative and, in some cases, half-baked; and with few instruments to realize these fuzzy objectives. They then gradually invested in knowledge and procedures that gave them the ability to carry out industrial and technological policies. In particular, we see the gradual creation of information resources, targets (or KPIs: key performance indicators), and resources. That does not mean that those policies were necessarily *good* or even better, but simply that they were (relatively) more internally consistent and better thought out. They had the potential to be industrial policies, rather than just wishful thinking. As more planning and resource allocation instruments have been put in place, they of course can be (and have been) repurposed by planners to meet new objectives.

Second, we can trace shifts in the guiding objectives of industrial policy and, thus, in its basic strategic orientation. Broadly speaking, the primary objective has shifted from economics to security. To be sure, security has always been an objective alongside economics, and today economic growth remains an objective alongside security, but the balance between the two has shifted dramatically. This simple shift, though, is only the beginning of a more complex characterization. The initial targeting of sectors was opportunistic and based on potential opportunities in sectors that were emerging in a global context (i.e., "strategic emerging industries"). However, the concept of strategic technological opportunity gradually shifted with the recognition that there was a rising wave of interrelated global technologies with potentially revolutionary implications. By the time the "innovation-driven development strategy" (IDDS) was formally adopted in

[4] The serious literature on the strategy and objectives of Chinese industrial policy is extraordinarily thin. To take an extreme example, Oxford has published a handbook on industrial policy and a handbook on Chinese innovation, neither of which contains a single chapter on what Chinese industrial policymakers are doing or trying to achieve.

2016, the identification of industrial policy with this wave of technological change had become commonplace and had been woven into various more concrete policies.

It should be noted that this shift from an opportunistic to a "revolutionary cluster" approach to technologies had a number of different implications. First, it implied that the logic of industrial targeting should be driven by the technological relationship among complementary technologies, rather than by economic or business logics. Second, it implied a shift toward more basic science and technology research, which would be required by the profound interactions among related technology.[5] Third, it contributed to the shift toward a security orientation. Since "the country that masters the new technologies will emerge as the dominant power," according to a frequently quoted maxim of Liu He, security demands a comprehensive push toward the totality of strategic technologies. This blend of technological utopianism and security obsession has characterized China's industrial policy since at least 2016. [6]

A strong orientation toward security inevitably drives policy in the direction of self-sufficiency. Yet in this case, slogans that seem to show considerable continuity have in fact been constantly redefined to create different meanings and policy objectives. These changing concepts effectively begin with "indigenous innovation" in the 2006 Medium and Long-Term Plan (MLP). However, the meaning of that term—always a little vague—has shifted in important ways, and has recently become part of science and technology "self-sufficiency and self-empowerment (科技自立自强)." Both terms of this slogan are significant: *Self-sufficiency* implies a defensive ability to survive technology blockades, and *self-empowerment* projects a present and future competitive advantage from existing capabilities. In Section 3, we will discuss the importance of this distinction in the current (post-2020) period.

[5] There is an important line in the IDDS: "embark upon a new development path that proceeds from strong human talent and strong science and technology, on to strong industries and economy, and a strong nation, and [thereby] create a new growth cycle for the next twenty or so years." Strategic Background Section.

[6] Chinese discussions often refer to technology with terms like "magic weapons" or "golden cudgels" or "assassin's mace." For a recent example, "Bring the superiority of the new-type national team into play to resolve the "bottleneck" problems," Jiangsu Web Office, September 19, 2022. Accessed at www.yangtse.com/content/1528371.html

2. Three Phases of Policy: Temporal Framework

For convenience, we will frequently divide the post-2006 period into three phases. Industrial and technology policy have generally changed in incremental fashion, so these periods are not qualitatively different. In particular, instruments are introduced incrementally, and old instruments remain in force even as new ones are added. However, there are a few useful benchmarks and characterizations that separate phases of policy. The phases are shown schematically in Table 1. In following sections, we will discuss aspects of the overall trajectory and then focus on the distinctive features of the most recent period, 2020–Present.

Table 1: Three Dimensions in China's Industrial Policies from 2006–Present

	2006–2012	2013–2019	2020–Present
Objective (why)	Economic development (with a stress on income and pecuniary advantage)	Economic development plus holistic national security	National security (including economic power and security)
Strategy (what)	Opportunistic sectoral targeting; Indigenous innovation to modify technology import	Innovation-driven development; broaden targeting to cover new tech revolution	S&T self-sufficiency and self-empowerment
Incremental Instruments (how)	Selective industrial policies	Market-conforming instruments; capacity-building industrial policies	New-style national team and NSS&TF

The first stage is from 2006 to around 2012 when China began to pursue "indigenous innovation" and developed plans for "strategic emerging industries" (SEIs). It's important to recall the economic context. China had just entered the World Trade Organization (WTO), and policymakers had spent a lot of time figuring out how to minimize the economic shock from WTO membership. As China became more deeply involved in the global economy, the Chinese Communist Party leadership also became more concerned about the risks brought by globalization. According to Long Yongtu (2021), the chief negotiator for China's WTO membership, China was most worried about the auto industry and agriculture upon WTO accession But this same process

generated explosive growth of exports, especially high-tech exports. Global value chains—especially those managed by Taiwan high-tech companies—moved into China very quickly after WTO membership. GDP growth nudged above 10% each year 2003–2005, then hit 12.7% in 2006 and 14.2% in 2007.

The objective of industrial policy, during this first phase, was to keep the economy running hot—not overheating too much, but most emphatically not running out of steam. National industrial policymakers provided what was essentially a portfolio of options. "New growth drivers" were sectors with growth opportunity that might require a little government boost in order to launch. This was a continuation, in other words, of the traditional Chinese system of highly motivated local governments. Early industrial policy gave local governments lots of choice. China attempted to climb up the global value chain by supporting certain industrial activities that might have higher added-value and thus more profit. Under this context, the industrial policies of China were led by the government but driven by the market.

Of course, the global economy was not all positive during this first phase. The Global Financial Crisis (GFC) was an enormous shock. Industrial policy responded to the immediate economic challenge of the GFC by becoming larger, but also more conservative, targeting traditional industries (essentially, bailouts). Thus, the industrial policies were mostly targeted at the "pillar industries," or the traditional industries, such as textile, automobile, and steel.[7] Such decision-making obviously made industrial policy even more opportunistic. Yet ultimately the GFC strengthened the confidence of Chinese policymakers in their ability to "concentrate resources to do big things," while also tarnishing the American free market model. Right after the GFC, in 2011, the Fukushima disaster in Japan and massive flooding in Thailand posed serious threats to the security of the global production networks, which might have deepened the concerns of China's policymakers about national economic security.

The second phase (2013–2019) can be characterized as the policies that Xi Jinping advocated when he had leeway to chart his own policy direction. On the one hand, this was marked by Xi's introduction in 2014 of the "holistic national security concept" (HNSC). This certainly increased the priority of security, but under the HNSC, in addition to political security, economic security was still prioritized over other types of security.[8] In 2014, an article by Lin Hongyu published on Renmin Wang (人民网) says that based on Xi's discourse on the HNSC, economic security is "always a priority" because in the

[7] See "State Council's industry revitalization plan (国务院行业振兴计划)" in http://finance.cctv.com/special/10dazhen xingjihua/01/

[8] In recent years, broader conceptions of security have entered the lexicon in many countries and include "economic security; energy security; environmental security; and even health, women's, and food security" (Holmes 2014).

long run, "economic elements will continue to be the core of China's international interactions." However, Lin also points out that China's economic interests should not be pursued at the expense of "core national security interests" (Lin 2014). On the other hand, the IDDS was proposed, initially in 2013, and then as a formal top-level policy document in 2016. As mentioned earlier, one of the fundamental features of the IDDS was the importance given to "a group of revolutionary new technologies—intelligent, green and ubiquitous—which are reshaping the global competitive landscape and changing the relative strength of nations" (Central Committee of CCP and State Council 2016). Also, clear consideration was given to preserving—and even strengthening—the role of the market. The dramatic rollout of RMB 10 trillion nominal value government guidance funds during 2014 to 2018 was a clear sign of this effort. Moreover, according to Jiang Feitao (2021), who participated in the formulating process of Made in China (MIC) 2025, some of the supporting plans of MIC 2025 are neutral capacity-building industrial policies rather than selective ones, such as the policies on manpower strengthening and innovation facility building, which avoid direct interventions into selected industries to some extent.[9]

A third phase (2020–Present) began under the dual impact of U.S. trade and technology blockades and the COVID pandemic. In April 2020, in a speech titled "Several Major Issues in the National Medium- and Long-Term Economic and Social Development Strategy," Xi officially proposed to build a "new development pattern" prioritizing the domestic economic circulation over the international circulation (Xi 2020). The proposal of the "new development pattern" marks the official turning point in China's policy objective from development to security. The speech was not openly published until November 2020, but the themes of the speech spread quickly in the official media. For example, this is the beginning of "dual circulation," as Xi's speech says the main part of the new development pattern is "domestic circulation," which along with the international circulation should "mutually promote" each other.[10] In May 2020, during the National People's Congress meetings, Xi explicitly stated that "China needs to gradually build a new development pattern with domestic circulation as the main part and the mutual promotion of domestic and international circulation." To achieve this goal, Xi mentions the necessity of "building a complete domestic demand system" (Cited in Xu et al. 2020).[11] In other words, the essence of the new development pattern is the dual-circulation strategy, which says that "domestic big circulation" will be the main

[9] We do not cover the IDDS period in detail here since it has been covered in earlier work. Naughton (2020).

[10] The original statement in Chinese is "国内循环越顺畅，越能形成对全球资源要素的引力场，越有利于构建以国内大循环为主体、国内国际双循环相互促进的新发展格局，越有利于形成参与国际竞争和合作新优势"

[11] The original statement in Chinese is "面向未来，我们要把满足国内需求作为发展的出发点和落脚点，加快构建完整的内需体系，大力推进科技创新及其他各方面创新，加快推进数字经济、智能制造、生命健康、新材料等战略性新兴产业，形成更多新的增长点、增长极，着力打通生产、分配、流通、消费各个环节，逐步形成以国内大循环为主体、国内国际双循环相互促进的新发展格局，培育新形势下我国参与国际合作和竞争新优势"

economic circulation (Wang 2020). While the dual-circulation economy features both domestic and international markets, the official explanation explicitly prioritizes the domestic circulation over the international one. Such logic can also be found in China's narrative regarding "integrating development and security" (统筹发展与安全), which stresses both development and security on the surface but intrinsically prioritizes the latter. The communiqué of the fifth plenary session in 2020 advocated "carrying out secure development throughout all fields and the whole process of national development." The statement's putting "secure" before "development" shows China's priority is security (Central Committee of CCP 2020).

Chinese academics and policymakers have interpreted China's pandemic experience as validating this approach. During the pandemic, China's "relatively complete industrial chain" was indispensable in keeping domestic circulation flowing smoothly and thus resisting disruption. In October 2021, in an interview with Sike, Wei Jianguo, former vice minister of finance, commented that China's "outstanding performance" (in international trade) should be attributed to China's "complete production and supply chains" relative to other countries (due to China's "early success in controlling the pandemic"), which (according to the source) were reflected in the gradual return of many orders from Southeast Asia (Cited in Wu 2021). Similarly, according to Ni Jianjun (倪建军)[12] in an interview with China Youth Daily, "the weaknesses in the supply chains in traditional developed countries were quickly revealed by the pandemic" and thus the "integrity and resilience of China's industrial chain have become more and more irreplaceable in the global supply chain" (Cited in Ma 2021). In the current period, then, the new development pattern, or dual-circulation strategy, is characterized by security concerns outweighing development concerns. Moreover, industrial chain security is the most important concern under the new development pattern.

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3. Self-Sufficiency and Self-Empowerment

The centrality of supply chains; the threat of American technological embargoes; and the increased emphasis on security by Xi Jinping understandably led to a new emphasis on scientific and technological self-reliance. At the fifth plenary session of the 19th Central Committee in 2020, the concept of science and technology (S&T) self-sufficiency and self-empowerment (科技自立自强) was officially proposed as the "strategic support" of national development (Sun 2020), and it was subsequently incorporated into the 14th Five-Year Plan. The term "strategic support of development" had previously been applied to S&T innovation (Xi 2017) and building a "global S&T powerhouse" (Chen and Yu 2018), neither of which has anything to do with self-reliance. On the surface, the increasing external risks certainly explained the self-sufficiency part of this newly declared policy objective, but not so much the self-empowerment part. For many, only the first half matters, and in fact the term often appears in a shorter version with only the first half included. However, this understanding is inaccurate—although self-sufficiency is the core part that makes the concept unique, and somehow worrisome—the second half, namely self-empowerment, is also important in the long run.

Understanding both halves of the new policy orientation is key to understanding the breadth of China's technology ambitions, as well as the unresolved tension in China's policy goals. For more than a decade, China has promoted "key core technologies (关键核心技术)," but no definition of this umbrella term has ever been given, much less applied consistently applied. However, we can use the distinction between technology self-sufficiency and technology self-empowerment to shed light on core technologies, and illuminate the trade-offs and tensions that lie behind this not-so-simple term.

Technology self-sufficiency essentially means mastering the "choke point technologies" (卡脖子技术), or, more prosaically, the bottleneck technologies, where China is dependent on imports, and which are blocked or might be blocked by foreign countries in the future. In the Chinese literature, these technologies are frequently called "short boards" for which China needs to compensate ("补短板"). In these areas, China is currently unable to fully realize import substitution. Short-board technologies are certainly part of "key core technologies," but only one part. Policymakers understand that realizing S&T self-sufficiency, or improving the short boards, will be costly, since China does *not* possess comparative advantages in the bottleneck technologies and investing in them might *not* bring China greater profits than simply relying on imports,Technologies aimed at S&T self-empowerment are also included in key core technologies, but have very different economic and technological features. These areas, also called "long boards" (长板) are areas where China currently possesses competitive advantages, or in which China has a reasonable chance of establishing competitive advantage in the near-term future.

In some cases, it is thought that future competitive advantage can be achieved by investing in disruptive new technologies and potentially "passing on the curve."[13] Overall, the areas of key core technologies include not only the ones where China has disadvantages (short boards), but also the ones where China has or might have advantages (long boards), depending on the definition being used.

Since it is impossible for China to do everything on its own, the question then becomes, in what areas does China attempt to achieve S&T self-sufficiency? The repeated official declarations about key core technologies provide no practical answers to this question.. Xi Jinping himself has never clearly differentiated S&T self-sufficiency from S&T self-empowerment. In 2016, at a cybersecurity conference, Xi categorized "core technologies" into basic and general technologies, asymmetric and "assassin's mace" technologies, and frontier and disruptive technologies, which doesn't provide much guidance (Xi 2016). In his speech in 2018, when he stressed the importance of "making key core technologies independent and controllable," he mentioned four types of technologies—"key generic technologies, cutting-edge leading technologies, modern engineering technologies, and disruptive technologies" (关键共性技术、前沿引领技术、现代工程技术、颠覆性技术) (Xi 2021).[14] More recently, at the academicians' conference in 2021, Xi said efforts should be made to make breakthroughs in key core technologies related to "urgent national and long-term needs," including oil and gas, basic raw materials, high-end chips, industrial software, agricultural seedsinstruments and equipment for scientific experiments, and chemical preparations. In addition to these areas, he also emphasized the "basic core areas related to overall development and national security," including artificial intelligence, quantum information, integrated circuits, advanced manufacturing, life and health, brain science, biological breeding, aerospace technology, and underground and deep sea exploration (Xi 2022). After Xi added "high-level" before S&T self-sufficiency and self-empowerment in 2021, a Chinese scholar identified this as a new requirement to have "independent and controllable key core technologies" (Zeng 2021). The only certainty, then, is that controlling key core technologies includes both S&T self-sufficiency and S&T self-empowerment.

[13] "Passing on the curve" (弯道超车) originally refers to overtaking other vehicles at a curve in the road (or on a winding road), something that is generally considered high-risk due to limited visibility. However, in the Chinese context, this term refers metaphorically to a latecomer country overtaking a developed country incumbent in an industry that is being disrupted by technological change.

[14] The speech was delivered by Xi Jinping in 2018 at the 19th Academician Meeting of the Chinese Academy of Sciences and the 14th Academician Meeting of the Chinese Academy of Engineering, but it was not published until 2021.

If a clear definition of key core technologies is absent from Xi's policy statements, and the areas covered seem too broad to be categorized, we can glean some information from more specialized publications.. In August 2022, the Ministry of Science and Technology (MOST) and the Ministry of Finance issued the "Action Plan for Improving Enterprises' Technological Innovation Capability (2022–2023)" (《企业技术创新能力提升行动方案（2022—2023 年）》). Emphasizing the necessity to "encourage enterprises to conquer key core technologies," the plan mentions that a "guidance catalog of key areas encouraged by the state" will be formulated, indicating that the discussion among policymakers is still ongoing. The definition of key core technologies is still a moving target. Nevertheless, we can gain some insight by looking separately at coverage of technology self-sufficiency and technology self-empowerment.

China's efforts to realize S&T *self-sufficiency* are targeted at the short-board technologies, a few of which have already been embargoed by the United States. Thus, considering the impact of the United States blockades on China's chip production, the integrated circuit (IC) industry is undoubtedly the top immediate priority. This can be shown by China's provincial 14th Five-year Plans for Scientific and Technological Innovation (14F STI Plans; the national plan has not been released to the public). In the 14F STI Plans of Shanghai, Beijing, Guangdong, Jiangsu, and Zhejiang provinces, predominant emphasis is put on the IC industry in the sections on key core technologies (see Table 2). There is a parallel case in the biomedical industry where the import of artificial blood vessels from the two major producers in Germany and Japan was disrupted (due to the relocation of factories and change of suppliers, not embargoes). Artificial blood vessels are indispensable materials in vascular and cardiac surgeries, and China is currently without domestic substitutes for this high technology item(Chen 2022). Since biological security is one of the sixteen national securities in Xi's HNSC, the shortage of artificial blood vessels also affects China's national security in Xi's era. In this way, the corresponding technology is one of the short-term bottleneck technologies as well.

Table 2: Areas of Short-Board Key Core Technologies in Provincial 14F STI Plans

	Shanghai	Beijing	Guangdong	Jiangsu	Zhejiang
Integrated Circuit	√	√	√	√	√
Biopharmaceutical	√		√	√	
Artificial Intelligence	√				
General Key Components		√	√		√
Key New Materials		√	√		
Key Equipment		√			
Software			√	√	√
Agriculture			√	√	

However, it is much harder to reach a consensus on the long-run bottleneck sectors, because China still relies on imports for many products, and embargoes are difficult to predict. For example, in the above-mentioned biopharma industry, according to Fan Yubo (樊瑜波),[15] more than 80% of China's high-end medical equipment still relies on imports. Also, although some medical equipment may have realized "localization" in the assembly process, their core technologies, materials, or key components are still monopolized by foreign companies ("More deadly than the chip" 2022). In fact, China has now moved aggressively to require localization of medical equipment. As shown in Table 2, the provincial 14F STI Plans all target short-board key core technologies which are described as the most urgent tasks in the provincial plans.

Back in 2018, *Science and Technology Daily* published a series of articles on the 35 specific core technologies that can cause "strangulation" problems. In other words, the 35 technologies are the short-board key core technologies, because the articles reveal China's heavy reliance on import and lack of independent and stable capability to produce the listed products. The list is shown in Table 3.[16] At present we cannot discriminate between the short-term and long-term priorities without further analysis.

[15] Dean of Beijing University of Aeronautics and Astronautics Institute of Medical-Engineering Interdisciplinary Innovation, Director of Beijing Advanced Center for Biomedical Engineering.

[16] The original 35 articles are no longer available on the official website of Science and Technology Daily, but we can still find them on another website: 科技日报【专题报道】亟待攻克的核心技术（1-5） | 科塔学术 (sciping.com), see https://www.sciping.com/10679.html

Table 3: 35 core technologies listed by Science and Technology Daily

Number	Core Technology
1	Lithography
2	Integrated Circuits
3	Self-developed operating system
4	Nacelles of domestic aircraft engines
5	Tactile sensor
6	Vacuum evaporator
7	Cell Phone RF Devices
8	iCLIP technology
9	Heavy duty gas turbine
10	Lidar
11	Airworthiness Standard
12	High side capacitor resistor
13	Core industrial software
14	ITO target
15	Core algorithm
16	Aviation steel
17	Milling cutter
18	High-end bearing steel
19	High pressure plunger pump
20	Aerospace design software
21	Photoresist
22	High pressure common rail
23	Transmission electron microscope
24	Roadheader main bearing

Number	Core Technology
25	Microspheres
26	Underwater connector
27	Key materials for fuel cells
28	High-end welding power source
29	Lithium battery separator
30	Medical imaging equipment components
31	Ultra-precision polishing process
32	Epoxy resin
33	High strength stainless steel
34	Database management system
35	Scanning electron microscope

Before publishing these articles, the then editor-in-chief of *Science and Technology Daily*, Liu Yadong (刘亚东), argued openly against the concept of "passing on the curve" (弯道超车), criticizing it for being opportunistic and unrealistic. From Liu's perspective at that time, the core technologies should be about "catching up" rather than "surpassing" (Liu 2018), and we would add they are "defensive" rather than offensive.

Between 2018 and 2020, China developed a second round of sixteen "megaprojects" to follow up on the initial sixteen megaprojects carried out as part of the 2006-2020 Medium and Long-term Plan for Science and Technology. Perhaps surprisingly, the second round of megaprojects are not targeted on short-board technologies but rather on areas where China either has current competitive advantages or reasonable prospects of developing that advantage in fast-moving technological conditions. The projects in the "Innovation 2030" Megaprojects program are shown in Table 4. Most megaprojects seem to be oriented toward "building the long boards" or "passing on the curve," namely S&T self-empowerment related to disruptive technologies. For example, twelve of the new-round megaprojects are in frontier disruptive areas, such as quantum technology, brain science, and smart grid, while only four projects (highlighted in green), are in short-board areas based on our definition. Of course, the second-round megaprojects were proposed several years ago, so chances are that China was not then as concerned with S&T self-sufficiency as it is now.

Table 4: List of Second-Round Megaprojects

Order	S&T Innovation 2030 Major Projects	Fields
1	**Aero Engines and Gas Turbines**	**Advanced Manufacturing**
2	Deep Sea Space Station	Space and Ocean Exploitation
3	Quantum Communication and Quantum Computer	Electronic Information
4	Brain Science and Brain-Like Research	Biological Health
5	National Cyberspace Security	Electronic Information
6	Deep Space Exploration and Space Vehicle In-Orbit Service and Maintenance System	Space and Ocean Exploration
7	**Independent Innovation in Seed Industry**	**Agriculture**
8	Clean and Efficient Utilization of Coal	Energy Environment
9	Smart Grid	Energy Environment
10	Integrated Information Network of Space and Earth	Electronic Information
11	Big Data	Electronic Information
12	Intelligent Manufacturing and Robotics	Advanced Manufacturing
13	Key New Materials R&D and Application	Advanced Manufacturing
14	**Beijing-Tianjin-Hebei Comprehensive Environmental Management**	**Energy Environment**
15	**Health Protection**	**Bio-Health**
16	New Generation Artificial Intelligence	Electronic Information

Similarly, we have compiled a list of the projects in the National Key Research and Development Program (NKRDP) for 2020 and 2021 as shown in the appendix.[17] We found that most of the projects announced in 2020 and 2021 were targeted at S&T self-empowerment instead of self-sufficiency. That is, they envisage investstment in areas where China believes it has the potential to "pass on the curve" by making preemptive moves. The latter category can also be understood as the "disruptive fields (颠覆性领域)," frequently seen in China's official narratives.

From Beijing's perspective, S&T self-empowerment plays a core role in the growth model transition process, as the long-board areas, such as electric vehicle (EV) and photovoltaic industries, can promote China's economy more efficiently. Since China has gained market/technological advantages in the "long-board" areas, it will be easier to rely on these industries to enter high-quality economic development with lower consumption of various resources and less environmental pollution (Zeng 2021). Second, from the S&T international competition perspective, China tries to enter the technological frontier by building advantages in future technologies and industries. According to Xi Jinping, in the past China was a latecomer in the previous "S&T race" and unable to "take the lead in the rules set by others," but the new-round S&T and industrial revolution can provide China with such an opportunity to "set the rules" (Xi 2014). At the same time, establishing advantages in disruptive S&T and industrial fields can ensure the technological security for China's future development, because they can "provide a strategic technology reserve to completely solve the 'strangulation' problems" (Hou 2021).

Official descriptions of the industries related to S&T self-empowerment are very vague and thus hard to be categorized. When explaining creating long boards, Wang Zhigang, Minister of Science and Technology since 2018, emphasized that China should strive to build "competitive advantages" in SEIs, including artificial intelligence, quantum information, advanced manufacturing, life and health, brain science, aerospace technology, and other "frontier areas" (Liu and Cao 2021). We differentiate "frontier" from "disruptive" areas. The "frontier" areas can also be understood as long-board areas where we believe China has already gained advantages, and the "disruptive" areas are those where China might be able to develop advantages in the future, simply because few countries have yet achieved a decisive advantage in a rapidly changing sector.

[17] This list might not be exhaustive considering the confidentiality and time constraint.

Although the central government does not provide a clear list of the frontier areas, or the long-board areas, some local governments do provide related descriptions in their provincial 14F STI Plans. We identified the potential frontier areas in five provincial 14F STI plans, which are shown in Table 5. Although the plans use the term "major and advantageous areas" (重大及优势领域) to refer to the industries, based on the descriptions, we categorize them as the long boards. We found that there are four areas of key core technologies recognized as frontier technologies by most provinces: new materials, intelligent manufacturing, modern energy technology, and marine technology. However, the choices of these five provinces might not reflect the central government's perception of frontier areas, and there might not be a consensus among Chinese policymakers on the definition and selection of frontier areas.

Table 5: Areas of "Major or Advantageous" Key Core Technologies in Provincial 14F STI Plans by Province

	Shanghai	**Beijing**	**Guangdong**	**Jiangsu**	**Zhejiang**
Areas of "Major or Advantageous" Key Core Technologies	New Materials			New Materials	New Materials
	New Information Infrastructure				
	Basic Software				
	Intelligent Networked Vehicles and New Energy Vehicles		New Energy Vehicles		
	Intelligent Manufacturing and Robotics			Intelligent Manufacturing	Advanced Manufacturing and Major Equipment Technology
	Aerospace				
	Energy Equipment		New Energy	New Energy	Modern Energy Technology
	Marine Technology and Engineering Equipment		Marine Economy	High-End Equipment	Marine Technology

	Shanghai	Beijing	Guangdong	Jiangsu	Zhejiang
		Artificial Intelligence			
		Biomedicine			Life & Health Technology
		Quantum Information			
			Digital Economy		Modern Service Industry
			Smart Sensing		
			Information Photonics		
					Ecological Environment and Public Safety Technology
					Modern Agricultural Technology

By contrast, unlike the vague definition of frontier technologies, China has a clearer description of "disruptive technologies," which also receives more attention from the government. According to MOST, disruptive technologies are "game-changing innovations that have the transformative effect of changing the course of technology and the pattern of interest distribution." From the industry's perspective, disruptive technologies can change mainstream products and market patterns (MOSTc 2022). It is clear that Beijing is ambitious about mastering disruptive technologies and is looking forward to the transformative changes it might bring. In Wang Zhigang's view, the proliferation of technological innovation supply is a prerequisite for the development of new industries (Yu 2018). Therefore, in order to achieve its goal of "seizing the high ground" in future technologies, the Chinese government is promoting the development of disruptive technologies through the implementation of various S&T plans or programs such as the Ten-Year Action Plan for Basic Research NKRDP, and MLP.

According to Wang Zhigang, disruptive technologies include carbon materials and devices, synthetic biology, metamaterials, process chemistry and catalysis, brain imaging, and gene editing. In addition, MOST is continuously soliciting opinions on R&D directions for disruptive technologies from research institutions to support the deployment of the S&T program (General Office of the MOST 2021). The Chinese Academy of Engineering Innovation Strategy (中国工程科技创新战略研究院)[18] provides us with a more specific list of technologies as shown in Table 6.

Table 6: Engineering S&T's Major Disruptive Technology Directions for 2035

Technology Requirement Classification	List of Disruptive Technologies
Open up the scientific frontier and seize the strategic high ground	• Quantum Information Technology • Artificial Intelligence • Mobile Internet Technology • Gene Editing Technology • Synthetic Biology Technology • Graphene • Metamaterials
Addressing major strategic needs and supporting rapid economic and social development	• Intelligent High-Speed Rail • Low Vacuum Tube Magnetic Levitation Railroad Technology • Nature-Rich Function Coordinated Watershed Construction Technology • Multi-Objective Joint Scheduling Technology for Hydropower Project Clusters • Intelligent Unmanned Aerial Vehicle Technology • Combustible Ice Mining Technology

[18] It is a think tank specializing in strategic research on disruptive technologies established by the Chinese Academy of Engineering (中国工程院) in 2016.

Technology Requirement Classification	List of Disruptive Technologies
Breakthrough key bottlenecks and maintain economic security	• Slurry Bed Residue Hydroconversion Technology • Direct Methane to Olefin and Aromatics Technology • New Electric Furnace Technology for Low C (Scrap) Era • Non-Ferrous Metal Continuous Extrusion Technology • Shaftless Rim Propulsion System Technology • Livestock Stem Cell Breeding Technology • Molecular and Gene Control Breeding Technology for Energy Crops • Zero-Addition Intensive High-Quality Drinking Water “Membrane” Treatment Process • Key Technology for Saline Land Cultivation
Promote industrial transformation and upgrading, transforming the development mode	• 3D Printing of Renewable Smart Textiles • Novel Bio-Intelligent Manufacturing • Micro System Technology (Mems) • BIM-Based Smart Construction Technology • Industrialized Construction • 3D Printing Construction Technology • Recycle Self-Contained Wastewater Purification Smart Factory

Technology Requirement Classification	List of Disruptive Technologies
Meet the needs of a good life and ensure the healthy development of society	• Oncology Immunotherapy • Artificial Virus Vaccine • Multiple In-Situ Solidification/Conversion Technology for Atmospheric CO2 and Major Pollution Components • Remote Online Intelligent Control Technology for Diesel Vehicles Based On "Telematics + Big Data" • Spectral/Satellite Based High-Resolution Telemetry/Remote Sensing Technology for Regional/Ecological Environment Elements • Multi-Media Environment and Ecosystem Sensing Technology Based on Big Data Fusion • Gene Pesticide Based on RNA Interference Technology • Biomass Oil and Biogas Co-Production Engineering Technology • Medical Artificial Intelligence

In summary, Chinese technology planners are torn between the relative importance to give to two different definitions of core technologies. The security emphasis leads them to stress the defensive need to invest in short-board key and core technologies, but this implies tremendous costs if potentially lucrative long-board technologies are not also fostered. The struggles between these different orientations, different technological priorities, and different assessments of possibility underlie a terminology that is often used in an inconsistent and even self-contradictory manner.[19]

[19] In addition, many high priority technology projects are wrapped in secrecy.

4. The New-Style National Team

As the security concerns peaked in 2020 with the proposal of a new development pattern, China's policymakers began to question their previous reliance on market forces and market-compatible instruments, and returned to strong and direct government interventions. Increasingly, emphasis has been put on the establishment of a new-style national team (新型举国体制) in order to master key core technologies.[20] At the fourth plenary session of the 19th Central Committee in 2019—that is, just prior to the COVID epidemic—it was proposed to "build a new-style national team for key core technologies under the conditions of socialist market economy" (Central Committee of CCP 2019). The term "national team" is familiar to the Chinese, but not to most outsiders. The core feature of the national team is "centralizing power to do great things (集中力量办大事)," a phrase strongly associated with the planned economy period. The phrase implies a pattern of government-led deployment of all necessary resources within the country to achieve a specific goal. It has also been considered as one of the significant advantages of the socialist system with Chinese characteristics for a long time (Central Committee of CCP 2019). Recent breakthroughs in the fields of manned spaceflight, lunar exploration, manned deep diving, supercomputers, and high-speed railroads have all been credited to the national team (Tang and Hao 2021). In Xi Jinping's view, China's new national team has produced a number of major achievements, including the Three Gorges Dam (三峡大坝), high-speed railroads, manned spaceflight, the 2022 Winter Olympics, and Lunar Exploration Program (探月工程).[21] In general, China used the national team in the highest priority areas of the economy during the planned economy (including the the selection of China's elite Olympic athletic teams). By contrast, after 1978, with the retreat of administrative means as the single means of allocating resources, the use of the national team was limited to a few specific areas. Now, policymakers are clearly displaying their intention to use the form of the new national team to address the spectrum of key corse technologies discussed in the previous section.

Figure 1 shows the frequencies of the three terms, "national team," the "new-style national team," and "centralizing power to do great things," in official media from 2002 to 2022.[22] It shows clear temporal patterns. The (unmodified) "national team" enjoyed a

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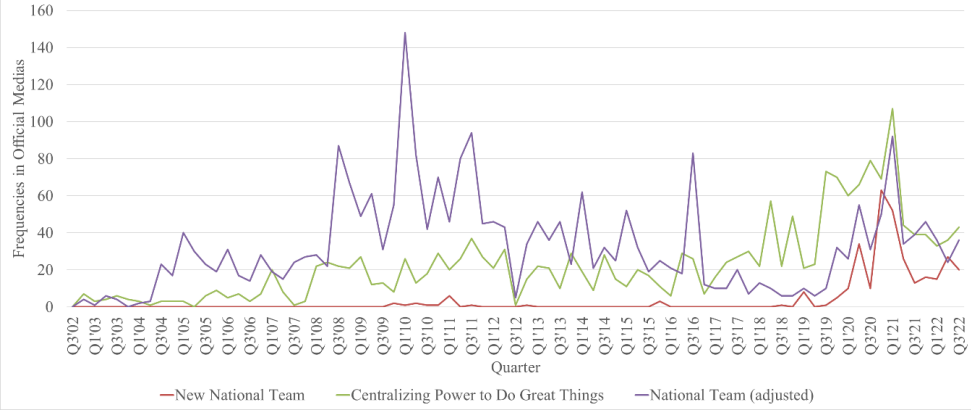
20 The literal translation of the Chinese term 新型举国体制 is "new-style whole-of-nation system," and it is often rendered this way in the English language literature. However, for reasons that will be clear in the following discussion, we prefer the simpler translation of "new national team."

21 This can be concluded from a series of official news reports. See https://www.sxxz.gov.cn/zwyw/gwyyw/202102/t20210223_3604000.shtml; http://www.qstheory.cn/dukan/qs/2022-04/01/c_1128515085.htm; http://www.qstheory.cn/wp/2021-06/10/c_1127549677.htm

22 The frequencies were calculated by Wisenews (慧科新闻). To avoid overlaps, the frequency of "national team" was calculated by that of "national team" minus that of "new national team."

surge of popularity in 2008–2011, as propagandists touted the role of state-owned enterprises in handling the GFC.[23] It then faded from view. At the end of 2019, the "new-style national team" began to be promoted, and "new style" and traditional national teams together reached an unprecedented prominence.

Figure 1: Appearance of Key Terms in Official Chinese Media



In 2020, the meaning of new national team was further explained in the "Proposal for the 14th Five-Year Plan and the 2035 Visionary Goals (中共中央关于制定国民经济和社会发展第十四个五年规划和二〇三五年远景目标的建议)," which emphasized that China should "improve the new national team under the conditions of socialist market economy and fight the battle of key core technologies." This formalized the linkage between the "new national team" and key core technologies (Central Committee of CCP 2020A).

The essential meaning of the new national team is the same as the old national team, which is still "centralizing power to do great things."[24] However, two characteristics are said to make it the new style. First, the new national team emphasizes the importance of *market mechanisms*. The traditional national team is a product of the planned economy, where administrative means were the only means to allocate resources for development, which led to the waste of resources and inefficiency. Chinese policymakers have emphasized that the new-style national team is only a special type of organizational approach and does not mean that the government becomes the sole distributor of resources. The old model, they argued, took the level of technology as the only consideration, while the new national team would attach equal importance to the level of technology and economic benefits, thus avoiding the problems of wasted

[23] Liu Yandong (刘延东), State Councilor, also used the term from 2006 through 2009 and it was included in the 12th Five-Year Plan for S&T Development, but referred primarily to government-organized consortia.

[24] For example, see the following websites: 新型举国体制"新"意何在--科技--人民网 (people.com.cn), http://scitech.people.com.cn/n1/2020/0518/c1007-31712918.html; 健全科技攻关新型举国体制-新华网 (news.cn), http://www.news.cn/fortune/2022-09/11/c_1128994703.htm

resources and low returns. The new "spin" on the national team may be just an attempt to reduce the sensitivity of people to the planned economy associations, so that the new national team can be accepted as an improved version while increasing government power and intervention.

Second, the new model has different goals from the traditional national team. In 2022, the 27th meeting of the Comprehensive Deepening Reform Commission (全面深化改革委员会第二十七次会议) pointed out that China should establish and consolidate the new national team with the core task of conquering the key core technologies (Yang and Hu 2022). However, it is still unclear among the short boards, long boards, and disruptive technologies, which category of key core technologies the new national team will be mostly applied in. According to the 27th meeting of the Comprehensive Deepening Reform Commission, the focus of the new national team should be on the "R&D of key technologies with first-mover advantages and basic frontier technologies that will lead future development (Yang and Hu 2022). In other words, at this meeting the new national team was regarded as most useful to conquer long-board and disruptive technologies. On the contrary, according to the comment of *Economic Daily* in September 2022, the task of the new national team is to address the weaknesses (namely "short boards") of China's industry and seek to capture the S&T high ground (Jin 2022). Many other scholars believe that the main task of the new national team is to break through the bottleneck technologies that restrict China's development.[25] We have already seen that there are different emphases about the nature of core technologies. It is not surprising to see these arguments play out in the definition of the new national team as well.

[25] For example, see the following reports: 依靠新型举国体制解决"卡脖子"问题--经济·科技--人民网 (people.com.cn), http://finance.people.com.cn/n1/2021/0307/c1004-32044721.html; 薛澜谈新型举国体制：真正卡住我们脖子的是什么？ - 科技资政 - 欧亚系统科学研究会 (essra.org.cn), https://www.essra.org.cn/view-1000-1454.aspx

5. Organizations and Institutional Arrangements

There is a kind of ambiguity at the heart of the notion of the national team. On the one hand, the selection of the national team is supposed to draw on the resources of the entire nation. In principle, nobody is left outside the system. The whole nation participates and the whole nation benefits. On the other hand, after the selection process is completed, there are team members and then there is everybody else. If you are not chosen for the Olympic Team (to take a simple example), you are not going to the Olympics, unless you buy a ticket in the bleachers. For the new national team conquering the key core technologies, which is it? Is there a designated team, or is the term simply being used in order to foster national identification and support for the national effort?

This question should be at the heart of our understanding of the current phase. There is not yet sufficient evidence to answer this question definitively. However, we believe there is sufficient evidence to sketch a hypothesis about organizational form. To do so, we rely on descriptions of the national strategic S&T force, which has four fundamental components. By examining the ways in which these components are discussed in conjunction with the new-style national team, we can glimpse the outlines of a new set of institutions.

Based on official narratives, the National Strategic S&T Force (NSS&TF), with four major components, comprise the main players of the new national team. In 2021, a *Qiushi* article by Bai Chunli (白春礼)[26] directly points out that "strengthening the NSS&TF will help to give better play to the advantages of the new national team under the conditions of the socialist market economy" (Bai 2021). Most recently, at the latest Comprehensive Deepening Reform Commission in September 2022, Xi emphasized that to strengthen the NSS&TF can "give full play to China's socialist system's remarkable advantage of centralizing power to do great things" (Yang and Hu 2022). Since "centralizing power to do great things" is the core feature of the new national team, based on Xi and Bai's statement, we speculate that projects regarding the NSS&TF can be seen as the major instruments used by the Chinese government to apply the new national team in practice. NSSTF is a combination of S&T players that "embody the will of the Party/State, guided by national strategy, and deployed and organized for the purpose of conquering key core technologies" Xinhua Agency Commentator 2020).[27]

[26] Bai Chunli is the former president of the CAS.

[27] NSS&TF was first used by Hu Jintao during his visit to CAS in 2004, when he pointed out that "CAS, as a national strategic science and technology force, should pursue the first class." When Xi came to the power, he used this term more and more frequently and enriched its connotation.

In 2021, the composition of the NSS&TF was finalized at the National Assembly of Academicians. In his speech, Xi emphasized that "national laboratories (国家实验室), national research institutes (国家科研机构), high-level research universities (高水平研究型大学), and S&T leading enterprises (科技领军企业) are all important components of the NSS&TF, and should "consciously fulfill the mission of high-level S&T self-sufficiency and self-empowerment" (Xi 2021A).

In the new national team, each component is supposed to play a different role:

(a) National laboratories are the core of the new national team, mainly carrying out basic research, precompetitive high-tech research,[28] and socially beneficial research. They undertake major national research tasks and produce strategic and critical S&T results ("The difference between" 2022). Currently, the Chinese government has approved the establishment of eleven national laboratories, six of which have been established in recent years and are located in Shanghai and Beijing.

(b) National research institutes, of which there are more than 1,000, represented by the Chinese Academy of Sciences (CAS), the Chinese Academy of Engineering (CAE), and the Academy of Military Sciences (AMS), are mainly responsible for solving major S&T problems that affect the overall development and long-term interests of China, including researching original theories and conquering key core technologies (Yin et al., 2021). In addition, the national research institutions, especially the CAE, also assume the function of high-end think tanks to provide advice for major S&T policymaking.

(c) Top research universities.

(d) S&T leading enterprises are the main force in the new national team that undertakes the task of industrializing technology. S&T leading enterprises, unlike ordinary enterprises, are leaders in industrial technology innovation, representing the highest technological innovation capability in the field and representing a country's participation in international innovation competitions.

Aside from these four components, the conscious creation of regional S&T clusters—so-called S&T Innovation Centers—should also be considered as a part of the NSS&TF. As Xi stressed at the academician conference in 2021, "all localities should support the construction of national science centers or regional S&T Innovation Centers based on local needs and advantages" (Xi 2021A). In practice, the S&T Innovation Centers contain

[28] Precompetitive technology is an early and very uncertain technology research and development activity based on the ability to be applied to future business or for a specific commercial prototype.

the four components of NSS&TF. For example, according to a *People's Daily* report, Zhangjiang National Comprehensive S&T Center should "develop all kinds of resources including national labs, major science devices, etc." (Meng 2021).

Thus, we can hypothesize that the new-style national team will look like this: First, there is a new organizational structure being put in place. The 27th meeting of the Comprehensive Deepening Reform Commission provided some clarifications on it. Beijing stressed that "a sound 'new national team' requires an organic combination of government, market, and society" and "promotes a better combination of an efficient market and an effective (or pro-active) government" (Yang and Hu 2022). Specifically, in terms of "effective government," the Commission said that China should establish "an authoritative decision-making command system under the leadership of the Party," including the establishment of a collaborative organizational mechanism and centralized allocation of S&T resources. This is a blueprint for a top-down method of organizing and allocating resources.

Second, these organizations will be organized around specific technologies. Since there is no universal agreement about bottleneck and competitive advantage technologies, we should anticipate a mixture of the two. The majority are likely to be targeted on bottleneck sectors (because of the urgency of the defensive actions) but with a substantial admixture of cutting-edge and disruptive technologies intended to buttress China's comparative advantage in manufacturing. Considering the published lists of 35 bottleneck technologies and 38 disruptive technologies discussed earlier, we should probably expect around 50 of these technology-specific organizations.

Third, these organizations will specifically coordinate activities of the disparate component parts of the NSS&TF. One must assume that tasks will be assigned to government-run national labs and research institutes, as well as research universities. The job of farming out trial production and scaling up will be contracted to high-technology enterprises. We should expect that local government-run high-tech parks—the (confusingly) labeled S&T Innovation Centers—will be delegated substantial responsibility for coordinating these activities on the local level. Shanghai in particular is trying to establish itself as a leader in this dimension.

Fourth, and finally, the coordination of activities with high-tech enterprises is likely to be handled through some kind of competitive and/or contractual relationship. This is presumably what is meant by the assertions that the new-style national team will bring the market mechanism into the heart of the national team and that attention will be paid to cost and competitiveness. Planners seem to believe that management of megaprojects (and, presumably, military industry) provides some experiential lessons for the new national teams. These would presumably provide opportunities to bring in fresh actors while also subjecting incumbents to the threat of failure or non-renewal.

Despite the incorporation of market mechanisms into the new-style national team, it is certain that the new national teams represent a substantial expansion of direct government intervention and even control. They will be expensive, they will distort market forces, and they will create new opportunities for moral hazard and even corruption. However, this is the price paid for absolute security: it is in line with the maxim “millions for defense, but not one cent for tribute,” which has been cited approvingly in the United States for more than two hundred years. The increasing weight given to security objectives inevitably reverses the effort to use market-conforming mechanisms to implement the IDDS and erodes some of the market robustness already established.

6. Conclusion

The complex of policies adopted after 2020 clearly demonstrate the triumph of national security over all other policy objectives. At the same time, the conceptually separate processes of refining strategies and developing institutions is proceeding apace and is also clearly evident in the discussions of key technologies and the approach to national technological self-strengthening. China, in other words, is getting better at running industrial policy, even as the objectives of that industrial policy become less beneficial to China and the world. In addition, a whole range of new pressures is being created in the economy, as increasingly numerous and conflicting plans and commands are passed down through the system. This fundamental tension inevitably undermines the efficiency of the market system. In more concrete terms, the creation of new national teams is undermining the vitality of China’s market system right now.

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