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RESEARCH BRIEF

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How China's Defense Innovation System Is Advancing the Country's Military Technological Rise

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The preceding brief provided an analytical framework for examining a country's defense innovation system and the factors that shape innovation outcomes. This brief applies the framework to examine the diverse array of factors at work in the Chinese defense innovation system. There are many reasons explaining the successful transformation of the Chinese defense innovation system from an ossified dinosaur in the 1990s to an increasingly credible military technological competitor on the global stage at the end of the 2010s. China's approach to defense innovation has undergone considerable evolution since it launched a full-fledged modernization of its defense science, technology, and industrial (DSTI) system in the late 1990s. Some of these changes mirror what has taken place within the civilian sector, but there is also much that is different because of the specific dynamics of the defense arena.

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CHIEF CHARACTERISTICS OF THE CHINESE DSTI SYSTEM

The Chinese defense innovation model between the 1990s and the late 2010s can be described as absorptive-statist in nature. Under Xi Jinping's rule since 2012, the absorptive-statist model is undergoing a far-reaching revamp to emphasize: 1) a greater role for market forces, although with the state still firmly in the driving seat; 2) greater attention to original innovation while still promoting absorption; and 3) a push for integration between the civilian and defense domains. This blurring of the civilian and military boundaries has picked up considerable pace since the mid-2010s and is a signature feature of Xi's defense innovation strategy.

Absorptive: The work of the Chinese DSTI system has been predominantly through absorption, which is the acquisition of foreign technologies and know-how and the digestion, adaptation, and re-engineering of these capabilities to local needs and conditions. This is what the Chinese define as 're-innovation.'

The key enabling factors within the defense innovation system include foreign technology transfers and diffusion and production processes. While this absorptive development model remains important, the Chinese DSTI system has been gradually expanding its focus towards more original higher-end innovation since the mid-2010s and this is likely to keep up pace in the coming years. The critical factors required for original innovation include an advanced research and development system, strong human capital, and a well-managed and integrated acquisition system.

Statist: The Chinese DSTI system is overwhelmingly a state-led, top-down apparatus where state and military agencies—under the watchful eye of the Communist Party—have enjoyed comprehensive control over

decision-making and policy implementation.

A key feature of the statist nature of the DSTI system is selective mobilization, in which the central authorities are able on a highly selective basis to mobilize resources and institutions across the entire country to pursue strategically critical defense technology development programs.

Compartmentalization: The defense innovation system as well as the defense economy have been largely separated from the rest of the civilian innovation system and national economy. This is a legacy of the highly segmented command economy that the Chinese authorities learned and imported from the Soviet Union in the 1950s. A major effort is underway to overcome these barriers and promote integration within the military and defense industrial systems as well as between the civilian and defense economies.

Big science and engineering: A clear preference in the science and technology (S&T) development approach of the Chinese authorities—both civilian and military—is for large-scale science and engineering projects. A distinguishing feature of a number of the major science and technology development programs that China has pursued between the 1990s and 2010s is the pursuit of so-called "big science" and "big engineering" projects. There are, for example, sixteen mega-projects in the 2006–2020 Medium and Long-Term Science and Technology Development Plan.

Leap-frogging: A central focus of China's approach to reforming its defense innovation efforts from the outset was on catching up through fast following and skipping stages, or what Chinese often refer to as leap-frogging. This meant that the Chinese DSTI establishment could not simply pursue routine or incremental innovation—the standard operating procedure of innovation ecosystems—

but had to engage in higher and more risky forms of innovation such as architectural, component, or disruptive innovation. To be able to pursue these higher innovation trajectories, especially on a sustained level, the Chinese DSTI system needed to have extraordinary outside intervening factors that would override its incremental nature. Consequently, catalytic factors are of the utmost importance as drivers of change.

Comprehensive development: There has been a broad-based transformation across almost the entire Chinese DSTI system, which is made up of the aviation, shipbuilding, space and missile, ordnance, nuclear, and electronics industries. Some sectors such as space and missile, shipbuilding, aviation, and electronics appear to be making more rapid progress in their development compared to the nuclear and ordnance industries, but the overall level of S&T advancement of the Chinese DSTI system is robust and multi-faceted. This comprehensive development approach is sectoral in nature, while the select mobilization model is focused on specific technologies and weapons platforms.

PROGRESS IN CHINESE DEFENSE INNOVATION

As noted in the previous brief, China's innovation outcomes are most likely to fall into the advanced imitation or incremental imitation types (Figure 1). The factors contributing the most to China's rapid advances in the last two decades are discussed in greater detail in the following sections.

Catalytic Factors

A fundamental reason behind the ability of the Chinese defense innovation system to successfully catch up technologically over the past two decades has been the powerful enabling role of catalytic factors: the threat environment, high-level leadership support, and major changes

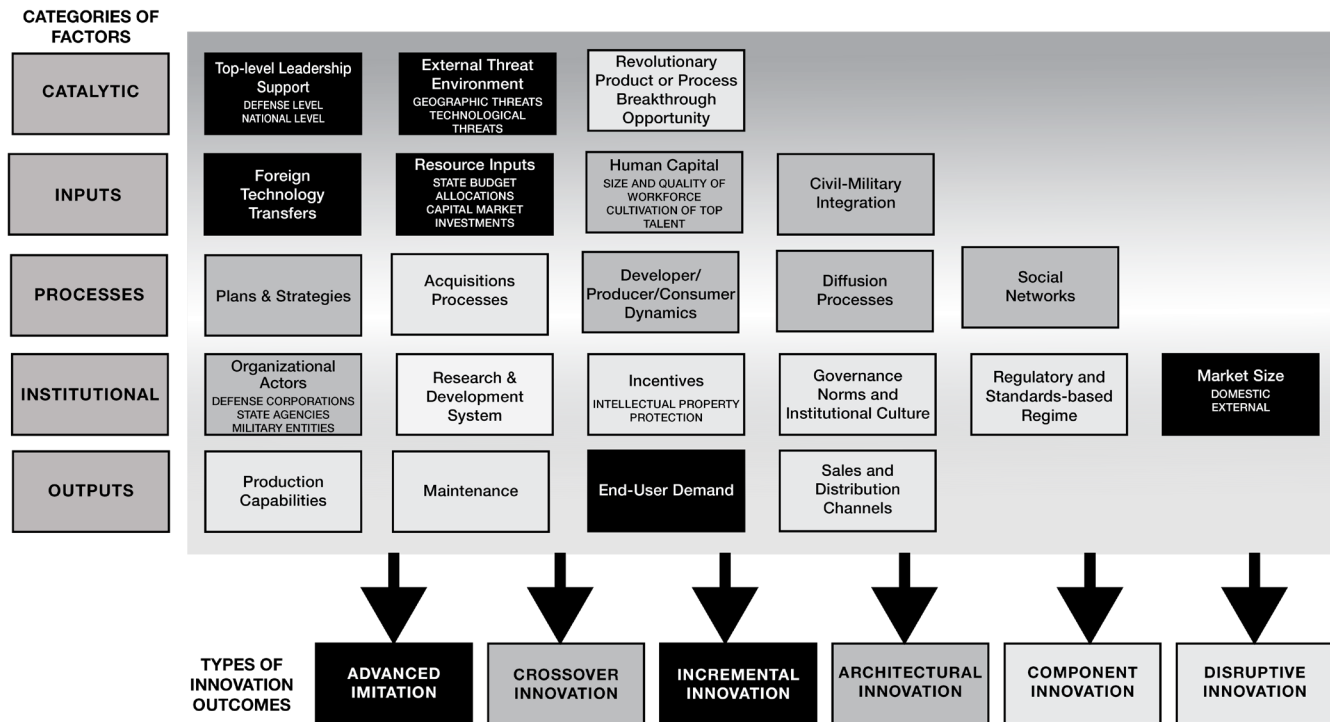


FIGURE 1. The state of Chinese defense innovation in the late 2010s

in the prevailing technology paradigm that allow for the opportunity for revolutionary product or process breakthroughs. It is very likely that the Chinese defense innovation system would have remained stymied by entrenched structural and legacy obstacles as it had done in the last few decades of the twentieth century without these outside intervening drivers. Two of these factors in particular stand out:

High-level leadership support: The most important of the catalytic factors is high-level and sustained support and guidance from Communist Party, state, and military leadership elites. Leadership backing and intervention has been vital in addressing bureaucratic fragmentation, ensuring adequate resource allocations, and tackling chronic project management problems. The involvement of the country's paramount leader is especially critical, and the People's Liberation Army (PLA) and DSTI system have benefitted enormously from

Xi's active and sustained interest in defense issues.

The external threat environment: A direct causal relationship appears to exist between the nature of the threat environment and the level and intensity of innovation that occurs within the Chinese defense innovation system. When official assessments such as the national military strategy determine that the country is facing severe external security threats, there is strong demand for the DSTI system to step up its research and development and pursue higher forms of innovation. The most obvious example is China's pursuit of nuclear weapons and intercontinental ballistic missiles between the 1950s and 1970s in the face of acute risks from the Soviet Union and United States.

Since the 1990s, a rise in official assessments of the threats facing China has been met with increasing pressure on the DSTI system to significantly step up its research, development, and innovation efforts. This

began in the early 1990s with Chinese alarm over the technological implications of the US-led victory in the first Gulf War, followed by deepening security tensions in the Taiwan Strait from the mid-1990s and the 1999 US bombing of the Chinese Embassy in Belgrade, and has continued to the present day.

Input Factors

Input factors have played a decisive role in powering the Chinese defense innovation system's progress. This is because a key characteristic of China's defense technological development over the past couple of decades has been the enormous investment and concentration of resources and manpower, especially in select high-priority projects. This brute force mobilization approach has allowed major advances to take place.

Four input factors have been especially important for the Chinese defense innovation system: foreign technology transfers, military civil fu-

sion (MCF), resource inputs (budgets, capital market investments), and the role of human capital. Of these, two are worth highlighting:

Foreign technology transfers: The absorption and re-innovation of foreign technology and knowledge has been a powerful enabler in advancing the overall modernization of China's armament capabilities since the late 1990s. This has allowed the PLA to close—and in some cases eliminate—the technological gap with regional and global competitors in an expanding number of areas. The biggest beneficiaries of these technology importation strategies have been in the aviation, naval shipbuilding, and select precision strike missile sectors.

Military civil fusion: Under Xi's tenure, there has been a far more proactive and high-level push to make MCF a viable policy tool. Foremost among these efforts was Xi's announcement in March 2015 to elevate MCF's strategic importance from the sectoral to the national level. Another important move occurred in January 2017 with the formation of the Commission for Integrated Civilian-Military Development. The appointment of Xi Jinping as its chair made clear the importance of this organization in leading MCF implementation.

Process Factors

Many of the factors in this category are 'soft innovation' in nature and are concerned with the operations, routines, and interactions that govern how the defense innovation system functions. At least five process factors are prominent in the Chinese defense innovation system: acquisition processes; plans and institutional arrangements; developer-producer-end user dynamics; diffusion processes; and social networks. Two of these are worth discussing in more detail:

Acquisition processes: A distinguishing feature of Chinese defense acqui-

sition processes for the past several decades have been their role in supporting a predominantly absorptive model of technology development. This is typical of catch-up countries whose domestic research and development capabilities lag far behind the world's advanced defense technology powers.

Absorption-oriented acquisition is organized and operates in a fundamentally different way from innovation-based systems like those of the United States. Two differences stand out. First, absorption is a low-risk, high-reward enterprise because the technological development path has already been mapped out. Second, absorptive processes and systems place overwhelming priority on investing in engineering capabilities, especially related to reverse engineering, and less on research and development.

The primary benefits from absorption are significant cost savings and shortened timelines. This has allowed the Chinese defense establishment to narrow, and in a few cases eliminate, the technological gap with regional and global competitors in an expanding number of areas. The biggest beneficiaries have been in the aviation, naval shipbuilding, and select precision strike missile sectors.

Plans and institutional arrangements:

The Chinese defense innovation system is a heavily top-down, state-led undertaking, so development strategies and implementation plans drawn up by central military and defense authorities are carefully adhered to. They include the PLA's Weapons and Equipment Development Strategy and long-, medium-, and short-term Weapons and Equipment Construction Plans and the 13th Defense Science, Technology, and Industry Five-Year Plan (13th Defense S&T FYP) that spans from 2016 to 2020. The 13th Defense S&T FYP has six key tasks: 1) facilitating so-called leapfrog development of

weapons and military equipment; 2) enhancing innovation capabilities in turnkey areas; 3) improving overall quality and efficiency; 4) optimizing the structure of the defense industry and vigorously promoting military civil fusion; 5) accelerating the export of armaments and military equipment; and 6) supporting national economic and social construction.¹ Compared to its predecessors, the 13th Defense S&T FYP has a stronger focus on the development of high-technology weaponry and military civil fusion. It also signals a significant shift in the direction of defense industry development from absorption and re-innovation to greater emphasis to original innovation.

Institutional Factors

Institutional factors play a central role in how the defense innovation system is organized, bounded, incentivized, and governed. The key institutional elements in the Chinese defense innovation system include organizational actors such as defense corporations, state administrative agencies, and military units; the research and development system; the regulatory and standards regime; incentive mechanisms; and market structure. The most important of these are the defense corporations and regulatory regime.

Defense corporations: Nine sprawling state-owned defense industrial corporations occupy a privileged position at the heart of the Chinese defense innovation system. Their contribution to technological advancement has been decidedly mixed, however. Between the 1950s and the end of the 1990s, these all-powerful state bureaucracies were formidable obstacles to innovation as they sought to protect their institutional interests. It was not until the beginning of the 2000s that the central government began major reforms to transform these entities from loss-makers

1 State Council, 2016年国防科技工业工作会议在京召开 [“2016 National Defense Science, Technology and Industry Working Conference was held in Beijing”], January 9, 2016, http://www.gov.cn/xinwen/2016-01/09/content_5031770.htm.

into more market-driven enterprises. Since then, these corporations have been slimmed down, allowed to shed heavy debt burdens, and given access to new sources of investment, especially from the capital markets. They are now engaged in an ambitious expansion strategy to become global arms and strategic technology champions.

Regulatory regime: The establishment of a robust and transparent regulatory system for the defense industry has been a key goal of the Chinese authorities for the past couple of decades, but conflicting views about the nature of this regulatory model, rooted in divergent bureaucratic and political interests, has meant progress has been mixed. The choices have been between a ‘developmental’ regulatory model found in other East Asian states and an ‘independent regulator system’ model that is the standard in Western developed market economies. The reform of the Chinese defense industrial regulatory system embraces many of the ideals of the developmental model, especially the willingness to support national champions, tight controls on market competition within the industry, and a lack of transparency.

Output Factors

The effectiveness of a country’s DSTI establishment can be judged by the nature of its output, which can be measured by technological quality, cost, market competitiveness, and time to production. The Chinese defense innovation system is beginning to make significant improvements in all of these performance indicators after concentrating its attention and resources over the past couple of decades on research and development.

Four factors are especially relevant in assessing China’s output effectiveness: maintenance, the role of market forces such as marketing and sales considerations, the influence of

end-user demand, and production capabilities, of which the latter will be examined in more detail:

Production capabilities: A long-standing Achilles’ heel of China’s DSTI system has been a weak high-end manufacturing capability. The defense industry’s manufacturing competence has primarily been in advanced imitation because of its long experience in incrementally improving Soviet-derived weapons systems. Sharp reductions in defense spending during the 1980s led to a severe curtailment in military orders for Chinese defense contractors, which resulted in the atrophy of production capabilities and a loss of experienced manpower and know-how.

China’s defense industry has been seeking to recover from this manufacturing interregnum since the beginning of the twenty-first century. While military orders have picked up substantially since the early 2000s, defense producers have struggled to meet this demand, especially for advanced equipment. A major initiative since the mid-2010s has been to upgrade the country’s advanced civilian and dual-use manufacturing capabilities through the “Made in China 2025” plan. A defense version called the “Defense S&T Industry 2025” plan runs in parallel. Information on this plan has been limited, but a priority is the development of manufacturing capabilities to produce military turbo-fan engines.²

CONCLUSIONS

One finding from the Chinese case that is relevant more generally is the central importance of catalytic factors in pushing defense innovation systems to step up their innovation activities from routine to higher levels. Without these catalytic factors, there is little impetus for undertaking higher and more risky levels of innovation. However, catalytic factors

by themselves are insufficient to produce far-reaching change within the innovation system, thus they need to coordinate and work with other factors in unison. For leadership support to have meaningful impact, for example, there need to be close linkages with process and input factors (such as strategies and plans that design and implement the guiding principles put forward by leaders) as well as resource inputs to fund activities. In other words, understanding the linkages between factors, especially between different categories of factors, is of crucial importance.

A second insight is that the factors that are most effective correspond to the nature of science, technology, and engineering activity that is primarily taking place within the DSTI system at that time. If absorption is the primary mode of activity, factors that are associated with the input of external technologies and knowledge and dealing with soft innovation capabilities such as improving management and quality control are more appropriate and useful. If original innovation is the dominant activity, then hard innovation capabilities such as having a more capable research and development system and fostering a tightly integrated acquisition process become more important.

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2 国防科工局表态首次确认 ‘国防科技工业2025’ [“SASTIND Statement Confirms for the First Time ‘Defense S&T Industry 2025’”], Shanghai Security News, June 19, 2015, http://military.china.com/important/11132797/20150619/19871906_all.html.