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POLICY BRIEF

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The Role of Foreign Technology Transfers in China's Defense Research, Development, and Acquisition Process

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China is making impressive progress in the development of its science and technology (S&T) capabilities, especially in the defense domain, but it remains a considerable distance from the global technology frontier. One of the most effective ways to close this gap is to leverage the technology possessed by advanced S&T powers. China, however, faces high barriers to gaining access to this technology and expertise because of long-standing Western export restrictions on defense and dual-use transfers. Nevertheless, China is actively pursuing an intensive campaign to obtain foreign technology transfers using a wide variety of means. It is spending heavily on importing technologies, engaging in joint collaboration, and attracting foreign firms to invest and locate research and development (R&D) facilities in the country. Covertly, China is conducting industrial and cyber-espionage and reverse engineering. Understanding how China obtains, absorbs, and transforms foreign defense technology and knowledge into its own local adaptations is crucial in assessing the country's defense technological rise and its long-term innovation prospects.

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THE IMPORTANCE OF ABSORPTIVE CAPACITY

In examining the role that foreign technology plays in China's defense research, development, and acquisition (RDA) process, a key analytical concept is absorptive capacity, which refers to the ability of a country to recognize, assimilate, and utilize new and external knowledge. This concept has been widely used in the fields of business management and organizational economics, and many of the same forces are also relevant for examining China's defense S&T system.

A useful framework of analysis views absorptive capacity as a dynamic capability embedded in a firm's routines and processes, geared towards effecting organizational change, and strategic in nature as it defines a firm's path of development and evolution. Moreover, absorptive capacity has four dimensions that can be grouped into two categories.

Potential absorptive capacity allows organizations to be receptive to the absorption of external sources of knowledge, but does not mean that they will be able to successfully exploit this knowledge. There are two key components of potential absorptive capacity: 1) **acquisition** signifies the capability to identify and acquire externally generated knowledge that is critical to operations; and 2) **assimilation** refers to the routines and processes that allow organizations to analyze, process, interpret, and understand the information obtained from external sources.

Realized absorptive capacity is the ability of an organization to turn its potential absorptive capacity into actual output. There are two key attributes: 1) **transformation** denotes a capability to develop and refine the routines that facilitate combining existing knowledge and the newly acquired and assimilated information; and 2) **exploitation** allows organizations to refine, extend, and leverage existing competencies or to create new ones by incorporating acquired and transformed knowledge into its operations.

In applying the absorptive capacity concept to the Chinese RDA system, it is important to recognize the fundamental differences in how the RDA process works in imitation-oriented and innovation-oriented regimes. For imitative countries like China, the research component of the RDA process is either absent or plays a limited role depending on the degree of imitation that is practiced.

The defining operational attributes of the Chinese defense innovation system are as follows:

- Imitation is the primary focus of activities, notwithstanding a growing effort to promote original innovation, especially incremental and architectural innovation.
- Leadership and management are hierarchical and top-down in nature.
- The system is insular and has restricted interactions with the outside world.
- The state plays a dominant role in setting priorities, providing strategic direction, and overseeing management of the system.

These determinants shape the nature of China's approach to absorptive capacity in a number of important ways. First, there is heavy reliance on imitative techniques and processes such as copying and reverse engineering. Second, the Chinese defense innovation system is dependent on foreign technology and knowledge to make major advances in technological development. As much of this technology and know-how is off-limits to China, especially defense and dual-use capabilities from the West, the use of covert means to gain access to this information has become an increasingly critical source to ensure the country's continuing technological progress.

THE ROLE OF FOREIGN TECHNOLOGY AND KNOW-HOW IN CHINA'S RDA SYSTEM

The development of China's defense RDA system has been a duel of foreign imitation and autonomous innovation. Reliance on external sources has been the dominant narrative for the sprawling conventional weapons establishment from its origins in the early 1950s right up to the past decade, while the smaller and more specialized strategic (nuclear, space, and ballistic missiles) arms complex forged a more independent development path because it was shut off from outside assistance. These two sectors were eventually consolidated in the 1980s and the defense economy has sought to pursue a twin-tracked imitation-innovation approach.

Although the Chinese leadership's stated goal is for defense technological self-sufficiency, this is a long-term over-the-horizon political aspiration and the near- to medium-term (5–10 years) reality is of continuing heavy reliance on foreign sources for technology and knowledge, although combined with increasing levels of domestic input. This is what the Chinese leadership means when it promotes the concept of "indigenous innovation," which as defined in the country's 2006–2020 Medium and Long-Term S&T Development Plan (MLP) as a way to promote original innovation by reassembling existing technologies in different ways to produce new breakthroughs and absorbing and upgrading imported technologies.

A more accurate and precise way to define this aspect of China's technological development strategy is a four-part process known as "introduce, digest, absorb, and re-innovate" (引进 *Yinjin*, 消化 *Xiaohua*, 吸收 *Xishou*, 再创新 *Zai Chuangxin*), or IDAR, which refers to the different steps required to turn foreign technology into a remade domestic variant.

This technology absorption strategy is most clearly articulated in a supplementary document to the MLP, "Opinions to Encourage Technology Transfer and Innovation and Promote the Transformation of the Growth Mode in Foreign Trade," which calls for encouraging the introduction of advanced foreign technology that can be digested and absorbed for re-innovation.

These four stages of the IDAR strategy correspond with the four elements of the absorptive capacity model as well with the different stages of the RDA cycle:

1. Acquisition/Introduction/ Pre-Concept;
2. Assimilation/Digestion/ Concept Refinement;
3. Transformation-Absorption-Technology Development/ Engineering and Manufacturing Development; and
4. Exploitation/Re-innovation/ Production and Deployment.

THE FOUR DIMENSIONS OF THE ABSORPTIVE CAPACITY MODEL AND THE CHINESE DEFENSE RDA SYSTEM

Acquisition/Introduction

Gaining access to external knowledge is vital for the Chinese defense RDA system to compensate for the gaps and inadequacies in its R&D base and to meet ambitious development targets. There are a multitude of acquisition and technology transfer mechanisms and channels: 1) arms and technology imports; 2) foreign direct investment and direct (explicit technology transfer agreements) and indirect (transfer of governance and other types of less-tangible, soft skill sets) spillover effects; 3) espionage through traditional industrial and information era cyber operations; 4) open source information collection and analysis; 5) establishment of foreign R&D centers; and 6) human capital transfers and exchanges. The most important of these channels for the RDA system are arms and defense technology-related imports, espionage, and open source information collection and analysis.

In the face of long-term international restrictions on defense-related technology transfers, two of the primary mechanisms that the Chinese defense S&T system employs to mitigate these limitations are open source information collection and espionage activities. For open source information collection, China has built a substantial infrastructure that dates back to the 1950s and initially was created to support the country's construction of its strategic nuclear weapons and ballistic missile capabilities. Information collection is an integral element of the information analysis and dissemination (IAD) system, which will be assessed in the next section on assimilation.

Espionage also plays an important and growing role in China's defense acquisition efforts, although its value is difficult to gauge because of the lack of transparency. This comes in two forms: industrial espionage and computer network exploitation, or cyber espionage. Traditional industrial espionage has been the bread and butter of China's spying efforts since the founding of the Communist republic, but its impact on improving the Chinese defense S&T system appears to have been limited and episodic until the beginning of the 1990s because of the country's economic and technological isolation from the global defense economy.

An important turning point in China's industrial espionage efforts took place in the early 1990s with the collapse of the Soviet Union, which allowed China to take advantage of the economic chaos in Russia and former Soviet republics and gain access to their defense industrial facilities and scientific and engineering personnel. This access to former Soviet defense technology may have helped select portions of the Chinese defense industry to advance by one or more generations. The most significant contributions have been in fighter aircraft programs, air-to-air missiles, radar, fire-control systems, aircraft carrier and other naval systems, and manned space.

A key role for defense S&T organizations is to provide technical targeting requirements to guide the work of collection units. Little is known about how this targeting process works, but the notoriously hierarchical and compartmentalized nature of the Chinese defense establishment would suggest that targeting requests by S&T organizations go up through their respective chains of command. Entities affiliated with the defense industry would report to the State Administration for Science, Technology, and Industry for National Defense, while units of the People's Liberation Army (PLA) would go through their own departments and service arms. Requirements by military units belonging to the armaments system, for example, will go up through the General Armament Department (GAD) hierarchy.

Assimilation/Digestion

In the digestion of foreign inputs, a key mechanism that has been built up is a S&T information analysis and dissemination apparatus. A number of major IAD entities were established within the S&T system, including the Institute of Scientific and Technical Information of China, which belongs to the Ministry of Science and Technology, and the Electronics Science and Technology Intelligence Research Institute that is affiliated with the Ministry of Industry and Information Technology (MIIT).

The IAD system consists of around 400 analysis and diffusion centers with around 50,000 personnel, according to a 2006 assessment. However, only around 35 of the centers belong to central government agencies; the rest are affiliated with provincial or lower-level institutions.

The vast majority of the external information that IAD organizations analyze comes from open sources such as media, online, and academic outlets.[1] The classified intelligence collected by PLA intelligence agencies are likely to be only available for the military component of the IAD system, which is centralized under the China Defense Science and Technology Information Center (CDSTIC) that is affiliated with the GAD. CDSTIC has grown rapidly over the past few decades, especially since the end of the 1990s, to cope with intensive demand for its S&T information and analysis services from the defense innovation system, military organizations, and the country's leadership.

Transformation/Absorption

A central goal in China's development of its national-level and defense absorptive capacities is to promote the ability to carry out its IDAR strategy. The IDAR approach is being actively pursued by defense and high-technology intensive industries that have major gaps in their technological capabilities which can be addressed by external technology transfers. This strategy is being carried out through an assortment of approaches that include collaborative international joint ventures as well as through illicit transfers and unauthorized reverse engineering.

The Chinese authorities are investing heavily in building up an extensive technology and engineering ecosystem to support efforts to combine digested foreign and local technologies. This includes the establishment of an extensive array of entities such as national engineering research centers, enterprise-based technology centers, state key laboratories, national technology transfer centers, high-technology service centers, and the recruitment of foreign technical experts through organizations such as the State Administration of Foreign Experts Affairs. National engineering research centers are one of the most important types of institutions designated by the Chinese government, transforming the acquired and digested external technology into actual output.

The commercial and military aviation and high-speed rail sectors are at the forefront in the implementation of the IDAR strategy. The development of China's first narrow-bodied jet airliner, the C919, is a prime example of this approach. Chinese aviation firms are mainly responsible for building the fuselage and other less technologically-advanced portions of the plane while Western companies are providing the engines, avionics, and other technologies that China lacks.

Exploitation/Re-Innovation

One of the major challenges for the Chinese defense economy is how to turn its efforts in acquisition, assimilation, and transformation into exploitation or actual output. A major bottleneck is underdevelopment of the advanced manufacturing capabilities critical to the precision production of high-technology products.

The Chinese authorities have made the development of civilian and defense-related advanced manufacturing capabilities a leading priority in their S&T and economic development plans. This includes the MLP and the 2012 Strategic Emerging Industries Plan. Moreover, MIIT issued a five-year program in 2012 that provided a detailed outline for the development of the country's high-end equipment manufacturing industry.

While these S&T development plans stress the importance of nurturing homegrown S&T capabilities, the reality is that China can only make major progress through gaining access to foreign technologies and know-how. The high-end equipment manufacturing industry development plan calls for conducting "secondary innovation based on the introduction and absorption of technologies," which is an oblique reference to the strategy of combining and integrating advanced foreign technology with domestic capabilities.

CONCLUSIONS

Using China's IDAR model offers a more precise guide in understanding how Chinese entities at the state and corporate level pursue much of their innovation, which is making use of foreign technology and combining with domestic capabilities to produce novel solutions suitable to Chinese conditions. China is designing and building a significant portion of its national innovation system to support its advanced-imitation IDAR strategy. This includes a burgeoning ecosystem of laboratories, information analysis and dissemination institutes, national and corporate engineering centers, and technology transfer centers.

Since the 1990s, a combination of foreign technology transfers and advanced imitation has allowed key portions of the Chinese defense economy to catch up in one to two generations. During the 1990s and early years of the twenty-first century, China benefited the most from authorized and unauthorized access to former Soviet defense S&T capabilities, especially in areas such as aviation, missiles, and naval technology. In the last few years, information and intelligence gained from the cyber domain appears to be gaining in importance.

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1 One study suggests that 80 percent or more of S&T technical information requirements can be obtained from open source publications, while the remainder needs to be collected by "special means."