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The Human Dimension in Chinese Defense Science, Technology, and Innovation: An Overview

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The human factor plays an indispensable role in the conduct of defense science, technology, and innovation (STI). While this may seem obvious, it has been overlooked in the study of how countries engage in defense and civilian STI activities. The research briefs in this year's annual review of the Chinese defense economy by IGCC look at the role that human factors play in shaping and driving China's defense STI affairs, including the influence of particular pools of expertise, such as academicians, designers, and engineers; the political and bureaucratic pressures brought to bear on the process; increasingly intense efforts by Chinese leaders to recruit and train human talent; and case studies into the development of specialized science and technology (S&T) professionals. This overview provides an introduction to the issues while also critiquing prevailing analytical frameworks of human agency and structure in an effort to bring human agency more prominently into the study of STI.

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INTRODUCTION

From scientists pursuing cutting-edge research to leaders intervening to support the development of favored projects, the human factor plays an indispensable role in the conduct of defense STI. Widely used frameworks of analysis and methodological concepts such as national innovation systems (NIS) and research, development, and acquisition (RDA) emphasize the macro-level dynamics of structure and process and give cursory attention to micro-level human factors.

This year's annual review of the Chinese defense economy looks at the role that human factors, or "agency" in academic-speak, plays in shaping and driving China's defense STI affairs. The central issue that is explored is the relationship between human agency and structural factors as China's defense S&T system steadily changes from a weak to an increasingly robust institutionalized apparatus and how this impacts its innovation capabilities and development trajectories.

CONTENDING SCHOOLS OF THOUGHT ON THE HUMAN AGENCY-STRUCTURE RELATIONSHIP

Human agency is defined here as the capacity of scientists, engineers, administrators, policymakers, and others involved in science, technology, and innovation acting individually or collectively to make independent choices. Structure refers to macro-level recurrent patterned arrangements such as organizations, institutional mechanisms, norms, and other social factors that influence or limit the choices and opportunities available to individuals.

There have been two schools of thought with regard to the agency-structure issue in the study of STI. The dominant camp uses what can be labeled a "technological deterministic approach" in which the development of technological capabilities are driven by structures and processes. This approach minimizes the actions and

influences of human actors. Some of the most influential models from this school, which originated in Europe and the United States, include the RDA paradigm, models of industrial innovation, and the NIS framework.

In these structurally deterministic approaches, there is little consideration for micro-level human agency factors, as the focus is on macro-level drivers such as developments at the state or industrial sector levels, strategic and socio-economic conditions, and long-term trends. The RDA paradigm, for example, focuses on the complex system of organizations and rules that are responsible for the conceptualization, design, engineering, testing, production, and operation of weapons and defense-related equipment. Numerous entities are involved in this process, ranging from scientific research institutes in the initial research phases, defense contractors in the design and engineering development phases, and military end-users and state regulatory bodies as the process reaches developmental finalization and production begins. The place of human agents is secondary in this framework because of the overwhelming focus on technology, hardware, and engineering-related development flows.

The second school of thought is the "strategic choice" approach, in which innovation is the primary outcome of social interactions and the political choices made by human actors. Structures and processes play a secondary role in allowing decision-makers to make their choices and implement their actions. This agency-centered strategic choice approach embraces micro-level analysis, more timely or proximate causes, and the specific subjective conditions shaping the actions of human actors. Alanna Krolkowski uses this approach in her examination of professional experts who reside in the Chinese aeronautic and space communities.

The strategic choice approach has been especially influential in Chinese thinking and operational management through the "Two Lines of

Command" and "Two Chiefs" management system, a two-line management system in which distinct strands of decision-making authority and responsibility are divided between technical experts and administrative officials.

While each of these approaches makes important contributions, on their own they can only offer partial explanations because of their biases towards either agency or structural factors. It is necessary to find ways to combine these two strands into a coherent, integrated framework in order to provide a more comprehensive understanding.

One approach that has particular applicability in the defense innovation domain is the concept of path dependence, which refers to "a specific type of explanation that unfolds through a series of sequential stages." A key early part in this sequencing is a "critical juncture," which is a relatively short period of time during which there is a substantially heightened probability that agents' choices will affect the outcome of interest. This notion of a critical juncture allows human actors to have an important impact at a decisive point in the decision-making cycle. Once decisions are made and acted upon, this leads to self-reinforcing, path-dependent trajectories.

The RDA paradigm is one model that would be suitable for adaptation to incorporate a path dependence approach to provide room for consideration of agency impact. There is a significant congruence between the different historical stages of the path dependence model and the RDA framework. There is an initial "pre-formation" phase for path dependence, which would correspond with the "requirements and pre-research" stage in the RDA set-up. This is when scientists and civilian and military bureaucrats and political leaders are involved in deciding on strategies and policies, as well as choosing specific projects for research and development. Eric Anderson explores some of these themes in more detail in his policy brief examining the political and

bureaucratic influence of the defense industrial lobby in the Chinese policy process. This preformation stage is where an extensive search for technological options for development takes place.

In the subsequent RDA stages where the focus is on development, engineering, prototyping, and production finalization, other types of human agency dynamics come to the fore. This includes the roles and influences of designers and engineers. This is the focus of the briefs by Kevin Pollpeter and Andrew Erickson.

ENABLING FACTORS FOR THE PROMINENCE OF HUMAN AGENCY INFLUENCES

Human agency in China can have far more influence and impact than in advanced states. There are a number of characteristics of the Chinese system that account for this. First is the under-institutionalization of the STI establishment in the initial stages of development. States often rely on the scientific community for expert guidance and administrative leadership when they embark for the first time on building an S&T system. But the ranks of capable scientists and engineers are thin, so they are heavily employed in numerous roles from scientific research to project management. This is especially the case for the building of complex strategic technology capabilities. In the building of the U.S. nuclear weapons, space, and other advanced military technology capabilities between the 1940s and 1970s, for example, many of the top scientists became high-level administrators managing these programs. This was also the case in China where a number of the scientific pioneers of the strategic weapons programs known as the “Two Bombs, One Satellite” movement were given responsibility for administrative oversight and had considerable clout in influencing policy directions.

This concentration of power among a small elite is a second char-

acteristic of the Chinese defense S&T system that can amplify the influence of human agents, whether individually or collectively. Jordan Wilson offers some fascinating insights into the country’s elite academician community (members of the Chinese Academy of Sciences and Chinese Academy of Engineering) and its contributions to defense S&T development in his brief.

Not only top scientists enjoy this convergence of power. The top-down flow of power and concentration of authority is a distinct feature of the highest levels of Chinese policy, administrative, and scientific decision-making, oversight, and management. Weak transparency and accountability controls and norms add to this and allow strong and determined leaders the ability to mobilize resources and institutional capabilities needed to carry out their goals.

As the science and technology system steadily becomes more developed, the next generations of scientists, engineers, and administrators gradually emerge through the ranks to be able to provide more choice and competition for positions and more specialization. But it is only when the pioneering first—and often the second—generations of scientists depart from office does the highly personalistic nature of the science and technology system, especially at the higher rungs, become more institutionalized. This transition from a personalistic to an institutionalized system only began to take place in China from the 1990s as the first generation of leading scientists, such as Qian Xuesen, and their powerful military and political sponsors, such as Zhang Aiping and Song Jian, stepped down from power. This transition gained momentum and reached a tipping point in the late 1990s as some of the key legacy S&T organizations were restructured or replaced by new structures, and younger generations of officials were promoted to take charge of these organizations.

This institutional transition remains a work in progress, and per-

sonalistic practices still abound. Such dynamics are still in evidence in how projects are selected. Combined with the deeply entrenched, politicized, and patronage nature of decision-making and resource allocations, the phenomena of pet projects tied to specific leaders should not be a surprising characteristic of the Chinese system. This also happens in more advanced and transparent regimes such as the United States. The larger and more costly a project, the more senior and influential the leader championing it needs to be. Only those at the very apex of the decision-making hierarchy have the authority and influence to be able to push ahead with major initiatives. For example, the Chinese manned space program required the personal backing of Deng Xiaoping to proceed.

Special institutional mechanisms have been put in place to utilize this concentration of authority to conduct high-priority strategic and defense S&T projects. The Central Special Committee is a prime example of a top-level organ with a small group of high-ranking leaders that was responsible for successfully managing many of the strategic weapons programs during the 1960s and 1970s. It was re-established in 1989 to carry out a similar mandate, and one of its successes is the manned space program.

CURRENT CHINESE LEADERSHIP THINKING ON HUMAN CAPABILITY BUILDING

Human agency issues have been a long-standing priority for the Chinese authorities, but until the past couple of decades most of the focus has been on ensuring political reliability rather than on fostering a state-of-the-art professional scientific and technical workforce. With a rapidly modernizing defense S&T establishment requiring growing numbers of more capable talents, the defense authorities have made concerted efforts to groom new generations of better trained person-

nel since the early 2000s through the establishment of a human talent strategic engineering program. This was a long-term initiative launched by then Central Military Commission (CMC) Chairman Jiang Zemin and continued by Hu Jintao. It was intended to cultivate large numbers of highly qualified personnel in five areas: commanding officers trained in informatized warfare; staff officers with expertise in policy planning and military operations; scientific research personnel; a technical cadre; and a contingent of non-commissioned officers. The program received occasional attention and support from military leaders and military media but did not appear to enjoy sustained high-level leadership support, especially following Jiang's retirement. This program was superseded in 2011 when the CMC issued the Military Talent Development Plan to 2020, which provided unified strategic guidance for human capacity building across the entire armed forces.

Many subordinate military commands have also put together their own military talent development initiatives. The PLA General Armaments Department (GAD) in 2012 issued a Talent Development Plan to 2020, and each of the service arms also have their own talent development strategies. There was also a special program for High-Level Military Personnel in Science and Technology Innovation that was established in 2009, in which 200 promising scientists and other military technical personnel would be selected every two years for advanced training, including the opportunity to be mentored by academicians. Another dimension of the development of military human science and engineering talent is the role of the higher education system, which is the focus of Daniel Alderman's brief.

Although many of these initiatives were established under Hu Jintao's rule, Xi Jinping has not only strongly endorsed these human capital development efforts but is giving them

even greater priority. In a keynote speech to the assembled ranks of the members of the Chinese Academies of Science (CAS) and Engineering (CAE) in June 2014, Xi stressed that "[p]eople are the most crucial element in S&T innovation work" and proclaimed that "our most long-standing and fundamental work should be to place human talent above all else." He further explained that "if China truly desires to be a world leader in S&T innovation," then "we must exert our greatest efforts to build up a contingent of innovative S&T human talent that is large in scale, logical in structure, and high in quality." While Xi's remarks were directed at a civilian S&T audience, he has also made similar comments to the defense S&T workforce, such as on a visit to the National University of Defense Technology in November 2013. The programs and activities behind these efforts are the focus of the policy briefs by Fan Yang, who surveys China's S&T human talents programs, and Liming Salvino, who looks at recruitment efforts such as the Thousand and Ten Thousand Talents programs.

Xi has acknowledged the enormous challenges that need to be tackled to achieve this aspirational goal, pointing out that China

lack[s] world-class S&T masters, and our leading human talent and cutting-edge human talent is lacking. The cultivation of engineering and technical personnel has become disconnected from the practice of production and innovation.

To address these issues, Xi said that "we must reform the mechanisms for human talent cultivation, importation, and utilization," explaining that this must be a long-term effort and should be prioritized over shorter-term demands. "We must avoid hastily seeking immediate success," he warned.

Xi highlighted another normative barrier in his comments: the risk-adverse nature of the S&T system that

meant that innovation was not highly valued.

We must actively create a positive atmosphere that encourages daring and courageous innovation and that is also accepting of innovation. We must value success but must also be tolerant of failure.

The acknowledgement by Xi that the cultivation of the human talent pool is a top priority in the construction of innovation capabilities is politically valuable in the internal battle for leadership support and resource allocations. However, Xi's administration faces an uphill task in overcoming deep-seated institutional biases. The dominant priority of the S&T system, and the defense S&T system in particular, is technology and hardware development, which is where funding, prestige, and promotion prospects for scientists and officials are most lucratively located. By contrast, human capacity building is of secondary importance and only receives episodic leadership attention and access to resources.

The military high-level STI personnel program is the principal effort to develop future generations of defense S&T leaders. A review of the program after its first two years pointed to impressive progress. Some of the personnel selected for this program were involved in the Shenzhou manned space program and the development of the Tianhe high performance computer. More than 100 academicians from CAS and CAE were said to have participated in this program as mentors.

Complementing the high-level STI personnel program is the GAD Talent Development Plan to 2020, which is aimed at cultivating the specialized professionals required for the management of the armaments system. The plan has ten main goals, which include cultivating highly-qualified command-level officers able to conduct joint operations, fostering high-level technological experts, training

better qualified military representative system personnel, and enlarging the limited pool of non-commissioned officer equipment specialists. There have so far been few reports on the progress of this new initiative, but its success will be vital in ensuring that the GAD has the qualified manpower to be able to meet its increasingly high-technology missions and tasks.

Two of the policy briefs provide fascinating case studies into the development of specialized S&T-related professionals. Darren Wright looks at the cultivation of defense S&T innovation teams and the roles that they have played in helping to advance key areas of defense S&T, such as in the space sector. Joe McReynolds, LeighAnn Ragland, and Amy Chang

examine the PLA's efforts to build up the human capital ecosystem to support the development of its network weapons capabilities.

CONCLUSIONS

Bringing human agency more prominently and explicitly into the study of defense STI is crucial in order to acquire a more comprehensive and nuanced understanding of how defense STI works. This is especially relevant for examining defense STI regimes still in the formative stages of development. Finding the appropriate balance and ways to combine agency and structure into an integrated approach is the biggest challenge, however. There is plenty of room for fur-

ther research in this area, especially by learning from efforts being undertaken in other disciplines.

A more nuanced agency-structure framework will allow more insightful analysis of how well China is doing in the development of its defense scientific and technological human capital base, which is now in a decisive stage. The ability of the Chinese defense STI system to move from catch-up imitation to become a global frontier innovation leader will depend to a great extent on its success in cultivating a highly capable and sufficiently large human talent pool.

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