

Benchmarking China's Civil-Military Integration

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May 2026

ABSTRACT¹

U.S. policymakers and researchers increasingly converge on the view that China possesses a decisive advantage in civil-military integration. At the same time, Chinese assessments identify a vast gap between the extent of civil-military integration in China versus the corresponding U.S. level. What gives? Even though a state's capacity to intermix its defense and commercial industrial bases is a crucial aspect of military innovation and industrial policy, scholars lack a reliable way to measure this variable. Aimed at correcting this gap, this article develops a theoretical framework for measuring the degree to which defense and commercial sectors share assets through four main channels: R&D, technology and technical know-how, infrastructure, and financial investment. This novel measure is validated by a case study of assessments of civil-military integration in the Soviet Union. When applied to China's "military-civil fusion" efforts, the four-channel measure reveals that China lags significantly behind the U.S. in terms of the efficient use of common technologies, facilities, and personnel for military and industrial purposes.

¹ For helpful feedback, I thank Aaron Bateman, Peter Dombrowski, Kendrick Kuo, Shira Pindyck, participants at the Ruger Innovation Seminar and Experience, and especially Fiona Cunningham and Charles Horne.

I. Introduction

In recent years, U.S. policymakers and researchers have increasingly converged on the view that China possesses a decisive advantage relative to the U.S. in civil-military integration (CMI). Richard Bitzinger, a leading expert on this subject, argued that Chinese military-civil fusion is “much more ambitious and far-reaching than any present U.S. efforts at CMI, particularly in terms of China’s determination to ‘fuse defense and commercial economies.’”² In 2018, Christopher Ford, the U.S. Department of State’s assistant secretary for international security and nonproliferation, also emphasized that China’s commercial and defense sectors were inextricably blended. “If any given technology is in any way accessible to China, in other words, and officials there believe it can be of any use to the country’s military and national security complex...one can be quite sure that the technology will be made available for those purposes,” he declared.³

It is perplexing, then, that Chinese assessments have arrived at the opposite conclusion. Indeed, Chinese planners and scholars often identify a vast gap between the extent of CMI in China versus the corresponding U.S. level, even holding up the latter as a standard-bearer that they look to for inspiration.⁴ One 2017 study, authored by three influential National Defense University researchers who advise the Chinese government on defense industrial policy, estimates that China’s CMI level had not even reached half of the U.S. mark. It concludes, “China’s current level of civil-military integration is still relatively low, the scope is still

² Bitzinger, Richard A. “China’s Shift from Civil-Military Integration to Military-Civil Fusion.” *Asia Policy* 16, no. 1 (2021): 22.

³ Ford, Christopher. “Chinese Technology Transfer Challenges to U.S. Export Control Policy.” United States Department of State, July 11, 2018. <https://2017-2021.state.gov/remarks-and-releases-bureau-of-international-security-and-nonproliferation/chinese-technology-transfer-challenges-to-u-s-export-control-policy/>.

⁴ Stone, Alex, and Peter Wood. *China’s Military-Civil Fusion Strategy*. China Aerospace Studies Institute, 2020.

relatively narrow, and the degree is still relatively shallow...Compared with the deep civil-military integration in the world's developed countries, there is still a huge disparity.”⁵

These dueling perspectives cannot both be true, so what gives? Unfortunately, scholars struggle to resolve debates about civil-military integration because they lack a reliable way to measure this variable. Even though the relationship between commercial and defense sectors plays an important role in theories of military innovation⁶ and industrial policy,⁷ the political science literature rarely articulates measures of civil-military integration that are valid across countries and time.⁸ Instead, this gap has been filled by unsupported claims and misleading indicators — e.g., the proportion of defense firm revenues that come from commercial goods — which do not necessarily reflect the concept's core: the degree to which the defense and commercial bases efficiently share assets to benefit both military and economic interests.

⁵ Author's translation. Jiang, Luming, Weihai Wang, and Zuchen Liu. Initial Discussion on the Military-Civil Fusion Strategy [军民融合发展战略探论]. People's Press, 2017, 42.

⁶ Alic, John A., Lewis M. Branscomb, and Harvey Brooks. Beyond Spinoff: Military and Commercial Technologies in a Changing World. Harvard Business Press, 1992; Beckley, Michael. “Economic Development and Military Effectiveness.” *Journal of Strategic Studies* 33, no. 1 (2010): 43–79. <https://doi.org/10.1080/01402391003603581>; Chu, Ming-Chin Monique. “China's Defence Semiconductor Industrial Base in an Age of Globalisation: Cross-Strait Dynamics and Regional Security Implications.” *Journal of Strategic Studies* 47, no. 5 (2024): 643–68. <https://doi.org/10.1080/01402390.2023.2164852>; Dombrowski, Peter, and Eugene Gholz. *Buying Military Transformation: Technological Innovation and the Defense Industry*. Columbia University Press, 2006; Evangelista, Matthew. *Innovation and the Arms Race: How the United States and the Soviet Union Develop New Military Technologies*. Cornell University Press, 1988; Horowitz, Michael. “Artificial Intelligence, International Competition, and the Balance of Power.” *Texas National Security Review* 1, no. 3 (2018): 3. <https://tnsr.org/2018/05/artificial-intelligence-international-competition-and-the-balance-of-power/>.

⁷ Fong, Glenn R. “Breaking New Ground or Breaking the Rules: Strategic Reorientation in U.S. Industrial Policy.” *International Security* 25, no. 2 (2000): 152–86. <https://doi.org/10.1162/016228800560480>; Weiss, Linda. *America Inc.: Innovation and Enterprise in the National Security State*. Cornell University Press, 2014. For the burgeoning literature on CMI in China, see Cheung, Tai Ming. *Forging China's Military Might: A New Framework for Assessing Innovation*. JHU Press, 2014; Cheung, Tai Ming. *Innovate to Dominate: The Rise of the Chinese Techno-Security State*. Cornell University Press, 2022; Bitzinger, Richard A., and James Char. *Reshaping the Chinese Military*. Routledge, New York, 2019; Kania, Elsa B., and Lorand Laskai. *Myths and Realities of China's Military-Civil Fusion Strategy*. Center for a New American Security Washington, DC, 2021; Kardon, Isaac B., and Wendy Leutert. “Pier Competitor: China's Power Position in Global Ports.” *International Security* 46, no. 4 (2022): 9–47. https://doi.org/10.1162/isec_a_00433; Lindsay, Jon R., Tai Ming Cheung, and Derek S. Reveron, eds. *China and Cybersecurity: Espionage, Strategy, and Politics in the Digital Domain*. Oxford University Press, 2015.

⁸ Two exceptions: Millett, Allan R., Williamson Murray, and Kenneth H. Watman. “The Effectiveness of Military Organizations.” *International Security* 11, no. 1 (1986): 37–71; Wang, Raymond. “Guns and Butter: Measuring Spillover and Implications for Technological Competition.” *Journal of Strategic Studies*, 2025, 1–31. <https://doi.org/10.1080/01402390.2024.2445001>.

How should civil-military integration be measured? I propose a novel framework (the “*whole-of-ecosystem*” approach) to measure integration across four main channels through which the commercial and defense sectors can foster synergistic relationships: i) R&D, ii) technology products and know-how, iii) infrastructure and facilities, and iv) financial investment. Across these channels, defense and commercial industrial bases have opportunities to share technologies and resources in a way that produces more military and economic benefits than if the two sectors had remained separate. Compare, for example, one country with a defense industrial base that exclusively taps talent from military-affiliated universities to another country with a defense industrial base that attracts graduates from a broad range of universities rooted in the commercial base. Theoretically, the greater mobility of talent in the latter state facilitates knowledge and technology transfer between the two sectors, which produces benefits in terms of both military effectiveness and economic competitiveness.⁹ The whole-of-ecosystem approach aims to capture these types of interactions between the defense and commercial ecosystems, at the various stages in which these systems develop, adapt, and sustain new technologies.

Next, I illustrate the value of this measurement strategy with two empirical exercises. First, employing a case-oriented approach to validate my proposed CMI measure, I scrutinize assessments of civil-military integration in the Soviet Union during the 1970s and 1980s. This validation exercise shows that, compared to the standard indicators used by analysts to measure the Soviet Union’s CMI level, the four-channel measure better reflects the concept’s key components. I then apply my alternative measure to compare the U.S. and China’s degree of civil-military integration in the present period. Drawing on a wealth of quantitative data and

⁹ Office of Technology Assessment. *Assessing the Potential for Civil-Military Integration: Technologies, Processes, and Practices*. Washington, DC, 1994, 128; Gehlhaus, Diana, James Ryseff, and Jack Corrigan. *The Race for U.S. Technical Talent: Can the DOD and DIB Compete?* Center for Security and Emerging Technology, 2023.

Chinese-language documents, the results debunk the belief that China outpaces the U.S. in synergies between defense and commercial sectors.

Since civil-military integration is central to influential academic theories and high-stakes policy decisions, this article makes several contributions. The security studies literature regards CMI as essential to the development of new military capabilities and the adaptation of emerging dual-use technologies into military applications.¹⁰ Many scholars argue that it has become easier for militaries to imitate advanced capabilities, as the commercial sector has increasingly overtaken the defense sector as the main source of innovation.¹¹ Regarding the impact of AI on military power, Michael C. Horowitz writes, “If commercially-driven AI continues to fuel innovation, and the types of algorithms militaries might one day use are closely related to civilian applications, advances in AI are likely to diffuse more rapidly to militaries around the world.”¹² A clear measure of civil-military integration is essential to test these theories.

Additionally, a substantial number of political economy scholars draw attention to the potential for defense investment to spur commercial innovation and foster increased economic competitiveness — an effect that depends on the strength of linkages between the defense and commercial bases.¹³ For example, one research stream studies the commercial spillovers from U.S. military programs targeted at dual-use technologies.¹⁴ As explored further in the validation

¹⁰ Beckley, “Economic Development and Military Effectiveness”; Chu, “China’s Defence Semiconductor Industrial Base in an Age of Globalisation”; Dombrowski and Gholz, *Buying Military Transformation*; Evangelista, *Innovation and the Arms Race*.

¹¹ Goldman, Emily O., and Richard B. Andres. “Systemic Effects of Military Innovation and Diffusion.” *Security Studies* 8, no. 4 (1999): 79–125. <https://doi.org/10.1080/09636419908429387>; Horowitz, “Artificial Intelligence, International Competition, and the Balance of Power.” See also Gilli, Andrea, and Mauro Gilli. “Why China Has Not Caught Up Yet: Military-Technological Superiority and the Limits of Imitation, Reverse Engineering, and Cyber Espionage.” *International Security* 43, no. 3 (2019): 141–89. https://doi.org/10.1162/isec_a_00337.

¹² Horowitz, “Artificial Intelligence, International Competition, and the Balance of Power,” 39.

¹³ For a review, see Wang, Shuai, Mengyue Xia, Xing Shi, Bojun Hou, and Shu Lu. “China’s Distinctive Civil–Military Integration Policy and Firm Innovation.” *Science and Public Policy*, April 30, 2024, <https://doi.org/10.1093/scipol/scae013>, 1.

¹⁴ Fong, “Breaking New Ground or Breaking the Rules”; Weiss, *America Inc.?*

exercise, one of the key points of contention in Cold War assessments of Soviet power was whether the defense industry could lift up the commercial sector's technological capabilities.¹⁵ A sound means of measuring CMI is also necessary to substantiate claims attached to this body of scholarship.

Finally, this article's findings intervene in US policy debates on how to manage China's rise. It directly rebuts one of the common presumptions in these discussions: that "China possesses a clear, perhaps decisive advantage relative to the United States in national defense because of MCF (its military-civil fusion strategy)."¹⁶ At a general level, top defense officials see China as the US military's pacing threat. Accurately measuring China's ability to integrate its commercial and military spheres is an essential component of assessing whether China will be able to narrow the technological gap with the US.¹⁷

More specifically, relying on the assumption that any technology accessible to China's commercial sector will be seamlessly incorporated into its military — as captured in the senior State Department official's comments above — US policymakers use China's purportedly extensive CMI to justify a wide range of actions, such as canceling visas for Chinese students and restricting U.S. companies from working with Chinese counterparts.¹⁸ This article suggests that many of these policies rest on misleading assumptions about the degree of civil-military integration in China.

¹⁵ Cooper, Julian. "The Civilian Production of the Soviet Defence Industry." *Technical Progress and Soviet Economic Development*, 1986, 31.

¹⁶ Kania and Laskai, "Myths and Realities".

¹⁷ Cheung, *Forging China's Military Might*"; for other work that assesses the U.S.-China power balance, see Beckley, Michael. "China's Century? Why America's Edge Will Endure." *International Security* 36, no. 3 (2011): 41–78; Ding, Jeffrey. "The Diffusion Deficit in Scientific and Technological Power: Re-Assessing China's Rise." *Review of International Political Economy* 31, no. 1 (2024): 173–98; Lind, Jennifer. "Back to Bipolarity: How China's Rise Transformed the Balance of Power." *International Security* 49, no. 2 (2024): 38.

¹⁸ Kania and Laskai, "Myths and Realities."

This article proceeds as follows. The next section defines the concept of civil-military integration, identifies crucial gaps in measuring this concept, and outlines a measurement strategy based on four channels. Subsequently, I validate this alternative measure by analyzing Western assessments of Soviet CMI in the 1970s and 1980s. Drawing from a wealth of Chinese-language sources as well as data derived from a diverse range of sources, I employ the whole-of-ecosystem approach to benchmark China's current level of civil-military integration against that of the U.S., before concluding with key implications for scholars and policymakers.

II. Measuring Civil-Military Integration

Before laying out a measurement strategy, it is necessary to clearly define the concept of civil-military integration. In this article, civil-military integration refers to the process of intermixing the defense and commercial industrial bases such that common technologies, material, facilities, and personnel can be used to meet both defense and commercial needs.¹⁹ Higher levels of integration indicate that a state has achieved substantial efficiency gains from the use of shared assets for military and industrial purposes. Reflecting this notion of positive spillovers across both domains, Chinese scholarship frequently deploys the slogan “one input, two outputs” to characterize civil-military integration.²⁰ You can have your guns and eat your butter too.

This core logic of CMI can be illustrated by the symbiotic relationship between coral and algae, which sustains coral reef ecosystems. Coral provide shelter and protection for zooxanthellae algae. In return, the algae provide coral with food via photosynthesis. When

¹⁹ Office of Technology Assessment, *Assessing the Potential for Civil-Military Integration*.

²⁰ Hagt, Eric Daniel. “China's Civil-Military Integration: National Strategy, Local Politics.” Johns Hopkins University, 2019, 5.

integrated, commercial and defense sectors can foster similar types of synergistic relationships. To enhance military effectiveness, the armed forces seek access to technologies from the private sector, which is sometimes better positioned to efficiently produce such technologies. Defense investments can be transferred into commercial applications as well, spurring greater economic competitiveness through spin-off effects. In short, with regard to contributions to military effectiveness and economic competitiveness, the whole (integrated commercial and defense sectors) is greater than the sum of its parts (separated commercial and defense sectors).

While much of the surrounding literature assumes that tighter integration between the commercial and defense sectors is net beneficial to the national interest, it is important to note that integration can also lead to significant costs. For instance, greater involvement by the private sector in defense production may present efficiency gains; however, it also risks leakage of classified information if commercial firms adopt looser security protocols.²¹ Critics of the military-industrial complex also point out that tight networks between military services and their industrial partners can lead to threat inflation and runaway spending.²² Other studies question the basic assumptions of CMI policies, such as whether defense-related R&D investments stimulate the development of civilian technologies.²³

Due to scope limitations, this article does not take a position on whether civil-military integration is an effective pathway to power and plenty. Rather, it provides a more bounded contribution: If policymakers and scholars are correct that an adversary's level of civil-military integration demands certain policy responses and portends shifts in economic and military power, then a more informed approach to measuring this variable is necessary.

²¹ Office of Technology Assessment, *Assessing the Potential for Civil-Military Integration*.

²² Evangelista, *Innovation and the Arms Race*.

²³ Wang et al., "China's Distinctive Civil-Military Integration Policy."

It is also important to note that commercial-defense sector interactions only cover one aspect of the general literature on civil-military relations. Often centered on interactions between political elites and senior military leadership, this broader scholarship analyzes the causes of coups, military defection, and civilian control of the military on key decisions like the use of force.²⁴ This article's ambit is less concerned about contests over authority between military and civilian actors; instead, it is situated in the civil-military relations literature that studies the relationship between the military and society at large.²⁵ For instance, in one of its last chapters, Huntington's *The Soldier and State* highlights the need for more research into the ties between the military and defense industry in the postwar era, as the advanced technological demands of the former had brought the latter into permanent existence.²⁶

A. Problems and gaps in measuring CMI

In debates over which countries are best positioned to merge their defense and civilian ecosystems, one notable gap is the lack of a measurement framework for CMI. An evaluation of the international relations scholarship on civil-military integration provides some systematic evidence of this shortcoming. I reviewed 30 articles from *International Security*, *Journal of Strategic Studies*, and *Security Studies* that discuss civil-military integration, selecting ten articles from each journal that ranked highest in a Google Scholar search for the following

²⁴ Brooks, Risa A. "Integrating the Civil–Military Relations Subfield." *Annual Review of Political Science* 22, no. Volume 22, 2019 (2019): 379–98. <https://doi.org/10.1146/annurev-polisci-060518-025407>. A conflictual relationship between political leaders and military officials could interfere with civil-military integration. Saddam Hussein's efforts to prevent collusion among military officers had the side effect of reducing the military's ability to adapt complex technologies. Biddle, Stephen, and Robert Zirkle. "Technology, Civil-military Relations, and Warfare in the Developing World." *Journal of Strategic Studies* 19, no. 2 (1996): 171–212. <https://doi.org/10.1080/01402399608437634>.

²⁵ Brooks, "Integrating the Civil-Military Relations Subfield."

²⁶ Huntington, Samuel P. *The Soldier and the State: The Theory and Politics of Civil–Military Relations*. Harvard University Press, 1981, 361–367.

keywords: commercial, military, and integration.²⁷ Only three texts present potential indicators of the interconnectedness of a state's commercial and military capabilities. Among these, Allan Millett, Williamson Murray, and Kenneth Watman's seminal piece "The Effectiveness of Military Organizations" provides measures that are most closely linked to this article's concept of civil-military integration; however, their framework is limited to the spin-on direction and lacks procedures to develop scores for the cases being analyzed.²⁸

Without a well-grounded measurement approach, analyses of CMI may mislead more than they inform. One glaring problem is the reliance on blanket measures of CMI that are not supported by clear data sources and methodologies. For instance, numerous Chinese assessments estimate that China's civil-military integration level is 30 to 40 percent of the US level, but they do not specify how these figures were derived.²⁹ In some cases, English-language scholarship adopts these unverified claims without critical examination. Testimony before the U.S.-China Economic and Security Review Commission, for example, cites a statistic on China's commercialization rate of defense patents (15% compared to 50-60% in developed countries) based on Chinese-language analyses.³⁰ Yet, despite exhaustive efforts to trace the source for this figure, there is no evidence that substantiates this claim.³¹

Measurement problems also confound assessments of CMI in more subtle ways. Consider, for example, one oft-cited indicator of CMI: the proportion of sales by defense

²⁷ See supplementary appendix A for full dataset and coding procedures.

²⁸ Millett et al., "The Effectiveness of Military Organizations."

²⁹ Hagt, "China's Civil-Military Integration", 13; Stone and Wood, "China's Military-Civil Fusion Strategy," 39 fn xxix.

³⁰ Weinstein, Emily. "Don't Underestimate China's Military-Civil Fusion Efforts." *Foreign Policy*, February 5, 2021. <https://foreignpolicy.com/2021/02/05/dont-underestimate-chinas-military-civil-fusion-efforts/>.

³¹ The original source of these claims is likely: Li, Ping, Shuhui Ma, and Meng Wang. "Research on Problems and Countermeasures of Promoting and Transforming China's National Defense Scientific and Technological Achievements[我国国防科技成果推广转化存在的问题及对策研究]." *Aerospace Industry Management[航天工业管理]*, 2013. However, Li et al. provides no supporting evidence for the commercialization rate in developed countries. In fact, in the empirical analysis section, I show that the U.S. rate is much lower than 60 percent.

conglomerates that go toward military versus civilian goods.³² Some analysts compare the ability of China’s major defense companies to produce a diversified range of dual-use and civilian goods — arms sales account for only 30 percent of total sales — against the Russian defense industrial base’s high dependency on arms sales (90 percent of total sales).³³

However, the mere existence of diversified civilian and military production does not necessarily reflect that a defense industrial base has removed barriers between the two domains in a way that effectively utilizes shared assets. For example, in the 1980s and early 1990s, China pushed for defense *conversion*, which encouraged military factories to adapt their production lines for commercial production. However, as noted by an Office of Technology Assessment report, since “there [was] little use of common technologies and equipment to meet both defense and commercial needs,” these conversion efforts were neither profitable nor cost-effective, so Chinese defense firms had to rely on state subsidies to compete in commercial markets.³⁴

To further clarify why some conversion projects and other surface-level linkages do not satisfy this article’s conceptualization of CMI, one useful exercise is to consider a counterfactual situation in which the assets of defense conglomerates were separated into one group of firms that solely produced defense products and another group that only manufactured civilian products.³⁵ If, compared to this counterfactual scenario, a state’s conversion efforts do not

³² Béraud-Sudreau, Lucie, and Meia Nouwens. “Weighing Giants: Taking Stock of the Expansion of China’s Defence Industry.” *Defence and Peace Economics* 32, no. 2 (2021): 151–77.

<https://doi.org/10.1080/10242694.2019.1632536>; Moura, Sylvain, and Jean-Michel Oudot. “Performances of the Defense Industrial Base in France: The Role of Small and Medium Enterprises.” *Defence and Peace Economics* 28, no. 6 (2017): 652–68. <https://doi.org/10.1080/10242694.2016.1195574>.

³³ Weinbaum, Courtney, Caolionn O’Connell, Steven W. Popper, et al. *Assessing Systemic Strengths and Vulnerabilities of China’s Defense Industrial Base*. RAND Corporation, 2022.

https://www.rand.org/content/dam/rand/pubs/research_reports/RR900/RR930-1/RAND_RRA930-1.pdf; Hart, Brian. “How Developed Is China’s Arms Industry?” *ChinaPower Project*, February 18, 2021. <https://chinapower.csis.org/arms-companies/>.

³⁴ Office of Technology Assessment. *Other Approaches to Civil-Military Integration: The Chinese and Japanese Arms Industries*. Washington, DC, 1995, 21.

³⁵ Alic et al., *Beyond Spinoff*, 61–64

generate added economic and military benefits, then that state has not effectively capitalized on shared resources and synergistic interactions between the two domains. This is conversion without integration.

B. A new measurement strategy: Channels of CMI

To address the problems of existing measures, this article proposes a novel measurement strategy that evaluates the strength of civil-military integration across four main channels through which commercial and defense sectors share resources: i) R&D, ii) technology products and know-how, iii) infrastructure and facilities, and iv) financial investment (Table 1). This “whole-of-ecosystem” measure is based on conceptualizing CMI as a relationship between two complex organisms (the defense and commercial sectors) that develop synergistic interactions in numerous, complex ways, not limited to the most visible channels such as the adaptation of commercial products for military use or commercial spin-offs from military R&D.

Drawing on insights from the National Innovation System literature, this article’s approach sees the potential for many diverse interactions between the defense and commercial ecosystems, at each stage in which system actors initiate, modify, diffuse, and maintain new technologies.³⁶ Though the channels follow a sequence from initial research to the infrastructural and financial resources needed to commercialize and deploy mature technologies at scale, these steps also overlap. A civil-military partnership on R&D, for instance, could also involve sharing laboratory equipment (infrastructure). Additionally, this framework is not exhaustive. One possible gap is in the stage of technology development in which technologies are adapted to

³⁶ Nelson, Richard R. *National Innovation Systems: A Comparative Analysis*. Oxford University Press, 1993. See also Ding, Jeffrey. *Technology and the Rise of Great Powers: How Diffusion Shapes Economic Competition*. Princeton University Press, 2024.

various user communities. Through initiatives like harmonization of technical standards, the two sectors can collaborate to develop technologies that can be tailored to fit the needs of both civilian and defense customers. Still, overall, these four channels encompass the vast majority of ways through which the two ecosystems share assets.

This framework builds on other recent undertakings to systematically measure civil-military integration. Raymond Wang's 2025 article introduced a novel measure of technological spillovers between defense and civilian sectors, which leverages patent citations to track knowledge transfer networks.³⁷ This is an important first step, but, as Wong acknowledges, the spillover measure only captures one pathway through which countries seek to deepen civil-military integration.³⁸ It does not account for channels through which the defense and commercial bases share assets beyond technology products and technical know-how. For instance, defense R&D that supports human-robot teaming research can produce dual-use applications (even if resulting defense and civilian patents do not cite each other).

For each of the four channels, this section proceeds with a description of the relevant synergies followed by a justification for possible indicators. Both military and commercial technologies begin from the R&D phase. Since states often dedicate substantial amounts of total research spending towards defense R&D, it is a significant potential source of both military and commercial technologies. When these technology transfer channels are robust, countries can reap positive commercial spin-offs from defense R&D. For instance, in their efforts to meet the high-performance demands of Navy communication systems, U.S. Naval Research Laboratory scientists Ishwar Aggarwal and Jas Sanghera discovered materials that could facilitate fiber optic transmission at higher wavelengths. Ultimately, industrial partners licensed a prototype of their

³⁷ Wang, "Guns and Butter."

³⁸ Wang, "Guns and Butter."

method to use for fiber optic manufacturing.³⁹ R&D integration can also occur through cooperative research and development agreements, joint centers that pair technology companies with defense firms, and development programs in which results are shared among military and commercial participants.⁴⁰

Empirical work has linked states' military innovation capabilities to their levels of CMI in R&D. In his analysis of Soviet weapons innovation processes during the Cold War, Matthew Evangelista determined that stringent classification restrictions isolated military researchers from their civilian counterparts, which inhibited the Soviet Union's ability to generate breakthroughs in weapons innovation.⁴¹ Additionally, Bitzinger's comparison of Israel and Singapore found that differences in R&D integration partially explained why the former was more capable of state-of-the art military innovations than the latter.⁴²

For this channel, useful measures include the robustness of linkages between military and civilian researchers, especially as it relates to engagement in dual-use projects. Other indicators track the effectiveness of technology transfer from defense R&D sources. To track the commercialization of defense laboratory research, one "transfer rate" metric divides a lab's number of new patent licenses granted by the total number of patent applications filed.⁴³

Second, the defense base and civilian economy can share technology products and technical know-how. Personnel movements that traverse the defense/civilian boundary can

³⁹ Faith, Kay Sullivan. "Patterns of Creation and Discovery an Analysis of Defense Laboratory Patenting and Innovation." PhD Thesis, The Pardee RAND Graduate School, 2013.

⁴⁰ Office of Technology Assessment, *Assessing the Potential for Civil-Military Integration*, 132; Kania and Laskai, "Myths and Realities."

⁴¹ Evangelista, *Innovation and the Arms Race*, 42-45.

⁴² Bitzinger, Richard A. "Military-Technological Innovation in Small States: The Cases of Israel and Singapore." In *Comparing Defense Innovation Around the World*. Routledge, 2022.

⁴³ Choudhry, Vidita, and Todd A. Ponzio. "Modernizing Federal Technology Transfer Metrics." *The Journal of Technology Transfer* 45, no. 2 (2020): 544–59. <https://doi.org/10.1007/s10961-018-09713-w>.

enable the diffusion of knowledge and new techniques.⁴⁴ For example, in aerospace firms that have both defense and nondefense divisions, intrafirm movement of technical personnel spreads ideas across divisions.⁴⁵ In spin-on processes, military organizations procure and adapt commercial technologies, often resulting in cost-savings compared to the alternative of using military-specific components. To illustrate, in developing a tail kit for GPS-guided munitions, the Joint Direct Attack munition, the DOD allowed contractors to use commercial products and acquisition procedures. This reduced the unit price from \$68,000 to below \$20,000.⁴⁶

In the spin-off direction, military technologies are converted into civilian applications. For instance, Raytheon adapted its military radar technology into microwave ovens, which became a great commercial success (and a boon to leftover lovers everywhere). Spinoffs are not necessarily “free” benefits of defense investment. In most cases, companies must invest substantial costs to modify military products for commercial use, and barriers between the defense and commercial sectors exacerbate these costs.⁴⁷ There are also indirect spin-offs from military demand for commercial technologies. As illustrated by the U.S. military’s role in supporting large-scale, standardized production of semiconductors, the defense sector can underwrite the development of dual-use technologies in the uncertain stages before large-scale commercialization.⁴⁸

To evaluate this channel of civil-military integration, indicators must reflect the national innovation system’s ability to leverage technical know-how for dual purposes. Useful metrics

⁴⁴ Ding, Jeffrey. “The Rise and Fall of Technological Leadership: General-Purpose Technology Diffusion and Economic Power Transitions.” *International Studies Quarterly* 68, no. 2 (2024).

⁴⁵ Alic et al, *Beyond Spinoff*, 112-113.

⁴⁶ Gansler, Jacques, “Defense Acquisition Reform: Rethinking the Packard Commission Approach After 30 Years,” Center for Strategic and International Studies, July 17, 2015.

⁴⁷ Alic et al, *Beyond Spinoff*, 56-61.

⁴⁸ Misa, Thomas J. “Military Needs, Commercial Realities, and the Development of the Transistor, 1948-1958.” In *Military Enterprise and Technological Change*, edited by Merritt Roe Smith. MIT Press, 1985.

include patent citations and talent flows that document the mobility of knowledge and labor between the defense and commercial sectors.⁴⁹ Competition rates (the proportion of defense contracts that receive two or more offers) and private sector participation rates in the defense supply chain function as other additional indicators that capture the ability of the military acquisition system to incorporate commercial components.

Table 1: Four key channels of civil-military integration		
<i>What is shared?</i>	<i>Integration benefits</i>	<i>Proposed indicators</i>
R&D	Incentivizes development of dual-use technology	- Technology transfer rates for defense research organizations - Strength of linkages between military and civilian researchers
Technology products and technical know-how	Produces spin-ons from commercial to defense sector and spin-offs in other direction	- Extent of private sector participation in the defense supply chain - Competition rates for defense contracts - Patent citations that reflect spillovers - Talent mobility between the two sectors
Infrastructure and facilities	Improves resource efficiency and transmission of best practices	- Commercial access to defense facilities - Effectiveness of public-private partnerships in shared infrastructure - Capacity of defense logistics, maintenance, and testing to adopt commercial practices
Financial investment	Supports long-term ventures and fosters transparency	- Proportion of defense companies that access financial markets - Total quantity of defense investment directed at commercial sector

Third, CMI takes the form of shared infrastructure and facilities. If military and commercial producers share production facilities, then there is enhanced potential for technology spillovers. For example, the Chinese military benefits from co-locating naval shipbuilding

⁴⁹ Wang, “Guns and Butter”; Gehlhaus et al., “The Race for U.S. Technical Talent.”

programs at shipyards used by commercial firms, which enables access to infrastructure improvements, such as dry-docks and computerized cutting and welding tools.⁵⁰

Other infrastructure that could benefit from CMI include maintenance depots and test facilities. As the DOD considers efficiency initiatives related to maintenance depots, government-owned and contractor-operated facilities (GOCOs) — in which a commercial workforce performs the maintenance work — could provide significant cost savings over government-owned and government-operated depots (GOGOs).⁵¹ Compatible technical standards represent a type of soft, or intangible, infrastructure that enables military and commercial sectors to adapt technologies from each other without costly modifications.⁵²

To assess the extent of CMI at the infrastructural level, it is necessary to distinguish between the appearance and actuality of integration. In keeping with the core logic of synergy that underlies the concept, higher integration levels in this channel involve the use of common facilities and production lines to satisfy both commercial and defense needs. Conversely, companies that employ separate production lines for defense and commercial production, even if they are engaged in both activities, do not capture the efficiency gains promised by CMI advocates. In China's defense conversion activities during the 1980s, for instance, "plug-in lines" that made both military and civilian goods were the most efficient method for retooling defense production capacity, whereas "dedicated line production" often resulted in loss-making projects.⁵³

⁵⁰ Bitzinger, "China's Shift."

⁵¹ Avdellas, Nicholas J., Joseph L. Berry, Michael D. Disano, David M. Oaks, and Earl R. Wingrove III. *Future Capability of DOD Maintenance Depots*. Logistics Management Institute, 2011.

⁵² Erickson, Andrew S. "China's Naval Shipbuilding Sets Sail." *The National Interest*, February 8, 2017. <https://nationalinterest.org/feature/chinas-naval-shipbuilding-sets-sail-19371>.

⁵³ Hagt, "China's Civil Military Integration," 121.

Therefore, the most suitable indicators for this channel of CMI should reflect the extent to which infrastructure capabilities — whether in the form of production lines, maintenance depots, or test facilities, etc. — are efficiently shared for military and commercial purposes. Possible indicators include: the proportion of major defense facilities that allow access for private companies; the effectiveness of public-private partnerships related to maintenance depots; the capacity of defense infrastructure to adopt commercial practices to manage costs and enhance military readiness.⁵⁴

Lastly, financial investment serves as another channel of CMI. In settings where defense companies can access capital markets, they can make long-term investments and the entire ecosystem benefits from the transparency of financial disclosures. Spurred by reduced U.S. defense spending in the 1990s, defense firms tapped private lending institutions to fund consolidations, which “reinforc[ed] the relationship between the defense industrial base and Wall Street.”⁵⁵ In the 1920s, the U.S. stock market established itself as a source of funding for the expansion of young firms, including defense contractors in dual-use fields. In 1921, only two U.S. aviation companies traded on stock exchanges; from 1928 to 1930, aviation firms conducted over 100 public offerings of stock.⁵⁶

The defense sector also funnels financial capital into the private sector. France’s Ministry of the Armed Forces has established two funds that invest in start-ups and innovative companies

⁵⁴ Gansler, Jacques S., and William Lucyshyn. *Evaluation of Performance Based Logistics*. Acquisition Research Program, 2006. <https://www.dair.nps.edu/handle/123456789/2714>.

⁵⁵ Mahoney, Charles W., Benjamin K. Tkach, and Craig J. Rethmeyer. “Defense Contractors, Private Equity Firms, and US National Security.” *Journal of Global Security Studies* 7, no. 4 (2022), <https://doi.org/10.1093/jogss/ogac018>.

⁵⁶ O’Sullivan, Mary A. “Funding New Industries: A Historical Perspective on the Financing Role of the U.S. Stock Market in the Twentieth Century.” In *Financing Innovation in the United States, 1870 to Present*. 2007.

that are developing dual-use technologies.⁵⁷ Shortly after the CIA established its venture capital firm In-Q-Tel in 1999, U.S. defense agencies set up their own versions of In-Q-Tel to invest in private firms that could support military needs, including the Army's OnPoint initiative, the Defense Department's Venture Catalyst Initiative, and the National Geospatial-Intelligence Agency's Rosettex fund.⁵⁸

Measures of financial integration must account for investment flows in both directions. In the first pathway, if defense firms have better access to commercial funding sources, such as capital markets, this suggests higher levels of CMI in this channel. Appropriate indicators include the proportion of defense companies that tap into financial markets, including both large conglomerates and smaller firms. In the other route, indicators must reflect the strength of institutions that channel defense financing into private companies. One baseline indicator is the total amount of defense investment that goes toward the private sector. For both directions, quantitative measures should be supplemented by assessments of the quality of these investment flows.

Taken together, indicators from all four channels provide a more thorough measure of civil-military integration. For the article's purposes, this measurement strategy helps scrutinize claims about the CMI level in one state *relative* to another. Since these four channels function as additive components of CMI, scores in each channel could also be aggregated through an equal weighting scheme to provide a final score. As the U.S.-China benchmarking exercise will demonstrate, one could assign a score of 1 (weak), 2 (somewhat weak), 3 (somewhat strong), or

⁵⁷ Ministère des Armées. *Guiding Defence Innovation*. 2022.
<https://www.defense.gouv.fr/sites/default/files/aid/DrOID%202022-%20Anglais-1.pdf>.

⁵⁸ Weiss, *American Inc.*?, 69.

4 (strong) to a state's performance in each channel, based on the relevant set of indicators. Then, the four scores could be averaged into a single score.

C. Differences in styles of CMI

Thus far, in assessing China's CMI, this article has focused on differences of degree; however, differences of kind also deserve scrutiny.⁵⁹ In a *Foreign Policy* piece, Emily Weinstein argues that it is a "false equivalency" to compare China's civil-military framework to the U.S. system. Concretely, China's one-party state and weak rule of law mean that "Chinese leadership has the power to demand information and assistance from companies that have little choice but to agree."⁶⁰ On a similar thread, citing China's system of state capitalism, one *Survival* article labels China's MCF strategy as "peculiar."⁶¹

Influential US policymakers also frame China's approach to CMI as distinctive. In a March 2020 briefing on China's MCF strategy, a senior State Department official conceded that other states also leverage the civilian sector to support military modernization but emphasized, "There is a huge difference between our approach and the PRC's approach."⁶² As evidence of this dissimilarity, the State Department briefer cited Chinese laws, including the National Intelligence Law, which "compel any Chinese person or entity to collaborate with Chinese security and intelligence services."⁶³

⁵⁹ I am very grateful to Fiona Cunningham for advice on this section.

⁶⁰ Weinstein, "Don't Underestimate China's Military-Civil Fusion Efforts."

⁶¹ Duchâtel, Mathieu. "Europe's China Problem: How Not to Feed Beijing's Military-Civil Fusion." *Survival* 65, no. 4 (2023): 55–78. <https://doi.org/10.1080/00396338.2023.2239059>.

⁶² Office of the Spokesperson. "Briefing With Senior State Department Official On the PRC's Military-Civil Fusion Strategy." *United States Department of State*, March 12, 2020. <https://2017-2021.state.gov/senior-state-department-official-on-the-prcs-military-civil-fusion-strategy/>.

⁶³ For an analysis of Chinese leader Xi Jinping's aims to blend China's economic and military systems at the highest level, see the concept of National Strategic Integration in Cheung, Tai Ming. *Back to the Future: The Rise of Militarization in China in the 2020s*. IGCC, 2025. <https://igcc.ucsd.edu/wp-content/uploads/2025/05/Tai-Ming-Cheung-Back-to-the-Future-05.16.25.pdf>.

Qualitative distinctions do not preclude quantitative comparisons. This article's central endeavor — assessing a state's capacity to intermix its defense and commercial sectors in a way that generates synergistic spillovers — travels across widely varying systems. As demonstrated by section four's descriptive assessment of U.S. and Chinese CMI levels, this paper's proposed measures are valid despite the differences in CMI styles. Take, for instance, the preceding claim that China possesses a unique ability to compel civilian entities to collaborate with the military. Compellence may distinguish China's system from others, but my measurement framework still applies. In fact, in contrast to those cited above who assume that this characteristic of China's system corresponds with greater integration, compellence can hinder spillovers of R&D, technology, infrastructure, and finance. Forcing high-tech private companies to give up intellectual property rights to state-owned defense conglomerates may transfer some technologies in the short term; however, it undermines the trust necessary for sustained partnerships between the Chinese commercial and defense sectors.⁶⁴ In other instances when the interests of Chinese civilian entities were not properly safeguarded, military organizations requisitioned civilian equipment without payment.⁶⁵

In fact, Chinese thinkers recognize the limitations of this coercive approach. Leading architects of China's defense industrial policy advocate for stronger protections of private companies against government intrusion.⁶⁶ Chinese military officials highlight the need for new

⁶⁴ Other studies underscore that contracts between the Chinese military and defense firms are vague and have limited legal standing. Cheung, "Forging China's Military Might," 52; Puska, Susan M., Joe McReynolds, and Debra Geary. "China's Military Representatives: Striving Toward Professional Contracting and Procurement." SITC 2011 2011, no. Policy Brief 21 (2011), 3.

⁶⁵ Stone and Wood, *China's Military-Civil Fusion Strategy*, 48; Jiang et al., *Initial Discussion on the Military-Civil Fusion Strategy*, 213-215. Relatedly, the Soviet Union's CMI style also undercut trust between commercial and defense actors; the Soviets let their military industry pick the best production lines in shared plants, leaving civilian industry with inferior equipment. Becker, Abraham Samuel. *Sitting on Bayonets: The Soviet Defense Burden and the Slowdown of Soviet Defense Spending*. RAND Paper Series, 1983.

⁶⁶ Stone and Wood, *China's Military-Civil Fusion Strategy*, 48; Jiang et al., *Initial Discussion on the Military-Civil Fusion Strategy*, 213-215.

laws that clarify the management of classified information, as a foundation for commercial actors to gain more trust from the military.⁶⁷ Now, one could posit that trust is not necessary to sustain these partnerships because the Chinese party-state can just ensure compliance; however, as evidenced by cases when Chinese technology companies refused to share data with government regulators, forced partnerships will falter if companies see compliance as in opposition to their interests.⁶⁸ Indeed, finding that “coercive power has so far been an ineffective instrument to compel or create the conditions for widespread participation in MCF,” one expert study concludes that compellence “cannot feasibly provide the basis for an ecosystem that powers genuinely collaborative innovation.”⁶⁹

The above discussion points toward future research that investigates the conditions under which CMI thrives. Difference in CMI levels between countries could be rooted in the type of political regime, economic system, and policies. While this paper does not seek to explain the causes or consequences of CMI, a sound measure of this variable is a prerequisite for both directions of further investigation. For this article’s purposes, the key point is that compellence and other qualitative characteristics of China’s military-civil fusion policies complicate but do not confound assessments of CMI.

III. Validation Exercise: Assessments of Soviet CMI

To validate my proposed measure of civil-military integration, this paper scrutinizes assessments of CMI in the Soviet Union during the 1970s and 1980s. Given the importance of civil-military integration to the Soviet Union’s capacity to sustain economic and military power,

⁶⁷ Nouwens, Meia, and Helena Legarda. *China’s Declassification of Defense Patents: Novel But Not (Yet) a Game Changer*. The International Institute for Strategic Studies, 2018.

⁶⁸ Kania and Laskai, “Myths and Realities.” See also Lafferty, Brian. “Civil-Military Integrations and PLA Reforms.” In *Chairman Xi Remakes the PLA*. National Defense University Press, 2019.

⁶⁹ Kania and Laskai, “Myths and Realities.”

many analysts and scholars attempted to measure this variable. Thus, this case provides a valuable opportunity to explore whether the article's proposed indicators or other oft-cited indicators better fit the concept of interest.

Adopting a case-oriented approach to content validation, this section first evaluates if traditional CMI indicators adequately captured the extent to which the Soviet defense and commercial industrial bases shared assets to augment its military and economic strength. Next, it evaluates whether the four-channel framework produces a different measure that is better suited to the CMI concept. Lastly, in line with general guidance on measurement validation, it considers refinements to the four-channel indicator based on the application to this case.⁷⁰

A. Conventional indicators of Soviet CMI

High stakes surrounded the debates over the level of civil-military integration in the Soviet Union. With respect to gauging Soviet power, one of the most critical questions was whether the Soviet Union's outsized military expenditures inhibited its economic growth. The affirmative case's rationale was that military goods and services diverted resources away from civilian production. However, this view could have overestimated the size of the Soviet defense "burden", if integration enabled defense investments to produce spillovers to civilian industry.⁷¹

During this period, prevailing indicators of Soviet civil-military integration suggested strong synergies between the defense and commercial sectors. In a 1986 report, the CIA Directorate of Intelligence reviewed developments in the "world's largest military-industrial base" over the past two decades, with an eye toward appraising future trends in Soviet military

⁷⁰ Adcock, Robert, and David Collier. "Measurement Validity: A Shared Standard for Qualitative and Quantitative Research." *American Political Science Review* 95, no. 3 (2001): 529–46.

⁷¹ Becker, *Sitting on Bayonets*, 19-21.

and economic power.⁷² One of the report's findings was that "the lines between the [civilian and defense sectors] have become increasingly blurred as Soviet weapons have grown in complexity."⁷³ To support its claim that the "[defense] industry's support to the Soviet economy is extensive", the report cited a metric that 42 percent of defense industry output was dedicated to civilian goods.⁷⁴ This indicator came from comments made by Leonid Brezhnev, former leader of the Soviet Union, at a congress of the Communist party in 1971.⁷⁵

On the whole, Western researchers assumed that there was substantial spillover of expertise and methods from the Soviet military industry to the civilian industry.⁷⁶ In particular, Brezhnev's "42 percent" metric attracted substantial attention in the West, prompting many to speculate that the defense industry could help raise the technical standards of the overall economy.⁷⁷ One influential intelligence analyst during the Cold War, William T. Lee, reasoned that the Soviet defense base was better positioned than its U.S. counterpart at conversion to civilian production, citing the existence of diversified civilian and military outputs from the Soviet defense base as an indicator of civil-military integration. In a piece on the Soviet Union's military-industrial complex, Lee wrote, "Because most Soviet factories produce both military and civilian products, the U.S.S.R. probably could cope with a very rapid conversion to civilian products more easily than the United States[...]."⁷⁸

⁷² CIA, *The Soviet Weapons Industry: An Overview*. 1986. <https://www.cia.gov/readingroom/docs/CIA-RDP89T01363R000200310005-3.pdf>, 1.

⁷³ CIA, *The Soviet Weapons Industry*.

⁷⁴ CIA, *The Soviet Weapons Industry*, 3.

⁷⁵ CIA, *The Soviet Weapons Industry*, 3.

⁷⁶ Agursky, Mikhail. *The Soviet Military-Industrial Complex*. Vol. 31. Magnes Press, Hebrew University, 1980, 26; Campbell, Robert W. "Management Spillovers from Soviet Space and Military Programmes." *Soviet Studies* 23, no. 4 (1972): 586–607.

⁷⁷ Cooper, "The Civilian Production of the Soviet Defence Industry," 31.

⁷⁸ Lee, William T. "The 'Politico-Military-Industrial Complex' of the U.S.S.R." *Journal of International Affairs* 26, no. 1 (1972): 73–86.

Focused on the most visible elements of integration, these oft-cited measures did not faithfully reflect the extent of civil-military integration in the Soviet Union. First, the fact that the Soviet defense base produced both commercial and military goods did not signify that shared technologies and equipment were efficiently used to satisfy commercial and defense needs. As detailed in subsequent sections, the defense industry would often requisition materials and machinery from civilian industry, which resulted in divisions between the two sectors. In electrical domestic appliances, one of the domains that saw substantial involvement from defense industry ministries, just 40 percent of the output came from “assimilated” (*assimilyatsiya*) processes, which used the same production facilities to make both military and civilian goods.⁷⁹

Second, and most importantly, these assessments mistook one aspect of CMI to represent all the varied interactions between the defense and commercial innovation systems. This neglected other crucial stages in which these two ecosystems develop technologies. In contrast, if measured across four channels through which commercial and defense sectors share resources (R&D, technology and technical-know how, infrastructure, and financial investment), Soviet CMI was much weaker than what conventional estimates depicted.

B. Four-channel approach to measuring Soviet CMI

To start, in the R&D channel, there were significant obstacles to research collaboration between the commercial and defense sectors. Reports from Soviet emigres suggested that military researchers were isolated from civilian counterparts due to strict secrecy requirements.⁸⁰ In addition, the defense research institutes were also separated from the design bureaus and

⁷⁹ Cooper, “The Civilian Production of the Soviet Defence Industry,” 42.

⁸⁰ Evangelista, *Innovation and the Arms Race*, 42-45.

production facilities, which slowed commercial utilization of defense R&D outputs.⁸¹ One outlier was the Academy of Sciences, which was an open, civilian institution that had strong ties to the military, though this integration of basic and applied research priorities did not filter down into later stages of technology development and transfer.⁸²

Similar dynamics existed in the second channel. The Soviet system's preoccupation with secrecy hindered the flow of methods and expertise between the Soviet defense and commercial bases. Classified research centers struggled to attract the most capable civilian scientists, as they could attain higher compensation at civilian institutions and could openly publish scholarly work.⁸³ To illustrate the limited defense-commercial spillovers, Mikhail Agursky, a Soviet emigre who previously worked in a research institute involved in missile production, recalls an exhibition of economic achievements in 1959, attended by Soviet Premier Nikita Khrushchev. At one pavilion, after seeing a novel fishfinder device adapted from military equipment, Khrushchev called for the exhibit to be removed and asked for the event organizer. The organizer hid for two hours before he was discovered, upon which Khrushchev condemned him in front of other Soviet leadership.⁸⁴ Agursky concludes, "As far as the spillover of military technology per se into the civilian sector is concerned, one can state with confidence that it barely exists."⁸⁵

What about the integration of facilities and production lines? In this third channel, some evidence suggests that advanced Soviet plants in the civilian sector did share some capabilities with the defense industry; however, the best instruments and machinery were reserved for military needs, and Soviet sources recounted that the defense industry would commandeer key

⁸¹ CIA, *The Soviet Weapons Industry*. Holloway, David. "Innovation in the Defence Sector." *Industrial Innovation in the Soviet Union* 2 (1982).

⁸² Agursky, *The Soviet Military-Industrial Complex*, 27; Kassel, Simon. *The Relationship between Science and the Military in the Soviet Union*. 1974. <https://apps.dtic.mil/sti/tr/pdf/ADA004613.pdf>.

⁸³ Evangelista, *Innovation and the Arms Race*, 43-44.

⁸⁴ Agursky, *The Soviet Military-Industrial Complex*.

⁸⁵ Agursky, *The Soviet Military-Industrial Complex*, 25.

materials from civilian industry.⁸⁶ In contrast to lean manufacturing methods adopted by firms in Japan and other countries, Soviet plants managed inventory and logistics based on centralized directives, which resulted in idle capacity and substantial delays in delivery of supplies.⁸⁷ As mentioned above, though defense industry enterprises produced both civilian and military output, only a fraction came from shared production processes and facilities. In fact, by the early 1980s, the trend was toward greater use of specialized equipment for civilian outputs.⁸⁸

Notably, this bifurcation of infrastructure thwarted efforts by U.S. intelligence agencies to assess Soviet military strength. To track Soviet military capabilities in the early 1980s, the CIA and the Defense Intelligence Agency (DIA) placed great emphasis on satellite measurements of floor space at Soviet military production enterprises.⁸⁹ For instance, the DIA's 1984 *Soviet Military Power* report cited these floor space indicators to support its claim that "the growth of facilities dedicated to naval and aerospace weapons production has been extraordinary."⁹⁰ Yet, these estimates likely overstated the actual expansion of Soviet military capacity, since they did not take into account the fact that more and more of this floor space was allocated to civilian production in a manner that was separated from military production.

In the financial investment channel, civil-military integration was very minimal. The Soviet defense sector did not invest capital into the private sector, as most funds were allocated to state-affiliated scientific institutes that specialized in military technology.⁹¹ These scientific institutes, which numbered around 1,700 in the 1960s, were the main source of new technologies

⁸⁶ Holloway "Innovation in the Defence Sector," 311; Agursky, *The Soviet Military-Industrial Complex*. Becker, *Sitting on Bayonets*, 21.

⁸⁷ Aron, Paul H. "The Securities Market in the USSR." *Financial Analysts Journal* 46, no. 6 (1990): 12.

⁸⁸ Cooper, "The Civilian Production of the Soviet Defence Industry," 43.

⁸⁹ Cooper, "The Civilian Production of the Soviet Defence Industry," 191 fn 93.

⁹⁰ Department of Defense, *Soviet Military Power*, 1984, 91-93.

⁹¹ For context, the U.S.'s SBIR did not start until 1982.

in the Soviet Union.⁹² In addition, since the Soviet Union only had rudimentary capital markets — there was no formal stock exchange — the defense sector could not attract funds from commercial investors. It was only after the collapse of the Soviet Union, when government defense spending significantly dropped, that Russia’s Ministry of Defense supported the creation of “financial-investment groups”, which allowed the defense industry to consolidate and access funds from private investors.⁹³

A brief comparison to civil-military integration in the U.S. during this period further highlights the Soviet Union’s relative weakness in these four channels. In the U.S., there were more opportunities for civilian researchers to collaborate with peers working on classified projects, as demonstrated by special ad hoc convenings such as Project Beacon Hill.⁹⁴ The U.S. also boasted stronger spillovers of talent and technical know-how between defense and nondefense lines.⁹⁵ As for financial flows, major U.S. defense contractors were listed firms that attracted investment from the commercial sector.⁹⁶ Even in the domain where Western analysts warned of a Soviet advantage — infrastructure and facilities — an OTA survey of 11 randomly selected industrial sectors found that about 46 percent of the defense industrial base’s production of goods and services came from integrated processes, higher than the comparable figure for the Soviet Union.⁹⁷

⁹² Sedaitis, Judith B. “Waking the Sleeping Giants: Commercializing State R&D in the United States and Russia.” *Technological Forecasting and Social Change* 53, no. 3 (1996): 293–308. [https://doi.org/10.1016/S0040-1625\(96\)00095-9](https://doi.org/10.1016/S0040-1625(96)00095-9).

⁹³ Sánchez-Andrés, Antonio. “The Transformation of the Russian Defence Industry.” *Europe-Asia Studies* 47, no. 8 (1995): 1269–92; Sedaitis, “Waking the Sleeping Giants.”

⁹⁴ Evangelista, *Innovation and the Arms Race*.

⁹⁵ Office of Technology Assessment, “*Assessing the Potential for Civil-Military Integration*.”

⁹⁶ Gholz, Eugene, and Harvey M. Sapolsky. “Restructuring the U.S. Defense Industry.” *International Security* 24, no. 3 (1999): 5–51.

⁹⁷ Office of Technology Assessment, “*Assessing the Potential for Civil-Military Integration*,” 104–105; The Soviet figure was derived from a single sector that was more amenable to integration than the average sector. Cooper, “The Civilian Production of the Soviet Defence Industry.”

C. Modifications to CMI measure induced by case application

With one exception, it is relatively straightforward to employ the four-channel framework to measure civil-military integration in the Soviet Union. Even though the Soviet Union's command economy limited the capacity of the commercial base to benefit from market forces, it is still feasible to evaluate the extent to which, say, plants under the civilian machine-building ministry interacted and collaborated with machinery plants controlled by the Ministry of Defense Industry in R&D, technology and technical know-how, and infrastructure.⁹⁸ The application of this whole-of-ecosystem approach to the financial channel, however, raises concerns about whether certain indicators discount integration in socialist economies. Specifically, since the Soviet economic system did not allow for formal stock exchanges, measures of Soviet defense enterprises' access to capital markets are unsuitable for assessing the extent to which the defense and commercial bases shared financial resources.

This exercise suggests two modifications. First, the article's measurement approach is more appropriate for economies in which market forces play a significant role in organizing economic activity. Nowadays, very few states are organized as socialist economic systems in the mold of the Soviet Union. According to one analysis of 61 of the largest economies in the world, only two countries (Cuba and Venezuela) have "old-style socialist economies," with highly centralized planning and weak market forces.⁹⁹ In fact, Russia now possesses a mixed market-oriented economy, which can be traced back to reforms that established modern stock markets and incorporated other free market principles.¹⁰⁰ Crucially, this scope limitation does not affect

⁹⁸ Sánchez-Andrés, "The Transformation of the Russian Defence Industry."

⁹⁹ Witt, Michael A., Luiz Ricardo Kabbach de Castro, Kenneth Amaeshi, Sami Mahroum, Dorothee Bohle, and Lawrence Saez. "Mapping the Business Systems of 61 Major Economies: A Taxonomy and Implications for Varieties of Capitalism and Business Systems Research." *Socio-Economic Review* 16, no. 1 (2018): 5–38. <https://doi.org/10.1093/ser/mwx012>.

¹⁰⁰ Aron, Paul H. "The Securities Market in the USSR." *Financial Analysts Journal* 46, no. 6 (1990): 11–14.

the China-U.S. comparison that follows; China's capital market is the second largest in the world, and its economy is increasingly driven by market-oriented private enterprises.¹⁰¹

Second, for socialist economies like the Soviet Union, it may be possible to capture financial CMI by tracking bank-based financing instruments, as opposed to market-based financing ones. For example, commercial banks such as the Promstroibank supplied lines of credit for Soviet defense enterprises. Still, some evidence suggests that, during this period, the state supplied almost all financing for defense enterprises, and other avenues of support, such as conversion credits and bank-based credit, only opened up after 1989.¹⁰² Thus, taking into account this modified indicator, a re-assessment of the degree of Soviet civil-military integration in the finance channel does not produce meaningful changes.

IV. Application: Re-Assessing China's CMI

What is China's current level of civil-military integration? This question has drawn so much attention but so few well-considered answers. As laid out in the introduction, the received wisdom among Western analysts surmises that China outpaces the U.S. in terms of civil-military integration. A recent book written by two leaders of the Pentagon's Defense Innovation Unit (which aims to bridge the gap between the DOD and Silicon Valley) captured this accepted belief that integration is seamless in China and inoperative in America. They write, "In an era when America's chief rival, China, has ordered that all commercial firms within its borders make

¹⁰¹ Hu, Grace Xing, Jun Pan, and Jiang Wang. "Chinese Capital Market: An Empirical Overview." Working Paper No. 24346. Working Paper Series. National Bureau of Economic Research, February 2018. <https://doi.org/10.3386/w24346>. It should be noted that a system of SOE-dominated sectors exists in parallel to this market economy.

¹⁰² Aron, "The Securities Market in the USSR."

their research and technology available for military exploitation, strengthening the relationship between Washington and Silicon Valley was always advisable.”¹⁰³

These assumptions have not been adequately interrogated for two main reasons. First, scholars in this field have developed in-depth knowledge of either the U.S. or China’s defense-industrial base but not both. In the robust, growing body of literature that explores connections between China’s defense-industrial base and the broader economy, studies rarely advance and defend comparative claims.¹⁰⁴ Second, there is a dearth of analytical frameworks that are available to place China’s CMI in context with other countries.

Based on the whole-of-ecosystem measurement strategy, the following section benchmarks China’s civil-military integration against that of the United States across all four channels. I relied on Chinese-language resources from the China Documentation Center (Gelman Library), leading science and technology periodicals such as *Science & Technology Progress and Policy* [*keji jinbu yu duice*], and defense industry journals such as *Defense Science & Technology Industry* [*guofang keji gongye*]. Notably, some of the most informative Chinese-language sources were reports published by Chinese investment banks and other securities firms such as Essence Securities [*anxin zhengquan*], which closely follow developments in China’s defense sector. I also analyzed data on U.S. CMI from a wide range of organizations, including TechLink, the DOD’s partnership intermediary for technology transfer. To preview the results, China’s civil-military integration lags far behind the U.S. level across all four channels (Table 3, at end of section).

¹⁰³ Shah, Raj M., and Christopher Kirchhoff. *Unit X: How the Pentagon and Silicon Valley Are Transforming the Future of War*. Simon and Schuster, 2024.

¹⁰⁴ Wang, “Guns and Butter.”

A. R&D

Both the U.S. and China struggle to cultivate commercial spillovers from defense lab research. Using 2016-2020 data, the transfer rate (proportion of patent applications filed that convert to licenses) of DOD labs is about 11 percent, which sits below the rate for labs based in other agencies such as the Department of Health and Human Services.¹⁰⁵ China's transfer rate for defense lab research is 10 to 20 percent, according to a 2013 article authored by researchers at an influential institute under the China Aerospace Science and Industry Corporation.¹⁰⁶

Qualitative evidence corroborates the low transfer rates for both Chinese and American defense labs. According to a 2023 report based on 200 interviews with DoD personnel and private-sector partners, key barriers to technology transfer from defense labs include: inadequate funding and staffing, inconsistent management of intellectual property agreements, and lack of support to disclose inventions to industry.¹⁰⁷ Chinese experts also bemoan the unrealized commercial potential of defense patents, describing them as “sleeping beauties.”¹⁰⁸ They attribute these issues to rigid classification requirements for defense IP, an inflexible system for approving defense patent transactions, and the lack of funds for commercialization efforts.¹⁰⁹

The U.S. has a clear advantage in the R&D channel's second indicator — the bridging capacity of military-supported university research centers. While R&D conducted by DOD laboratories is quite isolated from the commercial sector, the U.S. has developed another system

¹⁰⁵ Author's compilation based on National Institute of Standards and Technology. *Federal Laboratory Technology Transfer Fiscal Year 2020: Summary Report to the President and Congress*. U.S. Department of Commerce, 2022. https://www.nist.gov/system/files/documents/2022/12/15/Federal%20Laboratory%20Technology%20Transfer%20Report_FY2020.pdf.

¹⁰⁶ Li et al. 2013, “Research on Problems and Countermeasures.”

¹⁰⁷ TechLink. *DoD T2 Impact Model Project*. Department of Defense, 2023.

¹⁰⁸ Jiang et al., *Initial Discussion on the Military-Civil Fusion Strategy*, 90.

¹⁰⁹ Li et al. 2013, “Research on Problems and Countermeasures,” Zhang, Fan, Lining Zeng, and Chaofeng Huang. “Research on Financial Support to the Transformation of Defense Intellectual Property[金融支持国防知识产权成果转化问题及策略研究].” *Science & Technology Progress and Policy[科技进步与对策]* 37, no. 9 (2020): 138–44. <https://doi.org/10.6049/kjbydc.2019120095>.

that more effectively bridges military research with the broader technology ecosystem. The DOD sponsors 10 federally-funded research and development centers (FFRDCs) and 14 University Affiliated Research Centers (UARC)s that meet the military’s long-term needs and core competencies.¹¹⁰ Described by Eugene Gholz and Harvey M. Sapolsky as “special public-private hybrid organizations” which other nations “cannot easily copy”, these organizations ensure R&D efforts are efficiently shared with commercial partners and aid the military with systems design and integration.¹¹¹

Since they are part of a broader university ecosystem, UARCs enable higher levels of engagement between the DOD and the civilian sector. For instance, Johns Hopkins University’s Applied Physics Laboratory (APL), a UARC sponsored by the Navy, boasts a 50 percent transfer rate, which is about five times higher than the average rate of a DOD lab.¹¹² In 2020, APL executed 92 new licenses on its own, which exceeded the total licenses secured by all DOD labs that same year.¹¹³ One analysis of 100,000 papers authored by DOD-affiliated researchers found that institutions home to a UARC comprised four of the 10 academic institutions that co-authored papers most frequently with DOD research institutions.¹¹⁴ This suggests that UARCs serve as a launching pad for expanded collaborations between defense and civilian researchers.

In this dimension of CMI, China has not developed hybrid organizations as strong as the U.S. system of UARCs. I selected a sample of five Chinese institutions that are most similar to

¹¹⁰ Nicastro, Luke A. *The U.S. Defense Industrial Base: Background and Issues for Congress*. Congressional Research Service, 2023.

¹¹¹ Gholz, Eugene, and Harvey M. Sapolsky. “The Defense Innovation Machine: Why the U.S. Will Remain on the Cutting Edge.” *Journal of Strategic Studies* 44, no. 6 (2021): 854–72.

<https://doi.org/10.1080/01402390.2021.1917392>. See also Dombrowski and Gholz, *Buying Military Transformation*, 115-132.

¹¹² Based on 24-year cumulative data (1999-2022) from APL tech transfer portal.

¹¹³ APL. *The Johns Hopkins Applied Physics Laboratory 2020 Annual Report*. 2022.

¹¹⁴ Probasco, Emelia, and Autumn Toney. *A Quantitative Assessment of Department of Defense S&T Publication Collaborations*. Center for Security and Emerging Technology, 2024.

UARCs, and then I matched each to an analogous UARC based on research competencies.¹¹⁵ For example, both the Defense S&T Key Lab of Airfoil and Blading Aerodynamics and the Georgia Tech Research Institute specialize in aerodynamics and test airfoil designs. Basic measures of staff and annual funding illustrate the significant advantage in the research capacity of U.S.-based UARCs. From this sample, U.S. UARCs employed an average of more than 3,000 personnel, whereas the Chinese labs only employed around 70 staff on average (Table 2).¹¹⁶

Table 2: Chinese and American UARC Comparison			
Chinese “UARC”	Research capacity (personnel and annual research funding)	U.S. UARC	Research capacity (personnel and annual research funding)
Defense S&T Key Lab of Airfoil and Blading Aerodynamics (NWPU)	50 personnel (2016)	Georgia Tech Research Institute	3,968 personnel; 941 million USD (2023)
State Key Laboratory of Pulsed Power Laser Technology (NUDT)	~153 personnel; 74m RMB (2021)	University of Hawaii Applied Research Laboratory	~100 personnel; 27 million USD (2023)
DSTKL of Antennas and Microwave Technology (Xidian University)	62 personnel; 30m RMB annual research funding (2019)	Johns Hopkins Applied Physics Laboratory	8,800+ personnel; 2.33 billion USD (2023)
DSTKL of Communications Anti-Jamming Technology (UESTC)	77 personnel (2020)	Pennsylvania State University, Applied Research Laboratory	1558 staff; 416m USD (2023)
DSTKL of Underwater Information and Control at NWPU	20 personnel (2023)	University of Texas at Austin - Applied Research Laboratories	793 researchers; 106 million USD (2021)
China sample average	~72 personnel	U.S. sample average	~3,044 personnel

¹¹⁵ Supplementary appendix C provides more details on sample selection as well as the sources and methods used to derive these figures.

¹¹⁶ It is possible but very unlikely that China’s deficit in average research capacity is balanced out by differences in the quantity of these hybrid organizations. By my estimates, there are about double the number of Chinese defense S&T key labs than DOD-sponsored UARCs. Multiplying the Chinese sample average by a factor of two would still leave a 20x gap with the U.S. sample average in terms of research capacity. I thank Charles Horne for his insights on this section.

B. Technology and Technical know-how

In the second CMI channel, the first two indicators relate to the defense sector's capacity to absorb commercial technologies. At the end of 2019, about 22,000 Chinese private enterprises had obtained the necessary licenses to participate in the defense supply chain.¹¹⁷ That means less than a tenth of a percent of China's 27 million private companies were engaged in defense work.¹¹⁸ By comparison, the private sector's engagement in the defense supply chain was much higher in the United States. In 2021, nearly 60,000 companies contributed technology and services to the U.S. defense industrial base.¹¹⁹ These constituted one percent of the 6 million total firms in the U.S. economy.¹²⁰ It should be noted that while China's state-owned defense enterprises are, technically speaking, civilian entities, Chinese experts value private participation in order to ensure the defense industry is "deeply rooted in the national industrial system."¹²¹

Beyond licensing, integration also demands that private companies can effectively compete for defense contracts. After all, status as an approved military vendor means little, if one cannot ultimately secure contracts. The DOD's competition rate ranges from 90 percent, when measured by the proportion of total contract actions that receive two or more offers, to between 50 and 60 percent, as measured by the proportion of total procurement spending obligated to

¹¹⁷ Qianji Touhang. 2022 *Civil-Military Integration Industry Research Report [2022 年军民融合行业研究报告]*. 2022. <https://www.21jingji.com/article/20220519/herald/737e24d99a53c423c12885c3b186c651.html>.

¹¹⁸ Du, Maorong. "Opportunities and Challenges of 'Civilian Participation in Defense ['民参军'的机遇与挑战, '民参军'的机遇与挑战]." *Jiefangjun Bao [PLA Daily]* (Beijing, People's Republic of China, Beijing, People's Republic of China), March 2, 2019.

¹¹⁹ National Defense Industrial Association. *Vital Signs 2023: Posturing the U.S. Defense Industrial Base for Great Power Competition*. 2023.

¹²⁰ Figures for total firms come from U.S. Census SUBS data.

¹²¹ Xu, Yida, and Wenhui Ouyang. "A Preliminary Discussion on the Reform and Development of Military-Civil Integration of Military Industry Groups 军工集团军民融合改革发展刍议." *Defense Science & Technology Industry [国防科技工业]*, 2019.

competitive contracts.¹²² By contrast, according to China Defense Science and Technology Information Center data for the early 2010s, only 25 percent of China's defense procurement projects involved competitive bidding.¹²³ Given the dominant position of central state-owned enterprises in China's defense industrial base, this disparity in competitive defense acquisition is not surprising.¹²⁴

China's defense industry's monopoly structure limits the private participation and the competitiveness of defense contracting. A select group of state-owned conglomerates control their own sectors, and government efforts to set up two contenders in a particular domain (e.g., China Shipbuilding Industry Corporation and China State Shipbuilding Corporation) have largely failed after the SOEs merged back into one.¹²⁵ Of the small fraction of contracts that do undergo competitive bidding, the vast majority involve supply chain logistics and non-combat support equipment.¹²⁶ China has made some limited progress to reduce the number of required licenses needed for civilian companies to produce military weapons and equipment; at the same time, it has also raised barriers by tightening the confidentiality qualifications to undertake military research and production.¹²⁷ In a *PLA Daily* article that judged the extent of private sector participation in China's defense sector, procurement expert Maorong Du concluded, "In certain regions and time periods, there is even a phenomenon of deceleration or stagnation."¹²⁸

¹²² Office of the Under Secretary of Defense for Acquisition and Sustainment. *State of Competition within the Defense Industrial Base*. Department of Defense, 2022.

¹²³ Stone and Wood, *China's Military-Civil Fusion Strategy*, 67. For an alternative perspective, see Gholz and Sapolsky, "Restructuring the U.S. Defense Industry." They argue that effective competition is extremely difficult in major weapons systems.

¹²⁴ Supplementary appendix B provides additional evidence of the U.S.'s clear advantage in this channel, with respect to patent authorization timelines, FFRDCs, licensing requirements, and technology transfer intermediaries.

¹²⁵ Weinbaum et al., *Assessing Systemic Strengths and Vulnerabilities of China's Defense Industrial Base*

¹²⁶ Cheung, *Forging China's Military Might*, 51-53.

¹²⁷ Stone and Wood, *China's Military-Civil Fusion Strategy*, 69; Kania and Laskai, "Myths and Realities".

¹²⁸ Du 2019; See also Cheung and Hagt 2020.

This channel's last two indicators reflect knowledge flows through patent citations and talent pathways. Patent citation patterns show that China is on par with the U.S. in knowledge spin-off flows (defense-to-civilian) but far behind in knowledge spin-on flows (civilian-to-defense). Based on his analysis of over 116,000 defense-related patents published between 2012 and 2022, Wang calculates the average number of civilian patents that cite each defense patent (spin-off) as well as the average number of civilian patents cited by each defense patent (spin-on). In terms of the spin-off flows the U.S. has a small advantage over China (~2.6 and ~1.8, respectively); however, when it comes to spin-on flows, the U.S. figure (~9.3) far outpaces the Chinese one (~2.9).¹²⁹

Since civilian universities train much of the high-quality science and engineering talent in both the U.S. and China, one relevant metric of skills mobility is the defense industrial base's access to talent from universities anchored to the commercial innovation system. On this front, the Chinese defense industry struggles to absorb talent from comprehensive civilian universities; instead, it heavily relies on seven defense universities that are relatively disconnected from the broader academic and commercial community. Per one 2007 article published by two researchers at the Nanjing University of Aeronautics and Astronautics, the seven defense universities ("China's Seven Sons of National Defense") trained 50 percent of the workforce with graduate degrees at national defense research institutes and key enterprises.¹³⁰ Another study of 2019 employment data from 29 leading Chinese universities found that the seven defense universities produced 75 percent of the graduates who took jobs at defense SOEs.¹³¹

¹²⁹ Wang, "Guns and Butter," 13-14. I use Wang's average measures because they correspond with the efficiency of knowledge flows across the defense and civilian sectors. I thank Raymond Wang for his guidance on this section.

¹³⁰ Yang, Zhihong, and Yongbo Cheng. "Research on several Problems for Higher Educational Institutions Participating in National Defense R&D[高等学校参与国防科研工作若干问题研究]." *Heilongjiang Research on Higher Education* 4, no. 156 (2007).

¹³¹ Fedasiuk, Ryan, and Emily S. Weinstein. *A Quantitative Assessment of Department of Defense S&T Publication Collaborations*. Center for Security and Emerging Technology, 2020.

Talent pathways between civilian universities and the U.S. defense industrial base are much stronger. Based on LinkedIn data between 1998 and 2021, Center for Security and Emerging Technology researchers found that the vast majority of technical talent employed in the U.S. defense industrial base graduated from civilian universities, with fewer than .5 percent coming from a military academy.¹³² To gauge the U.S.'s capacity to access a broad base of civilian talent, I analyzed the universities attended by 1,959 recipients of the National Defense Science and Engineering Graduate Fellowships, which supports advanced study in fields designated as priority areas by the DOD. This sample is useful proxy for technical talent in U.S. defense industrial base, as the majority of awardees go on to support the DOD's scientific mission as government workers or contractors/grantees.¹³³ Among awardees from 2000 to 2010, only 2.7 percent of fellows attended the seven US universities most rooted in the defense ecosystem.¹³⁴ Compared with the Chinese talent flow indicators above, the US defense base is much less reliant on a narrow set of defense-affiliated universities.

It is important to acknowledge that China could use government-sponsored talent plans, such as the Thousand Talents Plan, to absorb know-how into the defense sector. However, these schemes have limited linkages to the defense sector. Per one analysis of 3,586 awardees under China's Youth Thousand Talents Plan, only 8 percent were selected to work at military-affiliated institutions.¹³⁵ "This finding challenges the prevailing narrative that China's talent awardees frequently contribute to the country's military or defense-industrial base," the study's researchers

¹³² Gehlhaus et al., "The Race for U.S. Technical Talent."

¹³³ Belanich, James, William A. DeMaio, Katherine I. Fisher, and Melissa A. Cummings. *Review of National Defense Science and Engineering Graduate Fellowship*. Institute for Defense Analyses, 2019.

¹³⁴ Supplementary Appendix D details the methodology for analyzing this sample.

¹³⁵ Fedasiuk, Ryan, and Jacob Feldgoise. *The Youth Thousand Talents Plan and China's Military*. Center for Security and Emerging Technology, 2020. <https://cset.georgetown.edu/publication/the-youth-thousand-talents-plan-and-chinas-military/>.

conclude.¹³⁶ Moreover, from a comparative perspective, China still significantly trails the U.S. in attracting technical talent from around the world.

To be sure, when judged on the ability to draw STEM talent from top universities, there is a gap between the U.S. defense industrial base and large technology firms like Google and Microsoft. Between 1998 and 2021, roughly 40 percent of the technical talent in the defense industrial base received degrees from top-ranked computer science schools, compared with a 60 percent mark for six commercial technology giants.¹³⁷ Still, the U.S. defense sector is better positioned to tap into talent from schools at the technology frontier than the Chinese defense sector, which is rarely able to attract graduates from top-ranked universities such as Peking University and Shanghai Jiaotong University.¹³⁸

C. Infrastructure

As for the infrastructure channel, after decades of investment in public-private partnerships, the U.S. military has found some success in its efforts to share its major technical facilities — the depots, ammunition plants, and arsenals that make up the organic industrial base — with private firms. Across the DOD’s 20 major maintenance depots based in the United States, commercial partners account for about 45 percent of the workloads.¹³⁹ The number of public-private partnerships for depot-level maintenance increased from just 19 in 1998 to 348 in

¹³⁶ Fedasiuk and Feldgoise, *The Youth Thousand Talents Plan and China’s Military*, 8-9.

¹³⁷ Gehlhaus et al., “The Race for U.S. Technical Talent.”

¹³⁸ Yang and Cheng, “Research on Several Problems”; Fedasiuk, Ryan, and Emily S. Weinstein. *A Quantitative Assessment of Department of Defense S&T Publication Collaborations*. Center for Security and Emerging Technology, 2020.

¹³⁹ Gansler, Jacques S., William Lucyshyn, Lisa H. Harrington, and Amelia Cotton Corl. “The Current State of Performance Based Logistics and Public-Private Partnerships for Depot-Level Maintenance: Operating Models, Outcomes, and Issues.” *Center for Public Policy and Private Enterprise*, 2010.

2005. Of the U.S. Army's 14 ammunition facilities, the five plants that provide the main ammunition production capacity are contractor-operated.¹⁴⁰

In principle, these partnerships should increase the utilization of these technical facilities and equipment, thereby enabling depots to adopt commercial practices, manage costs, and enhance military readiness. In practice, the DOD has struggled to collect the right metrics to assess whether PPPs have been successful in achieving these aims.¹⁴¹ Furthermore, one of the biggest barriers to enhanced integration in this channel is a U.S. law that mandates that no more than 50 percent of depot-level maintenance funds can be allocated to private contractors. Any efforts to change that law to encourage greater integration would be highly scrutinized by Congressional representatives of the districts that house the 20 major maintenance depots, which have formed a "Congressional Depot Caucus."¹⁴²

While there is much less open-source data on the private sector's access to China's major defense facilities, the obstacles mentioned in secondary sources suggest that it is very likely that the commercial utilization rate is much lower than the U.S.'s 45 percent figure.¹⁴³ In 2017, Xu Zhanbin, the deputy director of the State Administration for Science, Technology, and Industry for National Defense (SASTIND), commented that private firms are often blocked from using large-scale facilities and instruments in the defense sector.¹⁴⁴ In the space domain, Mingyan Nie, a scholar at the Nanjing University of Aeronautics and Astronautics, finds that private enterprises face excessive hurdles to obtain the necessary licenses and qualifications to access military-

¹⁴⁰ Government Accountability Office. *Depot Maintenance: Public-Private Partnerships Have Increased, but Long-Term Growth and Results Are Uncertain*. Washington, DC, 2003; Gansler et al., *The Current State of Performance Based Logistics*."

¹⁴¹ Government Accountability Office, *Depot Maintenance*.

¹⁴² Gansler et al., *The Current State of Performance Based Logistics*."

¹⁴³ Wortzel, Larry M. *Dragon Extends Its Reach: Chinese Military Power Goes Global*. Potomac Books Inc., 2013.

¹⁴⁴ Nouwens and Legarda, *China's Declassification of Defense Patents*.

controlled launch sites and other space facilities.¹⁴⁵ According to Nie, China is a “latecomer” relative to the U.S. in leveraging public-private partnerships in the space field.¹⁴⁶

Another important factor in this channel of CMI is whether the logistics infrastructure adopts commercial practices that have proven to be effective. To improve the efficiency of distribution, repair, and procurement of parts and equipment, the DOD has turned toward performance-based logistics (PBL), which structures sustainment contracts to include specific performance obligations for suppliers, such as delivery of a part within two days at a 95 percent success rate. PBL contracts can lead to both cost-savings and enhanced readiness, since they incentivize suppliers to implement commercial best practices that improve the reliability and availability of components.¹⁴⁷ By one estimate, conducted by the Defense Logistics Agency’s former director of enterprise transformation, the DOD could save 10-20 percent on its logistics and sustainment costs if it fully adopted PBL.¹⁴⁸

Although other militaries have more fully embraced these commercial practices, the DOD has made moderate progress on PBL usage. In areas that were judged to be most promising for adopting the PBL approach, about 30 percent of DOD spending went to contracts with PBL content (2012-2014).¹⁴⁹ As for China, it is reasonable to estimate that its defense supply chain and logistics infrastructure have very limited, if any, adoption of PBL-like practices. Two researchers from China Astronautics Standards Institute, a subunit of one of China’s large

¹⁴⁵ Nie, Mingyan. “The Growth of China’s Non-Governmental Space Sector in the Context of Government Support for Public-Private Partnerships: An Assessment of Major Legal Challenges.” *Space Policy* 59 (February 2022): 101461. <https://doi.org/10.1016/j.spacepol.2021.101461>.

¹⁴⁶ Nie, “The Growth of China’s Non-Governmental Space Sector.”

¹⁴⁷ Gansler, Jacques S., and William Lucyshyn. *Evaluation of Performance Based Logistics*. Acquisition Research Program, 2006. <https://www.dair.nps.edu/handle/123456789/2714>.

¹⁴⁸ Gansler, Jacques S., William Lucyshyn, and Lisa H. Harrington. “An Analysis of Through-Life Support: Capability Management at the UK’s Ministry of Defence.” *Report, University of Maryland Center for Public Policy and Private Enterprise*, 2012, 1–118.

¹⁴⁹ Hunter, Andrew, Madison Riley, Gregory Sanders, and Jesse Ellman. *Performance-Based Logistics: A Process Analysis for the Defense Logistics Agency*. Center for Strategic & International Studies, 2015, 60.

defense conglomerates responsible for space technology, characterized the U.S. military's implementation of PBL as a "relatively complete standard for equipment sustainment support." In contrast, they assessed that China's defense logistics system lacked "effective introduction channels or mechanisms" for "contractor's participation in equipment support process, fund management, assessment and evaluation."¹⁵⁰

Corruption within China's defense logistics system further hinders the introduction of commercial practices and partners. According to Joel Wuthnow and Phillip Saunders, two experts on China's military, the logistics system is "afflicted with corruption in the purchase and delivery of military supplies, as well as in the sale of PLA-owned land and facilities."¹⁵¹ As evidence of this limited oversight, in 2014, China's former deputy chief of the General Logistics Department, Gu Junshan was charged with bribery and embezzlement. His malfeasance included exploiting his position as head of the infrastructure and barracks division to purchase several hundred villas for high-ranking officers and three dozen homes in central Beijing for himself.¹⁵²

Before moving to the last channel, it is worthwhile to consider claims of Chinese advantages in CMI for two particular sectors: shipbuilding and drones. That Chinese shipyards support both military and civilian construction has become one of the most prominent talking points for the notion that China's defense industrial base is more integrated than that of the

¹⁵⁰ Liu, Y., B. Jin, and H. Cheng. "Performance Based Sustainment Support Mode of US Military and Its Enlightenment to China's Project Construction." *12th International Conference on Quality, Reliability, Risk, Maintenance, and Safety Engineering (QR2MSE 2022)* 2022 (July 2022): 743–47. <https://doi.org/10.1049/icp.2022.2955>. See also Mahnken, Thomas G., and Tai Ming Cheung. *The Decisive Decade: United States–China Competition in Defense Innovation and Defense Industrial Policy in and Beyond the 2020s*. 2023. <https://csbaonline.org/research/publications/the-decisive-decade-united-stateschina-competition-in-defense-innovation-and-defense-industrial-policy-in-and-beyond-the-2020s>, 34.

¹⁵¹ Wuthnow, Joel, and Phillip C. Saunders. *Chinese Military Reforms in the Age of Xi Jinping: Drivers, Challenges, and Implications*. Center for the Study of Chinese Military Affairs (National Defense University), 2017. See also Puska et al., "China's Military Representatives."

¹⁵² Ansfield, Jonathan. "Leader of China Aims at Military With Graft Case." *World. The New York Times*, March 31, 2014. <https://www.nytimes.com/2014/04/01/world/asia/chinese-military-general-charged-in-graft-inquiry.html>.

United States.¹⁵³ However, since there are few synergies between naval and merchant shipbuilding, coproduction at Chinese shipyards may not qualify as effective integration — i.e., it does not lead to more commercial and military benefits than the counterfactual in which the shipyards had separate facilities for producing military and commercial vessels. On this point, the Chinese civilian shipbuilding industry has resisted efforts to adhere to military-compatible standards as a “costly burden.”¹⁵⁴ In a volume compiled by the China Maritime Studies Institute, experts Sue Hall and Audrye Wong conclude, “The intermingling of merchant and naval construction is more likely to be detrimental to both, as a result of the conflicts and complexities it brings to shipyard management.”¹⁵⁵

Furthermore, even if China’s shipbuilding approach does count as infrastructural integration, it is the exception not the rule. The co-location setup found in shipbuilding is rare in other sectors, as most of China’s defense industrial base is scattered far from its coastal commercial hubs. This geographic separation is the product of former Chinese leader Mao Zedong’s “Third Front Movement” campaign to move China’s national defense infrastructure to interior provinces.¹⁵⁶

Citing evidence that the PLA adapts consumer drones produced by global leader DJI, analysts also spotlight unmanned aerial vehicles (UAVs) as a successful model for integration. For instance, industrial parks and military-civil fusion zones, which allow defense institutions

¹⁵³ Jones, Seth G. “China Is Ready for War.” *Foreign Affairs*, October 2, 2024.

<https://www.foreignaffairs.com/china/china-ready-war-america-is-not-seth-jones>; Bitzinger, “China’s Shift.”

¹⁵⁴ Erickson, “China’s Naval Shipbuilding Sets Sail.”

¹⁵⁵ Hall, Sue, and Audrye Wong. “Key Factors in Chinese Shipyards’ Development and Performance: Commercial-Military Synergy and Divergence.” In *Chinese Naval Shipbuilding: An Ambitious and Uncertain Course*. Naval Institute Press, 2016, 106.

¹⁵⁶ Naughton, Barry. “The Third Front: Defence Industrialization in the Chinese Interior.” *The China Quarterly*, no. 115 (1988): 351–86; Weinbaum et al., *Assessing Systemic Strengths*.

and private companies to cluster, could boost China's production capacity in military UAVs.¹⁵⁷ Thus far, infrastructural spillovers are limited. In Shenzhen, where DJI is headquartered, most of these CMI zones — including a CMI-UAV Industry Alliance — involve just a few small firms, are dispersed across different districts which limits agglomeration effects, and lack anchor defense institutions.¹⁵⁸ To reiterate, connections certainly exist, but the Chinese military mostly relies on Chinese commercial drone producers for lower-tier components or off-the-shelf systems.¹⁵⁹

D. Financial Investment

Regarding the Chinese defense sector's investment into the private sector, China's military-civil fusion (MCF) funds have drawn considerable attention. A type of public-private investment vehicle, MCFs purportedly support start-ups and small businesses that develop technologies with defense and dual-use applications. Elsa Kania and Lorand Laskai see these funds as an example of China's ability to marshal resources through top-down policies, which they argue “may afford China a structural advantage in MCF initiatives.”¹⁶⁰ Citing one estimate that MCF funds have raised \$68.5 billion since 2015, they note that this mark “appears to dwarf the budgets of the Defense Innovation Unit (DIU), In-Q-Tel, and other defense-related investment vehicles in the United States.”¹⁶¹

¹⁵⁷ Oudenaren, John. *TAKING FLIGHT: CHINA'S MILITARY UNMANNED AERIAL VEHICLE (UAV) INDUSTRY*. China Aerospace Studies Institute, 2025, 11, 136.

¹⁵⁸ Hagt “China's Civil-Military Integration,” 312, 325.

¹⁵⁹ Hagt “China's Civil-Military Integration,” 308; Cheung, Tai Ming, and Eric Hagt. *China's Efforts in Civil-Military Integration, Its Impact on the Development of China's Acquisition System, and Implications for the U.S.* Technical Report. Acquisition Research Program, 2020. <https://dair.nps.edu/handle/123456789/4170>, 44-45. One exception is Sichuan Tengden Technology Company, which supplied the PLA with an integrated military UAV system. McFaul, Cole, Sam Bresnick, and Daniel Chou. *Pulling Back the Curtain on China's Military-Civil Fusion*. CSET, 2025, 23.

¹⁶⁰ Kania and Laskai, “Myths and Realities.”

¹⁶¹ Kania and Laskai, “Myths and Realities.”

There are two main problems with this comparison between China's MCF funds and U.S. defense investment vehicles. First, any benchmarking exercise is incomplete without accounting for the U.S.'s Small Business Innovation Research program (SBIR), established in 1982 to help small companies commercialize their innovations. Described by one expert as "the largest source of seed and early-stage funding for high-technology firms in the United States," SBIR receives 97 percent of its funding from national security agencies, with half provided by the DOD.¹⁶² Each year, SBIR invests \$4 billion into small businesses with 500 or less employees.¹⁶³

Second, China's MCF fund totals are substantially inflated. To be sure, the top-line figures are impressive: From 2012 to 2020, these funds raised an average of \$17.5 billion each year.¹⁶⁴ However, many of these vehicles do not target the integrative activities that their names imply. As Tai Ming Cheung's probe into the ten largest MCF funds shows, an "overwhelming proportion" of their investment portfolios were "largely focused on civilian investment with a very small exposure to defense and dual-use activities."¹⁶⁵ Moreover, these government guidance funds often invest a very small percentage of their reported total funds. One analysis of 18 such funds in Sichuan province found that only 4.7 percent of the raised funds had been invested.¹⁶⁶ Lastly, for most of these funds, the Chinese military and defense conglomerates only supply a very small portion of the funds (often 5-15 percent), with the rest coming from non-defense SOEs, investment groups, and local governments.¹⁶⁷

¹⁶² Weiss, *American Inc.*?, 59.

¹⁶³ U.S. Small Business Administration. *Annual Report Fiscal Year 2021: America's Seed Fund Powered by the SBA*. 2021.

¹⁶⁴ Cheung, *Innovate to Dominate*, 134.

¹⁶⁵ Cheung, *Innovate to Dominate*, 132.

¹⁶⁶ Feng, Emily. "China's State-Owned Venture Capital Funds Battle to Make an Impact." *Chinese Business & Finance*. *Financial Times*, December 23, 2018. <https://www.ft.com/content/4fa2caaa-f9f0-11e8-af46-2022a0b02a6c>.

¹⁶⁷ Cheung, *Innovate to Dominate*, 124,

When these three qualifications are taken into account, U.S. defense investment into the private sector overshadows the Chinese equivalent. Even if we use very generous assumptions — that 25 percent of MCF funds go to activities with dual-use potential, 25 percent of the announced endowments are actually spent, and 25 percent of the funds come from the Chinese defense sector — then China’s annual MCF investment totals about \$250 million. By comparison, each year, the U.S.’s SBIR alone provides 16 times more in seed funding to high-tech firms. The disparity widens further when including annual expenditures from other defense-related vehicles such as In-Q-Tel (\$75 million) and the Defense Innovation Unit (\$1 billion budget).¹⁶⁸

The *quality* of U.S. defense investment into the private sector is also much higher than corresponding Chinese financial flows. Per data on DOD funding for 16,959 SBIR projects (1995-2018), TechLink estimated that the seed programs contributed to \$350 billion in economic impact, which represents a 22:1 return on investment. These projects also resulted in \$28 billion in sales of new products to the U.S. military.¹⁶⁹ Because U.S. defense investment funds are trusted by venture capital funds and other private investors, recipients of SBIR or In-Q-Tel funding often benefit from follow-on funding from other sources. For instance, each dollar In-Q-Tel invests is matched by \$15 from other funds.¹⁷⁰ In contrast, the effectiveness of China’s MCF funds, many of which were established after 2015, is unproven. Citing alleged incidents of

¹⁶⁸ Crane, Keith W., Evan Linck, Sara A. Carioscia, and Bhavya Lal. *Appendix B.: Case Studies of Government Strategic Investment Funds*. Assessment of the Utility of a Government Strategic Investment Fund for Space. Institute for Defense Analyses, 2019. <https://www.jstor.org/stable/resrep22819.11>; Albon, Courtney. “Defense Innovation Unit Would Get Major Funding Boost in Spending Bill.” *Battlefield Tech. C4ISRNet*, March 21, 2024. <https://www.c4isrnet.com/battlefield-tech/2024/03/21/defense-innovation-unit-would-get-major-funding-boost-in-spending-bill/>.

¹⁶⁹ TechLink. *National Economic Impacts of Department of Defense SBIR/STTR Program, 1995-2018*. Department of Defense, 2019.

¹⁷⁰ Paletta, Damian. “The CIA’s Venture-Capital Firm, Like Its Sponsor, Operates in the Shadows.” *Tech. Wall Street Journal*, August 30, 2016. <http://www.wsj.com/articles/the-cias-venture-capital-firm-like-its-sponsor-operates-in-the-shadows-1472587352>.

corruption, critics claim that the funds funnel money back into the entrenched defense SOEs.¹⁷¹ Others point to the tendencies of guidance funds to spur redundant and inefficient investments, which can “inflate prices and crowd out sophisticated private investors.”¹⁷²

In the reverse direction, China’s defense industry struggles to tap investment flows from financial markets. Starting in the mid-2000s, the Chinese government has gradually allowed state-owned defense conglomerates to raise financing from capital markets, with the first asset securitization deal — a private share placement by China Shipbuilding Industry Corporation — completed in 2013.¹⁷³ To benchmark China against the U.S. on this dimension of CMI, Chinese analysts employ the asset securitization rate (*zichan zhengquanhua lv*), a measure of a defense firm’s assets that are listed on stock exchanges. At the end of 2021, the average asset securitization rate of China’s ten defense SOEs reached 49 percent.¹⁷⁴ The comparable ratio for US defense prime contractors is around 75 percent.¹⁷⁵

This gap likely widens when the scope of the defense industry is extended beyond the conglomerates. While new entrants into the U.S. defense industry do face challenges in raising

¹⁷¹ Kania and Laskai, “Myths and Realities.”

¹⁷² Acharya, Ashwin, and Zachary Arnold. *Chinese Public AI R&D Spending: Provisional Findings*. Center for Security and Emerging Technology, 2019. <https://cset.georgetown.edu/publication/chinese-public-ai-rd-spending-provisional-findings/>.

¹⁷³ Cheung, *Innovate to Dominate*, 120.

¹⁷⁴ Essence Securities. *National Defense Industry In-Depth Analysis* [国防军工行业深度分析]. 2023. <https://www.hangyan.co/reports/3008636325545903598>. Listed on the Hong Kong Stock Exchange since 2003, the Aviation Industry Corporation of China boasts the highest asset securitization rate, but other defense sectors have not been as successful in leveraging capital markets. Clemens, Eli. *How Some Chinese Companies Obscure Ties to China and What Policymakers Should Do About It*. 2025. <https://itif.org/publications/2025/11/03/some-chinese-companies-obscure-ties-to-china-what-policymakers-should-do-about-it/>.

¹⁷⁵ Cheung, *Innovate to Dominate*, 123. One could argue that Chinese SOEs can always secure financing because the government will bail them out. In addition, when it comes to Chinese private defense firms, state-owned capital investment companies could make up some of the shortfalls, though these instruments typically purchase small stakes. However, *integration* with and access to public capital markets brings benefits beyond just funding, including increased transparency of defense firms (which improves information flows for all stakeholders) and enhanced competition (which encourages more innovation). Yang, Zeng, Changyuan Xia, Shuai Zhao, and Daiguo Fu. “Chinese Defense Industry Reforms and Military Firm Performance: Evidence from the Civil—Military Integration Strategy.” *Defence and Peace Economics* 35, no. 3 (2024): 367–82. <https://doi.org/10.1080/10242694.2022.2154926>.

additional capital, companies like Palantir and SpaceX demonstrate that small firms can scale up to become major defense contractors by attracting funding from public exchanges and secondary marketplaces.¹⁷⁶ No Chinese equivalent of Palantir or Space X exists. In fact, Chinese private military enterprises struggle to raise capital from stock markets and early-stage funds due to many factors. These include: confidentiality requirements that make it difficult for fund managers to obtain company data, uncertainty about intellectual property rights regarding ventures that spin-out from Chinese military research institutes, and a competitive landscape tilted toward state-owned enterprises.¹⁷⁷ Some experts estimate that only 10 percent of Chinese firms involved in defense work have the ability to introduce funds from capital markets.¹⁷⁸

E. Summary

In sum, China is not getting the best of both worlds. The four-channel measure reveals that China lags significantly behind the U.S. in terms of the ability to capitalize on common technologies, facilities, and personnel for military and industrial gain. China's overall CMI score is nearly three times lower than that of the United States (Table 3). To be clear, this standalone figure only serves to illustrate the gap between the two countries in a preliminary exercise. This paper's objective is to develop, defend, and apply a conceptually valid measure of civil-military integration. Further extensions of the CMI score require deliberations over aggregation rules, including whether some channels should be weighted more than others.

These findings also require future updating, as some of China's MCF initiatives will take time to bear fruit; nevertheless, in order to track trends, a baseline snapshot is required. Scholars

¹⁷⁶ Doubleday, Justin. "DOD's Silicon Valley Outfit Seeks to Shift from 'Experimental' to 'Transformative.'" *Inside Missile Defense* 26, no. 6 (2020): 11–14.

¹⁷⁷ Taihe Industry Observer. "90% of Defense Industry Companies Are Unable to Introduce Formal Capital." *Taihe Industry Observer* [钛禾产业观察], August 6, 2018.

¹⁷⁸ Taihe Industry Observer, "90% of Defense Industry Companies Are Unable to Introduce Formal Capital."

and analysts familiar with the deficiencies of the US defense industrial base may think that these findings place the U.S. on too high a pedestal. However, equipped with this article's measurement strategy to analyze civil-military integration in the U.S. *relative* to levels in other states, they might discover that the U.S. has the weakest form of CMI — except for all the others.

Table 3: Comparison of US-China CMI Levels			
Channel	Indicator	China	US
R&D	Tech transfer rate for defense research organizations	10-20%	11%
	Capacity of military-supported university research centers	~72 research staff (avg, sample of Chinese "UARCs")	~3044 (avg, sample of U.S. UARCs)
Technology and technical know-how	Private sector participation in defense supply chain	<.1% of companies	>1% of companies
	Competition rate for defense procurement projects (received two or more offers)	25%	90% (total contract actions); 50-60% (total dollars obligated)
	Avg # of civilian patents that cite each defense patent; average # of civilian patents cited by each defense patent	~1.8 (spin-off); ~2.9 (spin-on)	~2.6 (spin-off); ~9.3 (spin-on)
	Talent flows from civilian universities to defense industrial base (DIB)	50% of DIB workforce comes from outside 7 defense universities	> 97% of DIB workforce comes from outside 7 most militarized universities
Infrastructure	Commercial access to defense facilities	Uncertain (though likely much lower than U.S. figure)	Commercial partners account for 45 percent of workloads at U.S. military's 20 major maintenance depots
	Performance-based logistics adoption rate (defense infrastructure adopting commercial practices)	~0% adoption rate (still in theoretical stages)	30% adoption rate in most promising application areas
Financial investment	Asset securitization rate (capital from financial markets to defense industry)	50%	75%
	Annual defense investment into private companies	~\$250 million	~\$5 billion
Overall Score (aggregation)	1 (weak), 2 (somewhat weak), 3 (somewhat strong), 4 (strong)	1, 1, 1, 2 = 1.25	3, 4, 3, 4 = 3.5

V. Conclusion

In closing, this paper has advanced two main points. First, it has developed and justified a novel measure of civil-military integration, based on four channels through which defense and commercial sectors cultivate symbiotic relationships: i) R&D, ii) technology products and know-how, iii) infrastructure and facilities, and iv) financial investment. Effective indicators of CMI must reflect the concept's core: synergistic interactions between the commercial and defense sectors such that the whole (the combined impact on military effectiveness and economic competitiveness) is greater than the sum of its parts (the military and economic outcomes of a counterfactual scenario in which the two ecosystems remained separate). Validated with a case study of Western assessments of civil-military integration in the Soviet Union, this whole-of-ecosystem approach operationalizes a crucial variable for both the security studies and political economy fields.

Second, equipped with this four-channel measure, this paper provides a net assessment of civil-military integration in the U.S. and China. Counter to the received wisdom that China has a decisive advantage over the U.S. on this front, I find that the U.S. has a clear lead in civil-military integration — a finding supported by 10 numeric indicators and in-depth qualitative appraisals across all four channels. On the one hand, it is quite surprising that, to the best of my knowledge, no such net assessment has been conducted, given all the hubbub that surrounds China's military-civil fusion drive.¹⁷⁹ On the other hand, perhaps there is an obvious reason for this gap. Without a sound measure of the variable in question, comparative analysis is impossible.

¹⁷⁹ Wang, *Guns and Butter*."

When it comes to China's civil-military integration level, it is of paramount importance to measure twice and cut once. U.S. strategists incorporate CMI as a key factor in their judgments of China's ability to narrow the technological gap. As the application of the four-channel measure to the Soviet case demonstrated, assessments of CMI in great power rivals must rest on sound measures. Arbitrary estimates of the Soviet Union's CMI significantly overstated its capacity to sustain military and economic strength in the long-run. Additionally, U.S. policymakers have justified restrictions on Chinese students and firms on the basis of unexamined assumptions about the extent of civil-military integration in China. As the U.S. and China navigate interdependence in strategic industries, this paper's whole-of-ecosystem approach to assessing CMI in China might lead to a more measured approach.

This paper is an exploratory, not definitive, exercise. Moreover, this framework is limited to civil-military integration in peacetime settings, so more research is needed to evaluate whether it travels to wartime mobilization.¹⁸⁰ In some areas, data limitations in the U.S.-China benchmarking effort thwarted apples-to-apples comparisons. Some of the figures are also based on reports from before the intensification of China's military-civil fusion initiatives.

Future research should extend this framework with sector-specific studies. China's achievements with integration in shipbuilding and drones, albeit diminished when scrutinized through my framework (see infrastructure section), underscore the need to account for sectoral variation in CMI. While a general, system-wide assessment is more appropriate for this paper's scope, the four-channel framework can be applied to specific sectors as well. For instance, China's Strategic Support Force sometimes mobilizes technical talent from cybersecurity firms,

¹⁸⁰ Regarding this distinction in the context of Chinese overseas port holdings, see Kardon, Isaac B., and Wendy Leutert. "Pier Competitor: China's Power Position in Global Ports." *International Security* 46, no. 4 (2022): 9–47. https://doi.org/10.1162/isec_a_00433.

data centers, and other civilian assets to carry out cyberwarfare operations.¹⁸¹ Under my framework, a sectoral analysis of CMI in cyber capabilities would evaluate the degree to which these assets were shared efficiently to advance both military and commercial interests.

I tried to acknowledge these constraints up front in the text, but they warrant reiteration here. Simply put, this should by no means be the last word on debates over China's civil-military integration; rather, I hope it serves as an opening statement that provokes more productive and *measured* discussions.

¹⁸¹ U.S.-China Economic and Security Review Commission. *2022 Annual Report to Congress*. 2022. <https://www.uscc.gov/annual-report/2022-annual-report-congress>, 419.