The Best of Both Worlds? Benchmarking China's Civil-Military Integration Efforts

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ABSTRACT[1]

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.

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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, argues 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 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 innovation and industrial policy, the political science literature rarely articulates measures of civil-

[2] Bitzinger 2021, 22.
[3] Ford 2018.
[4] Stone and Wood 2020.
[5] Author's translation. Jiang et al. 2017, 42.

military integration that are valid across countries and time.[6] 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.

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.[7] 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

[6] On CMI's importance for military innovation, see Alic et al. 1992; Beckley 2010; Chu 2024; Dombrowski and Gholz 2006; Evangelista 1988; Horowitz 2018. Scholars also highlight CMI as a vehicle to spur economic competitiveness. Fong 2000; Weiss 2014. For the burgeoning literature on CMI in China, see Cheung 2014; Cheung 2022; Bitzinger and Char 2019; Kania and Laskai 2021; Kardon and Leutert 2022. As for the absence of CMI measures in this scholarship, two exceptions are Millett et al. 1986 and Wang 2025.

[7] OTA 1994, 128; Gehlhaus et al. 2023.

compare the U.S. and China's degree of civil-military integration in the present period. Drawing on a wealth of quantitative data and 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.[8] 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.[9] 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."[10] 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.[11] For example, one research stream studies the commercial spillovers from U.S. military programs targeted at dual-use technologies.[12] As explored further in the validation 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.[13] A sound means of measuring CMI is also necessary to substantiate claims attached to this body of scholarship.

[8] Beckley 2010; Chu 2024; Dombrowski and Gholz 2006; Evangelista 1988.
[9] Goldman and Andres 1999; Horowitz 2018. For a discussion of why China has not been able to adopt the U.S.'s advanced military capabilities, despite some of this literature's implications, see Gilli and Gilli 2019.
[10] Horowitz 2018, 39.
[11] For a review, see Wang et al. 2024, 1.
[12] Fong 2000; Weiss 2014.
[13] Cooper 1986, 31.

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)."[14] 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.[15]

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.[16] This article suggests that many of these policies rest on misleading assumptions about the degree of civil-military integration in China.

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

[14] Kania and Laskai 2021.
[15] Cheung 2014; Bitzinger and Char 2019. For other work that assesses the U.S.-China power balance, see Beckley 2011; Brooks and Wohlforth 2016; Lind 2024, 38.
[16] Kania and Laskai 2021.

commercial industrial bases such that common technologies, material, facilities, and personnel can be used to meet both defense and commercial needs.[17] 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" [一分投入、两分产出] to describe civil-military integration.[18] 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 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.[19] 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.[20] 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.[21]

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[17] OTA 1994

[18] Hagt 2019, 5.

[19] A more competitive industrial base could also allow states to reduce their dependence on foreign suppliers for key military capabilities.

[20] OTA 1994.

[21] Evangelista 1988.

Other studies question the basic assumptions of CMI policies, such as whether defense-related R&D investments stimulate the development of civilian technologies.[22]

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 higher levels of civil-military integration demand certain policy responses and portend shifts in economic and military power, then a more informed approach to measuring this variable is necessary.

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.[23] 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.[24] 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 about the latter into permanent existence.[25]

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

[22] Wang et al. 2024.
[23] Brooks 2019. Of course, a conflictual relationship between political leaders and military officials could interfere with civil-military integration. In the case with Iraq in the 1990s, 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 and Zirkle 1996.
[24] Brooks 2019.
[25] Huntington 1981, 361-367.

integration, selecting ten articles from each journal that ranked highest in a Google Scholar search for the following keywords: commercial, military, and integration.[26] 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.[27]

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.[28] 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.[29] Yet, despite exhaustive efforts to trace the source for this figure, there is no evidence that substantiates this claim.[30]

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 conglomerates that go toward military versus civilian goods.[31] 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

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[26] See supplementary appendix A for full dataset and coding procedures. The author conducted the initial scan in July 2024.

[27] Millett et al. 1986. They measure CMI at the political and strategic level. The former evaluates to what degree military organizations have access to industrial technologies; the latter assesses to what extent the military's strategic objectives are consistent with the orientation and capabilities of the national industrial base.

[28] Hagt 2019, 13; Stone and Wood 2020, 39 fn xxix.

[29] Weinstein 2021.

[30] The original source of these claims is likely Li et al. 2013, but there is no supporting evidence for the commercialization rate in developed countries. In fact, in the empirical analysis section, I show that the U.S. commercialization rate of defense patents is much lower than 60 percent.

[31] Breaud-Sudreau and Nouwens (2019) point to this indicator as evidence of "the success of the (Chinese) government's policy to call for a 'civilianisation' of the arms-manufacturing entities." See also Moura and Oudot 2017.

sales — against the Russian defense industrial base's high dependency on arms sales (90 percent of total sales).[32]

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.[33]

To further clarify why some conversion projects (and other interactions that look like CMI on the surface) 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.[34] If, compared to this counterfactual scenario, a state's conversion efforts do not 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)

[32] Weinbaum et al. 2022; Hart 2021.
[33] OTA 1995, 21.
[34] For a similar exercise, see Alic et al., p. 61-64

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.

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.[35] 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.[36] 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 any resulting defense and civilian patents do not cite each other). 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 these innovation systems initiate, modify, diffuse, and maintain new technologies.[37]

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, which makes this first CMI channel a natural starting point. 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 fulfill 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 method to use for fiber optic manufacturing.[38]

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[35] Wang 2025.
[36] Wang 2025.
[37] Nelson 1993.
[38] The existence of commercial markets connected to defense patents also allows militaries to benefit from production economies of scale. Faith 2013.

Commercial and defense researchers can share R&D resources in a variety of ways. In the U.S., many R&D integration efforts between DOD labs and private organizations are formalized through cooperative research and development agreements (CRADAs), established by the Federal Technology Transfer Act of 1986. By ensuring that each participant can protect their existing intellectual property (IP) and also license or acquire new IP from partners, CRADAs encourage research collaborations that benefit both the commercial and defense ecosystems. For instance, to bolster dual-use R&D in the automotive sector, the Army's National Automotive Center established CRADAs with General Motors, Ford, and Chrysler.[39] By one estimate, between 1996 and 2018, the DOD established over 12,800 CRADAs.[40] Other forms of R&D integration include joint centers such as the collaboration between Chinese technology giant Baidu and defense conglomerate China Electronics Technology Group as well as development programs in which results are shared among military and commercial participants.[41]

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.[42] 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.[43]

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.[44]

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[39] OTA 1994, 121.
[40] TechLink and Business Research Division (University of Colorado Boulder) 2019
[41] OTA 1994, 132; Kania and Laskai 2021.
[42] Evangelista 1988, 42-45.
[43] Bitzinger 2022.
[44] Choudhry and Ponzio 2020.

Second, the defense base and civilian economy can share technology products and technical know-how. Personnel movements that traverse the defense/non-defense boundary can enable the diffusion of knowledge and new techniques. 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). It should be emphasized that 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 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

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[45] Alic et al. 1992, 112-113.
[46] Gansler 2015, "Overcoming the Barriers of Civil/Military Industrial Integration and of Buying Commercial Goods and Services".
[47] Alic 1992, 56-61.
[48] Misa 1985.
[49] Wang 2025; Gehlhaus et al. 2023.

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

What is shared?	*Potential benefits of CMI*	*Proposed indicators*
R&D	Shared R&D resources incentivize researchers in commercial and defense sectors to develop new dual-use technologies	- Technology transfer rates for defense research organizations - Strength of linkages between military and civilian researchers
Technology products and technical know-how	Firms leverage common technical know-how for competitive edge in civilian and defense markets in spin-off and spin-on directions	- Extent of private sector participation in the defense supply chain - Competition rates for defense contracts - Patent citations that reflect spillovers (defense patent cites a civilian patent and vice versa) - Mobility of talent between defense and commercial sectors
Infrastructure and facilities	Defense and commercial activities benefit from shared testing infrastructure, maintenance facilities, or production lines	- Commercial sector's level of access to major defense facilities - Effectiveness of public-private partnerships in shared infrastructure - Capacity of defense logistics, maintenance, and testing to adopt commercial practices
Financial investment	Financial capital flows between commercial and defense sectors	- 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, including production lines, test centers, and maintenance depots. 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 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 forms of 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]

[50] Bitzinger 2021.
[51] Avdellas et al. 2011.

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.[52]

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.[53]

Lastly, financial investment serves as another channel of CMI. Access to capital markets allows defense companies to finance long-term investments as well as mergers and acquisitions. 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."[54] 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.[55]

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 that are

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[52] Hagt 2019, 121.
[53] Performance-based logistics is one example of a practice that enables synergies between the commercial and defense sectors when it comes to sustainment. Gansler and Lucyshyn 2006.
[54] Mahoney et al. 2022.
[55] O'Sullivan 2007.

developing dual-use technologies.[56] 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.[57]

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 stock 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.[58] As the U.S.-China benchmarking exercise will demonstrate, one could assign a score of 1 (weak), 2 (somewhat weak), 3 (somewhat strong), or 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

[56] Ministere des Armees 2022.
[57] Weiss 2014, 69.
[58] Gerring 2012, 165-166.
[59] I am very grateful to Fiona Cunningham for advice on this section.

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]

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 of CMI. Moreover, this paper's proposed measures also capture the consequences of differences in CMI styles. Returning to the claim that China possesses a unique ability to compel civilian entities to collaborate with the military, compellence can hinder the integration 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 military-civil fusion strategy advocate for stronger protections of private companies against

[60] Weinstein 2021.
[61] Duchâtel 2023.
[62] Office of the Spokesperson 2020.
[63] The briefer also cited a national security law, which does not exist. This might have been due to confusion with Hong Kong's national security law, which is not relevant to CMI.
[64] Other studies underscore that contracts between the Chinese military and defense firms are vague and unenforceable. Cheung 2014, 52; Puska et al., "Commissars of Weapons Production", 97.
[65] Stone and Wood 2020, 48; Jiang et al. 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 1983.

government intrusion.[66] Chinese military officials highlight the need for new laws that clarify the management of classified information, as a foundation for commercial actors to gain more trust from the military.[67] Indeed, analysts attribute the "robust foundation for public-private collaboration" in the U.S.'s CMI approach to "the rule of law and public accountability."[68] This aligns with the broader literature on civil-military relations, which finds that trust between civil leadership and senior defense officials is essential for grand strategies that integrate military and economic concerns.[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 CMI strategy. Sound measures of cross-national variation in civil-military integration are prerequisites to further investigations of these deeper causes. 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, 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

[66] Stone and Wood 2020, 48; Jiang et al. 213-215.
[67] Nowens and Legarda 2018.
[68] Kania and Laskai 2021.
[69] Feaver 2003.

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 and economic power.[72] One of the report's findings was that "the lines between the two sectors [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

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[70] Adcock and Collier 2001.
[71] Becker 1983, 19-21.
[72] CIA 1986, 1.
[73] CIA 1986.
[74] CIA 1986, 3.
[75] CIA 1986, 3.
[76] Agursky 1980, 26; Campbell 1972.

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]

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.

[77] Cooper 1986, 31.
[78] Lee 1972.
[79] Cooper 1986, 42. This estimate comes from a Soviet text published in 1978.

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 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. The defense sector struggled to attract the most capable civilian scientists, since secrecy concerns made it difficult to publish scholarly work and researchers could attain higher compensation in the commercial sector.[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 radar device that could locate large groups of fish which was adapted from military equipment, Krushchev called for the exhibit to be removed and asked to speak with the event organizer. The organizer hid for two hours before he was discovered, upon which Kruschev 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

[80] Evangelista 1988, 42-45.
[81] CIA 1986. Holloway 1982.
[82] Agursky 1980, 27; Kassel 1974.
[83] CIA 1986; Evangelista 1988, 35-36.
[84] Agursky 1980.
[85] Agursky 1980, 25.

industry; however, the best instruments and machinery were reserved for military needs, and Soviet sources recounted that the defense industry would commandeer key 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 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

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[86] Holloway 1982, 311; Agursky 1980. Becker 1983, 21.
[87] Aron 1990, 12.
[88] Cooper 1986, 43.
[89] Cooper 1986, 191 fn 93.
[90] DOD, *Soviet Military Power,* 1984, 91-93.
[91] For context, the U.S.'s SBIR did not start until 1982.
[92] Sedaitis 1996.

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]

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 this sector interacted and collaborated with the defense sector in R&D, technology and technical know-how, and infrastructure. 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

[93] Sánchez-Andrés 1995; Sedaitis 1996. In its last years, the Soviet Union did issue legislation that allowed enterprises to sell stock to the public. Aron 1990.
[94] Evangelista 1988.
[95] By one estimate, about 24 percent of scientists and engineers at defense-related positions in 1982 had switched to civilian-oriented employment four years later; 27 percent in defense-oriented jobs in 1986 had been in non-defense jobs in 1982. OTA 1994.
[96] Gholz and Sapolsky 1999.
[97] OTA 1994, 104-105; The Soviet figure was derived from a single sector that was more amenable to integration than the average sector. Cooper 1986.

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.[98] In fact, Russia now possesses a mixed market-oriented economy, which can be traced back to reforms in the 1990s that sought to incorporate more free market principles into the Soviet command economy, including an act that established modern stock markets.[99] Crucially, for this article's purposes, this scope limitation does not affect the China-U.S. comparison that follows; China's capital market is the second largest in the world, and it has embraced market-oriented private enterprises.[100]

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.[101] Still, some evidence suggests that, during this period, the state supplied almost all financing for defense enterprises, and other avenues of support — including 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. Policymakers and analysts see China's military-civil fusion strategy as

[98] Witt et al. 2018.
[99] Aron 1990.
[100] Hu et al. 2018. It should be noted that a system of SOE-dominated sectors exists in parallel to this market economy.
[101] Aron 1990.
[102] CISAC, "Defense Industry Restructuring in Russia: Case Studies and Analysis," 1994.

central to its pursuit of economic and military dominance.[103] The U.S.-China Economic and Security Review Commission, an influential body that advises Congress on U.S.-China relations, publishes an annual report that distills key findings from staff studies and expert hearings. The 2023 annual report contained 77 references to "military-civil fusion" or "MCF"; the 2018 version included just 23.[104]

The received wisdom, at least among Western analysts, surmises that China outpaces the U.S. in terms of civil-military integration. A recent book written by two men who launched 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. "In an era when America's chief rival, China, has ordered that all commercial firms within its borders make their research and technology available for military exploitation, strengthening the relationship between Washington and Silicon Valley was always advisable. Today, it is an urgent necessity," they write.[105]

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.[106] 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. As for

[103] Department of State, "Military-Civil Fusion and the People's Republic of China," 2020; Bitzinger 2021; Cheung 2022.
[104] Author's analysis based on reports from: https://www.uscc.gov/annual-reports.
[105] Shah and Kirchhoff 2024.
[106] Wang 2025.

civil-military integration in the United States, I analyzed data from a wide range of organizations, including TechLink, the DOD's partnership intermediary for technology transfer.[107] To preview the results, China's civil-military integration lags far behind the U.S. level across all four channels, which results in an overall CMI score that is nearly three times lower than that of the United States (Table 2).

Table 2: Comparison of US-China CMI Levels

Channel	Indicator	China	US
R&D	Transfer rate (commercialization of defense lab innovations)	10-20%	11%
R&D	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
Technology and technical know-how	Competition rate for defense procurement projects (received two or more offers)	25%	90% (total contract actions); 50-60% (total dollars obligated)
Technology and technical know-how	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)
Technology and technical know-how	Talent flows from civilian universities to DIB	50% of DIB workforce comes from outside 7 defense universities	> 97% of DIB workforce comes from outside 7 most militarized universities
Infrastructure	Shared utilization of major defense technical facilities (public-private partnerships)	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
Infrastructure	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%
Financial investment	Defense investment into private companies (annual)	~$250 million	~$5 billion
Overall Score, aggregation of four channels	1 (weak), 2 (somewhat weak), 3 (somewhat strong), 4 (strong)	1, 1, 1, 2 = **1.25**	3, 4, 3, 4 = **3.5**

[107] My analysis was informed by consultation with experts based at the Center for Security and Emerging Technology and the U.S. Air Force's Office of Commercial & Economic Analysis.

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 oto her agencies such as the Department of Health and Human Services.[108] 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.[109]

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.[110] Chinese experts also bemoan the unrealized commercial potential of defense patents, describing them as "sleeping beauties."[111] 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.[112]

As for the R&D channel's second indicator, the strength of linkages between military and civilian sectors, the U.S. has a clear advantage. While R&D conducted by DOD laboratories is quite isolated from the commercial sector, the U.S. has developed another system 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 (UARCs) that meet the military's long-term needs and core competencies.[113] Described by Eugene Gholz and Harvey M. Sapolsky as "special public-

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[108] Author's compilation based on National Institute of Standards and Technology 2022.
[109] Ping et al. 2013. This statistic has been cited by other Chinese texts, which also append an unsourced claim about the transfer rate of defense patents in developed countries (purported to be between 50 to 60 percent); despite the lack of verification, American analysts have repeated this comparison. Stone and Wood 2020. Weinstein 2021b.
[110] TechLink 2023.
[111] Jiang et al. 2017, 90.
[112] Ping et al. 2013. Zhang et al. 2020.
[113] Nicastro 2023.

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.[114]

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.[115] In 2020, APL executed 92 new licenses on its own, which exceeded the total licenses secured by all DOD labs that same year.[116] 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.[117] 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 UARCs, and then I matched each to an analogous UARC based on research competencies.[118] 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 3).[119]

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[114] Gholz and Sapolsky 2021. See also Dombrowski and Gholz 2006, 115-132.
[115] Based on 24-year cumulative data (1999-2022) from https://www.jhuapl.edu/tech-transfer.
[116] APL 2022.
[117] Probasco and Toney 2024.
[118] Supplementary appendix C provides more details on sample selection as well as the sources and methods used to derive these figures.
[119] It is 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.

Table 3: 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

B. Technology and Technical know-how

The first two indicators relate to spin-on benefits from the incorporation of commercial technologies in the defense sector. At the end of 2019, about 22,000 Chinese private enterprises had obtained the necessary licenses to participate in the defense supply chain.[120] That means less than a tenth of a percent of China's 27 million private companies were engaged in defense work.[121] 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.[122] These constituted one percent of the 6 million total firms in the U.S. economy.[123] It should be noted that while China's state-owned

[120] Qianji Touhang 2022.
[121] Du 2019.
[122] National Defense Industrial Association 2023.
[123] Figures for total firms come from U.S. Census SUBS data.

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."[124]

Beyond licensing, integration also demands that private companies can effectively compete for defense contracts. After all, it is not very helpful to become an approved military vendor if one cannot ultimately secure contracts. The DOD's competition rate sits consistently around 90 percent, as measured by the proportion of total contract actions that receive two or more offers. When measured by the proportion of total procurement spending obligated to competitive contracts, the DOD's competition rate is typically between 50 and 60 percent.[125] 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.[126] Given the dominant position of central state-owned enterprises in China's defense industrial base, this disparity in competitive defense acquisition is not surprising.[127]

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.[128] Of the small fraction of contracts that do undergo competitive bidding, the vast majority involve supply chain logistics and non-combat support equipment.[129] 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.[130] In a *PLA Daily* article that judged the extent of private sector

[124] Xu and Ouyang 2019.
[125] Office of the Under Secretary of Defense for Acquisition and Sustainment 2022.
[126] Stone and Wood 2020, 67. For an alternative perspective, see Gholz and Sapolsky 1999. They argue that effective competition is extremely difficult in major weapons systems.
[127] For additional benchmarking on patent authorization timelines, FFRDCs, licensing requirements, and technology transfer intermediaries, see supplementary appendix B.
[128] Weinbaum et al. 2022.
[129] Cheung 2014, 51-53.
[130] Stone and Wood, 69; Kania and Laskai 2021.; Taihe Industry Observer 2019.

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."[131]

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).[132]

Since civilian universities train much of the STEM talent base 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 in the wider economy. 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 not as connected to 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.[133] 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.[134]

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

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[131] Du 2019; See also Cheung and Hagt 2020.
[132] Wang 2025, 13-14. I use Wang's average measures because it corresponds with the efficiency of knowledge flows across the defense and civilian sectors. I thank Raymond Wang for his guidance on this section.
[133] Yang and Cheng 2007.
[134] Fedasiuk and Weinstein 2020.

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.[135]

To more precisely measure whether the U.S. accesses a wider base of talent in the civilian sector, 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. Given that the majority of awardees go on to support the scientific mission of the DOD and other government agencies as part of either the government workforce or as contractors/grantees, this sample is a useful proxy for technical talent in U.S. defense industrial base.[136] Among awardees from 2000 to 2010, only 2.7 percent of fellows attended the seven US universities most rooted in the defense ecosystem.[137] Compared with the Chinese talent flow indicators above, the US defense base is much less reliant on a narrow set of defense-affiliated universities and can tap into universities embedded in the wider civilian ecosystem.

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.[138] 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.[139]

C. Infrastructure

After decades of investment in public-private partnerships (PPPs), 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

[135] Gehlhaus et al. 2023.
[136] Belanich et al. 2019.
[137] Supplementary Appendix D details the methodology for analyzing this sample.
[138] Gehlhaus et al. 2023.
[139] Yang and Cheng 2007; Fedasiuk and Weinstein 2020.

based in the United States, commercial partners account for about 45 percent of the workloads.[140] The number of PPPs for depot-level maintenance increased from just 19 in 1998 to 348 in 2005. Of the U.S. Army's 14 ammunition facilities, the five plants that provide the main ammunition production capacity are contractor-operated.[141]

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.[142] 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."[143]

While there is much less open-source data on the private sector's access to China's major defense facilities, the significant 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.[144] 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.[145] In the space domain, Mingyan Nie, a scholar at the Nanjing University of Aeronautics and Astronautics, finds that private enterprises face excessive obstacles in obtaining the necessary licenses and qualifications to access military-controlled launch sites and other space facilities.[146] According to Nie, China is a "latecomer promoting the PPP model in the space field," as compared to the

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[140] This is data from fiscal years 2007 through 2009. Gansler et al. 2010.
[141] GAO 2003; Gansler et al. 2010
[142] GAO 2003.
[143] Gansler et al. 2010.
[144] One report does state that the General Armament Department managed civilian factors that produced military equipment and weapons. Wortzel 2013.
[145] Nouwens and Legarda 2018.
[146] Nie 2022.

U.S., where "the PPP model in space exploration is utilized to promote a robust commercial space industry."[147]

The private sector's close involvement with nuclear weapons laboratories serves as a particularly striking illustration of the U.S.'s robust CMI level in the infrastructure channel. Due to the high classification demands, nuclear weapons represent the defense sector that is most separated from the commercial sector. Yet, in the United States, the nuclear weapon laboratories are GOCOs managed by private contractors or non-government entities. Justified partly by CMI logic, this set-up allows for the labs to transfer some of their unique capabilities to commercial applications as well as attract a wider base of civilian scientific and engineering talent. According to one exhaustive analysis of five cooperative research and development agreements between private firms and the Lawrence Livermore National Laboratory (one of the nuclear weapon labs), all the firms emphasized the access to "specialized facilities and equipment" as a major advantage from such collaborations.[148] In 2019, Department of Energy laboratories held 1,072 active CRADAs in total, with 287 signed in that year alone.[149] In 2012, these labs allowed industry and non-federal entities to perform work valued at $250 million that draws on lab facilities and equipment.[150]

Conversely, China's main nuclear weapons lab, the China Academy of Engineering Physics (CAEP), is a state institution that is more isolated from the commercial sector. Though its research portfolio suggests that deeper integration with the civilian economy would be welcome, CAEP has not embraced technology transfer.[151] According to insights from Eric Hagt's interviews in Mianyang, the city that houses CAEP, researchers adopt a "superiority complex" toward civilian counterparts, as reflected in one employee's remarks: "Even if we wanted to really engage in CMI locally, Mianyang doesn't have the S&T capacity to match us."[152] This reluctance to partner with outside entities is also reflected in CAEP's underinvestment into

[147] Nie 2022.
[148] Ham and Mowery 1998.
[149] National Institute of Standards and Technology 2022.
[150] Bin-Nun 2017.
[151] It is unsurprising that CAEP is less integrated than US national labs given the small and rudimentary PRC nuclear arsenal. I thank Fiona Cunningham for this point. See also Cunningham 2025.
[152] Hagt 2019, 242.

its technology transfer department, which is staffed with relatively low-ranking personnel and holds devalued institutional status.[153]

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 (private contractors, in most cases) to implement commercial best practices that improve the reliability and availability of components.[154] 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.[155]

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).[156] DOD adoption has been slowed by lack of long-term commitments and resistance from providers that benefit from conventional practices. Some indicators suggest that other countries — in particular the UK, with its adoption of Through-life Capability Management — have achieved more intensive adoption of PBL-like approaches.[157]

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 defense conglomerates responsible for space technology, analyzed the U.S. military's implementation of PBL, characterizing the approach as a "relatively complete standard for equipment sustainment support." In contrast, in their assessment of China's defense logistics system, they

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153 Hagt 2019, 234 fn 719.
154 Gansler and Lucyshyn 2006.
155 Gansler et al. 2012.
156 Hunter et al., 60.
157 Gansler et al. 2012.

state that there is a lack of "effective introduction channels or mechanisms" for "contractor's participation in equipment support process, fund management, assessment and evaluation."[158]

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."[159] 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.[160]

To be sure, China has undertaken significant reforms of its military logistics system since 2016. The Logistics Support Department (LSD) and the Joint Logistics Support Force (JLSF) represent important steps to centralize logistics operations and more effectively contract with civilian suppliers. Still, even the optimistic view recognizes that it is premature to judge these early-stage developments as effective.[161] Fragmentation in logistics and sustainment management is one of the notable limitations. Rather than allow the LSD and JLSF to coordinate all aspects of defense logistics (like the U.S. military's Defense Logistics Agency and Transportation Command), Chinese service components under theater commands continue to operate their own supply departments.[162]

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

[158] Liu et al. 2022. See also Mahnken and Cheung 2023, 34.
[159] Wuthnow and Saunders 2017.
[160] Ansfield 2014.
[161] Wuthnow and Saunders 2017.
[162] Wuthnow 2021.

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."[163] 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."[164]

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.[165] Each year, SBIR invests $4 billion into small businesses with 500 or less employees.[166]

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.[167] 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."[168] 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.[169] 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.[170]

[163] Kania and Laskai 2021.
[164] They do qualify this claim by noting uncertainties about the effectiveness of these funds. Kania and Laskai 2021.
[165] Weiss 2014, 59.
[166] U.S. Small Business Administration 2021.
[167] Cheung 2022, 134.
[168] Cheung 2022, 132.
[169] Feng 2018.
[170] Cheung 2022, 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).[171]

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/STTR 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.[172] 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.[173] In contrast, the effectiveness of China's MCF funds, many of which were established after 2015, is unproven. Citing alleged incidents of corruption, critics claim that the funds funnel money back into the entrenched defense SOEs.[174] Others point to the tendencies of guidance funds to spur redundant and inefficient investments, which can "inflate prices and crowd out sophisticated private investors."[175]

In the reverse direction, investment flows from financial markets into China's defense industry are also relatively weak. 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

[171] Crane et al. 2019; Albon 2024.
[172] TechLink 2019.
[173] Paletta 2016.
[174] Kania and Laskai 2021.
[175] Acharya and Arnold 2019.

share placement by China Shipbuilding Industry Corporation — completed in 2013.[176] 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.[177] The comparable ratio for US defense prime contractors is around 75 percent.[178]

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 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.[179] 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.[180] Some experts estimate that only 10 percent of Chinese firms involved in defense work have the ability to introduce funds from capital markets.[181]

176 Cheung 2022, 120.
177 Essence Securities 2023.
178 Cheung 2022, 123.
179 Doubleday 2020.
180 Taihe Industry Observer 2019.
181 Taihe Industry Observer 2019.

Table 2: Comparison of US-China CMI Levels			
Channel	Indicator	China	US
R&D	Transfer rate (commercialization of defense lab innovations)	10-20%	11%
R&D	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
Technology and technical know-how	Competition rate for defense procurement projects (received two or more offers)	25%	90% (total contract actions); 50-60% (total dollars obligated)
Technology and technical know-how	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)
Technology and technical know-how	Talent flows from civilian universities to DIB	50% of DIB workforce comes from outside 7 defense universities	> 97% of DIB workforce comes from outside 7 most militarized universities
Infrastructure	Shared utilization of major defense technical facilities (public-private partnerships)	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
Infrastructure	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%
Financial investment	Defense investment into private companies (annual)	~$250 million	~$5 billion
Overall Score, aggregation of four channels	1 (weak), 2 (somewhat weak), 3 (somewhat strong), 4 (strong)	1, 1, 1, 2 = **1.25**	3, 4, 3, 4 = **3.5**

Before summarizing these results (Table 2), it is worthwhile to consider claims of Chinese advantages in CMI for one particular sector: shipbuilding. That Chinese shipyards support both military and civilian construction has become one of the most prominent talking points to support the notion that China's defense industrial base is more integrated than that of the United States.[182]

[182] Jones 2024; Bitzinger 2021.

Exposing this claim to further scrutiny reveals two rejoinders. First, 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."[183] 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."[184]

Second, 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.[185]

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

[183] Erickson 2017.
[184] Hall and Wong 2016, 106.
[185] Weinbaum et al. 2022.

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 quantitative 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.[186] On the other hand, perhaps there is a very obvious reason for this gap. Without a sound measure of the variable in question, how can one conduct a comparative analysis?

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

[186] Wang 2025.

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 a preliminary, not definitive, exercise. While these indicators provide initial evidence for the presence of dual-use spillovers from shared usage of assets and technologies, this measurement approach must be informed and corroborated by field research and domain-specific, in-depth studies. 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.[187] 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. 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 discussions grounded on valid measures.

[187] Regarding this distinction in the context of Chinese overseas port holdings, see Kardon and Leutert 2022.

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