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The Role of New Defense Innovation Intermediaries in the Emerging Defense Innovation Ecosystem

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Preface

This research was sponsored by the Office of the Secretary of Defense and conducted within the Acquisition and Technology Policy Center of the RAND National Defense Research Institute (NDRI), a federally funded research and development center (FFRDC) sponsored by the Office of the Secretary of Defense, the Joint Staff, the Unified Combatant Commands, the Navy, the Marine Corps, the defense agencies, and the defense intelligence community. Comments or questions on this draft report should be addressed to the project leaders, Jon Schmid and Jonathan P. Wong at jschmid@rand.org and jonwong@rand.org.

For more information on the Acquisition and Technology Policy Center, see https://www.rand.org/nsrd/atp.html or contact the director (contact information is provided on the webpage).

Abstract

The U.S. Department of Defense (DoD) and the military services have, in recent years, established a group of new defense innovation intermediaries (DIIs) to accelerate the development and adoption of new technologies by the DoD. The primary functional role of these organizations is to boundary-span: to establish and strengthen ties between other system components that otherwise do not exist or are impeded by organizational structures or norms. The efficacy of these DIIs in accelerating defense technology innovation and adoption will depend on how ties are created and maintained. In this study, we conducted analysis on the functions purported to be performed by a set of DIIs. Specifically, we looked at how the organizations present themselves externally, on public-facing websites, reports, speeches, and marketing material. We find that the new defense intermediaries considered here report to perform 17 of the 20 functions that are provided by the commercial intermediary baseline defined here. However, based on analysis of publicly available resources, the DIIs considered here do not report to perform three functions: equity investment, patient capital, and alumni management. Policy-makers should consider filling these gaps, but only after deeper analysis and investigation into the efficacy of modeling DIIs after commercial intermediaries.

Summary

The last five years have seen the advent of a new type of innovation intermediary focused on accelerating the rate at which the Department of Defense (DoD) adopts commercial technology. The creation of these organizations is motivated by a recognition among policy-makers that the majority of innovation in high-priority technology sectors occurs in a portion of the commercial sector that rarely does business with the DoD. At first blush, these new defense innovation intermediaries (DIIs), in terms of functions performed, appear to mirror their commercial counterparts. These organizations, for example, provide nascent firms or individuals with access to physical space, educational programming, insight into the demand environment, and financing. However, little systematic investigation into the functional roles performed by these organizations has been conducted. This study seeks to begin to fill this gap.

In this study, we compare the functions performed by commercial innovation intermediaries to those claimed to be performed by a set of four new DIIs. To this end, we utilize a gap analysis approach. First, we catalog the functions performed by commercial innovation intermediaries. This list of functions constitutes the baseline against which the new DIIs are compared. We then catalog the intermediary functions claimed to be performed by four new DIIs: Defense Innovation Unit (DIU), National Security Innovation Network (NSIN), National Security Innovation Capital (NSIC), and the Defense Innovation Board (DIB). Specifically, we looked at how these four prominent DIIs present themselves externally, on public-facing websites, reports, and marketing material.[1] Comparing these defense innovation intermediaries' functions to the commercial baseline reveals possible gaps: functions performed in the commercial system but not reported to be performed in the defense system.[2] These gaps, in turn, point to areas in which additional intermediation may be required.

We found that the DIIs report to provide a large portion of the functions provided by the commercial innovation intermediary baseline. Seventeen of the 20 functions that are provided by the commercial intermediary system are also purported to be provided by DIIs. This leaves three possible gaps or functions performed by commercial innovation intermediaries that are not reported to be performed by the DIIs considered here.

Two of the gaps revealed by comparing the commercial intermediary function portfolio to that reported to be offered by the new DII relate to provision of financing. Specifically, we find no evidence that the new defense intermediary ecosystem provides equity investment or patient capital. Equity investment—investment in which the investor is given an ownership stake in the firm in exchange for the investment—is the preferred investment approach for angel investors and venture capital firms. This financing mechanism, however, is absent from the defense intermediary system. The absence of such a major channel of investment funding may result in a capital scarce environment for firms that want to do business with the DoD.[3]

We also find no evidence that the DIIs considered here offer patient capital: long-term financing that is relatively insensitive to short-term perturbations in the fortune of the innovator. However, innovation involves uncertainty, and successful innovations are often preceded by multiple product iterations or product failures.[4] The absence of patient capital may result in defense intermediaries forgoing projects with long or uncertain development processes or disproportionately selecting low-risk projects that have short and predictable development timelines.

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[1] Research limitations prevented more detailed and direct examination of DIIs through structured interviews, focus groups, surveys, or other means. This can be the focus of future research.

[2] Because our objects of analysis are the defense innovation intermediaries, our focus is on the difference between the functions performed by commercial intermediaries and those performed by defense intermediaries (i.e., commercial functions minus defense functions). The commercial system is treated, in a sense, as normative.

[3] While our focus here is on the defense sector, it is worth noting that In-Q-Tel, chartered by the Central Intelligence Agency in February 1999, continues to serve as a private nonprofit venture fund to serve the intelligence community. Additionally, in 2013, the Army Venture Capital Initiative (AVCI) was launched to invest in defense-focused firms. However, the AVCI does not appear to currently be making investments.

[4] This may be especially true for technologies developed for military applications at the outset, which tend to have high performance requirements that demand significant research and development (R&D) investments before the technology matures enough to show promise. For a further discussion of R&D investment and technology maturity in the context of the military, see McNaugher (1989).

Finally, we find that, based on publicly available resources, the new DIIs fail to report linking innovators with program alumni. These alumni firms have been found to be a valuable resource to firms at earlier stages of growth. Given the particularly important role of specialized knowledge (e.g., understanding military demand and navigating the Federal Acquisition Regulation, or FAR) to selling technology to the military, the benefit of alumni networks that can supply this knowledge to new entrants may be particularly high.

This study is an exploratory effort to determine what aspects of DIIs merit further analysis. To arrive at more definitive conclusions regarding the functional coverage of the DIIs and their organizational efficacy would require direct access to the organizations of interest and the organizations they mediate with. The Conclusion of this paper describes a research agenda meant to more rigorously measure DII performance.

There are some limitations to this study. It relies on publicly available documentation of DII functions. This study may not be aware of DII functions not documented or that fail to perform a function that is described. The former would lead to identifying a functional gap where there was, in fact, not one. The latter would lead to a failure to identify a true gap. Nevertheless, this effort represents a new and systematic approach to understanding the efficacy of DIIs that can motivate more focused research.

Introduction

The functions performed by commercial innovation intermediaries are well documented. Venture capital firms such as Andreessen Horowitz provide multi-staged financing and access to professional networks. Technology accelerators like Y Combinator provide extensive programming, equity investment, and physical space. Angel investors provide patient, early-stage capital and often serve in a mentoring capacity. University technology transfer offices engage university faculty to identify means by which their research might be commercialized.

The salutary effect of these innovation intermediaries on the commercial innovation economy is well documented (De Silva, Howells, & Meyer, 2018). Innovation scholars find that technology accelerators have a positive effect on the likelihood of firms' reaching funding milestones (Hellen et al., 2014), incubators increase rates of firm survival (Lewis et al., 2011), venture capital funding drives firm growth (Engel, 2002), and patenting (Samila & Sorenson, 2010), angel investment increases firm survival (Kerr, Lerner, & Schoar, 2011), and university technology transfer offices reduce university–industry information asymmetry (Debackere & Veugelers, 2005) and increase university-spawned start-ups (O'Shea et al., 2005).

Since 2014, a new type of innovation intermediary has emerged, focused on accelerating the rate at which the DoD adopts technology developed by the portion of the commercial sector that rarely does business with the federal government. The creation of these organizations is motivated by a recognition among policy-makers that the majority of innovation in military-relevant technologies, such as artificial intelligence (AI) and machine learning (ML), occurs in the commercial sector. At first blush, these new DIIs, in terms of functions performed, mirror their commercial counterparts. However, in contrast to their commercial counterparts, little systematic investigation into the functional roles performed by these new DIIs has been conducted. This study seeks to begin to fill this gap.

In this study, we compare the functions performed by commercial innovation intermediaries to those claimed to be performed by a set of four new DIIs. To this end, we utilize a gap analysis approach. First, we catalog the intermediary functions performed by commercial innovation intermediaries. This list of functions constitutes the baseline against which the new DIIs are compared. We then catalog the intermediary functions claimed to be performed by four new DIIs: Defense Innovation Unit (DIU), National Security Innovation Network (NSIN), National Security Innovation Capital (NSIC), and the Defense Innovation Board (DIB). We looked at how these four prominent DII present themselves externally, on public-facing websites, reports, and marketing

material. We compared these defense innovation intermediaries' functions to the commercial baseline, revealing possible gaps: functions performed in the commercial system but not in the defense system.[5] These gaps, in turn, point to areas in which additional intermediation may be required.

We find that the DIIs considered here are, based on the functions described in publicly available resources, relatively limited in terms of their approach to financing. Namely, these organizations do not report to offer equity investment or patient capital, two means of financing that are central to the innovation financing process in the commercial sector. Finally, we find that the new DIIs fail to report linking innovators with intermediary program alumni. Given the importance of specialized knowledge of selling to the military, alumni networks may be of particular benefit.

This research is an exploratory effort to begin assessing the efficacy of DIIs. We were limited to using publicly available data on the organizations' claimed roles and had no appreciable access to their actual roles or data on their outputs. However, it is still important to begin systematically analyzing these organizations, identify areas for future investigation, and offer timely indications to policy-makers about their effectiveness.

Commercial Innovation Intermediaries

Recognition of the role that is played by intermediaries in the process of innovation coincides with the proliferation of a systems of innovation (SI) approach to understanding innovation (Howells, 2006). An SI approach focuses on the system components (e.g., individuals, firms, universities, government labs, and research teams) and the ties (e.g., financial and knowledge) that link them.[6] Within an SI approach, innovation intermediaries emerge as actors that specialize in facilitating the flow of resources between nodes. As will be shown, the functions performed by innovation intermediaries are widely varied. From the perspective of the system, the defining feature of innovation intermediaries, though, is sitting between an innovator and another party.

Typically, innovation intermediaries' initial point of engagement is with the innovator: an individual or start-up thought to have an invention with commercialization potential.[7] These innovators are, at this point in the relationship, typically resource and experience poor. Thus, the principal role of the innovation intermediary is to furnish resources and knowledge to the innovator with the aim of commercializing the invention in question. How these resources or knowledge are furnished constitutes the functions performed by the innovation intermediary.[8]

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[5] Because our objects of analysis are the DIIs, our focus is on the difference between the functions performed by commercial intermediaries and those performed by defense intermediaries (i.e., commercial functions minus defense functions). The commercial system is treated, in a sense, as normative.

[6] This is, of course, a simplification of the SI approach. This characterization is meant to underscore the central role of networks—and thus intermediaries—to the SI approach. Omitted here is the institutional context in which these actors transmit and receive flows.

[7] Innovation intermediaries are fond of emphasizing that they invest in people rather than ideas, pointing to the frequency with which the eventual product releases of successful start-ups are often different than the products envisioned at the time of the intermediary's initial investment. However, this does not change the essential role played by innovation intermediaries in the commercialization process, namely, that innovation intermediaries facilitate the commercialization of ideas though the direct or indirect provision of resources lacked by the innovator.

[8] Throughout this study, we use the term *function* to refer to the services provided by innovation intermediaries. We prefer the term function to service as function directs attention to the role of the

Intermediation implies two parties. Innovation intermediaries may link the innovators with whom they engage to, inter alia, financiers, intellectual property (IP) lawyers, skilled executives or technical talent, firms with compatible products, firms looking to acquire start-ups, or consumers. In some cases, the resources that the innovation intermediary provides are internal to the intermediary, as is the case when technology accelerators provide intensive programming such as mini business school courses. In others, such as when an angel investor introduces a client to an IP attorney, the resources are located outside of the intermediary.

It is important to observe that while commercial innovation intermediaries and DIIs may perform similar functional roles within an innovation system, they have different objectives.[9] In general, DIIs strive to accelerate the process by which new technologies reach the military. To this end, DIIs use performance metrics such as program adoption rate: the proportion of funded projects that become programs of record. Commercial innovation intermediary objectives are more varied. For example, accelerators may have objectives centered on maximizing internal rate of return, driving regional economic growth or employment, or accelerating firm formation within a given technology sector. Ultimately, the appropriateness of the functional mix performed by an intermediary will depend on the extent to which the functions advance organization-level objectives. For example, we find that DIIs appear to emulate the commercial innovation ecosystem, but previous research does not systematically explore the degree of that emulation or its appropriateness to the DoD's goals. We propose further research to evaluate DII operation/objective match in the Conclusion.

The empirical literature on innovation intermediaries finds that appropriately designed intermediary organizations can drive positive firm-level economic outcomes for the innovators with whom they engage. The qualifier "appropriately designed" emphasizes the contribution of organizational design to an intermediary's success. In fact, recent research on innovation intermediary performance finds that heterogeneity in the performance of innovation intermediary alumni can be explained largely by variation in design elements.

In a 2019 study of 146 technology accelerators, researchers examined the performance of graduating firms on three performance variables: receipt of a significant capital investment (more than $500,000), total investment raised, and post-graduation valuation (Cohen, Fehder, Hochberg, & Murray, 2019). Accelerator design elements were found to explain much of the variation in alumni performance. For example, accelerator program duration was found to have a positive effect on all three performance metrics. The study also found that alumni of firms from investor-sponsored technology accelerator programs were more likely to receive significant capital investments than those graduating accelerator programs sponsored by other types of parties such as governments or universities. Participation in government- or corporate-funded programs, in constant, was not found to correlate with the receipt of large capital investments. However, participants in corporate-funded accelerators tended to have higher than average valuations, even absent funding, suggesting that "engagement with corporations might provide a substitute for capital spurring start-ups to be able to achieve more (and thus be worth more) with less capital inputs" (Cohen et al., 2019, p. 1794).

Empirical analysis of other types of innovation intermediaries also finds positive impacts for participating firms. Receiving funding from venture funds is found to be correlated with firm survival (Engel, 2002) and being granted patents (Samila & Sorenson, 2010). Firms that receive angel

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innovation intermediaries to the operation of the innovation system in question rather than to the bilateral relationship between the intermediary and the innovator.

[9] We thank Tim Webb for making the astute observation regarding heterogeneity in organizational objectives.

investor funding and those that go through an incubator survive longer than those that do not (Kerr et al., 2011). Tech-focused law firms were found to measurably reduce the transaction costs of their clients (Gilson, 1984). The presence, and extent of resourcing, of university technology transfer offices within universities have been found to be correlated with high rates of university-birthed startups (O'Shea et al., 2005; Siegel, Waldman, & Link, 2003).

Commercial innovation intermediaties have also been linked to negative impacts, especially when viewed from the perspective of a founder or startup. For example, when founders accept venture capital (VC) funding, they often cede a portion of control of their firm. Often this includes the right to terminate the founder (Hellmann, 1998). Control, even control below 50%, gives the VC the ability to influence corporate decisions. Because VCs seek to maximize the return to their startup *portfolio*, not necessarily the return for any individual investment, the founder's and VC's incentives can be imperfectly aligned. For example, in some cases, VCs push startups to scale and grow more quickly than is optimal from the startup's perspective (Zetlin, 2017).

Defense Innovation Intermediaries

Since 2014, several new government agencies have been organized to accelerate the rate at which the DoD develops and adopts technology. The most recent push to enhance defense innovation can be sourced to a November 15, 2014, memorandum by Secretary of Defense Chuck Hagel establishing a "Department-wide initiative to pursue innovative ways to sustain and advance our military superiority for the 21st Century and improve business operations through the Department" (The Defense Innovation Initiative, 2014). We identified 11 innovation-focused organizations created following this memorandum: Defense Innovation Unit (DIU), National Security Innovation Network (NSIN), National Security Innovation Capital (NSIC), SOFWERX, Defense Digital Service, Defense Innovation Board (DIB), Kessel Run, AFWERX, Army Futures Command, the Army's 75th Innovation Command, and MGMWerx.[10]

Not all of these organizations are properly understood as innovation intermediaries. A small number of organizations such as Defense Digital Service participate directly in the development of military technology. Still others such as Kessel Run both participate in the direct development of military technology and serve as intermediaries between the military and the commercial firms. The focus here is on new defense innovation intermediaries or organizations whose primary functional roles relate to the linking of inventors to some portion of the DoD. Post-Hagel memo organizations that are properly understood as innovation intermediaries (i.e., those for whom the vast majority of their functional roles relate to the linking of commercial and military actors) include the National Security Innovation Network (NSIN), National Security Innovation Capital, and Defense Innovation Unit (DIU), the Defense Innovation Board (DIB), and Army Futures Command.

[10] The efficacy of novel organizational forms in leveraging civilian scientific and technological capacity to advance military ends has historical precedent. Established in 1941, the Office of Scientific Research and Development (OSRD) was a government organization charged with the coordination of research and development for military purposes during World War II. The organization was given the authority to contract with universities and the private sector.

The DoD's Case for Defense Innovation Intermediaries

Irrespective of how the DIIs perform their intended function in practice, the DoD has advanced a strong theoretical case for the need for intermediation at the intersection of commercial technology innovation and the DoD. Specifically, it has articulated two arguments in favor of DIIs:

- The DoD believes commercially-developed technology can contribute to military advantage.
- Commercial technology is best accessed with the assistance of intermediaries.

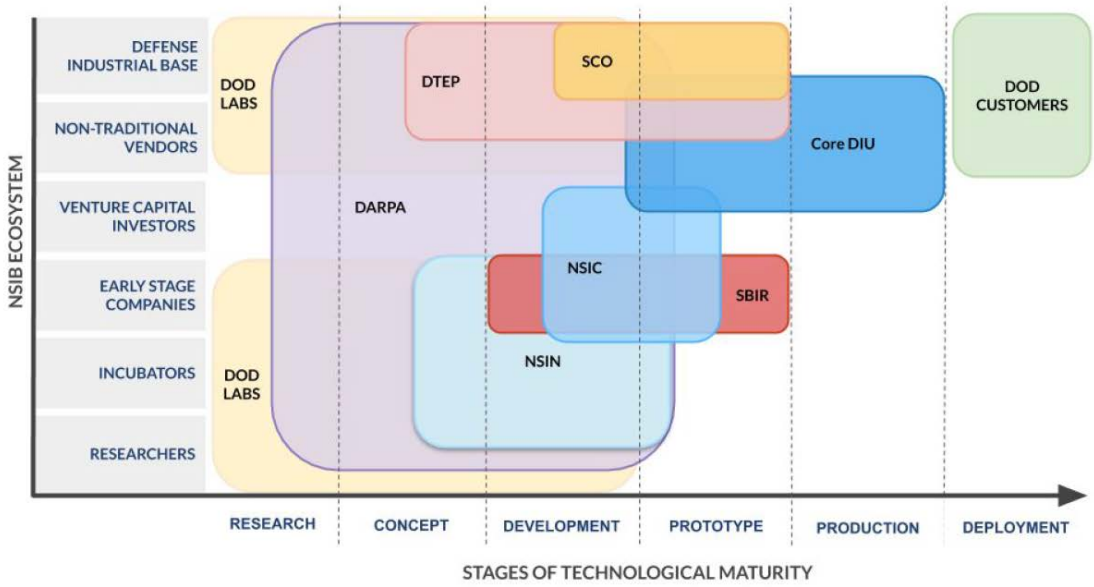
The DoD Believes Commercially-Developed Technology can Contribute to Military Advantage

The first argument for the advent of the defense intermediaries can be understood as a syllogism taking the following form (DIU, 2019):[11]

- Major premise: The DoD believes that it has "maintained decisive military advantage over its adversaries due, in large part, to superior technology capability."
- Minor premise: The DoD believes that "[m]uch of the future technological advantages will be based on capabilities such as autonomous deep learning systems, human-machine collaboration, assisted human operations, human-machine combat teaming, and network-enabled semi-autonomous weapons. The private sector is pioneering the development of most of these advanced dual-use technologies by leveraging software, open source data sets, and advanced processing speed—all primarily for commercial use."
- Conclusion: The DoD believes that the national security innovation base that contributes to military advantage can be made more robust by "exposing more of the commercial industry to national security problems."

Note that this argument pertains to technologies already developed for commercial use and would presumably be modified for military application. Other DoD entities, such as DARPA or DoD laboratories (i.e., Army Research Laboratory, the Naval Research Laboratory, and Air Force Research Laboratory) would continue to conduct and sponsor pure and applied research, conceptualization, and development for military applications. Intermediaries such as DIU, NSIN, and NSIC would provide commercial technology a path into the DoD that does not start at the pure and applied research phase (see Figure 1). This role has been fulfilled to some degree by In-Q-Tel, although it is unclear why it was not included in DIU's conception of its place in DoD technology development.

[11] Owing partially to the efforts of the OSRD, the proportion of R&D performed by non-government entities in the United States was greater than other WWII belligerents (Mowery, 2012, p. 1705). Similarly, the DoD and intelligence community formed a number venture capital-like organizations to access commercial technologies before the current wave of innovation activity (Webb, Guo, Lewis, & Egel, 2014).



Note: DTEP: Developmental Test, Evaluation & Prototyping; SBIR: Small Business Innovation Research; SCO: Strategic Capabilities Office.
Defense Innovation Unit (2019)

Commercial Technology is Best Accessed With the Assistance of Intermediaries

The case for defense intermediaries can also be made by considering the role of specialized knowledge in doing business with the DoD. In a commercial market, frequent feedback from testers and consumers creates a feedback-rich environment that allows developers to quickly match product features to customer demand. In the case of selling to the military, the monopsonist buyer determines product requirements in a much more unilateral way (Schmid, 2018). Further, these requirements tend to be much more stringent than those that would satisfy a consumer market (Alic, Branscomb, Brooks, Carter, & Epstein, 1992). Intermediaries, in this context, could transmit information to the inventor regarding the character of military demand or provide the patient financing required to allow the inventor to meet stringent military technical specifications.

Further, the process of doing business with the military requires specialized knowledge. Complying with the FAR and Defense Federal Acquisition Regulation (DFARS) is costly and would thus likely preclude many nascent firms from selling to the government. This specialized knowledge has already been attained by prime defense contractors. Such contractors have the resources to comply with FAR and DFARS demands, including a high-quality accounting system, certain levels of cybersecurity practices, and the ability to work in a classified setting. This provides an incumbency advantage to firms that have linkages to the DoD and that have learned how to navigate the acquisition system.

Intermediaries could surmount this obstacle by assisting in navigating the administrative portion of selling to the government. In fact, in practice, the new defense innovation intermediaries are successfully performing this boundary-spanning function. For example, DIU has refined an internal capability to enter into streamlined contracting vehicles known as Other Transaction authority (OT) that reduce administrative burden and lead time associated with selling a technology to the DoD.

The organizations on which this study focuses can be understood as resulting from the conclusion of the syllogism described previously. That is, these organizations are means by which the DoD is seeking to leverage the commercial innovation ecosystem in a context in which commercial R&D predominates government R&D in militarily relevant technology sectors. They are

conduits for accessing a pool of innovation resources that is thought to be underutilized for military applications.

Some Aspects of Commercial Intermediation May Not be Suitable for the DoD

While the case for intermediation between commercial technology developers and the DoD is strong, one must be careful not to rely too heavily on the analogy to commercial intermediaries. One critical difference between the commercial innovation system and the defense innovation system relates to tolerance for failure and risk. Ultimately, differences in failure- and risk-tolerance between defense and commercial innovation intermediators are driven by the objectives of the intermediary organizations. Commercial innovation intermediaries seek to maximize owner value and are thus relatively indifferent regarding the particular products that achieve this end. This allows commercial intermediaries to stop supporting or pivot away from unpromising products and to invest in a large portfolio of products in hope for a handful of large payouts. The objective of defense innovation intermediaries, in contrast, is to deliver technology that fills operational needs for the DoD. Defense innovation intermediaries may have some flexibility in terms of how this need is met, but the larger DoD still struggles at times to support such iteration with its contractors (Blume & Parrish, 2019, pp. 8–9). This can limit the extent to which the defense innovation intermediaries can stop supporting or pivot away from a product. Doing so could result in the targeted operational need remaining unfulfilled. Risk-tolerance, and thus engagement approach, for defense innovation intermediaries is thus likely to be lower on average than for commercial intermediaries.

Data and Methods

In this section, we discuss our methods for identifying intermediary functions in commercial and defense innovation systems.

Commercial Innovation Intermediary Functions

Our approach to identifying possible functional gaps within the emerging defense innovation system is to compare the reported functions (i.e., the services that intermediaries claim to provide) of a set of new defense innovation intermediaries to the known functions performed by a set of commercial innovation intermediaries.

To catalog the functions performed by commercial innovation intermediaries, we consult the academic literature on the roles, performance, and operations of particular innovation intermediary types and of commercial innovation intermediaries generally. We rely on the innovation intermediary typology proposed by Clayton, Feldman, and Lowe (2018) to assure broad coverage of major organization types. Table 1 provides Clayon et al.'s typology of four major types of innovation intermediaries as well as the major sub-types of each category and definitions.

Table 1. Commercial Innovation Intermediary Types, Sub-Types, and Definitions

Clayton et al. (2018)

Type	Sub-type	Definition	Included in baseline?
Physical space intermediaries[12]	Incubator	Physical space for start-up formation	Yes
	Accelerator	Cohort-based physical space complemented with programming and investment	Yes
Financial intermediaries	Venture capital firms	Firms that raise funds to invest in high-growth start-ups	Yes
	Angel investors	Individual investors that provide early-stage investment for start-ups	Yes
	Public funding programs	Government-run lending programs that provide financial assistance to new ventures	Yes
	Crowdfunding platforms	Aggregators of large numbers of small investments	No[13]
University intermediaries	Tech. transfer offices	University offices that manage IP of university-developed technology	Yes
Service intermediaries	Professional service firms	Third party firms that provide services to innovators (e.g., law or accounting firms)	No[14]
	Other assisting organizations	Public or non-profit groups that provide networking or specialized programs to start-ups	Yes

From this list, we omit innovation intermediaries for which no military-specific functions are necessary. For example, we do not catalog the functions performed by professional service intermediaries because there is no reason to believe that inventors seeking to engage with the DoD would benefit from a distinct set of such organizations. We also omit crowd-funding innovation intermediaries because, at least in the near to medium term, it is infeasible that advanced technology meant for the DoD will be crowd-funded through public platforms. This leaves seven types of commercial innovation intermediaries from which to gather functional roles: incubators, accelerators, venture capital, angel investors, public-funding programs, university technology transfer offices, and other assisting organizations.

To determine the functions performed by these commercial innovation intermediaries, we search for descriptions of organizational action within the academic literature.[15] When evidence of an action is found, it is documented and described generically. For example, as evidence of a

[12] Clayton et al. (2018) include “co-working spaces” under the category of physical space intermediary. We have omitted this intermediary because the functional contribution of such organizations is entailed in those provided by incubators.

[13] Excluded due to infeasibility of crowd-funding military technology via currently available public crowd-funding platforms.

[14] Excluded because there does not appear to be any plausible case for defense-servicing firms to utilize a set of professional service firms that is distinct from those utilized by the rest of the private sector.

[15] The following journal articles were coded for evidence of intermediary functions: Clayton et al. (2018); Cohen et al. (2019); Siegel et al. (2003); Hathaway (2016).

technology accelerator performing an alumni relationship management function, the following passage from Cohen et al. (2019) is cited: “The program also encourages ongoing networking among ‘alumni’ firms through formal and informal meetings and online platforms” (Cohen et al., 2019, p. 1782).

The result of this process is a list of functions performed by the seven selected types of commercial innovation intermediaries. The functions provided fall into four categories based on the type of resource the intermediary is enabling. Financial functions refer to how an intermediary provides capital to the innovator with whom they engage. For example, angel investors were found to make long-term patient investments in startups. Knowledge functions are those that involve the intermediary transmitting knowledge to the intermediated parties. Illustrative of the knowledge functions are the formal training programs run by many technology accelerators. Network functions are those that involve the intermediary linking parties. An example of a network function is when a university technology transfer office engages with university faculty to identify research that may be commercially valuable. Other functions are functions performed by the intermediary that do not fit into other categories. The functions found to be performed by commercial innovation intermediaries are provided in Table 2.

Table 2. Commercial Innovation Intermediary Functions

Financial	Knowledge	Network	Other Functions
Equity investment (i.e., dilutive)	Articulate demand signal	Alumni relationship management	Cohort-based programming
Non-dilutive investment	Formal education (e.g., mini-MBA)	Engage entrepreneurs and startups	Post-investment support
Patient capital	Internal mentorship (i.e., intermediary as mentor)	Engage university research faculty	Prototyping assistance
	Legal/IP advice	Engage university students	Provide physical space
		Connect to external mentors	Provide support services
		Provide platform/venue or peer-to-peer learning	Select firms via competitive process (i.e., perform a filtering function)
			Agenda setting

Defense Innovation Intermediary Functions

There is no appreciable academic literature on the defense innovation intermediaries. To identify the functions these organizations claim to perform, we look at how the organizations present themselves externally on public-facing websites, reports, and marketing material.

While the source material was more varied for the defense innovation intermediaries, the coding process was identical. For example, as evidence that DIU performs the function of articulating the demand signal, the following texted was cited: “The content presented to the technology firms would be provided by the government entity though DIUx may assist with communicating the issue details” (Wong, 2017, p. 6).[16] Table 3 provides a list of the source

[16] DIU was previously known as Defense Innovation Unit Experimental (DIUx).

material coded to determine the functions claimed to be performed by the defense innovation intermediaries.

Table 3. Sources for Cataloging Defense Intermediary Functions

RAND (n.d.).

Source	Organizational focus
"Report to Congress," DIU, April 2019	DIU-core
"Enhancing ACC Collaboration with DIUx"	DIU-core
"Report to Congress," NSIC, June 2019	DIU-core, NSIN, NSIC
NSIN websites	NSIN
Hatch Website (NSIN accelerator)	NSIN
H4D Website (NSIN program)	NSIN
FedTech Website (NSIN program)	NSIN
DIU website	DIU-core
DIB website	DIB
DIB Charter	DIB

We focus our analysis of defense innovation intermediaries on functions reported to be performed by four organizations: DIU, NSIN, NSIC, and DIB. The first three of these organizations share a common organizational hierarchy and are coordinated in terms of the portion of the research spectrum on which they focus. In terms of organizational structure, all three organizations currently are under the administration of DIU.[17] In terms of the portion of the research spectrum on which they focus, the DIU organizations are explicitly situated on the basic-research/applied-research spectrum of technological maturity.[18] A 2019 report depicts a six-phase technological maturity spectrum comprised of research, concept, development, prototype, production, and deployment (DIU, 2019). NSIN is assigned responsibility of the concept and development phases. NSIC is assigned responsibility for development and prototyping. DIU-core has responsibility for the prototyping and production phases.

The organizations also have differing missions. NSIN attempts to build networks of innovators to solve defense challenges. NSIC seeks to articulate military demand and invest in commercial hardware developers. DIU seeks to accelerate the prototyping and fielding of near-ready commercial technology. DIB is comprised of representatives from technology firms and is primarily an advisory and agenda-setting organization.[19]

[17] In February 2019, the name of MD5 was changed to NSIN, and the organization was placed, along with NSIC, under the umbrella of DIU.

[18] While the DIU organizations are situated around a phases of innovation model, planners appear to have been careful to avoid adopting a naïve linear model (i.e., a model that assumes the automatic transition from basic research to applied research to a final product). For example, the organizations are explicitly organized around a unitary overhead structure and have been designed to promote the flow of information between the phases of innovation.

[19] Our initial survey of DIIs yielded 36 intermediary organizations in the DoD, including 11 founded after Secretary Hagel's 2014 initiative that launched the current wave of defense innovation activities. The number of organizations and their roles raises the question of how efficient or inefficient these efforts are for the DoD.

We select these organizations for several reasons. For one, these organizations are high-profile initiatives into which considerable resources and attention have been invested.[20] More importantly, these organizations fit our study's object of analysis. Namely, these organizations represent new defense innovation intermediaries or organization whose primary mission is to link the civilian innovation system to the DoD. As opposed to organizations such as Kessel Run that have both internal technology development and intermediation mandates, these organizations are each predominantly intermediaries. In other words, from the perspective of the innovation system, the primary functional role of these organizations within the system is to boundary-span: to establish and strengthen ties between other system components. Finally, we select these organizations because there is publicly available information regarding their reported functional contributions. While organizations such as the Strategic Capabilities Office (SCO) and the service-specific rapid capabilities offices are also properly classified as defense intermediaries, much less information regarding their operations is publicly available.

Results

We find DIIs report to provide a large portion of the functions provided by the commercial innovation intermediary baseline. However, we identified three possible gaps in the defense intermediary system.[21] Later, we briefly elaborate these gaps and speculate how they might affect the functioning of the defense innovation intermediary system. To this end, we consider the demonstrated effect of these functions on the commercial innovation system and then attempt to imagine how they, if present, would affect DIIs' goals to introduce more commercially developed technology to the military and strengthen the national security innovation base.

Equity Investment: For certain innovation intermediary types such angel investors and venture capital firms, equity investment—investment in which the investor is given an ownership stake in the firm in exchange for the investment—is the most common financing approach. When an investor takes an equity stake in a firm, the incentives of the investor and the innovator become aligned, although sometimes imperfectly. From the perspective of the innovator, equity investment can be attractive because the investment does not impose a cash flow burden on the firm as it grows. From the investor's perspective, in contrast to a conventional loan where the investor's upside is limited by the terms of the loan, equity investment is attractive because the investment's upside is unlimited.

While it is impossible to determine with precision the effect that the absence of an equity investment function has on the efficacy of the defense intermediary innovation system, the absence of a major channel of investment funding would likely to result in a capital-scarce environment for firms that want to do business with the DoD. Thus, capital scarcity would limit the pipeline of technologies developed with a military buyer in mind by limiting the number of technologies that receive investment. Further, the absence of an equity investment function would limit the upside available to intermediaries and thus their growth and self-sustainability potential. Allowing a defense innovation intermediary to take an equity stake could increase the aggregate

[20] The last three years of appropriations to DIU-Core were USD $10 million (2017), USD $41 million (2018), and USD $71 million (2019). In 2019, $75 million and $25 million were appropriated to NSIC and NSIN, respectively (DIU, 2019).

[21] Gaps represent services not available to innovators seeking to do business with the DoD. The existence of a gap should be interpreted not as clear-cut evidence of a need to expand the offerings of existing defense innovation intermediaries, or to create new organization, but rather areas on which future research should focus. The Appendix provides additional detail regarding the evidence that was used to document a function as being performed by a defense innovation intermediary.

capital resources available to defense innovation intermediaries and thus increase the extent of their capacity to engage with the commercial sector.[22]

Patient Capital: Often provided by angel investors or family offices, patient capital represents long-term, often equity-based, financing that is relatively insensitive to short-term perturbations in the fortune of the innovator.[23] Relative to other types of financing, patient capital is particularly effective in funding innovation. Innovation involves uncertainty, and successful innovations are often preceded by multiple product iterations or product failures. If an innovation is funded only through short-term financing approaches or ones that kill projects early on in the development process, innovations that require several iterations will never emerge. The salutary effect of patient funding streams on innovation has been demonstrated empirically. Azoulay, Graff Zivin, and Manso (2011) find that science funded by the Howard Hughes Medical Institute—an organization that provides long-term, grant-based, funding that is tolerant of early failure—is more creative and impactful than that which is funded through short-term channels that kill projects that fail to meet early deliverable deadlines (Azoulay et al., 2011).

There is reason to believe that the absence of patient capital in the emerging defense innovation intermediary system would affect what types of technologies are supported. Weapons systems tend to have very high performance requirements. Achieving these is likely to increase the average duration and duration variability of the product development cycle. Thus, the absence of long-term financing for the new entrants targeted by the new defense intermediaries would result in forgoing projects with long or uncertain development processes or a positive bias for projects that are low-risk and have short and predictable development timelines.

Alumni Relationship Management: Many of the functions provided by innovation intermediaries are provided for a temporary period and then cease once the innovator reaches a given milestone. This approach to service provision results in an ever-growing supply of alumni firms: firms that have completed a program provided by an innovation intermediary. These alumni firms have been found to be a valuable resource to firms at earlier stages of growth, and thus the management of this alumni network represents a valuable intermediary function in itself. Given the particularly important role of specialized knowledge (e.g., understanding military demand, negotiating OTAs, navigating the FAR and DFAR) to selling technology to the military, the benefit of alumni networks that can supply this knowledge to new entrants might be even greater for defense-servicing firms than for civilian-focused ones.

Discussion

These results suggest that additional scrutiny into possible functional gaps within the DII system is warranted. However, three issues should be explored before considering policy changes:

- Analysis could benefit from improved data on DII activities
- Some gaps identified may not need to be filled
- Test the assumption that commercial innovation should be fully emulated

[22] A government-facing innovation intermediary taking an equity stake in firms is not without precedent. In-Q-tel, a private equity organization that seeks to supply commercial technology to the intelligence community, has enjoyed success using this model.

[23] Often the distinction between patient capital and equity investment is not clearly delineated, as equity investors can also use relatively long investment time horizons. We make the distinction here to underscore the link between tolerance for early failure and innovation.

This section will discuss these considerations in detail.

Analysis Could Benefit From Improved Data on DII Activities

These results are limited to analysis based on publicly observable functions of DIIs. These functions are articulated by the DIIs through their public-facing documents and self-reporting but may not fully characterize the full scope of their actual activities. For instance, it is conceivable that a DII was not initially designed to conduct alumni relationship management but may actually undertake it in the course of their operations in ways that are not described in the data sources used for this analysis (i.e., a false positive). It is also possible that the DIIs considered here, in fact, do not perform some of the functions reported in publicly available resources. This would result is a failure to identify a true gap (i.e., a false negative).

However, the mission of defense innovation intermediaries to link inventors to the DoD may incentivize the complete disclosure of their activities. Inventors may need a range of intermediary functions to establish and grow a connection with the DoD; DIIs need to ensure that these inventors are aware of their services. This may moderate any tendency to omit or obscure a DII function. In any case, further research with direct access to DIIs for observation and expert interviews can help clarify this.

Additional data would also allow for a more precise characterization of how individual functions are performed. In this study, we treat the functions performed by intermediaries as binary. Functions for which we find evidence are coded as present, those for which no evidence is found are coded as absent. In practice, however, there is likely to be inter-organization heterogeneity in the quality in which a given function is performed.

Some Gaps Identified May Not Need to be Filled

In some cases, features of the commercial innovation ecosystem may create undesirable outcomes if applied to defense. For instance, equity investment aligns investor and innovator incentives, but only around the success of the innovator's product or firm. This may be problematic because the defense investor should be most motivated to solve the problem, of which the innovator's product is only one potential solution. Equity investments may align incentives, but not around the mission and defense problem at hand.

Additionally, some functionality present in the commercial innovation ecosystem may not be compatible for a public sector organization. For instance, the DoD may not wish to make an equity investment in a firm developing a technology with dual-use implications. The federal government may wish to preserve its role in preserving a fair and competitive market, applying its resources only to address market failures such as in the case for public goods, addressing externalities, natural monopolies, or rectifying information asymmetries (Weimer & Vining, 2011). Traditional defense R&D and procurement activities address these issues of market fairness through the FAR and DFAR, but these regulations are the very ones that DIIs believe impede the DoD's access to new dual-use technologies. Avoiding equity investments in certain cases may be a means of balancing these competing priorities.

Test the Assumption That Commercial Innovation Should be Fully Emulated

Lastly, this research does not fully explore the assumption that the commercial innovation ecosystem is a model to be strictly emulated. The empirical innovation literature highlights the positive effects of innovation intermediaries on firm-level outcomes, such as firm valuation (Cohen et al., 2019), firm survival generally (Engel, 2002), patents granted (Samila & Sorenson, 2010), and reduction of client transaction costs (Gilson, 1984). Commercial intermediary functions were presumably designed and then optimized to yield these results, which focus on the benefit to innovative firms, not their customers.

The purpose of the defense innovation ecosystem is more expansive. There is some alignment between the purpose of commercial intermediaries (firm success) and the 2018 NDS, which specifically highlights the need to protect the national security innovation base

(DoD, 2018). However, protecting that innovation base is a means to a greater end: build a more effective military force by harnessing emerging technology. Since the defense innovation ecosystem's goals are more expansive than the commercial one, it raises a question for future research: How fully should DIIs emulate commercial innovation intermediaries?

Conclusion

This research explores the roles of defense innovation intermediaries (DIIs). DIIs are an increasingly prominent feature of the DoD's research, development, and acquisition efforts and are meant to improve the linkages between the DoD and innovative commercial firms developing technologies with civilian and military implications.

DIIs appear to emulate the commercial innovation ecosystem, but previous research does not systematically explore the degree of that emulation or its appropriateness to the DoD's goals. This research compares DII and commercial innovation intermediary functions using publicly available information on both. We find that DIIs may lack three functions present in the commercial analogue:

- **Equity investment** to align commercial innovator and DoD goals
- **Patient capital** to support long-term, iterative product development efforts
- **Alumni relationship management** to build on successful interactions between firms and the DoD

This research also identifies several considerations policy-makers should weigh when considering the utility of filling these functional gaps. First, this analysis is based on publicly available data on DIIs; access to DIIs themselves may yield additional data, results, and insight. Furthermore, policy-makers should more rigorously consider why some gaps exist. Some gaps such as equity investments for certain technologies may not be appropriate for filling. Lastly, policy-makers should systematically consider the merit of emulating the commercial innovation ecosystem for national security purposes.

Agenda for Future DII Research

Given the paucity of recent systematic research on the DII system, this study was designed to be exploratory. To this end, we sought to identify a set of analytically tractable and defense policy–relevant research questions that would allow defense planners and security researchers to more rigorously characterize the functioning and efficacy of the system, and individual system components, described here. At least three research questions stand out as likely to yield productive results.

Is the current DII system appropriately designed to achieve its intended objectives? The previous section observed that seeking strict functional matching between the commercial and defense intermediary systems may not be optimal for realizing DII objectives. Logic models have shown to be a fruitful method for tracing the complex set of inputs and processes that are meant to drive organizational objectives (Greenfield, 2006; Landree & Silberglitt, 2018). To determine whether the current DII system is aligned with its objectives, we recommend a systematic investigation into how each organization's operations are linked to their strategic objectives.

Is the current DII system, or its constituent organizations, effective? While organizations such as NSIN and NSIC are too new to yield sufficient data to allow for a thorough performance evaluation, other DIIs have long enough tenures to allow for performance evaluation. For example, DIU, founded in 2015, is a strong candidate for evaluation. DIU's long-term viability will depend largely on two factors: DIU's ability to transition useful technologies to the military services and DIU's ability to continually engage the private sector in R&D and prototyping contracts. We recommend a study to evaluate DIU's performance on these two dimensions. To evaluate the demand side (i.e., DIU's success in transitioning technologies to the military services), we recommend investigating the current status of all DIU-funded programs. Interviews with individuals

from the military services that engage with DIU will supplement this demand-side analysis. To evaluate DIU's success in engaging the private sector, we recommend a survey of the experiences of both funded and non-funded firms regarding their engagement with DIU.

Where does the United States stand, relative to China, in its overall efforts to integrate civilian innovation into its military? Motivated by similar circumstances as the United States, China has initiated a set of policies seeking to leverage its domestic commercial innovative and productive energy for military ends. These initiatives—known collectively as civilian–military integration or civilian–military fusion (CMF)—seek to erode barriers between the civilian and defense spheres and take advantage of China's increasingly technologically sophisticated private sector.[24] Lafferty (2019) summarizes the objective of civilian–military fusion, stating that it "seeks to dramatically increase cross-fertilization and sharing between military and civilian institutions in a growing spectrum of activities like technology development, logistics, finance, and training" (p. 632).

Viewed in the context of strategic competition between the United States and China, China's CMF efforts and U.S. attempts to access its commercial innovation resources through intermediation assume additional import. Both states rightly recognize that the bulk of leading-edge innovation activity that they host is located in the dynamic clusters of firms centered around cities such as Silicon Valley, Boston, Shenzhen, and Beijing. CMF and the new defense intermediaries represent conduits through which each state's respective militaries can take advantage of this innovation activity. Integration can be measured in several ways, including the flows of resources (personnel, financial, ownership) between traditional and non-traditional military contractors, the concentration of military procurement spending across firms, and the number of firms participating in the system. We recommend the development, and population, of measurement framework for assessing the extent of civilian–military integration in China relative to that of the United States.

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[24] Illustrative of the intended outcome of CMF is China's 2017 "New Generation Artificial Intelligence Development Plan," which is geared towards assuring that commercially developed artificial intelligence advancements can be leveraged for military purposes.

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Appendix: Examples of Evidence Used to Demonstrate Defense Innovation Intermediary Functions

Table A.1: Examples of Evidence Used to Demonstrate Defense Innovation Intermediary Functions

Rand (n.d.)

	Function	Performed by	Example of evidence[25]
Financial	Equity investment (i.e., dilutive)	No evidence of function	
	Non-dilutive investment	DIU-core	“non-dilutive capital investment that preserves the equity stake” (Wong, 2017, p. 3)
	Patient capital	No evidence of function	
	Knowledge		
	Articulate demand signal	DIU-core, NSIN, NISC	“The National Security Innovation Capital (NSIC) will both provide a strong demand signal” (NSIN Report to Congress, 2019, p. 3)
	Formal education (e.g., mini-MBA)	NSIN, NISC	"Provide advisory services; security consultations; management coaching" (NSIN Report to Congress, 2019, p. 9)
	Internal mentorship (i.e., intermediary as mentor)	NSIN	"Throughout the program, participants will be given continual support from NSIN and special access to defense mentors within the Founder Institute network." (Website, Hatch)
	Legal/IP advice	No evidence of function	"This often involves initiating discussions with you about a licensing deal" (Website, FedTech)
Network	Alumni relationship management	No evidence of function	
	Engage entrepreneurs and startups	DIU-core, NSIN, NISC	“Curating DoD challenges for early stage companies, students, and faculty from academia to prototype novel concepts and solutions to current warfighter challenges” (DIU Report to Congress, 2019, p. 29)
	Engage university research faculty	NSIN	“Leading research universities partner with NSIN to develop novel solutions to national security needs by hosting a hackathon. Participation in a hackathon helps the university, its students, and faculty members deepen knowledge of

[25] In consideration of space, in cases where more than one organization was found to execute the function, this table provides just a single example.

			civil-military market opportunities, explore collaborative problem-solving, and position new ventures for national security applications."
	Engage university students	NSIN	"H4D pairs DoD end users with top university students for collaborative problem-solving over the course of an academic semester." (website, H4D)
	Connect to external mentors	NSIN, NSIC	"Through a multi-month process, with the guidance of commercial mentors and DoD liaisons, cohort members improve their technology, strengthen their understanding of customer needs, and build their team into a viable business." (Description of Propel program, NSIN website)
	Provide platform/venue or peer-to-peer learning	NSIN	"Through a multi-month process, with the guidance of commercial mentors and DoD liaisons, cohort members improve their technology, strengthen their understanding of customer needs, and build their team into a viable business." (Description of Propel program, NSIN website)
Other	Cohort-based programming	NSIN	"The FedTech cohort participants are selected through a highly competitive process." (Website, FedTech)
	Post-investment support	NSIN	See Figure 3 (NSIN report to Congress, 2019, p. 9)
	Prototyping assistance	DIU-core, NSIN	""DIU has a strategic partnership with JAIC wherein DIU's prototype AI applications assess proven commercial solutions applicability to military missions" (DIU Report to Congress, 2019, p. 33)
	Provide physical space	NSIN	"The cohort spends 15 hours per week in classroom sessions, collaborative work, and interacting with real end users." (Website, FedTech)
	Provide support services	NSIN	See Figure 3 (NSIN Report to Congress, 2019, p. 9)
	Select firms via competitive process (i.e., perform a filtering function)	NSIN	"The FedTech cohort participants are selected through a highly competitive process." (Website, FedTech)
	Agenda setting	DIB	See, for example, recommendations on DIB website, https://innovation.defense.gov/Recommendations/

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