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Defense promotion and industrial development

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Abstract
Major economies are rearming, and rearmament is itself industrial policy. I ask whether defense promotion—especially innovation policy—can drive industrial development beyond the defense sector. I synthesize evidence on supply-side instruments (including R&D tax credits and grants) and demand-side procurement, tracing each from its effects on firms' own R&D investment through innovation and productivity outcomes to spillovers beyond the recipient firm. The evidence is conditionally positive: public support more often crowds private effort in than out, but returns concentrate among particular firms, technologies, and designs, and weaken as one moves from investment to outputs and from civilian to defense settings. Defense spillovers, in particular, cannot be assumed. I draw five lessons for designing defense industrial policy that delivers broader economic returns, with the greatest weight on Europe's rearmament. The developmental promise of defense promotion is real but conditional: whether rearmament also strengthens the wider industrial economy turns on how it is designed.

Keywords: defense economics; industrial policy; innovation policy; R&D; procurement; EU
JEL codes: H57; L52; O25; H56; O38

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1 Introduction

Major global economies are rearming, and doing so requires shaping the industrial economy. Driven by geopolitical shocks, military spending has surged across advanced economies through the 2020s (Liang et al., 2026). Among the most salient examples, the EU has embarked on an expansive rearmament drive. The European Union's Readiness 2030 initiative aims to mobilize as much as €800 billion to rebuild military-industrial capacity, backed by a myriad of instruments, including the European Defence Industry Programme and the European Defence Industrial Strategy (European Commission, 2025b). The defense industrial push arrives amid Europe's economic malaise, one marked by eroding competitiveness and an eroding innovative edge, which Letta (2024) and Draghi (2024) have made central to Europe's economic future. Can defense drives, like Europe's rearmament, hasten industrial development?

Industrial policy is often a keystone of defense promotion. After all, building domestic military capability requires the material and productive forces to sustain it; it involves a myriad of economic decisions, from directing investment and pushing types of technologies to building production capacity. Such state action to shape the structure of the economy is, by definition, industrial policy (Juhász, Lane, and Rodrik, 2024). Defense-industry promotion does not happen in a vacuum but can often spill over to the rest of the economy. Thus, the choices behind defense promotion can have important consequences for industrial development. However, the degree to which defense promotion can deliver development ambitions is neither incidental nor fixed. It hinges on the conditions and parameters of industrial policy design. If defense promotion is to confer broader economic benefits—greater externalities and social returns—design is essential.

This study examines how defense industrial policy, especially innovation policy, can promote broader industrial development. I focus on instruments aimed at R&D, technological change, and industrial upgrading. This emphasis is practical and economic. Defense procurement and development require sophistication, which is a central objective of many defense industrial policies. The U.S. Department of Defense (DoD) alone accounted for 41% of all federal R&D obligations in FY 2019 (Pece et al., 2022); it also supplies the world's military hardware. Europe, by contrast, sends 78% of its procurement abroad (European Commission, 2024). Its rearmament ambitions hinge on building the technological base and industrial capability to bring this spending home. As the Draghi Report makes clear, technological catch-up is also central to Europe's long-run economic goals. I synthesize evidence on public innovation and technology policies close to—though not exclusively—defense. The current rearmament is global, and so is this paper, with particular weight on Europe. The evidence points to the essential role of design.

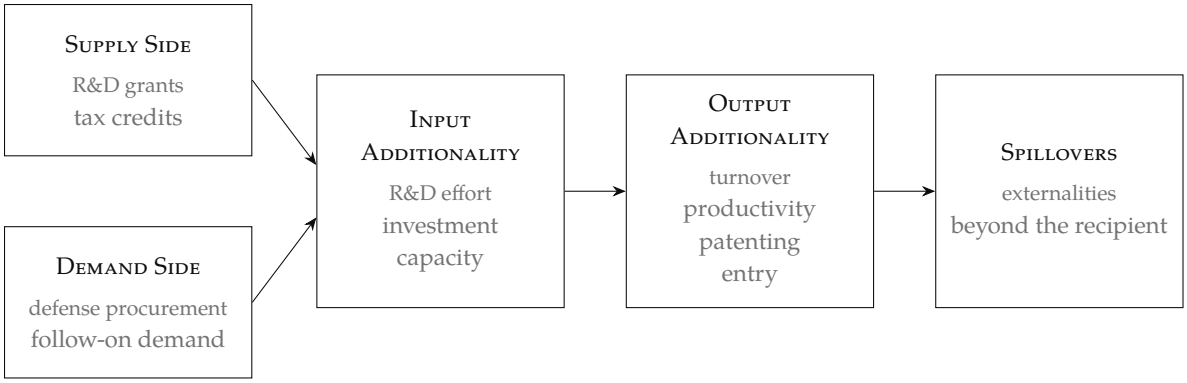

Figure 1. Instruments and the industrial policy chain. Supply- and demand-side policies trace a chain from input additionality to output additionality and, ultimately, to spillovers beyond the recipient.

Empirical research on innovation-oriented industrial policy has quickly shifted from *whether* to *how*. This paper is thus not about litigating whether such interventions work, but about understanding their variation, what that variation tells us about policy practice, and how to square this work with defense promotion.

I organize the evidence along two axes: the policy instrument and the stage of the causal chain where its effects appear (Figure 1). On the first, I distinguish supply-side policies (e.g., directed R&D grants) from demand-side policies (e.g., procurement and guaranteed demand). On the second, I follow each instrument along the policy chain: from *i*) *input additionality*—whether policy crowds in or crowds out private R&D and investment—through *ii*) *output additionality* in industrial outcomes such as turnover, productivity, and patenting, to *iii*) *spillovers*: externalities beyond the recipient firm. The first two links (i–ii) concern firm-level effects, whereas the last (iii) concerns broader impacts. Evidence from this final step is both important and speculative, especially for defense; I therefore dedicate a separate section to spillovers and their ultimate social returns (Section 4.1).

Demand-side policies—especially procurement—are also central to defense promotion. Yet until recently, procurement drew far less scholarly attention than supply-side policy (see Chiappinelli, Giuffrida, et al., 2025). This neglect is perplexing given their scale. Procurement accounts for nearly 14% of GDP, or some €2 trillion, each year across EU economies (European Commission, 2025a).[1] Europe's rearmament has made this still

1 Recent estimates for the EU are even larger; across OECD economies, procurement averages roughly 13% of GDP (OECD, 2025).

more salient, accelerating a shift from clearly supply-side policies toward ones that also engage the potential—and necessity—of demand-side policy. The rise of these "harder" procurement policies comes as Europe's fragmented procurement regime is seen as a bottleneck to industrial development (Draghi, 2024).

The punchline of this study is that the developmental promise of policy is conditional: it hinges on policy choice and design. Contemporary work shows the *potential* of public policies—civilian and defense-led—to promote industrial development, yet the evidence is context-dependent and uneven, mostly in quantity, across the stages of production in Figure 1.[2] First, evidence on the impact of industrial policies on (i) inputs is strongest: interventions can promote additional private investment in innovation and capital, and crowding out is by far the exception, not the rule. Second, evidence on output additionality, while promising, is sparser. Policies do move real outcomes—patenting, productivity, new-firm entry—yet the literature is more heterogeneous and diffuse. Third, evidence on spillovers, while difficult to measure, shows the potential for positive policy externalities and, increasingly, substantial social returns from public R&D policy. Across the three slices of evidence, modal results belie important heterogeneity; the impacts and returns to policy are concentrated among specific types of firms, technologies, products, and sectors. This heterogeneity is not a confounder, however. This paper argues that it directly informs how to build defense industrial policy that does *more*. Where public R&D policy—and defense policy in particular—produces social returns, they will result from engineering, not economic gravity.

Although evidence continues to point to social returns from public R&D interventions and innovation-oriented industrial policies, it does not establish spillovers from defense. Pessimism about spillovers from defense industrial policies has a long conceptual—and empirical—history. Among other things, the clandestine nature of production and the specificity of technologies and outputs work against the idea that greater industrial externalities are a given. Where evidence on broader public policies is optimistic, contemporary evidence on defense remains incomplete and conflicting. For the EU and others pursuing industrial development, this pessimism is a useful baseline, and empirical heterogeneity indicates where to focus. Put differently, pessimism is a productive prior, but not the posterior.

I provide five lessons for more beneficial interventions (Table 1). First, empirical research shows that targeting matters. Across instruments, average policy effects conceal deep heterogeneity in firm responses, pointing to firm-level constraints as an important factor. This heterogeneity implies more focused, rather than horizontal, policies. Although

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2 It is worth being clear at the top. Throughout this study, it is important not to conflate the quantity of evidence with the precision of evidence. In other words, "absence of evidence is not evidence of absence".

targeting may seem radical, the rationale is vanilla economics: target policy where constraints bind. Second, taking frictions seriously means going beyond financial resources. New entrants and dual-use technology adoption face large informational and institutional constraints, and the EU must build an innovation ecosystem that bridges commercial technology and procurement, as NATO's Defence Innovation Accelerator for the North Atlantic (DIANA) does. Third, procurement does more than produce mechanical demand; it can dynamically promote industrial development and innovation. Evidence shows that its payoff hinges on design choices, including guaranteed demand, supply-side complementarities, and SME entry. Fourth, we cannot assume spillovers from defense are inevitable; they must be engineered by tilting policy toward high-spillover activities and attending to the connective tissue between the civilian and defense economies. Fifth, administrative capacity underwrites each of these lessons; investment in skilled administrators and organizational capacity will be instrumental.

The remainder of the paper is organized as follows. Section 2 examines supply-side instruments—R&D tax credits and direct grants—tracing their effects from input to output additionality and the firm-level heterogeneity that conditions both. Section 3 turns to the demand side, where procurement and guaranteed demand can act as developmental instruments whose payoff depends on design. Section 4 takes up the social returns and spillovers that reach beyond the recipient firm, and asks whether defense spillovers are different in kind. Section 5 distills the lessons for policy, and Section 6 concludes.

2 Supply Side Policy

I start with supply-side instruments and consider how innovation-oriented industrial policies affect firm-level development. These are among the best-evidenced instruments in industrial policy, making them a natural starting point and benchmark. I organize this deep literature along two dimensions: i) tax incentives versus grants, and ii) the stage of production, tracing effects from upstream input additionality to downstream innovation and firm-level outputs. The answer is conditionally positive: well-designed credits and grants crowd private R&D *in* rather than out. However, empirical certainty weakens as one moves from input to output outcomes, and still further from civilian settings to defense-specific claims.

Innovation policy is among the most empirically studied areas of industrial policy, and its conceptual case is canonical: knowledge spillovers make R&D imperfectly appropriable, private returns fall short of social returns, and firms underinvest in innovation. Financing

frictions may compound this underinvestment, making innovative activity especially costly for small and young firms (Hall and Lerner, 2010). However, the case against is just as canonical, centering on long-standing concerns about crowding out: public support may substitute for private innovative activity rather than add to it, and early empirical work suggested these concerns were first-order (see Wallsten, 2000; Goolsbee, 1998).

Despite early crowding-out pessimism, current evidence suggests that well-designed supply-side innovation policy crowds *in* private R&D investment—generating input additionality—with effects extending to downstream outcomes such as patents and industrial upgrading (Bloom, Van Reenen, et al., 2019; Becker, 2015; Becker, 2019a; Becker, 2019b). On R&D spending and investment, evidence rejects crowding out and strongly favors crowding in. For outputs, effects are positive but more heterogeneous, as qualitative reviews and meta-analyses document.[3] The debate has thus evolved from "does public innovation policy work?" to "for whom, on which outcome margin, over what horizon, and through which instrument?"

Two features of the supply-side evidence condition what we learn about defense-specific policies. First, much of it comes from civilian contexts. Many studies, especially on tax credits, do not—or cannot—differentiate civilian from defense settings. When defense-specific supply-side policy is studied, it is usually through discretionary subsidies and grant programs, such as the U.S. Small Business Innovation Research (SBIR) program. Yet limited defense-focused studies, such as Moretti et al. (2025), support crowding-in effects at both the country and firm levels. Still, this section's relevance for defense lies mainly in principles and lessons, though grant-level evidence suggests strong overlap between civilian and defense settings. Second, the magnitude of the policy response depends on which firms receive support. I therefore begin with tax credits, which provide a benchmark for discretionary grants, the instruments most applicable to defense.

2.1 Tax Credits

R&D tax credits are the OECD's most widely deployed supply-side innovation instrument and the best studied. The weight of evidence supports their effects, strongly for inputs and more tentatively for outputs. Heterogeneity in these estimates is not simply a matter of samples and methods but of design, especially how well a program targets the most responsive firms, a question I take up directly in Section 2.3.

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3 Meta-regression analyses of the evaluation literature reach the same verdict: the modal estimate rejects crowding out, and additionality is positive on average but heterogeneous across instruments, industries, and study designs (Castellacci and Lie, 2015; Dimos and Pugh, 2016; Dimos, Pugh, et al., 2022).

Input Additionality

The best firm-level evidence rejects crowding out and shows that private R&D spending rises substantially in response to tax credits (Hall, Mairesse, et al., 2010; Bloom, Van Reenen, et al., 2019; Hall, 2022). Quasi-experimental studies using reforms to the UK's R&D tax incentives estimate elasticities between −1.6 and −4 over 2002–2011 (Guceri and Liu, 2019; Dechezleprêtre et al., 2016; Dechezleprêtre et al., 2023). These elasticities have large aggregate implications: Dechezleprêtre et al. (2016) calculates that UK business R&D would have been roughly 10% lower without the policy.

Crowding-in is not unique to any one setting, but it is observed in R&D tax policies across the globe. For the US, using IRS microdata, Rao (2016) estimates an elasticity of around −2, and state-level credits show crowding-in at both the firm and aggregate levels (Balsmeier et al., 2024; Melnik and Smyth, 2024). Comparable elasticities appear in Australia (Thomson, 2017), Canada (Agrawal et al., 2020), Ireland (Acheson and Malone, 2020), and Japan (Kasahara et al., 2014).

But the growing body of evidence does more than confirm crowding-in; it points to clear heterogeneity across firm size and industries. This heterogeneity is not merely methodological; it is substantive, revealing differences in firm responses and policy design (see Rao and Simcoe, 2026). These considerations are relevant for the EU, where R&D tax credits are a significant industrial policy instrument.

Appelt et al. (2025) use OECD-wide data to show how heterogeneity is tied to design. Because tax credits are broad instruments, they do not finely target the firms with the strongest behavioral responses. Across regimes, a substantial share of fiscal outlays goes to firms or projects with low additionality. For that reason, the OECD-wide elasticity is around −0.6, below many micro-level elasticities recovered in quasi-experimental settings. This gap is not a contradiction but a feature of policy incidence: a credit can generate large responses where it bites and still produce modest policy-wide additionality when support is spread broadly. The design question is not simply whether firms respond somewhere, but whether support reaches the most responsive firms.

If R&D tax credits raise R&D spending, are those outlays real? That is, does spending reflect actual research effort, or simply *relabeling*: the reclassification of existing spending to qualify for tax credits? Chen et al. (2021) study China's notch-based corporate tax regime and, while finding additionality, estimate that roughly 24% of the reported R&D increase reflects relabeling rather than new research activity. Since input elasticities are often computed using reported R&D, this flags an important methodological and design question. New micro-level studies have begun to test for relabeling, rejecting it in estimates by Agrawal et al. (2020) for Canada and Guceri and Liu (2019) for the UK.

Despite early pessimism, the literature broadly supports the conclusion that R&D tax credits crowd in private R&D investment. Yet if the goal is industrial development, new private R&D is only the first step. Does input additionality translate into output additionality?

Output Additionality

R&D spending is rarely the ultimate object of innovation policy. The deeper aim is for additional private R&D to become innovation outputs and real firm outcomes, or output additionality. Evidence on this question is less developed than evidence on input additionality reviewed above (Section 2.1), partly because output is measured across many margins. Still, the evidence is broadly supportive: R&D tax credits appear to raise downstream innovation and firm outcomes.

By construction, evidence on output should be more diffuse. Where input additionality has a reasonable measure—private R&D outlays—output additionality takes many forms. It is also a second-stage effect: tax credits must first induce genuinely additional R&D, and that extra R&D must then translate into patents, turnover, and more. If much of the credit finances inframarginal, relabeled, or weakly responsive spending, downstream gains will likely be correspondingly weaker.

Emerging work shows that R&D tax credits raise innovation outputs, though on different margins across settings.[4] Dechezleprêtre et al. (2023) document sustained gains in quality-adjusted patenting among UK SMEs and spillovers to technologically proximate firms (Dechezleprêtre et al., 2016). Liu (2026) find that UK R&D tax credits are associated with product and process innovation, with evidence of radical rather than merely incremental innovation. Czarnitzki, Hanel, et al. (2011) estimates that Canada's federal and provincial R&D tax credits raise new products, their sales share, and innovations new to domestic and world markets, but not profitability. Cappelen et al. (2012) find that Norway's SkatteFUNN scheme increases new products and processes, but not patent counts. Thus, patenting responds in some settings, while product and process innovation respond in all four.

The same design logic that shapes input additionality also shapes output additionality. Eligibility rules, take-up frictions, targeting choices, and other design features determine which firms a credit reaches and how they respond. Consider studies of US *state* tax policies: although all detect input additionality, output effects vary (e.g., Kao, 2018; Balsmeier et al., 2024; Melnik and Smyth, 2024). Both Balsmeier et al. (2024) and Melnik

[4] A related literature shows that corporate taxes more broadly also affect innovation outcomes (Atanassov and Liu, 2020).

and Smyth (2024) study US state-level credits, but they examine different outcomes and aggregate behavioral responses differently. Melnik and Smyth (2024) explain why their estimates for aggregate patents are smaller than UK estimates, such as those in Dechezleprêtre et al. (2023). US state credits are less targeted: marginal incentives are weaker, and eligibility extends to firms whose R&D may occur outside the state, so part of the credit subsidizes out-of-state activity. Sample composition compounds the design problem, since large firms dominate state-level aggregates and tend to be less responsive at the margin. Thus, a mechanism similar to that identified on the input side (e.g., Appelt et al., 2025) also holds for outputs: weak targeting attenuates responses.

Administrative data show that broad tax instruments can miss the firms most responsive to policy. Using registry data on the near-universe of Norwegian enterprises (2002–2013), Nilsen et al. (2020) find that the SkatteFUNN tax credit generates large output additionality among R&D starters (i.e., firms new to R&D): each NOK of support yields roughly 3.2–3.5 NOK in additional value added. Yet these effects are muted among R&D-experienced firms, where most of the budget is spent. Thus, credits are spread across firms with sharply different marginal responses, with the bulk flowing to the least responsive firms. This mismatch suggests the potential for more targeted tax instruments.

Together, the evidence on tax policy supports input additionality and also shows positive effects on outputs. Yet variation in the estimates above reflects much more than methodology; it reflects, in part, the degree to which policies flow to the most responsive firms. For tax instruments, there may be limits to how finely tax credits can be directed toward the right firms and activities. These limits thus introduce the possibility of more discretionary instruments, such as grants and direct subsidies.

While broadly useful, there are limits to how much this evidence directly applies to defense promotion. After all, the R&D tax policies herein are civilian in scope, and so is the evidence. Nevertheless, other supply-side instruments, such as grants, speak more directly to defense activity. We turn to these next.

2.2 Grants and Directed Subsidies

Relative to broad rule-based tax instruments, grants and direct subsidies for R&D are discretionary and targeted. This selectivity lets funding agencies direct research toward specific technologies or missions, with conditions tied to stated objectives. Grants are therefore potentially powerful tools in strategic domains and an important component of

defense and dual-use policy. A canonical example is the US SBIR program, which reserves a fraction of federal R&D agencies' budgets for competitive grants to small firms.[5]

The weight of evidence for grants and subsidies, while still emerging, is largely positive. Unlike R&D tax credits, evidence on direct instruments spans a wide range of program types (e.g., matching grants, marginal subsidies, and lump-sum grants) with varied objectives and channels. This naturally limits the comparability of elasticities and estimates. However, as with tax-policy evidence, sharper research designs and more granular data now provide evidence on input additionality and investment outcomes, as well as firm-level industrial development outcomes.

Input Additionality

Despite structural differences, grants are often evaluated like tax credits. Yet R&D spending is a cleaner signal for tax credits: by lowering the cost of eligible R&D, credits make reported R&D a natural response measure. Grants are more heterogeneous; some directly reduce research costs, while others determine which projects proceed, when firms invest, and whether they can finance complementary activities. Competitive grants may also fund activities that only partly enter standard R&D accounts. For example, DOE Phase I SBIR grants can be spent across numerous activities, not merely R&D. Thus, grant dollars need not appear one-for-one in measured R&D, and a modest spending response does not, by itself, imply weak impact.

Nevertheless, evidence across the globe consistently finds that R&D grants generate additionality in R&D spending and related investment. Pless (2026), in detailed work on the UK's Innovate UK scheme, finds that grants double R&D spending for eligible SMEs. Irish recipients show the same boost (Lenihan et al., 2024), as do German start-ups, where grants also crowd in intangible-asset investment (Hottenrott and Richstein, 2020). Place-based EU grant programs point in the same direction. Using geographic variation, Einiö (2014) studies Finnish R&D grants allocated by Tekes, the state innovation agency, under European Regional Development Fund rules, and estimates €1.40 of induced R&D investment per subsidy euro. Evidence of crowding-in also appears across Italian regional programs and EU structural funds (Bellucci et al., 2019; Cerqua and Pellegrini, 2014; Muraközy and Telegdy, 2023), albeit with heterogeneity.

Grants can also drive investment beyond conventional R&D. EU studies find that grants are associated with increased investment across asset classes, with the largest gains in intangible assets. Santoleri et al. (2024), using data from the EU's Small and Medium

5 Especially for the early stages of multiphase SBIR programs.

Enterprise (SME) Instrument and award discontinuities as identifying variation, finds that R&D grants substantially increased investment among winners, with gains concentrated in intangible assets. Mulier and Samarin (2021) study for-profit firms that received subsidies from Horizon 2020, the EU's flagship research and innovation program, and find that subsidized firms invested 13.9% more in tangible assets and 32.8% more in intangible assets than matched controls.

Targeted grants can also crowd in subsequent private capital. Howell (2017) shows that Phase I SBIR awards roughly double a recipient firm's probability of subsequently receiving venture capital and increase the probability of later acquisition or IPO. Hottenrott and Richstein (2020) find that both German subsidized lending and grants to start-ups crowd in future venture capital. Across the EU, Santoleri et al. (2024) finds that R&D grants generate up to a threefold increase in the probability of receiving future private equity. The mechanisms, however, are not uniform: Santoleri et al. and Howell attribute the effect to bridge funding rather than certification, while Hottenrott and Richstein's results are more consistent with signaling.

However, recent work suggests grants may indeed confer a certification effect for borrowers. Chiappini et al. (2022), using French administrative data, finds that public innovation subsidies increase long-term bank debt through certification rather than liquidity effects—a result that speaks directly to Lerner (1999)'s argument that the seal of approval conferred by a competitive award matters more than its monetary value. Other studies find similar mechanisms for prestigious Swedish innovation grants (Söderblom et al., 2015), whose effects are independent of award size, and for Italian bank lending (Bellucci et al., 2023).

Despite positive effects, estimates of input additionality vary with grant design and study methods. Several studies find that weak or null aggregate effects conceal substantial heterogeneity: the strongest crowding-in is concentrated among smaller and capital-constrained firms. Bajgar and Srholec (2025) rejects aggregate crowding-out for the Czech Republic's ALFA R&D program and finds average increases in private R&D spending, driven by strong responses among SMEs (see also Bronzini and Iachini, 2014, for proxy evidence from Italy). Across major EU R&D collaboration subsidies, Szücs (2020) likewise rejects crowding-out but finds no strong evidence of aggregate additionality in private R&D spending,[6] with significant effects concentrated among research-intensive firms and SMEs.

Yet program design also contributes to this variation. Szücs (2020) finds that the substantially redesigned Horizon 2020 program had strong positive effects on firms' own

[6] These include three programs from the European Commission's Framework Programmes for Research and Technological Development.

R&D spending: participation stimulated approximately 17% in additional private R&D spending.

Output Additionality

Evidence on output additionality from grants is also positive and growing. Across European R&D grants, Santoleri et al. (2024) finds that awards raise the probability of patenting by 8–15 percentage points, raise cite-weighted patent counts by 15–31%, and increase revenue and employment. For Horizon 2020, Mulier and Samarin (2021) find that recipients have 10.9% higher turnover and 7.5% higher employment, with patent stock and filing probability rising in parallel and the pattern persisting over time. UK Research Council and Finnish regional grants corroborate this pattern, with gains in employment and turnover and, in Finland, a lagged effect on labor productivity (Vanino et al., 2019; Einiö, 2014).

One of the more comprehensive studies comes from Dragojević et al. (2026), who evaluate Croatia's flagship EU-funded R&D grant program. Using confidential administrative data, they find significant impacts on firm revenue and employment, alongside increases in intermediates and tangible assets. They interpret the joint expansion of outputs and inputs as evidence that grants translate into genuine production scaling rather than accounting changes. Marginal firms are most responsive, suggesting that grants work by relaxing binding constraints. These effects also produce spillovers across the production network, which I discuss in Section 4.2.

Because R&D is dynamic and grants target early-stage firms, effects often unfold over time. Howell (2017) finds that Phase I SBIR grants raise recipients' cite-weighted patents by at least 30% and positively affect future revenue. Myers and Lanahan (2022) show that state-level matching programs also produce additional patents. Li et al. (2017) find that National Institutes of Health (NIH) grants affect knowledge production well beyond the initial award period. Reshid et al. (2025) study Swedish recipients of the Eurostars R&D grant program and, using award cutoffs, find that subsidies raise turnover, employment, and exports, with effects persisting more than seven years after project completion.

Commercialization is a telling long-run outcome and often an explicit objective of grant programs. Using evidence from the Department of Defense's SBIR program, Bottai et al. (2025) find that SBIR patents have a commercialization rate of 21.5%, substantially higher than that of comparable private patents. They also document indirect paths to commercialization through patenting spillovers, similar to those identified by Myers and Lanahan (2022). This evidence supports earlier case studies of DoD spinoffs by Ruttan (2006) and Mazzucato (2013). Beyond SBIR, Smith (2020) finds that Advanced Technology Program (ATP) grants, administered by the National Institute of Standards

and Technology (NIST), had long-run positive effects on commercialization, particularly in biotechnology and information technology. Because commercialization is difficult to measure and slow to materialize, short-run empirical studies systematically understate this dimension of impact.

2.3 Heterogeneity Matters

Heterogeneity is a clear fixture of this empirical literature for supply-side instruments. One consistent finding is that smaller firms are substantially more responsive to R&D policy than larger firms, though not universally across studies (Hyytinen and Toivanen, 2005; Bronzini and Iachini, 2014; Huergo et al., 2016). Such heterogeneity also appears in the recent OECD-wide work of Appelt et al. (2020). The lesson is not, however, to categorically target firm size, but rather to consider the more fundamental constraints faced by such firms.

Credit constraints are among the first-order constraints faced by SMEs and new entrants. Dechezleprêtre et al. (2023) finds that effects are concentrated among constrained SMEs. Appelt et al. (2025), in a cross-country micro-level analysis spanning nineteen OECD countries, finds that the smallest firms are approximately three times more responsive than large firms, and that limited uptake among eligible firms causes aggregate studies to underestimate the instrument's effectiveness. Sterlacchini and Venturini (2019) document the same pattern across fourteen EU countries.

This firm-size heterogeneity across the supply-side literature carries implications for defense promotion. Defense R&D spending is concentrated among a small number of large prime contractors with ready access to capital markets. If R&D tax credits are most effective for financially constrained SMEs, their marginal contribution to defense innovation—which occurs predominantly within large, unconstrained firms—may be modest. In the world of defense, small firms have a particularly hard time entering the daunting world of procurement, a class of policies we turn to next.

3 Demand Side Policy

Defense procurement is a substantial lever for states to shape production and innovation, and a core instrument of defense industrial policy. It operates in a market defined by pervasive failures and state monopsony, giving governments structural power over R&D, production, and spillovers into the wider economy. The intellectual argument is not

new. Whereas supply-side instruments lower the cost of innovation *inputs*, demand-side instruments work on other margins, such as raising the returns to successful development. This rationale for procurement-as-development policy has a long lineage in defense economics, especially in accounts of its role in incentivizing innovation (see Lichtenberg, 1995; Rogerson, 1995).

Despite its importance, the empirical evidence on demand-side policy is far less developed than that on supply-side industrial policy. Edler and Georghiou (2007) diagnosed this neglect in innovation policy and called for resurrecting the demand side. In the nearly two decades since, empirical work has grown. Evidence shows that procurement can promote both R&D and innovation outcomes; see Chiappinelli, Giuffrida, et al. (2025).[7] Like supply-side policy, this evidence is not monolithic. Emerging work points to meaningful heterogeneity across firm size, technology, and, importantly, design.

This section moves from broad to granular evidence, starting with the average effect of demand-side policy on innovation before turning to variation by contract design, firm characteristics, and interactions with supply-side instruments.

3.1 Input and Output Additionality

New empirical work shows that procurement can promote innovation investment and industrial development. On the input side, careful studies estimate effects on R&D additionality and private investment (Belenzon and Cioaca, 2026; Guceri and Liu, 2019; Slavtchev and Wiederhold, 2016). On the output side, evidence extends to downstream innovation outcomes (Castelnovo, Clò, et al., 2023; Czarnitzki, Hünermund, et al., 2020; Stojčić et al., 2020; Bastianin, Castelnovo, and Zirulia, 2025; Draca, 2013; Aschhoff and Sofka, 2009). This evidence spans European firm-level studies, European Big Science programs, and US federal procurement, including SBIR.

In the EU, firm-level evidence offers provisional support for procurement-led innovation. Stojčić et al. (2020) study 41,623 firms across Central and Eastern Europe—Bulgaria, the Czech Republic, Estonia, Croatia, Latvia, Hungary, Romania, and the Slovak Republic—and find that innovation procurement increases innovation output and commercialization. Czarnitzki, Hünermund, et al. (2020), using German data linked to a reform that introduced innovation-oriented procurement criteria, find that innovation-directed contracts

7 Also see Kundu, James, et al. (2020) and Kundu, Uyarra, et al. (2025) for methodological and bibliographical reviews.

increase the share of turnover from new products by approximately 7 percentage points, consistent with earlier evidence (Aschhoff and Sofka, 2009).

Large-scale European "Big Science", such as CERN's Large Hadron Collider, shows that technically demanding public contracts can operate as de facto industrial policy. Castelnovo, Florio, et al. (2018) study suppliers to the Large Hadron Collider and find associations with higher innovation, labor productivity, and profitability. Bastianin, Castelnovo, Florio, et al. (2022) finds that CERN suppliers increase patent applications with a five- to eight-year lag, while Bastianin, Castelnovo, and Zirulia (2025) shows that the response is strongest among new entrants and concentrated in procurement-related activities.

Similar evidence extends to Europe's space industry. Castelnovo, Clò, et al. (2023) study Italian Space Agency (ASI) procurement and estimate an increase of nearly 10% in supplier patenting, with effects that persist and grow over time, consistent with evidence on ASI's social returns (Florio et al., 2024). Across CERN and ASI, effects are strongest for high-technology firms, emerge with substantial lags consistent with learning and capability-building, and concentrate in activities directly tied to procurement relationships. As with supply-side policy, however, these effects depend on procurement design, a question taken up next (see Åberg and Bengtson, 2015).

Recent evidence shows that US federal procurement of high-technology products also crowds in private R&D. Slavtchev and Wiederhold (2016), using Federal Procurement Data System records for 1999–2009, examine how federal procurement of high-technology goods and services affects private-sector R&D investment across US states; they consider non-R&D contracts, focusing only on end-use products. They find that shifting $1 of procurement from low-technology to high-technology industries is associated with $0.21 in additional private R&D. This distinction matters, as studies may not separate the types of goods contracted.

Pallante et al. (2023) study military R&D, specifically the effect of DoD R&D obligations on firm activity. Their IV estimates, using exogenous variation in state exposure to national military R&D shocks, show positive crowding-in for private R&D and employment after four to five years. Employment effects concentrate in electronics and transport and among engineering occupations. Their defense R&D measure, however, combines R&D procurement contracts with R&D grants, including DoD SBIR awards. Methodologically and practically, the two may be difficult to disentangle (see Mowery, 2010).

Procurement is also a potent aspect of the Department of Defense's SBIR program (see Section 2.2). Although the studies above emphasize SBIR's innovation grants (Phases I and II), Phase III serves as a follow-on procurement channel: agencies purchase SBIR-developed technologies using non-SBIR budgets, with sole-source contracting rights

(Myers, Lanahan, and Johnson, 2026). This final stage is especially valuable because it can integrate firms into the US defense procurement system (Howell et al., 2025; Bhattacharya, 2021). The prospect of future demand helps bridge the valley of death, easing the transition from invention to deployment, and can also shape incentives for early-stage development. Procurement design therefore has important consequences for innovation.

3.2 Structure and Sequence Procurement

Procurement design shapes innovation and capacity investment by raising the expected payoff from early technical success. In defense, demonstrating feasibility, reliability, and delivery capability can create a path to follow-on production contracts. Expected demand can therefore induce firms to invest early: increasing R&D effort, deepening technical capabilities, or building capacity to scale. Because R&D effort is difficult to contract for directly, procurement can instead reward successful development through future production demand. A long literature in defense economics develops this logic, treating production-stage profits as innovation rents that induce early-stage investment (Rogerson, 1989; Rogerson, 1994; Lichtenberg, 1995); these mechanisms have become central to modern procurement-based innovation incentives (see Chiappinelli, Giuffrida, et al., 2025).

Work by Belenzon and Cioaca (2026) and Arora et al. (2025) shows that guaranteed demand in government R&D contracts incentivizes private investment in early-stage innovation. Linking US federal procurement contracts to publicly traded firms, Belenzon and Cioaca (2026) find that a $10 million increase in R&D contracts raises firm-funded R&D by about $5.3 million. These effects concentrate among firms positioned to benefit from later-stage production contracts, typically large, vertically integrated firms. Studying federal R&D contracts awarded to public firms between 1984 and 2015, Arora et al. (2025) find that event-study reactions imply potential revenue of roughly 19 times an R&D contract's nominal value, largely explained by future production obligations and concentrated among firms that subsequently receive DoD production awards.

Bundling R&D and production is not unconditionally desirable, however. Linking R&D to follow-on demand may be valuable when outside commercialization prospects are weak, as when the product is highly specific to the buyer rather than the broader private market. Yet bundling assumes that the innovating firm can capture downstream production rents (Iossa et al., 2018). It is therefore best suited to firms with capacity in both R&D and production and economies of scope between them. This limits many SMEs' ability to benefit. This is consistent with Belenzon and Cioaca (2026) and Arora

et al. (2025), who show that returns to bundled R&D contracts concentrate among large, vertically integrated firms. These design choices therefore depend on context.

Other design margins matter, since follow-on demand alone may be insufficient to overcome hold-up. This is especially true in defense, where monopsony buyers can renege or change contract terms after firms have sunk investments. Hold-up is a recurring problem for SMEs in the DoD SBIR program.[8] Bhattacharya (2021) suggests that reforms such as increasing profit sharing from future procurement or supplementing early-stage R&D investment may induce early R&D. Other contractual solutions, such as advance market commitments, have addressed hold-up in global vaccine markets by committing buyers to future demand before firms invest in R&D or production capacity (Kremer et al., 2020).

A related design margin is how the initial procurement problem is specified. Defense procurement has historically relied on tightly specified, top-down contracts, which critics argue can slow commercial-technology adoption, deter new entrants such as high-tech firms, and advantage incumbents familiar with contractual complexity. More perversely, firms may specialize in winning contracts rather than generating commercial spillovers, as with "SBIR mills" in the DoD.[9]

One solution has been to "open" procurement through solicitations that let firms propose their own technology solutions. This can bring outsider firms and private-market technologies into the defense base. Howell et al. (2025) finds that the Air Force SBIR open-topic reforms increased participants' subsequent defense procurement, venture capital investment, patenting, and patent novelty, while conventional awards affected only future SBIR awards. Even within conventional SBIR, less specific topics performed better on several innovation outcomes. Open-topic awards thus appear to give firms an initial foothold in defense markets and demonstrate downstream demand for dual-use technologies. These designs are especially relevant for newer, younger, and smaller firms outside the traditional defense sector, whose constraints I turn to next.

3.3 Firm Size and Constraints to Procurement

Evidence on procurement presents a firm-size conundrum: smaller firms often generate strong additionality yet are least able to access procurement opportunities. On the response side, empirical work finds especially strong effects among small firms (Chiappinelli, Dalò, et al., 2024). For instance, Aschhoff and Sofka (2009) find that procurement is

8 According to companies like Anduril, agencies do renege on scaling obligations: "[d]espite congressional direction, government agencies frequently do not uphold SBIR scaling obligations" (Milam et al., 2021).
9 Although the empirical evidence on SBIR mills is nuanced (Link and Swann, 2024; Swann, 2026).

particularly effective for smaller German firms and in economically distressed regions, where alternative sources of innovation demand are scarce. Similar size effects appear in Portugal (Duque Gabriel, 2024), Brazil (Ferraz et al., 2015), and studies of green procurement (Krieger and Zipperer, 2022). Bastianin, Castelnovo, and Zirulia (2025) provides especially clear evidence from CERN: effects on first-time patenting are strongest for smaller, high-tech firms facing the highest sunk costs and uncertainty in beginning to innovate.

Financial constraints are a likely explanation for why firms are so responsive. Theoretically, small firms may underinvest in R&D not because innovative opportunities are unprofitable, but because returns are uncertain, difficult for outside financiers to evaluate, and harder to collateralize. Procurement can relax this constraint in two ways. By creating a credible stream of future revenue, it makes those returns easier to finance. Winning a public contract can also certify firm quality, reducing information asymmetries in capital markets. Together, these mechanisms lower the effective cost of finance and support innovative investment that would otherwise go unfunded.[10]

Empirically, recent work suggests procurement relaxes firms' financial constraints. Using Portuguese microdata, Duque Gabriel (2024) show procurement contracts expand credit supply through a collateral channel: firms pledge anticipated procurement cash flows to secure borrowing, with the strongest investment and employment responses among small and micro enterprises—the SME-driven pattern documented above. For Chinese procurement, Dai et al. (2021) find procurement expands R&D investment and high-tech sales through a complementary reputational channel, with award-based certification easing access to external capital, particularly for small and young firms. Together, these studies identify distinct but reinforcing mechanisms—collateral and certification—and confirm that procurement relaxes binding capital constraints as theory predicts.

Even if small firms can be highly responsive to procurement policy, they may also face other barriers that preclude them from participating in demand-side policies.

On access, the evidence points to substantive administrative, informational, and institutional barriers limiting SME participation in procurement. These barriers are emerging as a stylized fact (e.g., Stake, 2017). In innovation-oriented procurement, where SMEs are important sources of emerging and dual-use technologies, Uyarra et al. (2014) and Divella and Sterlacchini (2020) document that smaller firms face greater obstacles than larger, established firms. SMEs face similar constraints in defense. US survey evidence emphasizes administrative complexity and informational failures (Schilling et al., 2017), while recent EU evidence highlights opaque procedures and qualification requirements

[10] Procurement may nevertheless tighten short-run liquidity if contracts require upfront capital, a separate constraint from the credit-market frictions discussed here.

in Dutch Ministry of Defense IT tenders (Driel et al., 2026). These frictions are echoed in surveys of SBIR participants (e.g., for the Air Force SBIR program Holt et al., 2024), and inform reforms around the DoD SBIR and related programs (see Section 5). The multiple frictions facing small firms and new entrants suggest that multiple instruments may be necessary. I turn to this next.

The section has established that procurement shapes innovation along multiple margins, each supported by a small number of well-identified studies. Yet that evidence base remains limited relative to the scale of procurement itself and to the comparative richness of the supply-side literature on grants and tax credits. This gap matters. As Europe enters a period of sustained defense spending and as procurement becomes an increasingly explicit instrument of industrial policy, the demand for credible design evidence will outpace the current supply.

4 Social Returns and Spillovers

Beyond the impact on firms, the ultimate question concerns spillovers and the social returns to such policies. Although estimating aggregate social returns is far more demanding, here too the literature has largely converged on substantial social returns to public R&D. Despite positive evidence on spillovers and social returns to public R&D and related industrial policies, whether the same holds for defense is far less clear and much more fraught. See Ilzetzki (2025) for an overview of the aggregate returns to policy.

While I have shown that policy crowds in private market activity, especially investment, the evidence on spillovers is more complicated. Theoretically, military R&D can create value well beyond the weapons and systems it is meant to improve. When defense contractors develop new materials, software, production methods, or design tools, some of that knowledge spreads to other firms through suppliers, worker mobility, follow-on research, and civilian applications. These broader gains are the classic spillover: they benefit parts of the economy that did not pay for the original research, and for which the original firm cannot fully charge.

4.1 The Social Returns to R&D: Public Versus Defense

Social returns to R&D dwarf private returns; the gap implies systematic private underinvestment and a first-order role for policy. Micro evidence from Bloom, Schankerman, et al.

(2013) puts social returns at roughly twice the private return, and more recent estimates raise that ratio to four times the private return (Lucking et al., 2019). Aggregate estimates from Jones and Summers (2022) point in the same direction: a social return of 67% on total US R&D, on the order of four to five dollars of social value per dollar invested.[11] These social returns mask more precise questions that I take up in this section: what are the social returns to public R&D and to defense R&D?

More precisely, evidence now suggests that the social returns to government-funded R&D are also considerable. Using US appropriations shocks, Fieldhouse and Mertens (2024) find that public non-defense R&D has large, robustly identified effects on total factor productivity, with implied social returns of 140–210%. Dyèvre (2024) reaches the same conclusion from a different angle, embedding micro estimates in a macroeconomic model to show that the post-1950 decline in federally funded R&D accounts for roughly a third of the decline in US TFP growth through 2017. The Fieldhouse-Mertens estimates are specifically for non-defense R&D. Whether the same returns extend to defense R&D—an important slice of the federal R&D portfolio—is where the evidence gets more complicated.

Fieldhouse and Mertens (2024) themselves surface the split between general public R&D and defense. When they disaggregate public R&D into defense and non-defense components, the defense returns contract. While positive, they are substantially smaller than the non-defense estimates and weak. Although defense spending crowds in private R&D, the authors fail to find substantial productivity spillovers. From this angle, the case for defense R&D looks thin, aligning with earlier pessimism about its social returns (Mowery, 2010).

However, parallel work makes a case for strong social returns to defense R&D. Using new long-run US data, Antolin-Diaz and Surico (2025) show that defense spending raises long-run growth via shifts in public expenditure toward R&D, not through public consumption or fixed-capital investment. This effect holds in peacetime and is not driven by any single military episode, such as the Korean War buildup. These effects are slow to arrive: in the short run, they are muted, sometimes negative, with positive returns accruing only over longer horizons. Cross-country work by Moretti et al. (2025) concurs, finding positive effects of defense spending on productivity.

The divergence is not fully resolved, but several factors plausibly contribute. Fieldhouse and Mertens (2024) identify from legislative appropriation shocks, concentrated in postwar peacetime; Antolin-Diaz and Surico (2025) identify from military buildups, which embed R&D expansions at a different scale from peacetime appropriations. The two approaches may therefore capture different slices of public R&D investment. Whether these factors

[11] See Fieldhouse and Mertens (2025) on how the micro and macro estimates can be reconciled.

fully account for the divergence, or whether a genuine disagreement remains about the magnitude of defense returns, is unsettled. What does seem to hold across the literature is that the returns are slow to accrue and depend on how the underlying research is organized.

The tension over the social returns, however, raises essential questions about design. Across the estimates, the return to defense R&D ultimately depends on whether the knowledge it produces reaches the civilian economy. The design question—how to organize military R&D so that its social returns are realized—therefore reduces to a question about spillovers: their size, the conditions under which they occur, and the policy levers that shape them. I turn to these next.

4.2 Spillovers from Public R&D

Spillovers are the central ingredient in estimates of social returns. In innovation policy, R&D spills over through contracting, labor mobility, and supply-chain relations (Hall, Mairesse, et al., 2010; Bryan and Williams, 2021). Accordingly, recent work examines spillovers from R&D investment decisions and public policies. Like social returns, however, much of this work concerns the civilian economy; evidence on defense-related policies is only emerging.

This section reviews spillovers from civilian public R&D. Recent work documents public R&D spillovers in technological space (Dechezleprêtre et al., 2023), geographic space (Santoleri et al., 2024), and the production network (Dragojević et al., 2026), extending core microeconometric estimates of technological spillovers (Bloom, Schankerman, et al., 2013; Lucking et al., 2019). The emerging literature delivers important insights: policy externalities are real, operate along margins that aggregate evidence can miss, and shift over time. Nevertheless, the evidence remains too thin to guide policy design, especially where spillovers are contested, as in defense R&D. Still, the margins and magnitudes from studies of spillovers reveal where defense spending may most benefit the civilian economy.

Firm Spillovers, Production, and Productivity

Evidence suggests public R&D produces large productivity spillovers, substantially larger than those from private R&D. Dyèvre (2024) establishes this using a 70-year panel of US firms matched to patents, with identification from exogenous variation in R&D spending across federal agencies. Public R&D spillovers to firm productivity are roughly three times the size of private ones: a 1% decline in firm exposure to public R&D is associated

with a 0.17% decline in productivity growth. These results align with aggregate findings from Fieldhouse and Mertens (2024). DoD R&D plays a disproportionate role in the US federal R&D portfolio, but whether its returns match those of other agencies remains an open question. Positive spillovers from R&D are not unique to the US.

Using Chilean administrative data, Crespi et al. (2020) document significant productivity spillovers from collaborative R&D funding allocated by Chile's Science and Technology Development Fund (FONDEF). FONDEF raised TFP among nontreated firms in the same region and sector as recipients. Whereas other R&D policies raise productivity only for recipients, the spillovers from FONDEF appear to reflect its design. Beyond funding public-private cooperation, the program draws on partner organizations whose knowledge is more generic and appropriable, and the collaboration itself opens more channels for informational leakage into the private sector.

Knowledge externalities can be an important mechanism in successful industrial policies, especially packages that include R&D subsidies. Banares-Sanchez et al. (2026) study the success of Chinese solar industrial policies, which combined demand-side and supply-side instruments, including innovation subsidies. The authors show that the policy package was not only effective at expanding the solar industry but also produced substantial returns. They find that innovation subsidies were the most cost-effective instrument, driven by their cross-firm knowledge spillovers. Similar spillover channels appear in China's FDI joint-venture policy (Bai et al., 2025) and through labor mobility across firms and locales (Matray, 2021).

Production Linkages as a Source of Externality

Production linkages are another potential source of externalities. R&D policy can induce demand through supply chains and ease pre-existing distortions faced by connected firms: a credit-constrained supplier may use the additional demand to relax financing frictions and expand investment. The resulting spillovers are pecuniary rather than technological, but they remain welfare-relevant in a second-best setting.[12]

Work by Dragojević et al. (2026) suggests that EU R&D grants may generate welfare-relevant spillovers to suppliers, examining how suppliers respond to such policy. Suppliers of upstream R&D recipients significantly increase revenue, hiring, investment, and input use after awards. The heterogeneity and timing of these effects suggest that the demand shock relaxed financial constraints. Spillovers concentrate among financially constrained suppliers. The evidence is suggestive, but it points to linkage effects of R&D policy that

[12]See the related discussion of indirect spillover effects from investment policy in Lerche (2025).

standard spillover analyses may overlook. The authors argue that conventional evaluations miss these effects, paralleling Lerche (2025) on the indirect effects of public financial support to firms. Nevertheless, evidence on this channel is less developed than on other types of knowledge spillovers.

Knowledge Diffusion and Innovation Spillovers

Public R&D also generates spillovers in innovation activity. Studying the Department of Energy's SBIR program, Myers and Lanahan (2022) show that the grants affect innovation outcomes beyond treated firms: each patent produced by a recipient generates roughly three additional patents through spillovers. They estimate that grant recipients capture only 25%–50% of the value created by their R&D.

Evidence from NIH R&D policy shows the long, diffuse shadow that public R&D can cast. Like the examples above, it illustrates spillovers to innovation that earlier work would have struggled to capture. Using institutional changes in NIH funding rules, Azoulay et al. (2019) find that a $10 million increase in public biomedical research funding generates 2.7 additional private-sector patents. Public research stimulates private innovation, not just private spending. Li et al. (2017) show that the indirect effects of NIH grants on biomedical patents dwarf the direct effects: more than a third of NIH grants are indirectly cited by private R&D years after the award.

Different modes of R&D can produce multidimensional spillovers into industrial science. Gross and Sampat (2025b) find far-reaching, long-run effects of the mission-oriented US Committee on Medical Research (CMR), which directed biomedical R&D during World War II (1941–1945). They document that the CMR catalyzed postwar growth in medical science, shaped the US pharmaceutical industry, and influenced medical practice. Gross and Sampat (2025a) find not just spillovers but what they term "combinatorial spillovers" across medical subjects; their evidence suggests bidirectional spillovers, both basic-to-clinical and clinical-to-basic.

The evidence above also shows the potential of mission-led R&D to produce knowledge spillovers, cutting against a common argument for the limitations of defense R&D (Section 4.3). Emerging work from South Korea's contemporary mission-led R&D push (G7P) likewise suggests that mission-oriented R&D may promote high-quality innovation, and that it was most effective for technologies with high potential for spillovers among participants (Jaramillo and Kim, 2025).

Public R&D infrastructure offers another margin through which policy produces knowledge spillovers. Bergeaud et al. (2025) examine the channels through which public research spills over to private firms, focusing on contracting between public and private bodies, such as research subcontracting. They find that each euro of academic

research expenditure generates an additional 0.81 euros of private R&D in the surrounding area. Labor mobility, such as hiring PhDs from public labs, also has a positive effect, but contracting relations emerge as an important and understudied channel for knowledge spillovers.

Broadly, the evidence points to multiple dimensions along which public R&D policy produces spillovers for the broader economy. Some studies implicitly cover defense R&D, but few address its spillovers directly. The question, then, is whether defense R&D is different.

4.3 Defense Spillovers—Is Defense Different?

Spillovers from defense innovation policy are a special case of public R&D. Theory—and prior scholarship in defense economics—points to structural reasons they should be limited, built on the inherent differences between military and civilian markets, production, technological demands, and more. Yet emerging empirical work suggests a heterogeneous and ultimately conflicting picture.

The Conceptual Case for Limited Spillovers

Ex ante, there is good reason to think that spillovers from defense may be limited. One reason is the mismatch between military and civilian needs (Mowery, 2010; Martí Sempere, 2018). Military and civilian specifications can differ sharply: consumers are not shopping for cars with tank-grade coatings resistant to thermal imaging and blast overpressure. Even when early-stage technologies find civilian uses, further development can deepen the divergence (Cowan and Foray, 1995). Early aircraft fed directly into commercial aviation, but high-performance fighters have since followed a trajectory largely detached from civilian flight. Exotic defense programs, such as Reagan's Strategic Defense Initiative (SDI, or "Star Wars") (Lichtenberg, 1989), signaled that modern defense production may be fundamentally unmoored from civilian use (Lichtenberg, 1995).[13]

How militaries procure and contract for R&D tends, structurally, to produce technologies with limited civilian application. Military R&D is mission-oriented, organized around narrow objectives and performance needs, and such knowledge transfers poorly across domains. More general applied research is often only a fraction of the defense portfolio (Mowery, 2010). The specificity of military R&D—and the contracts that procure it—has

[13] At the extreme, postwar weaponry raised concerns about a "Baroque Arsenal" (Kaldor, 1981), in which weapons seemed to defy not only economic logic but also military utility.

led to specialized defense production, which limits spillovers (Molas-Gallart, 1997). It is not uncommon for firms to maintain separate divisions for military and civilian work.

Limiting spillovers may be a feature, not a bug, given the secrecy of defense industrial policy. Even when defense R&D produces civilian-relevant knowledge, the channels through which it would normally diffuse are restricted by classification, export controls, and contractor-specific tacit knowledge. The regulatory and secrecy measures that protect national security necessarily limit the surface area for spillovers.

Evidence: Clusters, Wars, and Workers

A new body of contemporary evidence comes from WWII. Gross and Sampat (2023) examines patent activity generated by the Office of Scientific Research and Development (OSRD) and finds substantial industrial externalities that persisted for decades after the war. They point to Marshallian agglomeration as a source of external economies of scale. Within counties, OSRD-funded research clustered geographically, citation flows across related technologies grew, and spillovers compounded locally rather than diffusing evenly. The downstream effects were real: firm entry and manufacturing employment rose in treated clusters. Gross and Sampat read this as evidence that the concentrated, mission-oriented structure of OSRD funding—rather than its scale alone—was central to generating agglomeration externalities.

WWII research efforts such as OSRD and the CMR program discussed above complicate the claim that applied, mission-oriented R&D inherently yields low spillovers. This matters for defense R&D policy, since such work is often applied and mission-oriented. Kantor and Whalley (2025) find that Space Race spillovers and its manufacturing multiplier may have been low. This seems plausible, given the specificity of space R&D and the innovations it required (e.g., a lunar landing module). Like OSRD, the Space Race was geographically concentrated, but concentration among a narrow set of firms and industries (two, in fact) did not yield the same agglomeration effects. Both cases were mission-oriented, but moon missions may have had far more specialized objectives.

This evidence on military-industrial investment aligns with work on the intergenerational effects of wartime spending. Garin and Rothbaum (2025) estimate substantial returns from the "helicopter drop" of large, government-financed WWII plants across the United States. By 1970, after these plants had converted to civilian production, counties that received WWII investment had higher manufacturing employment, larger populations, and higher median family incomes. Garin and Rothbaum trace these gains to high-quality jobs, which raised intergenerational mobility. Their findings echo the mobility effects documented in Finland after Stalin's war reparations (Mitrunen, 2025). Together, these studies suggest that wartime investment can generate intergenerational spillovers that

persist long after the initial episode and that conventional data may miss, since both papers rely on administrative records.

Dual-Use and the Modern Spillover Channel

Modern defense procurement has also shifted structurally toward dual-use technologies and incentives for adopting commercial technologies in defense markets, encouraging their later commercialization. This shift complicates the simple military-to-civilian spillover model that organizes most empirical discussions. Howell et al. (2025), for instance, finds that changes to the Air Force SBIR program—where firms propose their own technology solutions—causally increase both commercial innovation and military adoption of commercial technology. They interpret this as evidence that open-ended awards produce more dual-use commercialization activity than conventional awards. One implication is that spillovers via commercialization may be less linear than a straightforward transfer of technology from military R&D to civilian markets. Despite the growing importance of dual-use technologies in defense investment, the empirical literature has not examined this channel closely.

Is defense different, then? Perhaps, but with modern caveats. The conceptual case for limited spillovers—mismatch, specificity, and secrecy—remains a sound baseline, yet the empirical record cuts against it: mission-oriented wartime research generated durable agglomeration and mobility externalities, while modern dual-use procurement opens channels the classic military-to-civilian model never anticipated. The most defensible reading is that defense spillovers are neither guaranteed nor foreclosed, but contingent on design—on research concentration, dual-use potential, and the openness of the procurement that carries them to market. I turn to the broader design lessons next.

5 Lessons

This paper explores whether defense promotion produces industrial development through innovation policies. The preceding sections traced that question across supply-side instruments (Section 2), demand-side procurement (Section 3), and spillovers that carry social returns beyond the recipient firm (Section 4). Broadly, the evidence showed that returns are real but contingent, concentrated under particular design choices and among particular firms. What are the design lessons?

Table 1. Design lessons for defense industrial policy

1	Target policy where constraints bind, not horizontally.*
2	Address informational and institutional constraints, not just financial ones.†
3	Use procurement as a development tool; its payoff depends on design.‡
4	Engineer social returns by tilting policy toward high-spillover activities.§
5	Underwrite each of the above with administrative capacity.¶

* Sections 2 and 3.
† Section 3.3.
‡ Section 3.
§ Section 4.
¶ Sections 2–4.

1. Target policy where constraints bind, not horizontally.

The empirical work makes a clear case for more targeted policy, cutting against slogans for horizontalism. The literature shows that returns to innovation incentives concentrate among particular firms, while resources often flow to firms whose response is weak or zero (Section 2.1). The review's most consistent finding—shared across meta-analyses—is that responses to public innovation interventions are heterogeneous. Across settings and instruments, returns concentrate among SMEs, new entrants, and firm types with clear binding constraints. Defense-led industrial policies will apply to an even narrower set of firms. Impactful policy will reach responsive firms.

Broad, scattershot policies can—and do—miss this concentration. In the tax credit literature (Section 2.1), such instruments may be taken up by firms with weak behavioral responses, while poor design may deter take-up among firms that could respond most. These design choices help explain a divergence in the literature: R&D elasticities estimated in micro-level studies run high, while aggregate estimates are attenuated. Appelt et al. (2025) show that aggregate estimates pool high- and low-responders, so weak responders dilute the measured effect. The data bear this out across the OECD (Appelt et al., 2025) and in granular, country-specific studies (e.g., Norway Nilsen et al., 2020). Thus, poorly targeted incentives can be squandered.

Although the average level of spending matters, so does *how* resources are targeted; judicious design, targeting, and take-up matter. Taken together, the evidence runs against the reflex toward horizontalism and favors more focused policy.

2. Address informational and institutional constraints, not just financial ones.

Thus, defense industrial policy must take firms' constraints seriously—not only financial constraints, but also informational and institutional ones. The firms required by the modern defense push are precisely those that face systematic frictions in policy participation. Evidence from procurement policy shows this clearly (Section 3). While financial resources are key, non-financial constraints require different interventions to integrate firms into defense R&D and procurement systems. The importance of addressing these frictions is reflected in the DoD's efforts to build an ecosystem of innovation organizations, including the Defense Innovation Unit (DIU), Army xTechSearch, Air Force AFWERX, Army Applications Laboratory (AAL), and the Department of the Navy Rapid Capabilities Office (DONRCO) (Mignano et al., 2026; Kotila et al., 2023).

Although less well studied empirically, such organizations play an increasingly important role complementary to financial resources. The EU, NATO, and their members have taken steps in this direction. In a defense ecosystem that is notoriously fragmented, Byzantine, and dominated by incumbents, such organizations are even more essential. Whereas the US DoD has a long history of engagement with SMEs and a deep defense innovation ecosystem, this capacity is more nascent in the EU. Organizations such as the Hub for EU Defence Innovation (HEDI), the European Defence Agency's intergovernmental platform, identify emerging technologies and promote outreach. Likewise, NATO's Defence Innovation Accelerator for the North Atlantic (DIANA) coordinates industry and military end users to help NATO members adopt innovations. Alongside growing initiatives such as Germany's Innovationszentrum der Bundeswehr (InnoZBw) and its proposed SPRIND.MIL, these nascent programs will be necessary to enable industrial spillovers.

3. Use procurement as a development tool; its payoff depends on design.

Procurement is an important lever; recent work shows that defense procurement can generate industrial development, but only with investment in design and implementation. Although procurement is less studied than supply-side instruments, evidence shows that it does more than generate mechanical demand: it can also promote innovation. Because innovation and R&D are difficult to contract for directly, future production contracts can incentivize early upstream effort and capacity investment. Emerging evidence on procurement-as-innovation policy shows that these policies can promote innovation, investment, and industrial development outcomes (Section 3).

However, both theory and empirics suggest that performance requires judicious design. Bundling R&D with production requires the right conditions, such as economies of scope

and suitable capacity (see Iossa et al., 2018). Absent those conditions, procurement risks favoring large, vertically integrated firms able to carry production, sidelining upstarts. Moreover, defense procurement still poses hold-up risks, which fall hardest on SMEs that depend on scaling commitments. Thus, procurement programs increasingly seek to promote SMEs and dual-use technology adoption. Despite their smaller project size, SME projects can generate disproportionate spillovers (Myers, Lanahan, and Johnson, 2026).

4. Engineer social returns by tilting policy toward high-spillover activities.

Taking externalities seriously means targeting higher-spillover activities and the dual-use economy. Empirically, broad social returns to public R&D are increasingly well established, but they do not automatically transfer to defense (Section 4.1). The conceptual case for skepticism is sound. Mission-specific requirements, specialized production and applications, and secrecy can all limit spillovers. Thus, empirical evidence on social returns to defense does not, by construction, support promoting defense as an unconditional ticket to broader industrial development.

Yet the activities required by EU rearmament are critical commercial technologies and dual-use goods with high-spillover potential: e.g., advanced materials, microelectronics, high-performance computing, digital infrastructure, and cybersecurity (European Commission, 2025b; European Commission, 2023). Recent empirical evidence on public R&D externalities shows many margins where spillovers exist and externalities are profligate (Section 4.1). Moreover, emerging evidence shows potential spillovers from defense programs: mission-oriented wartime research has generated durable agglomeration and entry effects, and modern dual-use procurement opens commercialization pathways. Thus, pessimism is the right prior, but not the posterior. The policy implication is to take bottlenecks to defense spillovers seriously and tilt policy toward activities more compatible with the broader EU economy.

5. Underwrite each of the above with administrative capacity.

Each lesson points directly to robust investment in Europe's economic statecraft. No successful industrial policy has been implemented without intentional investment in state capacity, especially administrative capacity (Juhász and Lane, 2024). This holds especially for procurement and innovation grants, where staff expertise is first-order. Recent empirical work on procurement shows that organizations' characteristics and competencies translate into economic outcomes (Decarolis, Giuffrida, et al., 2020; Decarolis, Rassenfosse, et al., 2021; Giuffrida and Raiteri, 2023). This aligns with work on institutional and organizational bottlenecks in the current US defense-innovation ecosystem (Kotila et al.,

2023; Mignano et al., 2026). Industrial development will require building and deepening these administrative capacities.

6 Conclusion

Does defense promotion promote industrial development? I consider the role of innovation policy related to defense and the extent to which it can impact treated sectors and, in turn, the broader industrial economy.

To answer this question, I draw from multiple literatures, organize the evidence along two axes—the policy instrument and the stage of the causal chain at which effects appear—and follow it from input additionality through industrial outcomes to the spillovers that carry social returns beyond the recipient firm. Read this way, a seemingly contradictory literature resolves into a pattern: across instruments and outcomes, public support more often crowds private effort in than out, with returns concentrated among particular firms, technologies, and designs. The lessons of Section 5 distill this evidence into guidance.

However, the evidence and the stakes are misaligned. The instruments we understand best are not the ones that now matter most, especially for the EU. R&D tax credits—broad, well-identified, and studied for decades—are among the smallest levers in the rearmament toolkit, while procurement, the largest and most strategically central instrument of defense industrial policy, remains the least understood: its credible evaluations are recent, few, and concentrated in a handful of settings (Section 3). This asymmetry is not a curiosity but a warning. As defense budgets expand, the demand for design evidence will outrun its supply where spending is heaviest, and decisions of enormous scale will rest on the thinnest evidentiary base. Closing that gap is thus crucial, and the agenda follows directly from where the evidence in this study thins.

The rearmament now underway will reshape Europe's industrial base for a generation, regardless of how it is conducted; whether it also leaves behind a stronger, more innovative economy hinges on the arduous task of designing a truly developmental industrial policy.

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