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Procurement as an Innovation Lever for Big Science: Mechanisms, Measurement, and an Agenda for Change

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Short Report

Keywords: public procurement of innovation, Big Science, knowledge spillovers, industrial liaison, research infrastructure, innovation policy

Posted Date: September 11th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10853574/v1

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Additional Declarations: No competing interests reported.

Abstract

Public procurement is one of the most direct and traceable channels through which Big Science investments generate wider socio-economic benefit, yet it remains significantly underexploited as an innovation lever. Drawing on the public procurement of innovation (PPI) literature and on practitioner perspectives from the European Space Agency, STFC/UK Industrial Liaison Office, NWO-I/INPROCAP, and the European Spallation Source ERIC, this paper examines three interconnected challenges: understanding the mechanisms through which procurement generates knowledge spillovers; developing measurement frameworks adequate to capture what matters; and closing the governance and design gap between known good practice and what organisations actually do. We argue that the binding constraint on progress is not evidence but capacity, culture, and political will — and that the ERIC governance model, industrial liaison functions, and the emerging INPROCAP network represent underused levers for change. The article closes with targeted recommendations for research infrastructure organisations, national intermediaries, and European-level governance bodies, and an agenda for future research.

1. Introduction

The socio-economic case for public investment in Big Science rests on knowledge externalities: the scientific outputs of large research infrastructures generate societal benefits that markets underprovide (Nelson, 1959; Arrow, 1962). This case is analytically robust but politically fragile. In an era of fiscal pressure, the benefits are diffuse, long-term, and almost impossible to attribute to specific investments. Governments increasingly demand more visible, near-term justification.

Procurement occupies a distinctive position in this landscape. Unlike publications, trained researchers, or spin-offs, which are spillover channels that diffuse slowly and broadly, contracts generate direct financial flows, contractual obligations, and traceable relationships between a public buyer and private suppliers. They are the most immediate and politically legible channel through which Big Science investment generates wider economic benefit. And yet procurement receives comparatively little analytical attention as an innovation lever within the Big Science literature, which has focused primarily on measuring aggregate socioeconomic returns rather than on the design conditions that shape them (Florio et al., 2018; Piazza, 2025).

This paper argues that the public procurement of innovation (PPI) literature offers a productive analytical lens that the field has not yet fully exploited. It draws on that literature alongside practitioner perspectives from four major European research infrastructure organisations, developed through the roundtable on “Knowledge Spillovers through Big Science Procurement” at the Economics of Big Science Workshop (LSE, April 2026). Section 2 sets out the PPI framing. Sections 3–5 examine mechanisms, measurement, and governance in turn. Section 6 offers recommendations and a research agenda.

2. Public Procurement of Innovation as an Analytical Lens

Interest in how public demand drives technological development is longstanding, and has evolved through successive waves of policy interest, from 1980s industrial policy debates through to today's economic security and mission-oriented agendas (Uyarra et al., 2020; Chiappinelli et al., 2025). Edler and Georghiou (2007) articulated PPI as a deliberate policy instrument distinct from supply-side R&D support, framing public buyers not merely as passive consumers but as active shapers of markets and innovation trajectories (Mazzucato, 2016).

Public procurement can influence the size, sophistication and direction of demand for innovation. Large public sector demand guarantees a level of production, reduces uncertainty, absorbs early-stage R&D risk, and signals that investment will be rewarded. The public sector can be a demanding, credible buyer that legitimizes new technology and helps diffuse it through standards. Indirectly, winning a contract has a reputational effect, potentially attracting investors and wider customers. And procurement influences competition and market structure through decisions about participation, contract size, and contract length (Uyarra and Flanagan, 2010).

Empirical studies confirm positive effects of public procurement on product and process innovation, R&D investment, and patenting; and these effects are generally stronger than comparable supply-side instruments and amplified when combined with R&D support (Guerzoni and Raiteri, 2015; Kundu et al., 2025). SMEs, financially constrained firms, and those in less developed regions tend to benefit most. Critically, there is evidence of harm as well as benefit if not well-designed: procurement focused exclusively on price compliance actively suppresses innovation (Chiappinelli et al., 2025, Krieger et al., 2024).

While PPI literature offers a useful starting point, Big Science procurement is distinctive in important ways. Research infrastructure organisations are simultaneously technology co-developers, sole guarantors of early demand for technologies with no clear commercial market, and industrial policy actors operating under governance logics with no domestic equivalent, including through *juste retour* (or georeturn) and in-kind contribution models. Some of the mechanisms, gaps, and design challenges the PPI literature identifies appear in concentrated and revealing form here.

3. Mechanisms: How Procurement Generates Spillovers

Three mechanisms appear most significant in the Big Science context. The first is reputational signalling. Winning a contract from a globally recognised research infrastructure functions as a quality certification with international reach, opening doors to other research infrastructures and to private market customers and investors that an equivalent R&D grant typically does not. This effect is particularly valuable for SMEs and younger firms seeking to establish credibility in technically demanding markets. How large research infrastructure organisations build capability and open market doors is illustrated by a manufacturer that began supplying components to CERN in 1984 and now exports 95 per cent of its output to global markets[1].

A second mechanism is buyer-supplier interaction. How buyers engage markets before a tender is issued, how they define what they need, and how they structure the contract itself all determine whether procurement stimulates genuine innovation or merely purchases existing capability. Market engagement practices significantly increase the likelihood of innovation outcomes from procurement (Berkhout et al., 2026). Outcome-based specifications allow defining the problem rather than the solution and open the field to approaches that prescriptive requirements would exclude. Pre-commercial procurement takes this further: buying R&D services in competitive parallel phases, with IP rights remaining with suppliers, so that solutions can be commercialised well beyond the procuring organisation's own domain. A concrete illustration is CERN's innovation challenge for a novel data-driven method to monitor Legionella growth in cooling towers: by defining the problem neutrally, structuring procurement in phased development stages, and preserving supplier IP rights, the exploratory project revealed commercialisation potentials at global level for an urgent program such as hospitals, offices and industrial plants.

The third mechanism is market structure: procurement shapes who participates in the supply chain, on what terms, and with what long-run capability implications. The georeturn principle and in-kind contribution models tend to favour large national incumbents, potentially limiting opportunities for newer and potentially more innovative firms. Addressing this requires deliberate and innovative institutional design. For instance, ESA has a dedicated industrial policy for SME involvement, consisting of various procurement and industrial policy measures that support SME inclusion in ESA procurements. These range from guaranteed advance payments for SME and dedicated clauses applied to technology development procurements limiting the eligibility of large system-integrators, to reserved share for SME in large development procurements, standardised contracts applicable to the entire contractual chain and supporting measures such as trainings and B2B opportunities for SMEs. This has demonstrably driven innovation and enabled the development and support of space industries in member states and firms that might otherwise have had more limited access to ESA programmes and funding. Today, more than 1700 SME working with ESA represent about 32% of all ESA contracted companies and are involved in almost 40% of all ESA contracts. ESA has also pioneered the Space Lending Envelope, a financial instrument providing around €1.5 billion in better-term loans to space-economy SMEs and start-ups in partnership with the European Investment Bank, providing improved access to finance for SMEs and start-ups.

None of these mechanisms is automatic. Each depends on buyer capability, governance flexibility, and a supplier ecosystem able to absorb the knowledge that procurement relationships can generate. Absorptive capacity as well as entrepreneurial intent of individual firms mediate whether a contract translates into durable capability development or merely a one-off transaction.

4. Measurement: What We Can and Cannot Observe

The dominant metric across Big Science organisations is the industrial return coefficient: the ratio of contractual value won by member-state suppliers to their financial contribution. It is visible, politically

legible, and almost entirely uninformative about innovation. It does not differentiate between servicing coffee machines and developing the next generation of semiconductors. It captures neither process innovation nor capability development, and provides no basis for understanding which procurement practices generate spillovers and which do not. Governance bodies continue to demand it precisely because it is countable, not because it measures what matters.

The academic literature faces its own measurement problems. Patent-based output measures are a poor way to capture process innovations, yet improvements in manufacturing precision, project management capability, and technical problem-solving are consistently identified by suppliers as the primary benefit of Big Science contracts. Knowledge spillovers of this kind are frequently too intangible to be captured through standard metrics and can only be gathered through direct relationships with firms and longitudinal case studies. The evidence base is also highly geographically concentrated: CERN, exceptional in its data transparency and scale, accounts for most of the rigorous causal work (Florio et al., 2018; Piazza, 2025). Recent work using synthetic control methods and input-output modelling suggests that firm-level studies significantly underestimate the full economic return from Big Science procurement (Crescenzi and Piazza, 2025; Streicher and Gabelberger, 2026). Whether these patterns generalise across procurement models, facility types, and member-state industrial structures remains open.

More adequate measurement would require longitudinal tracking of supplier outcomes after contract completion; survey instruments designed for the Big Science supplier ecosystem; administrative data linking procurement contracts to firm-level innovation, productivity, and export outcomes; and systematic classification of contracts by innovation content from the supplier's perspective, not merely by technological category from the facility's. Some organisations are beginning to move in this direction. STFC is developing three-year follow-up impact case studies on contracts won by UK firms, precisely because the contractual return metric fails to capture the innovation and capability effects that constitute the real prize. ESA structures measurement around Technology Readiness Levels set at programme outset, providing a first-order classification of innovation ambition that can be linked to follow-on investment and spillover tracking. Programmes are classified by their intended TRL progression and by whether they are mission-agnostic or mission-specific. Rather than spanning the full TRL scale, each programme targets a specific initial TRL reflecting their specific innovation objectives.

The constraint here is therefore not primarily methodological but organisational. What is lacking in most research infrastructure organisations is not conceptual understanding of what should be measured, but the people, time, and systems required to collect, structure, and analyse procurement outcome data.

5. Governance, Design, and the Implementation Gap

There is reasonable consensus on what innovation-oriented procurement looks like in practice, including open, neutrally specified challenges; phased competitive development; IP provisions permitting commercialisation; early market engagement before specifications are issued; long-term supplier

relationships; and post-contract follow-up are all documented as effective. The gap lies in absorptive capacity within procurement teams, in institutional cultures that equate procurement with compliance, and in governance structures that reward contractual return over innovation quality. A persistent barrier is for instance the tendency of facilities to arrive at the market with a fully developed technical solution and ask suppliers to manufacture rather than develop, curtailing the scope for innovation before a contract is even issued.

Three governance features of Big Science procurement are particularly consequential for innovation outcomes. First, the ERIC legal form, which is exempt from EU procurement directives, makes it possible to embed innovation as an explicit procurement principle and to revise rules iteratively as operational experience accumulates. Second, in-kind contribution models create a fragmented procurement landscape that limits the applying facility's leverage over design, specification, and supplier development. Whether in-kind or competitive cash procurement generates more spillovers is an open empirical question of direct relevance to facilities currently in the design phase. Third, while *juste retour* mechanisms are often a political prerequisite for member-state participation, they may also limit innovation if they favour large national incumbents over more innovative but less established firms.

Industrial liaison offices (ILOs) are the most direct institutional bridge between research infrastructure procurement and the national supplier ecosystem. Where they function effectively, they act as institutional entrepreneurs: actively shaping procurement cultures and supplier capabilities, and managing the knowledge flows that make procurement relationships innovation-productive, rather than passively distributing tender information (Selviaridis et al., 2023; Edler and Yeow, 2016; Selviaridis and Uyarra, 2025). The INPROCAP project (Horizon Europe, 2024–2027) represents the most ambitious current attempt to systematise this role across the European ILO network, building shared capacity in pre-commercial procurement, phased development, and IP-sharing approaches[2].

The procurement implications of the transition from construction to operations are often underestimated. Rather than a reduction in procurement complexity, operations-phase procurement may in fact be more innovation-intensive: it is at this stage when a facility encounters unforeseen problems, increasing the value of smaller, specialised firms. The European Spallation Source (ESS) offers a live illustration: as its target station moved from construction into operation, procurement needs shifted from delivering pre-specified components to solving problems that had not yet been anticipated at the design stage. This raises and important challenge for facilities currently in the design phase: how to structure procurement regimes that support both the scientific excellence requirements of construction and the adaptive problem-solving needs of operations.

Conclusion

Procurement is not a passive channel through which Big Science benefits happen to leak into the wider economy. It is a designable and measurable lever, and depends on choices made before contracts are tendered, in specifications, in governance rules, and in the allocation of resource for market dialogue and

post-contract follow-up. The PPI literature has established that good practice exists and that its effects are real. What we still do not know is how these effects vary across different Big Science contexts, including governance models, procurement regimes, facility types and life-cycle stages.

Several questions are directly tractable with better data and inter-institutional collaboration. Which procurement regimes generate the most spillovers, and under what conditions? How large are process innovation effects relative to product innovation effects? how far do multiplier effects extend through second- and third-tier supply chains? Do different stages of the life cycle require different metrics and procurement approaches, and if so, how should governance frameworks reflect this? What determines whether firms capture spillovers? And can procurement be used as a place-based instrument within Big Science, directing capability-building contracts towards regions with the capacity to absorb them without compromising scientific excellence?

Addressing these questions requires longitudinal data, inter-facility collaboration, and sustained academic–practitioner partnerships. The INPROCAP network and the Big Science Business Forum community are beginning to make this possible. More fundamentally, however, it requires a shift in how research infrastructure organisations understand procurement: not as an administrative function, but as a strategic instrument for shaping innovation outcomes

Declarations

Author Contribution

E.U. led the writing of the manuscript. A.M., S.F., R.K. and M.M. contributed empirical examples, practitioner perspectives and substantive revisions to the manuscript. All authors contributed to the development of the paper's arguments, reviewed successive drafts, and approved the final manuscript.

Acknowledgement

I would like to thank the organisers of the Economics of Big Science conference at the London School of Economics, particularly Gabriele Piazza and Ricardo Crescenzi, for creating the opportunity to develop and discuss the ideas presented in this paper. I am also grateful to Johannes Gutleber for his helpful comments on an earlier version of the manuscript.

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Footnotes

1. https://www.uk-ilo.org/case-studies/tesla-engineering-ltd-magnets-for-accelerators-to-mri-machines/
2. INPROCAP is a consortium of seven European partners (DTI, NWO-I, CDTI, NCBJ, EISCAT, XFEL, and Pedal Consulting) focused on strengthening innovation procurement capabilities in Big Science Organisations. It delivers training for ILOs and procurement professionals, based on sector needs and best practice, covering topics such as market consultation, analysis, and pre-commercial procurement. Materials are made publicly available, and the project also organises regional events to connect BSOs with industry and stimulate collaboration (Grant agreement ID: 101157621).