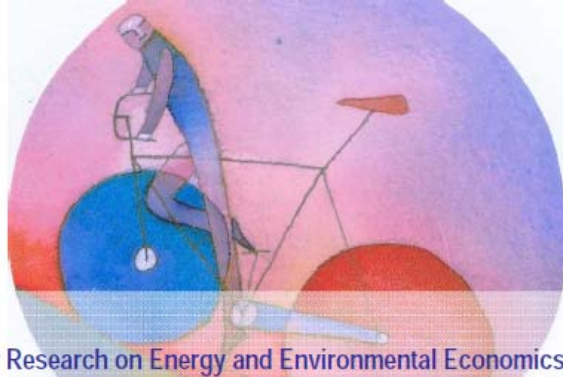


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Pre-commercial Procurement, Procurement of Innovative Solutions and Innovation Partnerships in the EU: Rationale and Strategy

Elisabetta Iossa¹, Federico Biagi² and Paola Valbonesi³

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Abstract: We consider alternative European public procurement mechanisms for acquiring R&D services and innovative solutions, focusing on Pre-commercial Procurement, Public Procurement of Innovative Solutions and Innovation Partnerships. For each of these mechanisms, we identify conceptual strengths and weaknesses. We highlight the role played by (i) economies of scope and externalities between R&D and large-scale production; (ii) degree of specificity of the innovation; (iii) role of SMEs in the market and level of market competition; (iv) risk of market foreclosure and supplier lock-in.

This article contributes to the literature on incentives in demand-side innovation policy by tapping into the contractual design features and by offering relevant implications for academics and policy makers.

Keywords: Innovation, Demand-side policies, Incentives, Pre-commercial Procurement, Public Procurement of Innovative Solutions, Innovation Partnership.

JEL Code: O31; O32; O38; H57.

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1. Introduction

Public procurement accounts for a substantial share of world trade flows, amounting to €1000 billion per year and 10-25% of the world gross domestic product (GDP); in the EU, it is estimated that the public purchase of goods and services accounts for 16% of GDP.⁵

By using this large purchasing power to procure and encourage innovation and its diffusion, governments can stimulate innovation and boost competitiveness and growth (Cabral et al., 2006).^{6, 7} Further, procuring innovative solutions can help improve the efficiency of public services in sectors such as education, energy, health, ICT and transport.

Of the public procurement mechanisms for acquiring Research and Development (R&D) services or innovative solutions, special attention is currently being devoted in Europe on Pre-commercial Procurement (PCP), Public Procurement of Innovative Solutions (PPI), and Innovation Partnerships (IP). In this paper, we discuss and compare these mechanisms and argue that the key difference between Innovation Partnerships, on the one hand, and Pre-commercial Procurement and Public Procurement of Innovative Solutions, on the other hand, is that the former is characterized by the bundling of two stages of the innovation process: the R&D stage and the large scale production/commercialisation stage. We then identify conceptually the potential strengths and weaknesses of such bundling in the light of the economic theory of contracts and incentives.⁸

Our discussion points out that the use of contract rights to reward highly valuable innovation may help exploit economies of scope, boost incentives for research effort, reduce commercial risk and ease access to finance. However, it may also create dominant positions in the market, favour lock-in situations at the expense of entrants and Small and Medium Enterprises (SMEs), and increase the risk of undue continuation of low-value projects.⁹ We thus argue that whether or not it is optimal to bundle the two stages of the innovation

⁵ <http://ec.europa.eu/trade/policy/accessing-markets/public-procurement/>

⁶ For example, innovation explained up to 80% of GDP growth in the US during the period 1909-1959 (Solow, 1957) and 68% for the period 1929-1982. The key role of innovation for European growth is emphasized in a number of documents. See European Commission (2014b) for a recent communication.

⁷ There are a number of definitions for innovation. For the purpose of this study, we shall focus on technological innovation: the transformation of an idea into a marketable product or service, typically encompassing a technological R&D and a commercialisation phase.

⁸ Laffont and Martimort (2002).

⁹ De Figuereido and Teece (1996), proposed a study on procurement contracts' hazard arising with technological innovation. They analyse vertical integration solutions and constellations of safeguards (i.e. relational safeguards) to ensure that high-powered incentives are maintained.

process (the R&D stage and the large scale production/commercialisation stage) depends on the following factors:

- the presence of economies of scope, and/or positive technical or knowledge externalities between R&D and large-scale production;
- the degree of specificity of the innovation to the needs of the public procurer, and thus whether it is expected that there will be a significant demand for the innovative solution beyond that of the public procurer;
- the role of SMEs in the market;
- the level of potential market competition, the risk of market foreclosure and the need to overcome supplier lock-in;
- whether it is possible for procurers to set clear performance targets on the required solutions, making the value of the innovation easy to observe and verify ex-post;
- the competency and efficiency of the procurer's organization.

We also highlight how public procurement can be an effective way of improving the efficiency of public services and stimulating innovation and competitiveness in key sectors and priorities, provided that the right incentives within the public sector exist. We discuss the factors that determine "procurement failure" and their implications for public procurement as an innovation policy.

Our paper contribute to the substantial body of literature on government support schemes for innovation (see Aschhoff and Sofka 2009 for an informal discussion of alternative policy instruments, focusing on public procurement for innovation (see Edquist et al. 2015 Uyarra, 2016; and Lember, Kattel and Kalvet, 2014).¹⁰ We contribute to this literature by studying public procurement for R&D based innovation and innovation processes, with a focus on the novel Innovation Partnerships introduced by the Procurement Directive. In particular, we use the principal agent theory to discuss, conceptually, the merits and pitfalls of bundling the two stages of R&D (up to prototype) and production/commercialisation.

The paper is organised as follows. In Section 2, we briefly highlight the differences between demand-side and supply-side innovation policies, providing a rationale for the use of public procurement of innovation. In Section 3, we describe alternative mechanisms for procuring innovation, focusing on Pre-commercial Procurement, Public Procurement of Innovation

¹⁰ See also Lember et al. (2014) for a wide discussion on real national experiences in public procurement of innovation.

and Innovation Partnerships. In Section 4, we compare these mechanisms in the light of the economic theory of contracts and incentives, focusing on the benefit and costs of bundling the R&D phase with the production phase. In Section 5, we draw attention to those factors that may cause procurement failure. In Section 6, we present our conclusions.

2. Demand and supply-side innovation policies to address market failure

A number of factors lead to an inefficient level of investment in R&D based innovation and innovation processes, leaving demand unsatisfied and causing technological lock-in.¹¹ Some of these factors mainly refer to the supply side of the market, others largely belong to the demand side, and others are due to the intrinsic characteristics of the innovation process, as summarized in Table 1. Notice that these factors might intertwine in the ongoing innovation processes and - thus - cells can result as not clearly separated as they look like in Table 1.

Asymmetric information issues characterize R&D activities, making it difficult to verify R&D effort or motivate researchers, see (1) in Table 1, and to raise funds to finance the investment - see (2) in Table 1. Risk aversion deters firms from investing in innovation projects - particularly SMEs, which have limited possibilities of diversifying their investments.

Innovations also have specific characteristics that may prevent firms from investing adequately. In particular, firms may not have the capacity for innovation - they may lack the human capital and physical capital necessary to undertake investment because of inefficiencies within their organizations or due to capital and labour market imperfections, see (3) in Table 1.

Information about potential demand for innovative products/services may be dispersed and it may not reach potential suppliers.¹² Potential private and public users may have information about their preferences and needs that they fail to communicate to the market because of communication costs or lack of incentives within organizations, see (4)

¹¹ For a more in-depth discussion on market failure in innovation, see the review by Martin and Scott (2000).

¹² Hippel (2005) emphasizes the importance of user involvement in innovation processes.

and (5) in Table 1.¹³ Public administrations with similar needs but located in different geographical areas or different countries may also fail to pool their demands and express them to the market, due to communication costs and coordination failures, see (6) in Table 1.¹⁴ Furthermore, knowledge is a public good with elements of non-rivalry and non-excludability, see (7) in Table 1, making suppliers unable to fully appropriate the benefits of their investment, even when the intellectual property rights (IPR) on the resulting innovations can be relatively well defined, see (8) in Table 1.¹⁵

Network externalities - occurring when the value of a network to users is positively correlated with the size of the network itself - represent a further factor that may impede efficient investment and the uptake of valuable innovations. The uptake of innovative products and the transition to new technologies may be difficult to achieve where there are lock-in costs. Once a network is established, it may be too costly for users to switch to a new technology, even if it is of superior quality, see (9) in Table 1.

Table 1: Main factors that cause market failure

Supply Side factors	Demand Side factors	Innovation Characteristics
(1) Difficulty to verify R&D effort , making it difficult to incentivize it within organization and across organizations.	(4) Unexpressed private demand for innovation, due to lack of knowledge from potential buyers on the potential supply of innovation or due to the cost of processing information by dispersed users.	(7) Difficulty to verify the value of innovation and make it contractible, creating inefficiencies in the purchase or R&D effort and its financing.
(2) Capital market imperfections make it difficult for innovators to find external financing and to diversity risk	(5) Unexpressed public demand for innovation due to lack of incentives in public	(8) Limited appropriability of the benefit from the innovation, because knowledge is a public good with elements of non-rivalry and non-excludability

¹³ The word “communication costs” is used to reflect all the direct and indirect costs of communication, including the time and the effort needed to communicate. The internet has clearly lowered these costs but the problem remains because a user, for example, may post a description of its needs on the internet but potential suppliers may fail to be informed about the post.

¹⁴ From 1945 to 2008, 59 collaborative defence procurement programmes were launched in Europe. Heuninckx (2008) reports that operational benefits were barely achieved, as compromises required by harmonization usually led to increased cost and delays.

¹⁵ Assigning well-defined intellectual property rights may sometimes be difficult, because of the characteristics and complexity of the innovation. Anticipating problems with the attribution of property rights, firms may lack appropriate incentives to invest in R&D. Litigation and weak enforcement are a widespread phenomenon (see Scotchmer, 2007).

	administrations to express a demand for innovative solutions	
(3) Little innovation capacity because of lack of human and physical capital due to inefficiencies within organizations	(6) Coordination failure between demand sources (e.g. public authorities of different countries), which does not allow to internalize network externalities	(9) Network externalities creating lock-in effects, thus weakening incentives to switch to new valuable technologies

Traditionally, supply-side policies have been the main instrument governments in Europe have relied upon in order to develop innovative markets and revive traditional segments. Supply-side policies are defined by the OECD (2012) as policies that strengthen the ability or the capacity of the economy to generate knowledge and produce innovation, by boosting public investment in R&D, and the formation of human capital and private R&D. Examples of supply-side policies are: subsidies to private R&D (such as R&D grants or loans), tax credits to R&D, publicly-sponsored R&D, enhanced capacities for knowledge exchange and support for education and training. Policies that support or ease knowledge transfer are also supply-side policies.¹⁶ To be effective, supply-side policies require that firms are able to identify the potential demand for innovation, recognizing unsatisfied needs.¹⁷ Only then can the removal of supply-side barriers to innovation lead to socially-valuable R&D investment.

An alternative, and also in many respects complementary, approach is provided by demand-side policies. These are at the centre of the current innovation policy in Europe (see also KOK et al., 2004 and Aho et al. 2006) and are used world-wide (see OECD 2011 and 2014 for a review of different countries' approaches).¹⁸

The rationale for demand-side innovation policies is that suitable innovations may fail to materialize because there may be a problem (or there may *also* be a problem) on the demand side. Even firms with sufficient innovation capacity may have insufficient incentives to invest because the demand for their innovation is uncertain and fragmented,

¹⁶ See also Edler (2007).

¹⁷ Hippel (2005) undertakes a large-scale impact assessment of US grant R&D programs and shows that traditional supply-side R&D measures tend to have a high failure rate (in supply-side/producer-driven R&D, 70-74% of new developments are not successfully commercialised). Inadequate understanding of user needs is identified as the most important reason for this high failure rate.

¹⁸ See Edler and Georghiou (2007) and Uyarra (2016).

or because users are locked into existing technologies (see Table 1). In these cases, demand-side innovation policies aim to increase the demand for innovation, improve the conditions for its uptake, or improve the articulation of demand in order to boost innovation and its diffusion (Edler, 2007).

In practice, there are many ways of achieving this; for example, by:

- facilitating the identification and transmission of users' needs;
- encouraging user coordination (e.g. through joint or collaborative procurement of R&D services);
- increasing the demand for innovation, incentivizing public buyers to purchase innovations via procurement of R&D or of innovative solutions, or through technology mandates and standard settings that define new functional requirements for products and services that can be met only by developing new solutions;
- catalysing policies, which involve the public sector buying the innovative good from the private sector;
- increasing demand to overcome lock-in effects due to network externalities.¹⁹

Following the OECD (2011), demand-side policies include²⁰:

- i) innovation-oriented public procurement (i.e. the purchase of innovative solutions and/or of R&D services by the public authorities);
- ii) innovation-oriented regulations, such as labelling and certification, recycling regulations, emission standards, which set performance levels as regards quality, compatibility requirements for allowed technologies or health, safety, environmental outcomes of products or services);
- iii) innovation-oriented standards (i.e. standards ensuring, for example, interoperability, minimum safety and quality, etc.).

¹⁹ See Edler (2007). A characterization of alternative demand-side instruments is presented in Edler (2013). We note, however, that there is no unanimous definition of demand-side policies.

²⁰ As highlighted by the OECD (2011), the idea of fostering innovation through demand-side policies is not new in sectors such as defence, energy and transport. The renewed interest may be understood if one considers the new societal challenges of ageing and the environment. Disappointment with the outcomes of traditional supply-side measures may also have played a part.

In our view, demand-side and supply-side innovation policies address the different barriers on the two sides of the market and they should be viewed as complementary policy instruments. On the one hand, the effectiveness of supply-side policies (e.g. research grants) requires that firms are able to identify a demand for their innovation. On the other hand, the effectiveness of a demand side policy (e.g. actions for joint procurement of innovation) requires that firms have the capacity to meet the demand requirements.²¹ As the OECD (2012) puts it *“Neither supply-side nor demand-side policies are likely to be optimally effective in isolation. Efforts to foster innovation will likely have greatest effect when they address the entire innovation chain.”*²²

3. Innovation-related Public Procurement: background

Innovation-oriented procurement strategies occur when a public agency purchases, or places an order for a product – service, good, or system – that does not yet exist, but which could probably be developed within a reasonable period of time as a result of additional or new innovative work by the organisation(s) willing to produce, supply, and sell the products being purchased (Edquist, Hommen and Tsipouri, 2000).

As a demand-side policy tool, public procurement – accounting for 16% of European GDP²³ – can play an important role in tackling market failures. First, by procuring R&D or innovative goods and services, public authorities in charge of providing public services can clearly express their needs to the market. This helps to overcome asymmetric information problems with the supply side and to ensure the delivery of higher quality and more cost-effective public services (OECD, 2011). Second, financial support to joint procurement may stimulate communication among procurers and overcome coordination problems among public authorities. Procurement of new technologies may also help to catalyse the demand for innovation and meet unsatisfied private needs. This, in turn, can reduce lock-in effects

²¹ In a recent paper, Cano-Kollmann et al. (2016) empirically show that the effectiveness of different publicly funded schemes supporting innovation is related to the “openness” of firms’ innovation practices.

²² As an example, consider the case of market failure due to capital market imperfections. A supply-side policy intervention that aims to facilitate access to financial sources will certainly help SMEs’ innovation. However, provision of funds without market opportunities for SMEs will still be ineffective. Facilitating access to funding by SMEs could become more effective if it goes together with innovation-oriented procurement mechanisms designed to induce SME participation (like PCP – see below). PCP will help to create market opportunities for SMEs, by easing access to the demand for innovation coming from the public sector.

²³ http://ec.europa.eu/invest-in-research/policy/pub_procurement_en.htm

due to network externalities, by creating a sufficiently large demand for the new technology. Third, a clear demand from the public sector may also incentivize investment in innovation by firms, including SMEs, by reducing the commercial risk of their R&D investment and helping them to gain access to funds. This would enhance the innovative performance of national industries, increasing their productivity, competitiveness and, ultimately, growth.

The potential of innovative public procurement has been emphasized in a number of European Union reports (European Commission, 2005; European Commission, 2007). Based on these reports, the European Commission is now calling on the European Union Member States to set aside dedicated budgets for Pre-commercial Procurement (PCP) and Public Procurement of Innovative products and services (PPI), and has devoted specific resources for procurement of innovation in the EU Framework Programme for Research and Innovation ("Horizon 2020"). Finally, the new European Directives on public procurement 2014/24 and 2014/25 have modernised the legislative framework on public procurement, making the rules more flexible in order to foster demand for innovative goods and services.

In what follows, we focus on the mechanisms that are at the centre of the European policy on PCP (3.1) and PPI (3.2), presenting their main characteristics in detail. In section 3.3, we then present Innovation Partnership (IP), a special procedure for the establishment of a long-term partnership for innovation.

3.1 Pre-commercial Procurement (PCP)

Pre-commercial Procurement (PCP) is a relatively new approach to procuring R&D services that does not constitute state aid. The approach is defined in the EC Communication COM/2007/799, and discussed in detail in Bos and Corvers (2006) and in Rigby (2016).

Under a PCP, having identified a specific procurement need that existing solutions cannot readily satisfy, the public procurement authority procures R&D services. Multiple private firms compete to carry out an exploratory phase and propose suitable solutions, up to prototype building and the production of a limited number of units to test the characteristics and properties of proposed solutions.

In particular, the main features of PCP are the following:

Unbundling of R&D and Production.²⁴ There is a separation (unbundling) between i) the procurement of R&D services (PCP phase) and ii) the (possible) purchase of commercial volumes of end products (from large-scale production) resulting from the R&D phase.²⁵ This means that a company that has undertaken R&D services and developed a working solution has no guarantee that it will also win a follow-up contract for the large-scale production of the proposed solution.²⁶

Benefits sharing. In PCPs, the benefits are shared between the procurer and the contractor(s). The public procurer is not the only beneficiary of the developed solution. Unlike traditional R&D procurement, under PCPs the public procurer does not obtain exclusive rights to the R&D results and the benefits from the resulting innovations are shared between the public sector and the firm which has developed the solution. In practice, this means that Intellectual Property rights (IPRs) are either fully assigned to the private PCP contractor,²⁷ with the procurer retaining a license to use, or shared between the public and private parties.²⁸

Competitive development in stages. The public procurer buys R&D services from several suppliers in parallel. These suppliers have alternative proposals/solutions and compete on economic and technical grounds. The procurement process is divided into multiple sequential phases, which include solution design, prototype development and testing of first products, as shown in Figure 1 below.

Figure 1. - Unbundling under Pre-commercial Procurement

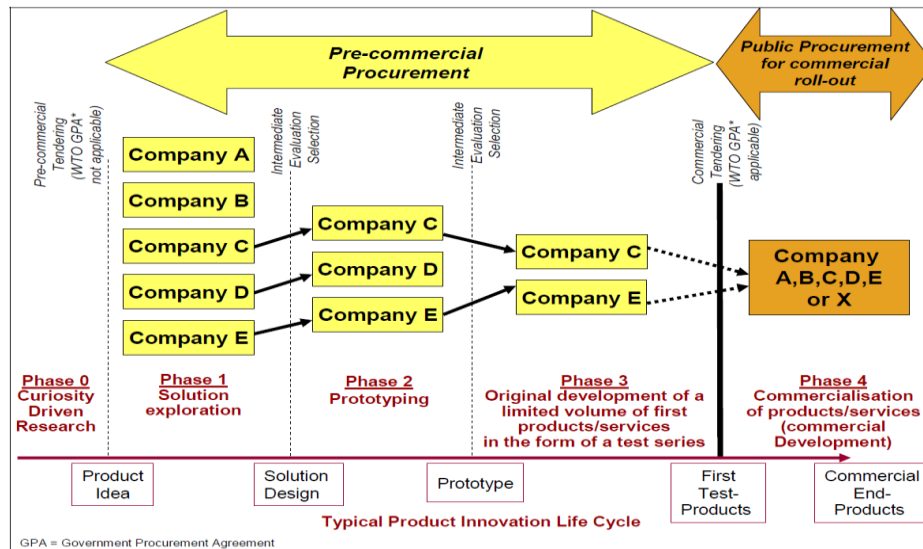
²⁴ This specific feature of PCP is also used for example in the well-known Small Business Innovation Research (SBIR) program (<https://www.sbir.gov/>), which inspired the European SME Instrument (<http://ec.europa.eu/digital-agenda/en/sme-instrument-0>). The SBIR funding program awards contracts to firms for the R&D phase (Phase I and II of SBIR) but not for Phase III (the commercialisation of the developed solutions).

²⁵ The R&D covers up to "original development" of a first product or service; it may include limited production or supply in order to incorporate the results of field testing and to demonstrate that the product or service is suitable for production, but it does not extend to quantity production. The latter is part of the commercial development and related activities such as integration, customisation, incremental adaptations and improvements to existing products or processes.

²⁶ Procurers can however buy the limited set of end-products already produced during the PCP as part of it. Moreover, the procurement directives foresee the possibility that procurers may use the negotiated procedure without publication to buy supplies that result from R&D procurements, under specific circumstances.

²⁷ With the public procurer keeping a free license of exploitation for internal use and the firm being required to grant non-exclusive rights to third parties under market conditions.

²⁸ For instance, through sharing of the rights to commercial exploitation.



After each stage, the procurer compares offers using the Most Economically Advantageous Tender (MEAT) criterion, and decides which solution can proceed to the subsequent stage.²⁹

Risk sharing. Not only benefits but also risks are shared between the private contractors and the public procurement authority. In each stage, the firms compete, bidding on the minimal contribution requested to the procurer in order to undertake the R&D services. This contribution (i.e. PCP) helps them cover all or part of the costs of the exploration phase and the costs of prototype and testing. The monetary value of the firms' IPR rights induces bids that, internalizing this value, are below the level that would arise under exclusive development: the greater the monetary value of the IPRs attributed to the firm, the lower the contribution requested from the procurer. This contribution can be either above or below the development costs, depending on the degree of competition in the PCP process and on the value of the IPRs. Should the project not succeed, both the public party and the private party face a loss. In this respect, there is risk sharing between the two parties.

²⁹ The MEAT criterion does not allow procurers to assess tenders by considering only the economic offer. Awarding the procurement contract to the lowest price offer is indeed unsuitable in many circumstances where quality and technical dimensions are important. The new European Directives on public procurements (EC Directives 2014/24 and 2014/25) emphasize the importance of this wider assessment criterion, clarifying that MEAT criteria can include also criteria related to social or environmental characteristics. This greater choice for procurers certainly helps them undertake innovation-oriented procurement. For example, by allowing whole-life costing assessment, the MEAT criterion favours innovative solutions that bring costs down and increase quality in the long run.

Multiple sourcing. There is multiple sourcing in the sense that multiple firms compete in parallel during all stages of the PCP. At least two firms reach the final stage, when they develop their prototypes and test a set of first products. This is specific to PCP, and highlights how it differs from traditional R&D procurement where single sourcing is typical.

Box 1: Recent examples of PCP in EU

In the ICT sector we can find recent examples of PCP. Cloud for Europe uses pre-commercial procurement to identify innovative solutions for cloud services that best fit public sector needs, and provides high quality information to public procurers about the potential of cloud services.³⁰ Another example is the 'Distributed European Community Individual Patient Healthcare Electronic Record' (DECIPHER). This was one of the responses to European procurement authorities' requests for solution exploration, prototyping and original development of interoperable mobile solutions that would enable secure cross-border access to existing patient healthcare portals and efficient and safe medical care of mobile patients in EU Member States. These solutions will be of special interest in the management of patients with chronic diseases or unplanned care episodes.³¹

The ITS (Innovative Transport System) Innovation Stockholm Kista is a catalytic PCP which was launched in 2012 by the City of Stockholm, the Swedish Transport Administration, Stockholm Public Transport and Kista Science. It aims to stimulate the development of new solutions for a more efficient use of transport infrastructure. The initial application is for transport to and from the city of Kista, but the long-term objective is to develop solutions to serve citizens of the wider Stockholm region.³² The proposed solutions are scalable and equipped with appropriate business models so that they can serve citizens in the wider Stockholm region after competition closure.

A very recent example of PCP in Europe is the German THALEA project which was launched in March 2015.³³ The aim of THALEA is to create a Telemedical control-centre software for tele-ICUs which can capture workflow-data, physiological parameters, laboratory results and current medication in order to set up a robust real-time analysis tool. This will enable telemedical ICU-staff to monitor and oversee an entire ICU patient population.

3.2 Public Procurement of Innovative Solutions (PPI)

Horizon 2020, the new EU Framework Programme for Research and Innovation, includes a legal definition of Public Procurement of Innovative solutions (PPI), which is a useful basis for deciding the eligibility of procurement actions for EU co-financing. PPI is defined as procurement where the contracting authority acts as a launch customer, an early adopter, for innovative goods or services that are not yet available on a large-scale

³⁰ See: <http://www.innovation-procurement.org/projects/ict/>

³¹ For the tender, see <http://ted.europa.eu/udl?uri=TED:NOTICE:052533-2015:TEXT:EN:HTML>. For a discussion of this case, see Bedin, Decarolis and Iossa (2015).

³² For a project description see <http://www.vinnova.se/en/innovationsupphandling/Projects/ITS-Innovation-Stockholm-Kista/>; see also Bedin, Decarolis and Iossa (2015) for more details on the PCP process.

³³ See <http://www.thalea-pcp.eu/>

commercial basis³⁴ (it may also include conformance testing).³⁵ PPI does not include the procurement of R&D services, as does PCP discussed above.^{36,37}

Some authors (see e.g. Edquist and Zabaka-Iturriagoitia, 2012) propose that a distinction should be made between two different types of PPI, depending on the degree of innovativeness of the innovation process: Adaptive PPI and Developmental PPI.

Adaptive PPI. This occurs when the procured product or system is only new to the country (or region) of procurement. Innovation is thus required in order to adapt an existing product/system to specific (national, local) conditions. It may also be labelled 'diffusion-oriented' or 'absorption-oriented' PPI. It implies *incremental innovation*.

Developmental PPI. This occurs with the creation of new-to-the-world products and/or systems through the procurement process. It may be regarded as 'creation-oriented' PPI and involves *radical innovation*.

The main characteristics of PPI can be summarised as follows:

Early adoption. Under PPI, the procurer acts as a launch customer and early adopter. Thus, the procurer is a first buyer for an innovative solution not yet available on a large scale.

Unbundling of R&D and large-scale production. PCP and PPI are separate but complementary instruments: following a successful PCP that has led to the development of a suitable prototype, the procurer may decide to procure the production of the solution on

³⁴ The European focus on PPI and its funding policy reflects the view that PPI could be an instrument to achieve Europe 2020 wider economic, environmental and societal objectives, in areas such as mobility, health, construction, e-government, waste management and recycling, where the public sector accounts for a big part of demand and can use procurement as a means to address key societal challenges such as sustainable transport, resource-efficiency or healthy ageing.

³⁵ Under Horizon 2020, the Commission will co-fund groups of procurers to undertake joint PPI procurements in order to have a single joint PPI call for tender and a single joint evaluation of offers. This is supposed to speed up the development of innovative solutions, by encouraging cooperation between procurers from across Europe, either by supporting networks of procurers (to prepare joint PPIs) or by co-funding the initial call for tender, the related coordination, and the networking activities.

³⁶ Notice that the acronym PPI is sometimes used to refer generically to public procurement of innovation, which includes PCP and PPI.

³⁷ For further information see: <https://ec.europa.eu/digital-agenda/en/public-procurement-innovative-solutions>

a large scale (PPI). It should be remembered, however, that the unbundling that characterizes the PCP process ensures that the awardees of the PCP have no special rights to the PPI. This separation between PCP and PPI allows companies that have developed products through means other than PCP (e.g. through R&D grants, own funding, venture capital) to participate in the PPI procurement on an equal footing with the PCP solution developer.

PPI is not a specific procurement procedure. Typically, it uses either a negotiated competitive procedure or a competitive dialogue.³⁸

BOX 2: Recent examples of PPI in EU

Consip, the Italian central procurement agency, provides an example of PPI. This agency was assigned the task of organising, implementing and monitoring the procurement of heating services for the Italian public administration. It did this by implementing in a large number of administrations a performance-based contract, which achieved cost efficiency. By introducing performance standards, the contract helped to encourage innovation in the supplier's solutions.

More generally, the European Commission has set up a platform for innovation on PPI projects, which provides a number of examples. In the food industry, INNOCAT encourages eco-innovation in the catering industry through a series of tenders published by public and private buyers across Europe. In the Health industry, the HAPPI project brings European health providers together to find and jointly procure innovative and sustainable solutions for healthcare for the elderly. The aim is to help hospitals with limited budgets find products which cater for the specific needs of elderly patients. In the construction industry, the Innobuild project's partners Falu (Sweden) and Layngdal (Norway) are currently working on a joint procurement strategy for sustainable high-tech building projects for senior citizens.³⁹

3.3 Innovation Partnerships (IP)

Art 31 of the new Procurement Directive EC 2014/24 introduced the Innovation Partnership (IP) as a new special procedure for the establishment of a long-term partnership for the development and subsequent purchase of new, innovative products, works and services, provided they can be delivered at agreed performance levels and costs. This procedure enables public procurers to have an innovative solution developed and tailored to their specific needs.

³⁸ In the new European Directive on Public Procurement 2014/24/EU, which came into force on 17 April 2014, Art 26 states that Member States shall provide that contracting authorities may apply a competitive procedure with negotiation or a competitive dialogue with regard to works, supplies or services including design or innovative solutions. The competitive procedure with negotiation is laid down in Art. 29; and the Competitive Dialogue in Art. 30. These procedures are characterized by a negotiation or dialogue phase which gives public procurers the flexibility they need to be able to acquire the innovation oriented goods, products or service they require.

³⁹ See: <https://www.innovation-procurement.org/>

The main characteristics of IPs are as follows:

Bundling of R&D and large scale production: the IP foresees the funding of R&D for an innovative solution in the same procedure as the procurement of the solution production. Thus, the R&D stage and the production/commercialisation stage are all bundled under the same procurement mechanism, rather than being kept separate as they would be in PCP and PPI procurement.

Competitive Development in phases: operators participating in the procedure submit research and innovation projects designed to meet the needs identified by the procurement authority. The procedure has several stages, including an R&D stage up to prototype and testing, and a subsequent production stage, namely the manufacturing of the supply or the provision of the services.

Solutions proposed by bidders are compared at each stage on economic and technical grounds, using the MEAT criterion. Based on the set criteria and targets, the contracting authority may decide to restrict the number of participants or even to terminate the partnership and launch a new procurement procedure for the remaining phases, provided that it has acquired the relevant intellectual property rights. The contract is awarded in accordance with the rules for a competitive procedure with negotiation (Article 27 of Directive EC 2014/24), which allow procurement authorities to negotiate the tenders submitted in order to improve the content of the offers so that they correspond better to the award criteria and minimum requirements.

Negotiation on partnership structure: there are no set rules on how costs and benefits should be shared. The only requirement is that, in the procurement documents, the procurer defines the arrangements applicable to IPRs. Negotiation between the public and private party can take place during the procurement process up until the final stage, provided that no confidential information is revealed to third parties and that the negotiations take place with all participants simultaneously.

Single or multiple sourcing: the procurement authority may decide to set up the partnership with one partner or with several partners, which conduct separate research and development activities.

Limit on the estimated value of supplies: if the process reaches the final stage of large-scale production, there is a limit on the estimated value of supplies (i.e. the volume of products that is bought under the partnership), which needs to be "not disproportionate to the R&D investment". There are no set guidelines, but the idea is that the innovation partnership should be structured in such a way that it provides the necessary "market-pull", without creating a long-term partnership that may foreclose the market.

BOX 3: Recent examples of IP in the US and the EU

So far as we know, there are no examples yet of Innovation Partnerships in Europe as the Procurement Directives still need to be transposed in most countries. However, the idea of bundling together research and production is not new. In the US, the Total Package Procurement Concept (TPPC) was first used for C-5A procurement in the Air Force.⁴⁰ This system required contractors to bid, in their original proposals, for the entire development and production of an aircraft or missile. The contract was awarded after a technical and price competition and it was negotiated by the government and Lockheed at a time when the administration sought to fight a guns-and-butter war in Vietnam. A later TPPC contract was negotiated for the [F-14](#) airplane.

IP-like procurement has also been implemented in Europe. An example is the tender for the online energy-efficient products facility launched in 2013 by the Executive Agency for Competitiveness and Innovation (EACI).⁴¹ The main tasks of the service contract consist of developing, managing and promoting a multilingual and multidisciplinary electronic facility on eco-design and energy labelling to support the implementation of the Eco-design and Energy Labelling Directives.⁴²

4. Procurement of Innovation: Choosing between Mechanisms

Having established that public procurement can help to address market failures in innovation, we now compare incentives under the procurement mechanisms discussed in the previous section. One of the key distinctions between these procurement mechanisms is the degree of bundling of the different stages of the innovation process. In this section, we review the benefits and costs of bundling, focusing on how it affects incentives for R&D effort.

⁴⁰ https://en.wikipedia.org/wiki/Lockheed_C-5_Galaxy

⁴¹ <http://ted.europa.eu/udl?uri=TED:NOTICE:281836-2013:TEXT:EN:HTML>

⁴² Note that a procurement project in the spirit of the IP was implemented in the US defence sector (Rogerson 1992, 1994), where the tender competition for the best prototype was followed by a non-competitive production stage, where the winner of the R&D competition was virtually certain to be awarded the follow-on contract.

4.1 Bundling Stages of Procurement: insights from literature and application

An R&D-based innovation process can be divided into two main stages: the R&D stage, where a solution is explored and a prototype is tested; and the production/commercialisation stage, where the industrial production of the proposed solution is carried out and commercialisation takes place. The two stages can be more or less integrated. At one extreme of the spectrum, we have complete separation, which occurs when one firm/organization performs the R&D activity and another the industrial production. At the other extreme, we have full integration, which occurs when the same firm/organization performs both the R&D and the industrial production in full coordination. Intermediate solutions are also possible, in which different firms/organizations coordinate among themselves (possibly by using contracts).

The problem can be looked at from a theoretical perspective by adopting the Principal-Agent framework, where a Principal (the Public authority in our case) can delegate two sequential tasks (R&D and industrial production) to the same Agent (i.e. if the tasks are “bundled”) or to two different Agents (i.e. if the tasks are “unbundled”).⁴³ The issue is relevant when contracts are incomplete, that is, when it is not possible to specify ex ante the level (or type) of effort that is required from the Agent in each single contingency (either because effort is not “verifiable” or because some contingencies are not verifiable⁴⁴) that may arise during the execution of the contract. In the pursuit of their own interests, Agents may put in suboptimal effort, without fully taking into account the interests of the Principal. In these cases, bundling or unbundling tasks is important, as it affects the extra-contractual incentives that the Agents will have when deciding how much effort they should make.

This issue is important in procurement for R&D based innovation and innovation processes. When contracting, the public procurer (the Principal) is typically unable to perfectly specify the level or type of effort that firms (Agents) should put into research, and may also be uncertain as to future demand for the product derived from the R&D effort. However, the procurer can specify some performance requirements that the innovation

⁴³ See Laffont and Martimort (2002) for a review of the Principal-Agent literature.

⁴⁴ “Verifiable” means that it can be observed by a Court of Law and therefore can be contractible.

should satisfy, for example in terms of system interoperability, energy efficiency, machine-time and so on. In these circumstances, the extra-contractual incentives that firms could have for undertaking research are affected by whether the task of undertaking R&D services is bundled or unbundled with the task of producing/commercialising the innovation.⁴⁵

Papers by Hart (2003) and Bennett and Iossa (2006) - reviewed in Iossa and Martimort (2015) - have shown that bundling of sequential tasks into one contract with a single Agent can be beneficial to the Principal (our procurer) when contracts are incomplete and there is a positive externality across the two sequential stages. A positive externality exists if the firm's effort in the first stage reduces costs or increases quality (yielding higher profit for the firm) in the second stage. For example, in infrastructure procurement, putting more effort into design/construction at the building stage results in better infrastructure, which generates the positive externality of reducing the cost of managing and maintaining the infrastructure during the operational stage and yields higher quality of service. In this case, bundling induces the firm in the first stage to take into account how its efforts will affect the second-stage payoff. This generates extra contractual incentives that increase the willingness of the firm to put more effort into the first stage than it would if it was not also in charge of the second-stage task.⁴⁶ Bundling the two tasks into one contract with one single Agent thus results in an incentive effect that creates "economies of scope" and leads to lower costs and higher quality.

In what follows, we analyse the potential benefits and costs of bundling the R&D stage with the production/commercialisation stage. Our focus is on the incentives that bundling provides for the R&D effort.

4.1.1 The Benefit of Bundling

The insights from literature on the Principal Agent have important implications for the design of efficient innovation procurement. With innovation procurement, there is moral hazard because the Agent's research effort is not verifiable by the public contracting

⁴⁵ The expression "extra-contractual incentives" refers to those incentives that are created by factors outside the procurement contract. A typical extra-contractual incentive is the desire to build a good reputation.

⁴⁶ Going back to our infrastructure example, anticipating that efforts made to design and build infrastructure well will reduce operational costs, the firm in charge of both building and operation will choose to put more effort into design/construction than a firm who is only in charge of the building stage. As a result, the infrastructure will be of better quality and users will benefit from better services and/or lower costs.

authority, and contracts are incomplete because this effort is difficult to specify ex-ante and to describe in a contract.⁴⁷ Extra contractual incentives are therefore important.

Consider first the case of an innovation that has a high degree of specificity for the public procurer and thus low market value, that is, it is valuable mainly to that procurer or within a limited sized public sector (we shall hereafter refer to this case as “high PA specificity”). Innovations that increase the quality of public services or reduce their costs may have a high degree of PA specificity because of the nature of the public good or service to which the innovation is targeted (e.g. innovation in traffic management systems). If there is a positive externality across stages, as may be the case in knowledge-based sectors, then there is an incentive gain in bundling the R&D stage with the production/commercialisation stage. If the same firm undertakes both tasks, the knowledge acquired in the R&D stage will help it to lower the cost of producing the innovative solution, and it may lead to more cost-effective innovations.

In particular, bundling induces the internalization of the positive externality, in the sense that it makes the firm at the R&D stage take into account how its research effort will affect the cost of producing the resulting innovation. Thus bundling incentivizes greater effort. Technological economies of scope that reduce the production costs of the proposed solution will reinforce this effect. Bundling R&D and production will also ease access to external funding, by reducing commercial risk and thus the risk premium required by the lender for financing a risky innovation investment.

Furthermore, Che, Iossa and Rey (2015) show that linking production to R&D services can provide extra-contractual incentives for research effort, even in the absence of positive externality or economies of scope. However, unconditional bundling is generally not optimal. They consider the case where the project is valuable only to the procurer and its characteristics can be verified,⁴⁸ but the effort undertaken by the firm at R&D stage cannot be described or specified in the contract. In this setting, they show that biasing the tender for the production contract in favour of the firm proposing the best solution at the R&D

⁴⁷ See also De Figuereido and Teece (1996) who discuss the contractual hazard arising with technological innovation.

⁴⁸ For example, it is possible to verify the level of energy efficiency of a proposed solution, or the machine time to complete a task.

stage, when the proposed project is of high value, helps to reward good projects and provides extra-contractual incentives to put more effort into R&D.⁴⁹

This is consistent with procurement practices observed in US defence procurement and described in Rogerson (1992, 1994). Contract rights act as an incentive to achieve high value innovations.⁵⁰ Calzolari, et al. (2015) find that a similar practice is used in German car manufacturing, where obtaining a sole-production contract is the carrot used to incentivize suppliers in the design and investment process. As the designs are specific to the car manufacturers, and thus have little or no market value, the anticipation of production rights can be a particularly valuable way of stimulating research effort. With unbundling, the procurer does not commit to buying the resulting innovation, and this exposes the firm to the risk of hold-up: unable to sell its innovation in the wider market, the supplier undersells it to the procurer. Anticipating this, the supplier will underinvest in research effort.

Consider now the case of an innovation that has low PA-specificity for the public procurer and thus high market value. In this case, extra contractual incentives for the R&D effort will arise from the opportunity to commercialise the innovation on the private market. The assignment of the intellectual property rights to the firm (with the procurer retaining, of course, a licence of use) will provide it with incentives to put effort into research to deliver valuable and profitable solutions even if there is unbundling. Underinvestment in R&D effort or an inefficient investment may, however, still result, especially if the procurer and the market's preferences are not fully aligned. Nevertheless, the need of bundling as an instrument to provide extra-contractual incentives is weakened.

4.1.2 The Cost of Bundling

What are the risks and costs of bundling? For the benefits of bundling to materialize, the procurer must be able and willing to take low-value projects away from the firm, or stop

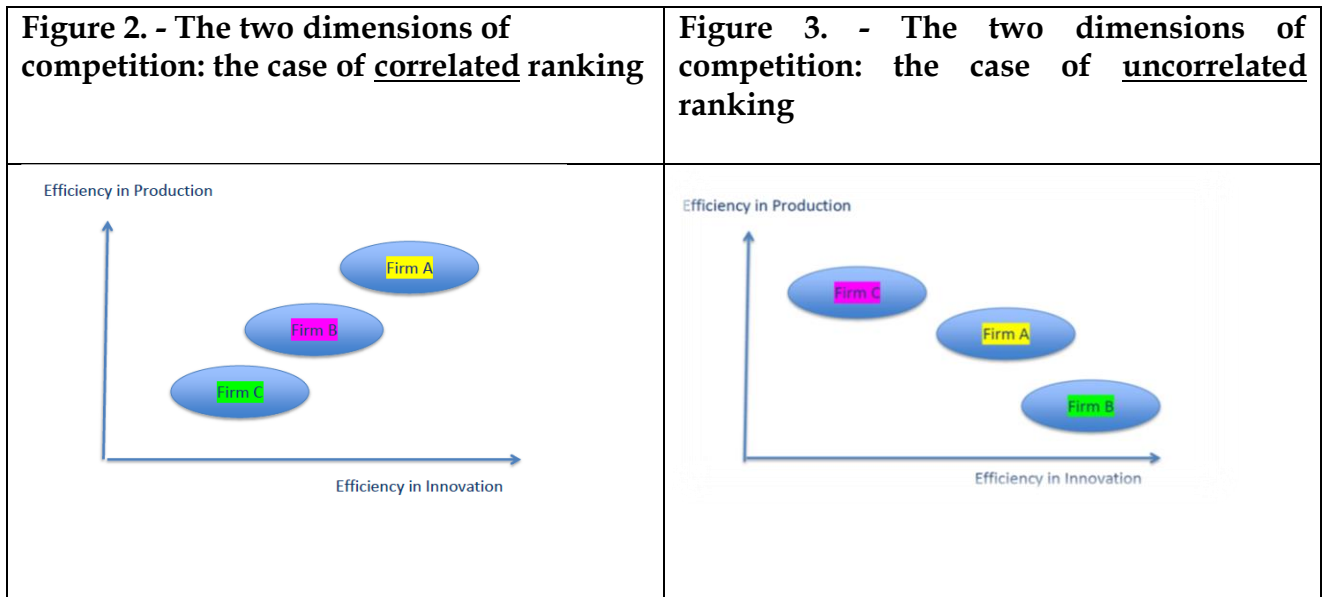
⁴⁹ The key insight here is that increasing the chance of the firm undertaking R&D to obtain lucrative production rights when it delivers a high-value innovation can motivate it to put more effort into research when the innovation has high degree of PA-specificity. However, unconditional bundling is generally not optimal. If the firm is certain to obtain lucrative production rights even when the innovation has low value, the efforts it puts into research will decrease rather than increase, compared to the case where the two tasks are unbundled.

⁵⁰ Che, Iossa and Rey (2015) also notice that monetary prizes, such as inducement prizes, have no impact on allocative efficiency, and as such they may appear to be a superior way of providing incentives for research effort than contract rights. But when agency problems generate some rents at the production stage, these rents can potentially be used to motivate the R&D performer, at no additional cost for the contracting authority. In practice, this occurs when bidders have better information on the cost of implementing the project than the contracting authority, and can therefore secure some extra profit at tender stage.

them altogether. Otherwise the firm would anticipate profitable sales even for low-value innovations and its research effort would therefore decrease (Che, Iossa and Rey, 2015). Doing so, however, requires the procurer to be able to translate its needs into well-defined project and performance specifications.

Thus, the project value must be clearly observable and measurable via performance measures, before undertaking large-scale production. Tamada and Tsai (2007) show that, when verification of this kind is difficult because of asymmetric information problems, unbundling may help by ensuring that low-value projects are not unjustifiably continued. Furthermore, agency problems within governmental organizations may impede the stopping of low-value projects. This may happen even when these have been identified, albeit not perfectly verified. Risk adverse officials may fear that there will be a judicial challenge from the firm, and they may be perceived as responsible for project failure. They may also fear that stopping a project will be viewed as admitting having made a mistake at the tender stage, which would incur a reputational loss.

Bundling also makes it more difficult for SMEs to access the market. To the extent that SMEs may be in a difficult position to handle complex and long-term procurement contracts with an integrated commercialisation phase, bundling (such as that of IP) may discourage participation by SMEs. This point is best explained by comparing Figures 2 and 3. In Figure 2, the ranking of firms in terms of their efficiency at the R&D stage is the same as their ranking in terms of efficiency at producing the resulting solution. Firm A is the most efficient firm in both dimensions and we can expect that this firm will be selected at the tender stage, regardless of whether there is bundling or not.



Consider instead Figure 3, where Firm B is the most efficient at the R&D stage, whilst Firm C is the most efficient at producing, and suppose that Firm B is an SME. If the R&D stage and commercialisation are separated, the SME would probably win the pre-commercial procurement for the R&D services. If, however, the two stages are bundled, this firm would probably not win the bundled contract.⁵¹ Bundling thus changes the characteristics of the firm that is likely to win the tender, and this may discourage SMEs from participating if they anticipate that they will not be able to compete in both the innovation and production dimensions.

When fixed costs are high, investment can be difficult to recover because the knowledge acquired is specialized and often customized to reflect specific market needs. This may discourage entry, especially if the entrants are SMEs with limited funding to cover the investment costs. In this regard, the risk sharing approach of PCPs can help SMEs to innovate, by reducing the amount of private investment they need to enter the market.

We also know that long-term partnerships with a single partner for a high contract value can be a threat to fair competition in the market. Secured by a long-term production

⁵¹ This argument does not take into account the possibility that an SME could undertake a joint venture with a larger firm. Joint ventures may facilitate SME participation but they are costly and time-consuming, and the issue remains: empirical evidence shows that the large size of contracts is probably the most important barrier for SMEs accessing public procurement. A survey conducted for the EC covering 296 European procurers and 887 European companies participating in public procurement between 2008-2012 showed that whilst SMEs won around 60% of contracts below 1 million euro, they won only 30% of contracts above 5 million euro. The regression analysis undertaken in the study confirms that the higher the value of the contract, the lower the likelihood that SMEs are awarded the contract. The value threshold above which SMEs are seemingly disadvantaged is at around 300,000 euro. See GHK (2010).

contract with a procurer, the firm may gain a lock-in position and long-term advantage over its competitors. Similar concerns apply to the bundling of R&D and production activities: by increasing dependency on one vendor, lock-in effects may be exacerbated. This may be a problem in some areas, such as ICT systems, where many buyers are 'locked' because detailed knowledge about how the system works is available only to the supplier, so that when they need to buy new components or licences only the latter can deliver⁵² (European Union, 2013). Moreover, buyers find it difficult to change supplier after the expiration of the contract, because not all the essential information or technologies for production are available for efficient takeover by another supplier. Hence, partnerships must be structured so that they do not lead to anti-competitive effects and supplier lock-in.⁵³

BOX 4. – Lock-in for ITC solutions procured by EU public buyers

A survey⁵⁴ carried out in 2011 on public procurement officials from 244 procuring authorities in the EU Member States found that at least 40% of them considered that changing their existing ICT solution would be too costly because it would involve changing many other systems that depend on the former. Of those surveyed, 25% felt they would not be able to change their ICT solutions for fear that their information would not be transferable. Moreover, 59% of the respondents reported that the interoperability of new software, which makes it compatible with software from other producers and product families, is most important, whilst 33% found that the software compatibility from other producers and product families was most important (8% said they did not know). This shows that a significant share of public administrations in practice lock themselves into proprietary technologies. Building open ICT systems by making better use of standards in public procurement is seen as a way to prevent this lock-in.

4.1.3 Benefit vs Costs: the Trade-offs

When we consider the alternative to bundling, namely a PCP (possibly) followed up by a PPI, the benefits and risks are somewhat reversed. For those innovations with high PA-specificity, the separation between R&D and production does not allow the internalization of the externalities across stages, but it helps the public procurer to filter technological risks before committing to the purchase. Compared to an IP, a PCP clearly gives more leverage

⁵² In a study commissioned by the European Commission, Bedin, Decarolis and Iossa (2015) investigate the economic impact of PCP, compared to other procurement methods that differ from PCP in some key dimensions. They collect evidence on eight European PCP tenders undertaken in Europe after 2011 and compare them with a sample of 32 cases of non-PCP procurements undertaken in Europe in the same period. Using a methodology based on Ordinary Least Squares (OLS) and Nearest Neighbour Matching (NNM) estimators, they find convincing evidence of a positive association between PCP and reduced lock-in. In their study, PCP cases witnessed SMEs participation, and in the 87.5% of cases, SMEs were also awarded the PCP contract as single bidders or as lead partners in consortium/entity groupings. Furthermore, they find empirical evidence to show that PCP increases both the number of SMEs that participate and the number that are awarded contracts, compared to conventional joint procurement of R&D services and supply.

⁵³ Finally, the European Directive on public procurement currently leaves unspecified many important aspects of Innovation Partnerships, such as the duration of the partnership, or on its value - apart from the statement that it should not be "excessive".

⁵⁴ See: <http://cordis.europa.eu/fp7/ict/ssai/docs/study-action23/study44-survey1results.pdf>

to the procurement authority not to continue with a PPI procedure a project that is not considered worth of further public financing. This helps solve project verification problems and the agency problem in governmental organizations, but it may make access to financing more difficult.

For those innovations with low PA-specificity, extra-contractual incentives under PCP are provided by the market, as the firm anticipates that greater research effort will result in more profitable innovative solutions. The assignment of significant property rights to the firm that characterizes PCPs (typically the public sector retains a licence of use) will therefore help to provide strong incentives. Finally, PCP leaves more space for SMEs, which otherwise would be restricted by their limited ability to undertake large-scale production, to express their innovation potential.

Our reasoning above suggests that in cases where *PA specificity* is low⁵⁵ there is great potential for a “dual approach” to innovation. Leaving IPRs to the firm can bring strong incentives for the firm to develop efficient solutions that will be valuable not only for the public sector but also for the private sector. Anticipating the gain from the commercialisation of its developed solution, firms in the market will have strong incentives to compete for procurement contracts, and to financially contribute to the project development costs.

In the light of the above considerations, we summarise our insights in Table 2. Specifically, the scope for IPs will be greater when:

(i) bundling R&D and production is beneficial, as there are significant technical economies of scope or other positive externalities between R&D and production;

(ii) the innovation is expected to have a high level of *PA specificity*: that is, the innovation is valuable for the public procurer but there is no significant demand for it from the private sector;

⁵⁵ The ICT sector provides examples of ICT systems, developed for the public sector, finding important external applications in the private sector. The *PA specificity* of these innovations is therefore low. For example, the origins of the Internet date back to research commissioned by the United States government in the 1960s to build communication via computer networks. The precursor network, the ARPANET, served as the backbone for interconnection of regional academic and military networks in the 1980s (Wikipedia). Other examples include the new robot algorithm for the iRobot Project, commissioned by the US Advanced Research Development Agency (DARPA) to develop a mobile tactile robot, which was successfully commercialised in the market, or the US supercomputing procurement program which led to the development of the first processor on a chip and set the basis for personal computers (for further examples, see Ramboll, 2008a and 2008b).

(iii) the value for the procurer of the resulting innovation is easy to verify, allowing performance specifications to be clearly described in the tender documents and used to decide whether to award the production contract to the same firm or not. This also reduces the risk of funding low-value projects;

(iv) SMEs have a limited role in the market addressed by procurement.

On the other hand, when none of the above conditions hold, it is preferable to separate the two stages, and use PCP for the R&D stage. The high market value (and thus little PA-specificity) of the solution, coupled with the absence of significant economies of scope or positive externality between the R&D stage and the production stage, will jointly help to ensure that the firm awarded the PCP has strong incentives to undertake an optimal research effort in order to develop a profitable solution and gain market shares (provided it has acquired the IPRs). The risk of continuing low value projects will also be minimized.

Table 2. - Suitable conditions for an Innovation Partnership or Pre-Commercial Procurement

Suitable conditions for an IP	Suitable conditions for PCP (possible follow-up PPI)
High level of PA specificity	High market value/private demand
High technological economies of scope or positive externalities between R&D and production	No significant economies of scope or positive externalities between R&D and production
No significant role for SMEs	SMEs present in the market
Limited potential market competition	Significant potential market competition.
No significant risk of market foreclosure and supplier lock-in	Desirable to boost market competition in order to overcome supplier lock-in
Strong institutional incentives within the procurer organization	Agency problems and weak incentives within procurer organization
Clear performance targets and project value observable and measurable ex post	Project value difficult to observe and measure ex post

In the intermediate situations where some but not all of the conditions hold, there will be a trade-off and the choice of the mechanism will have to be made after an accurate analysis of the market conditions and the type of innovation. For example, when only conditions (i), (ii) and (iii) hold, bundling of R&D and production will help to stimulate R&D effort. However, it will also be detrimental to SMEs in the market and it will be associated with a high risk of long-term supplier lock-in. When conditions (i), (ii) and (iv) hold but (iii) does not, then bundling will increase the risk that unsuitable projects are given the go-ahead and it will have ambiguous effects on research effort. Unbundling may then be preferred.

5. The Risk of Procurement Failure

In this section, we analyse how the capacity and incentives of the public sector affect the choice of procurement mechanism. As emphasized by the OECD (2011), to be successful, this innovation-oriented procurement requires significant capacity development in the public sector and a considerable break with traditional and risk-averse procurement practices.

In terms of capacity, the public procurer needs to be able to make an accurate internal assessment and identify its procurement needs and the functional requirements that adequately reflect these needs. The public procurer must also design the tender optimally so that it provides firms with adequate incentives to participate and compete for the procurement contract. Aspects of the tender design, such as the technical and financial prerequisites for participation (i.e. pre-qualification), the award criteria and the criteria weights, the number of lots and the tender format, are all key decisions that have great impact on procurement performance.

The design of tenders that are either for R&D services or for the provision of innovative goods or services is particularly complex, because of the risky nature of innovation. The capacity of procurers is therefore absolutely central to the success of the innovation procurement process. Lack of capacity may result in wrong technical or performance specifications, award criteria and weights that do not reflect the priorities of the procurer, lack of participation, and insufficient uptake of the innovation. Furthermore, procurement officials must have incentives to bear the high risks that innovation-oriented procurement brings. For procurers to be willing to take these greater risks, the presence of explicit or implicit incentives for officials in public procurement offices become key.

Relying on the intrinsic motivation of procurers is unlikely to suffice, as procurers are typically risk averse and thus disinclined to take risks unless there are explicit incentives. Career concerns may also disincentivise risk taking, if procurers face a reputational loss when procurements fail and no career gains when they succeed. Thus, the organization of governments and public institutions wanting to undertake innovation-oriented public procurement needs to be structured in order to ensure that the incentives of procurement officers are aligned with those of the organization.

Data gathering and performance evaluations should be used within the public sector. The outcomes of officials' decisions should be assessed, and used to provide public procurers with monetary and non-monetary rewards when they successfully complete projects that satisfy long-term objectives of the organization. Procurers need to anticipate career gains when they take the initiative and obtain formal recognition, and visibility. Continuous training should be arranged so as to ensure their professional and technical development.

6. Conclusions

In this paper, we have discussed a range of public policy instruments that could encourage the creation and uptake of innovations for the delivery of higher quality and more cost-efficient public services. The paper has highlighted how the choice of procurement mechanism to buy R&D services or innovative goods and services - or the decision to set up a public private partnership for research and innovation - must be made in light of the characteristics of the market and of the innovation. Factors such as the presence of positive externalities or economies of scope between R&D and commercialisation, the level of the innovation's PA specificity, the technological risk, the role of SMEs in the relevant market, and the degree of contractibility and verifiability of the innovation, are all important factors that should direct how procurers and policy makers choose one mechanism or another. We have then derived the conditions under which each of the alternative mechanisms discussed may be most suitable.

We have also highlighted how procurement failure may undermine the success of these mechanisms. There is great need to create capacities and expertise in public authorities, especially in subnational governments. Compared to traditional procurement practices, innovation-oriented public procurement makes capacity building even more central to the success of the procurement process. The difficulty to specify ex-ante all the desiderata of the innovation, and the risks and complexity of each specific procurement process, make standardisation in procurement practices difficult to achieve, and unsuitable

Mechanisms for managing the particular risks of innovation procurement and schemes to incentivize procurers to take appropriate risks when circumstances require it, are all necessary conditions for innovation-oriented public procurement to be successful. A

multi-disciplinary approach is needed to reshape many procurement offices currently too focused on ensuring the correct application of the law, rather than on the strategic design and efficient use of public procurement.

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