Quantifying the impact of Pre-Commercial Procurement (PCP) in Europe based on evidence from the ICT sector

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SUMMARY

1. EXECUTIVE SUMMARY

Pre-commercial procurement (PCP) is a competitive multiple-sourcing procedure for procuring research and development services. It involves different suppliers competing in parallel through different phases of development. The risks and benefits are shared between the procurers and the suppliers under market conditions. The PCP is complementary to Public Procurement of Innovative Solutions (PPI) that refers to a public procurement in which procurers act as early adopters of innovative solutions that are new arrivals on the market, but not yet available on a large-scale commercial basis.

The objective of this study is to quantify the economic impact of PCP using a sample of PCP and non-PCP cases implemented in Europe. In particular, the study aims to estimate the impacts of PCP on the following aspects, which constitute our nine research questions (see also page 8):

1) *Improvements in the quality and/or efficiency of the public services achieved by deploying the innovative solutions developed as a result of the PCP;*
2) *Increase in quality and decrease in prices of products resulting from the highly competitive multi-sourcing, phased procurement approach that distinguishes PCP from other procurement approaches;*
3) *Reduction in the risk of failure in large scale follow-up PPI procurements*
4) *Increase in the efficiency of R&D expenditures;*
5) *Speeding up time-to-market for firms and facilitating the access of SMEs to the procurement market;*
6) *Attracting financial investors to Europe;*
7) *Increased interoperability / impact on standardization / reduction of supplier lock-in;*
8) *Impacts on competition structure in the market;*
9) *Increased exploitation of IPRs and R&D results (IPR protected or not) in general.*

We have identified a suitable set of eight PCP cases and collected detailed information from PCP public procurers and awardees through analytical questionnaires. We have collected the same detailed information from public procurers and awardees for a set of suitable control cases. These latter cases are also procurements related to R&D services but differ from PCP along some key dimensions. The questionnaires were designed to obtain information on both the demand-side and the supply-side impacts of PCP compared to the control cases.

The empirical strategy that we have followed pools together three data elements: i) a dataset of procurements for which we have a variable indicating whether each procurement is a PCP or not, ii) a collection of variables measuring how large the impact is when using PCP compared to other procurement methods, iii) a rich set of variables (defined as "control variables" and specified in chapter 6, which allows us to determine whether this impact was really achieved because of the use of the PCP method or not (to isolate the causal effect produced by the usage of PCP, conditional on other forces that concur to determine such outcomes). Combining these three data elements, we estimate the effect of PCP on outcomes through a regression approach via Ordinary Least Squares (OLS) and Nearest Neighbor Matching (NNM) estimators (see section 6 for a basic discussion of these methods as well as a more technical description).

The evidence obtained from the data analysis shows that, **compared** to other procurement approaches, the PCP is having the following impacts:

- Increase in the quality of public services achieved by deploying the innovative solutions developed as a result of the PCP.
- Increase in the efficiency of R&D expenditures.
- Reduction in the risk of failure in large scale follow-up PPI procurements.
- Reduction of supplier lock-in.
- Speeding up time-to-market for firms and positive impact on competition structure in the market in terms of access facilitation for SMEs to the procurement market.
- Increased exploitation of IPRs and R&D results.

Instead, we have not found significant evidence of a **comparative** impact of PCP in European cases with regard the following aspects.

- Decrease in prices of products resulting from the highly competitive multi-sourcing, phased procurement approach.
- Attracting financial investors to Europe.
- Increased interoperability.
- Impacts on subcontracting and awardees' market shares.

We explain in the report that the lack of significant evidence on these last four types of impacts may be explained by the small sample size of PCPs in Europe that have been completed and by the fact that the PCP cases analysed did not include specific interoperability requirements for the solutions to be developed. As some of the PCP cases analysed in this study are still on-going, the products resulting from those PCPs are not deployed/ on the market yet (so the effect on decrease of prices of such products cannot be assessed yet) and suppliers of those cases could not be interviewed (so the possible impact on attracting additional financial investors could not be analysed).

Based on the lessons learnt from the impact analysis and the experience in the field of public procurement implementation, a series of recommendations is made for new actions to be undertaken at EU level and at national level to encourage the use of PCP and improve the link with potential follow-up public procurement of innovation (PPI).

2. INTRODUCTION

2.1. Scope of the work

This study aims at quantifying the impacts of PCP in Europe based on evidence from the ICT sector.

Pre-Commercial Procurement (PCP) is an approach for procuring R&D services that is defined in the Communication COM/2007/799 and the associated staff working document SEC/2007/1668. PCP enables the public demand side to identify the best value for money solutions on the market to address a specific procurement need, by making use of competitive development in phases, risk-benefit sharing under market conditions, and a clear separation between the procurement of R&D services via the PCP and possible Public Procurements of Innovative solutions (PPI) focusing on deployment of commercial volumes of end-products.

Public procurement of innovative solutions (PPI) refers to a public procurement implemented according to the applicable EU and national Legislations, in which public procurers act as early adopters, by procuring innovative solutions that are new arrivals on the market but not yet available on a large-scale commercial basis.

In this context, PCP and PPI are separate but complementary procurements. A split between PCP and PPI allows companies that have developed products through other means than a PCP (e.g. through SME funding instruments, other R&D grants, own company R&D resources) to still compete for PPI deployment contracts, avoiding issues of foreclosing of competition and crowding out of private R&D investments.

By acting as technologically demanding first buyers, public procurers can drive innovation from the demand side. This enables European public procurers to innovate the provision of public services faster and creates opportunities for companies in Europe to take international leadership in new markets. Reducing time-to-market, by developing a strong European home market for innovative products and services, is key for Europe to create growth and jobs in quickly evolving markets such as ICT.

To address this issue, Action 55 of the Digital Agenda for Europe puts forward a target to double total annual public spending on ICT R&D in Europe by 2020 and identifies PCP as a key instrument to achieve that goal. PCP and PPI are also new instruments in Horizon 2020, the new 2014-2020 European Union's research and innovation funding program, to speed up the time to market for innovative solutions.

A number of PCPs and follow-up PPIs have taken place in Europe over the past years and similar experiences exist in other parts of the world. To understand the implications of this evolution, there is a need to collect quantitative evidence from concrete cases that can demonstrate the impacts of PCPs relative to alternative

procurement systems. Addressing this gap in the knowledge about PCP effects is essential to encourage wider usage of PCP across Europe.

Accordingly, the objective of the study is to collect evidence on PCP cases held in Europe and to empirically evaluate their impacts. In particular, the study develops an empirical analysis to answer nine research questions:

1) *Did the quality and/or efficiency of the public services improve by deploying the innovative solutions developed as a result of the PCP?*

2) *As a result of the highly competitive multi-sourcing phased procurement approach that distinguishes PCP from other procurement approaches, did quality increase and prices decrease?*

3) *Did PCP reduce the risk of failure in large scale follow-up PPI procurements?*

4) *Did PCP lead to an increase in the efficiency of R&D expenditures?*

5) *Did the PCP speed up time-to-market for firms and facilitate the access of SMEs to the procurement market?*

6) *Did the PCP attract financial investors to Europe?*

7) *Did the PCP lead to an increase in interoperability / impact on standardization / and to a reduction of supplier lock-in?*

8) *Was there a positive impact of PCP on market competition?*

9) *Did the PCP lead to an increase in the exploitation of IPRs and R&D results?*

Based on findings from the literature review and the empirical analysis of a sample of procurement cases, the study makes recommendations for new actions to be undertaken at EU level (and, where possible, also at national level) to encourage wider use of PCP and the link with potential follow-up PPIs.

2.2. The methodology

In order to quantify the impact of PCP, we have developed a methodology consisting of seven steps.

2.2.1 Identify suitable PCP cases

We have identified suitable PCP cases according to the check-list reported below.

PCP characteristics: check list
• Tender object: R&D services (prevalence criterion)

• Type of contract: procurement contract.
  ○ Obligation of bidders: R&D services
  ○ Obligation of contracting authorities: payment of the agreed price

• Demand side driven approach (needs and requirements are defined exclusively by the procurer)
• Development in phases
• Multiple-sourcing contract, in the sense that there are multiple and competing firms along the whole trajectory of the PCP
• Retention of at least two participating companies until the last phase to ensure a (future) competitive market
• Separation between the PCP and the procurement of commercial volumes of end-product and no preferential treatment in the supply of the final products (the competition is re-opened and the awardee who has done the R&D and developed a working test series has no guarantee to win a follow-up contract for mass delivery)
• Contractual arrangements, rights and obligations of the parties (including IPRs), are decided upfront and made available to all interested bidders in advance (published in the tender documents)
• Absence of exclusive condition: the public purchaser does not reserve the R&D results exclusively for its own use, so that results are shared with or fully assigned to bidders with the public contracting authority retaining use licencing right
• Award criterion: MEAT (competition also on price)

The identification of suitable cases was done mainly by phone interviews, however the response rate has been low and we **have noticed that there is a very limited number of completed PCP cases that satisfy the check-list.**

Sometimes public authorities define their projects as PCP but, in fact, such tenders do not exhibit all the required characteristics specified in our check-list and thus do not

satisfy[1] the EC definition of PCP specified in the PCP Communication (COM 799) and the 2014 State Aid Rules on R&D&I in compliance with the conditions for the exemption in the 2014 Public Procurement Directives, which ensures the conditions for PCPs not to involve State aid.

In particular, we have frequently observed:

- lack of multiple sourcing until the last phase (only 1 vendor allowed to participate in the last phase and no safeguard to ensure a future competitive market),
- lack of R&D effort required (incremental applied research or organizational innovation),
- lack of definitions of IPRs allocation and contractual arrangements in the tender documents and admission of negotiation on that subject,
- lack of definition and description of the procurement object (R&D services content), that makes the procedure more similar to a call for ideas/proposals than a call for tender,
- lack of problem statement and description of the un-met need that makes the bids and resulting solutions not as easily objectively comparable as it should be in public procurements.

2.2.2 Characterize the control groups (group of other procurement approaches cases) and identify suitable cases

The main goal of the analysis is to assess PCP procurements (panel 1) relative to other procurement approaches that differ in some key characteristics from PCP, called the control groups/control cases. Therefore, our empirical strategy pools together three data elements: i) a dataset of procurements for which we have a variable indicating whether each procurement is a PCP or not, ii) a collection of variables measuring the outcomes corresponding to the 9 research questions, and iii) a rich set of control variables, described in Section 6 and 7, which allow us to isolate the causal effect produced by the usage of PCP, conditional on other forces that concur to determine such outcomes.

In order to identify a suitable control group, we have analysed tenders published in different specialized websites (e.g. TED, DG Market – Tenders worldwide) and contacted procurers that launched the tender. We have also analysed the tenders contained in the SISR Country Data Sets, provided by the EC, which contains tenders launched from 2008 to 2011 in the ICT and R&D Sector. Moreover, we have asked procurers that conducted the PCPs to provide also suitable control cases.

Within the large number of tenders present in these databases, we have selected those tenders that showed the following characteristics:

[1] This is for example the case for SBIR programs implemented in Europe.

Control group characteristics

Panel 2	Panel 3
Object of the procurements in panel 2: contracts that buy only Research & Development services (i. e. feasibility studies, preliminary or executive technical design services, prototyping services, testing services etc.).	Object of the procurements in panel 3: mixed R&D services and supply contracts (contracts that combine the purchase of R&D and supply of the resulting solutions in one and the same procurement) with a significant degree of innovation.

Both panel 2 and panel 3 cases are:

- Single-award/single source contracts – where only one awardee is chosen (for each lot, if the contract is split into lots)

and (predominately)

- Exclusive contracts - where intellectual property rights remain with the Public Procurer and not given to the awardee.

We have further reduced the sample of tenders satisfying the above characteristics by restricting attention to tenders with a CPV (common procurement vocabulary) describing a subject of procurement contract in the field of R&D and ICT.

The distinction in the object of the tender between the control cases in Panel 2 and Panel 3, as described in the table above, will play an important role for our analysis. Indeed, when assessing the impacts of PCP we will analyze whether and how much the impacts observed in PCPs (panel 1) differ from the impacts observed in the panels 2 and 3 of the control group of procurements.

For all the selected PCP and control group tenders, we contacted the public procurers by phone and by e-mail to ask them to fill our questionnaire. Moreover, when procurers were not able to provide information on the tender we have chosen, we asked them to provide information on another tender that satisfied the above mentioned characteristics.

2.2.3 Design and elaboration of questionnaires

We have designed and elaborated coordinated questionnaires that were submitted to both public procurers and awardees of the PCP cases and of the control cases. The questionnaires were designed to investigate the demand-side impacts and the supply-side impacts of both the PCP cases and the control cases. We have obtained both objective measures and subjective information from respondents. The subjective information helped us to identify the expected impacts that PCPs have on procurers and awardees. The questionnaires are reported at the end of this report.

2.2.4 Submission of the PCP questionnaire

We have submitted the questionnaires to public procurers and awardees of PCP cases to obtain information on:

a. Tender design and process;

b. Motivation and expectation of public procurers;
c. Motivation and expectation of awardees;
d. Impact of PCP on public procurers and on public services;
e. Impact of PCP on awardees and on the market structure.

2.2.5 Submission of the Control Group questionnaire

We have submitted the questionnaires to public procurers and awardees that were involved in non-PCP R&D services procurement (that were single-sourcing and exclusive development contracts) (panel 2) and in procurements that combine the purchase of R&D services and supply of commercial volumes of resulting end-products into one procurement (panel 3), so as to obtain information on:

a. Tender design and process;
b. Motivation and expectation of public authority;
c. Motivation and expectation of awardees;
d. Impact of the tender on public authority and public services;
e. Impact of the tender on awardees and the market structure.

2.2.6 Follow-up

We have contacted by phone the respondents to ensure a homogeneous understanding of questions. When needed, we have also supported respondents to integrate and finalize complete their responses based on answers received via e-mail and official documentation provided.

2.2.7 Analysis of results for the nine research questions

We have aggregated the responses obtained from selected PCP cases and compared them with those of public procurers and awardees in the control groups. The data analysis has been carried out using a methodology based on Ordinary Least Squares (OLS) and Nearest Neighbor Matching (NNM) estimators. We provide a basic discussion of these methods as well as a more technical description in section 6.

2.3. The PCP sample

We have restricted attention to PCP cases satisfying the check-list above. We had a target of six cases, but we extended the analysis to cover eight suitable PCP cases. Their characteristics are summarized in the Summary Tables at the end of this report.

The PCP sample includes the following seven cases to which we added an eighth case described further below:

Case	Country	Object
Asfinag/FFG	Austria	Mobile traffic management system for road work areas and major incidents

Lombardy Region and Niguarda Hospital	Italy	Automated universal system for moving hospital beds that is easy to use, equipped with all anti-collision and safety systems, which does not need tracks or guide lines and which can also be used on non rectilinear routes
Statoil	Norway	CO2 capture plant technology qualification and engineering services
City of Stockholm	Sweden	ICT solutions to make transportation and travelling more efficient
4S/Norrvatten	Sweden	New Technologies for secure joining of PE-pipes
AQUAS	Spain	R&D to integrate cross-border PHR services
European Space Agency (ESA)	EU	Developing innovative Earth Observation products and services in response to authoritative end-user requirements.

We have obtained responses from all of the public procurers of the above seven cases but not from all of the awardees. As the analysis is undertaken at aggregate level, we thought it suitable to enrich the sample with cases which were not part of the above list but that nevertheless satisfied our checklist. Adding these cases helped to increase the precision of the study. The following table lists the awardees of our sample and whether they refer to the PCP cases above or not. The name of three awardees is classified information, as they agreed to provide us their data only on this basis.

	PCP cases analysed	Questionnaire filled by the Public Procurer	Questionnaire filled by the Awardees
1	Asfinag/FFG (Austria)	yes (1)	
2	Lombardy Region and Niguarda Hospital (Italy)	yes (1)	
3	Statoil (Norway)	yes (1)	yes (1)
4	City of Stockholm (Sweden)	yes (1)	yes (1)
5	4S/Norrvatten (Sweden)	yes (1)	yes (1)
6	AQuAS (Spain)	yes (1)	

7	European Space Agency (EU)	yes (1)	
8	Classified cases		yes (3)
9	Tour Talk LLP (Ireland)[2]		yes (1)

We included in our analysis also an NHS case, which is another multiple sourcing procurement case.

Case	Country	Object
NHS Blood and Transplant	United Kingdom	To obtain a suitable design of blood donning chair which would be able to cope with patients who faint during the donation process

For this case we obtained responses from the public procurers and none from awardees.

	PCP cases analysed	Questionnaire filled by the Public Procurer	Questionnaire filled by the Awardees
1	NHS Blood and Transplant (UK)	yes (1)	

As explained in section 7, the NHS case was included within the sample of PCPs to study just some of the questions posed by the DG Connect.

We included this case in this analysis because, while not fully fitting the PCP classification shares with PCP features such that they make it useful to assess the effects of PCP on the nine research questions. The peculiarities of this case (discussed in section 5), however, suggest that an important robustness check for our analysis consists in repeating all the analysis excluding the NHS data from the sample.

[2] This case alone is taken from the UK SBRI program (https://sbri.innovateuk.org/), which is a program designed to stimulate new technology either as a standalone solution or underpinning a service solution for specific public sector needs. In the case here analysed, the Northern Ireland Tourist Board aimed to purchase the development of 3-7 innovative Apps suitable for download across mobile platforms. The Apps sought to increase visitor numbers and visitor spend in Northern Ireland, providing visitor information in a creative and engaging form, that could be tailored to personal preferences and interests. As in standard procurement, needs were clearly defined by the public authority and offers were compared on both qualitative and quantitative aspects. SBRI key characteristics: multiple sourcing, IPRs to firms, separation between R&D/Final Product procurement, as under PCP.

2.4. The control group sample

In section 5 we illustrate the key characteristics and report descriptive statistics obtained fr
questionnaire for the control group procurements (panel 2 and 3). We received responses fr
non-PCP procurement of R&D services (panel 2) and **nineteen** cases of combined procurem
(panel 3). We received responses from awardees for **five** cases of non-PCP procurement of
cases of combined procurement of R&D services and supply (panel 3).

The panel 2 of control group sample includes the fourteen cases with the following characte

Country	N° of cases
Italy	5
Spain	3
Slovenia	1
Latvia	1
Norway	1
Denmark	0
Poland	1
Finland	0
Switzerland	1
France	0
Greece	0
Cyprus	0
EU /International	1

Authority	N° of cases
Public Procurer	7
Policy maker	7

Sector	N° of cases
Health	2
Education	4
Environment & Energy	2
Transport	2
Space & Defence	2
ICT	2

Type of procurement	N° of cases
Direct	6
Catalytic	0
Hybrid	0

Contract value	N° of cases
0-500K€	7
501K€ – 1M€	1
1M€-5M€	4
> 5M€	0
not provided / classified	2

The panel 3 of the control group sample includes nineteen cases with the following characteristics:

Country	N° of cases
Italy	12
Spain	1
Slovenia	0
Latvia	0
Norway	0
Denmark	1
Poland	0
Finland	1
Switzerland	0
France	1
Greece	2
Cyprus	1
EU/International	1

Authority	N° of cases
Public Procurer	17
Policy maker	2

Sector	N° of cases
Health	6
Education	1
Environment & Energy	2
Transport	3
Space & Defence	1
ICT	6

Type of procurement	N° of cases
Direct	19
Catalytic	0
Hybrid	0

Contract value	N° of cases
0-500K€	5
501K€ – 1M€	2
1M€-5M€	5
> 5M€	3
not provided / classified	4

2.5. Main results

Based on the information and data collected we have carried out our empirical analysis (section 7) to quantify the impact of PCP compared to the control group of alternative procurement approaches, along the 9 research questions posed by the EC.

The total dataset with '**procurer**' responses used for this empirical analysis contains **41** cases: **7** PCP cases (panel 1) and **1** (similar to, but not, PCP) multiple-sourcing case represented by NHS, **14** cases of non-PCP R&D services procurements (panel 2) and **19** cases of combined procurement of R&D services and supply (panel 3).

The total dataset with '**awardee**' responses used for this empirical analysis contains **19** cases: **7** cases of PCPs (panel 1), **5** cases of non-PCP R&D services procurements (panel 2) and **7** cases of combined procurement of R&D services and supply (panel 3).

Under a number of caveats to the interpretation of the estimates that we describe in section 6 and section 7, we report below the main findings and results of our analysis:

- **Improvements in the quality and/or efficiency of the public services achieved by deploying the innovative solutions developed through PCP**. Overall, the analysis reveals a positive and statistically significant effect of PCP on improvements in the quality and/or efficiency of public services. Moreover, as explained in section 7, we argue this effect will likely emerge more strongly as larger datasets of more completed PCP cases becomes available.

- **Increase in quality and decrease in prices of products resulting from PCP**. For this specific research question, the data does not indicate any significant difference between PCP and non-PCP procurements (no significant comparative effects) in terms of cost reductions. We have to consider that such evidence is not detectable at present, given that most PCP cases analysed have only been completed very recently or are still in progress.

- **Reduction in the risk of failure in large scale follow-up PPI procurements.** The estimates reveal a positive association between PCP and the decline in the risk of failure of follow-up PPI. PCP enables procurers to de-risk large follow-up deployment contracts by first comparing the pros and cons of competing solution approaches from different suppliers.

- **Increase in the efficiency/intensity of R&D expenditures by firms.** All estimates confirm that there is a positive effect of PCP on increased R&D expenditure by participating firms after the PCP tender. Given the limited amount of responses from awardees, the study was not able to detect whether the company would have started the project absent the PCP procurement.

- **Speeding up time-to-market for firms / facilitating the access of SMEs to the procurement market / impacts on competition structure in the market.** Increased participation of SMEs in procurements can speed up time-to-market as SMEs are agile companies often challenging established suppliers by bringing disruptive research that speed up the introduction of new innovations in the market. We do not have sufficient data to assess the impact on the time to market of the solutions developed under the PCP, however there is overwhelming evidence that PCP increases both the participation of SMEs to the tender procedure and the awarding of actual contracts to SMEs. The data was not able to detect an association between PCP and changes in the market shares of firms. We have to consider that such evidence is not detectable at present, given that most PCP cases analysed have only been just completed or are still in progress. The data also does not reveal any statistically significant difference on the level of subcontracting between PCP and non-PCP.

- **Attracting financial investors to Europe.** The answers received from awardees was too limited to draw any statically significant conclusion on whether or not there is a difference between different procurement mechanisms in terms of increasing the ability of participating firms to attract financial investors. This effect will therefore need to be analysed further when larger datasets of more completed PCP cases will become available.

- **Increased interoperability / impact on standardization / reduction of supplier lock-in.** The estimates reveal a strong, positive effect of PCP on the reduction of supplier and technology lock-in. No statistical difference between PCP and the other forms of procurement is found in terms of increase in interoperability, but we note that the analysed PCP cases are either not finished yet or did not put specific interoperability requirements on solutions in their tender specifications. This latter finding is also because the cases analysed include only one joint procurement, that would naturally have more interoperability requirements.

- **Increased exploitation of IPRs and R&D results.** The data shows that there is some evidence of a positive association between PCP and increased exploitation of IPRs and R&D results.

In the table below we provide a synthesis of the empirical evidences obtained[3].

[3] These synthetic findings are best understood in light of our detailed discussion in section 6 and 7.

	Research Question	Estimated PCP Impact
1	Improvements in the quality and/or efficiency of the public services achieved by deploying the innovative solutions developed as a result of the PCP.	Evidence of positive and significant effects on quality
2	Increase in quality and decrease in prices of products resulting from the highly competitive multi-sourcing, phased procurement approach that distinguishes PCP from other procurement approaches.	No evidence of comparative effects on costs could be observed (too early)
3	Reduction in the risk of failure in large scale follow-up PPI procurements	Evidence of positive effects on reduced risk of PPI failure
4	Increase in the efficiency/intensity of R&D expenditure	Evidence of positive effects on increased R&D investments after the tender
5	Speeding up time-to-market for firms and facilitating the access of SMEs to the procurement market.	Evidence of positive effects on SMEs entry and winning
6	Attracting financial investors to Europe	No evidence of comparative effects could be observed (too early)
7	Increased interoperability / impact on standardization / reduction of supplier lock-in	Evidence of positive effects on reduced lock-in; no effect on interoperability could be observed (too early)
8	(other) Impacts on competition structure in the market, as regards subcontracting and market share increase	No evidence of comparative effects could be observed (too early)
9	Increased exploitation of IPRs and R&D results (IPR protected or not) in general	Evidence of positive effects on exploitation of IPRs/R&D results

The rest of the study is articulated as follows:

In Section 3, we provide an overview of PCP in the European framework. We discuss the elements that characterize the PCP and those that distinguish it from other procurement approaches.

In Section 4, we provide information from literature review about impacts on the nine research questions of PCP-like procurements.

In section 5, we briefly summarize the PCP cases analysed in this study and report descriptive statistics on the responses of the public procurers and the awardees of the PCP cases examined, as well as the main statistic comparative analysis between PCP and non PCP cases analysed in this study.

In Section 6, we describe the empirical methodology that we followed to assess the effectiveness of PCP using the survey data described in the previous section.

In section 7, we report: i) how the survey questions were transformed into a set of new variables usable for the empirical analysis, ii) the outcomes of the different estimation methods for each research question, iii) a discussion of the findings.

Finally, **in section 8**, based on findings from the empirical analysis, as well as from the experience in the field of public procurement implementation, we make recommendations for new actions to be undertaken at EU and national level to encourage wider use of PCP and the link with potential follow-up PPIs.

3. OVERVIEW OF PCP

As defined in the COM (2007) 799, Pre-commercial procurement (PCP) is a competitive, phased approach to procuring R&D services that does not constitute State Aid.

Under PCP a public procurer acquires R&D services from a number of providers who develop in competition alternative solution approaches to address one and the same problem of public interest faced by the procurer (multiple-sourcing). The R&D is split in a number of phases (typically solution design, prototyping and original development and field testing of a limited set of first products) with evaluations after each phase so that only the providers with the best competing solutions get contracts to proceed to the next phase. Offers are evaluated at different R&D phases according to set MEAT criteria (economic criteria related to the price/cost of R&D services and technical criteria related to the expected functionality/performance of resulting solutions). The aim is that at least two firms reach the final phase where a limited number of first test products/services are field tested to ensure a future competitive supply chain.

PCP is exempted from the EU public procurement Directives as the public contracting authority does not reserve all the results and benefits of the contract – in particular intellectual property rights (IPRs) resulting from the R&D – exclusively for its own use but instead it shares the IPRs with the R&D providers under market conditions. The PCP contract includes the development of prototypes and a limited set of first test products or services, whilst the purchase of larger commercial volumes of products or services is not part of the same contract. As in any R&D services contract, the total value of any product purchased through the PCP contract cannot constitute the majority of the contract value.

PCP covers the R&D stage before commercialization in a product development cycle. It can cover activities such as solution exploration and design, prototyping, up to the original development of a limited volume of first products or services in the form of a test series (original development of a first product or service 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 or supply in quantity to acceptable quality standards). The R&D stage does not include commercial development activities such as quantity production, supply to establish commercial viability or to recover R&D costs, integration, customization, incremental adaptations and improvements to existing products or processes.

The PCP communication COM (2007) 799 has also set the three constituent elements that characterize PCP and distinguish it from other procurement approaches:

- **separation between the R&D phase and the deployment of commercial volumes of end-products**: PCP is a preparation exercise to de-risk potential future follow-up large deployment contracts as it compares the pros and cons of (unknown) alternative solutions in order to filter out technological R&D risk before

(and without) committing to procure a large scale commercial volume of end-products;

- **risk-benefit sharing according to market conditions**: the PCP selection procedure must be open, transparent, non-discriminatory and unconditional and based on objective selection and award criteria specified in advance of the bidding procedure, ensuring that all potential bidders (in particular also smaller new players like SMEs) have equal chances to bid. The division of risks (e.g. those risks related to the technological development of the proposed solution or to its subsequent commercialization) and of benefits (e.g. IPRs allocation) must be specified beforehand in the tender documents. The procurement is awarded on the basis of criteria that select the most economically advantageous offers. As in pre-commercial procurement the procurer assigns to (or shares with) the participating companies the IPRs on their developed solutions, leaving companies the opportunity to resell to other markets afterwards, the public procurer obtains a financial compensation that brings the overall cost of the PCP development below the higher prices for exclusive development contracts (contracts in which procurers reserve all benefits including IPRs/commercialisation rights from the procurement for themselves). The price paid (that has to represent the market price, due to the competition) contains a financial compensation compared to exclusive development price that reflects the market value of the benefits received and the risks taken by the participating R&D service provider;
- **competitive development in phases**: the PCP awards multiple public procurement contracts to several providers (multiple-sourcing) for R&D services undertaken in phases over a period of time. To help ensure a future competitive market where the competition between providers creates a range of options the PCP has to be designed in advance so that it is able to retain (procure the R&D from) at least two competing providers until the last PCP phase.

Ultimately, PCP should be distinguished from:

- **Public procurement of innovative solutions** that occurs when contracting authorities act as lead customer (also called early adopter or launching customer) by procuring 'innovative' solutions (not the R&D to develop them) that are newly arriving on the market but that are not yet available on large scale commercial basis due to a lack of market commitment to deploy.
- **Exclusive R&D services procurement** which means the public procurement, in accordance with the EU public procurement directives, of research and development services when all benefits accrue exclusively to the contracting authority or contracting entity. In this case, the R&D development costs are fully remunerated by the procurer.
- **Innovation partnership procedure** that combines the purchase of R&D and the subsequent supply of commercial volumes of the end-products or services into one procurement procedure.

At European level, the debate on the use of public procurement (and in particular PCP) as an instrument to improve the commercialization and exploitation of research results has significantly grown over the last ten years.

The special attention of European institutions to these themes started from the European Commission's Research Investment Action Plan (2003) where the stated intention was to stimulate a set of "initiatives required to give Europe a stronger public research base and to make it much more attractive to private investment in research and innovation".

The so called Kok report (Kok et. Al., 2004) confirmed once again the pivotal role of public procurement as an instrument for private innovation and, in particular, stated that "public procurement could be used to provide a pioneer market for new research and innovation-intensive products and services". In 2006, the Aho Group Report "Creating an Innovative Europe" (Aho et Al., 2006) recognized that any innovation policy is sterile when it is not accompanied by a more comprehensive set of reforms which creates the basis for more nimble R&D investments. As a matter of fact, the Aho group suggested "to provide an innovation-friendly market for its businesses, the lack of which is the main barrier to investment in research and innovation". The report also stated that innovative and more competitive reforms of procurement and regulation laws are necessary for the development of innovation mechanisms.

Following this report, the EU Lead Market Initiative was implemented as the first attempt to link demand-based measures around selected technological areas. At the same time, individual Member States started their own initiatives. Furthermore, the European Council in 2006 largely took into account the Aho report's considerations, recalling the importance of Lisbon and Barcelona's goals; "the European Council calls on the EIB to support innovation and to reinforce its action in R&D, through a risk-sharing finance facility […]" (European Council, 2006).

These policy initiatives have highly emphasized the role of public sector as engine for innovation, even if they were silent on how these policies should be translated in practice.

A significant breakthrough comes from the PCP Communication COM (2007) 799 final and associated staff working document SEC(2007)1668 of the European Commission, dated December 2007. There the objective, the key aspects and the legal and economic rationale for pre-commercial procurement are explicitly described. This explains that PCP falls outside the scope of the EU public procurement Directives, but should still be implemented in compliance with the Treaty on the Functioning of the European Union (TFEU) without leading to unilateral (and illegal) State Aid to industry.

By providing as example a PCP implementation approach in line with the legal framework in the staff working document, the European Commission aimed to enhance the legal certainty around how one could practically procure R&D through

PCP and to persuade contracting authorities to act as an innovation demanding buyer and engage in procurement of R&D.

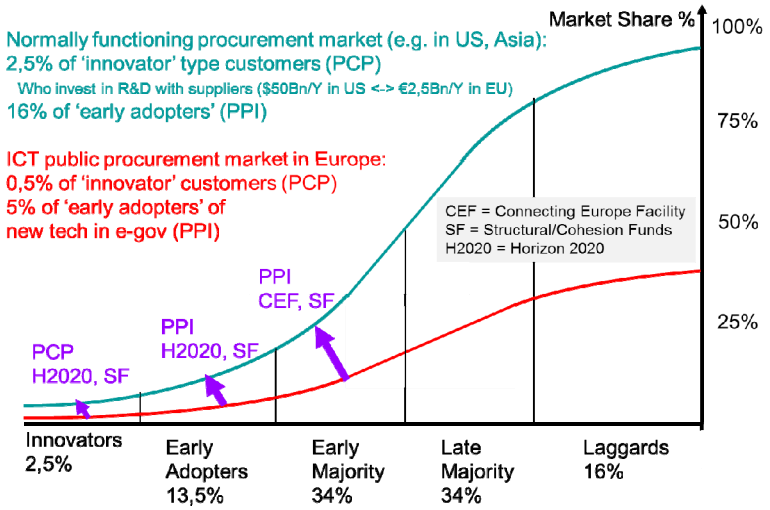
As mentioned above, with COM (2007) 799 the Commission emphasized the use of pre-commercial procurement as an effective way to identify the best value for money solutions on the market to address a specific procurement need, by making use of competitive development in phases, risk-benefit sharing under market conditions and a clear separation between the procurement of R&D services from the procurement of commercial volumes of end-products.

This initiative (both valuable from a policy and a regulatory point of view) was triggered by the observation that the United States succeeds more often than Europe to pull technological R&D into the commercialization phase and that this is partly due to the use of public procurement of R&D services that are implemented based on the three characteristic features of PCP explained above.

As the EU Commission has observed (see EC FAQ Document[4]), the low adoption rate of innovative solutions in the public sector in Europe (PPI) is in part driven by public procurers not searching for emerging innovations and not actively steering industrial developments to meet future public sector needs (PCP). According to Rogers' Bell curve, introducing innovations in a normally functioning market typically requires 16% of early adopters and 34% of early majority buyers. Together they enable innovations to reach the 50% market penetration tilting point that convinces the 'late majority' customers and 'laggards' to also buy the innovation. China is aiming by 2020 for 40% of PPI public procurements to deploy innovative solutions, ambitiously aiming to bring innovations very close to the 50% tilting point.

Underutilization of PCP and PPI in Europe results in Rogers' S curve (showing the market penetration speed for innovations) being significantly flatter in the European procurement market than in a normally functioning market. It is clear that the underutilization of PCP and PPI is undermining European competitiveness. A European public sector that does not sufficiently capitalize on the potential of innovations to modernize public services is destructive to competitiveness of the European market, especially since the European market is more dependent on public sector expenditure than the US or Asian market.

[4] Lieve Bos (2012), European Commission, FAQ Document published in CORDIS website.



Source: European Commission, DG Connect.

Indeed, the difference in R&D procurement expenditure represents approximately half of the overall R&D investment gap between the US and Europe, meaning half of approximately 1% of GDP or $100Bn in absolute value per year. Therefore the EC adopted additional actions to stimulate wider implementation of cross-border PCPs. The goal in this case was to encourage using public procurement as a demand side policy instrument and to foster cross-border competition in order to obtain best value for money for solutions modernizing the public sector. The need for more cross-border competition in Europe to create a stronger European internal market for innovative solutions in the public sector is evident if one considers that public procurers in Europe award around 98.77% of procurement contracts to national companies, with only 1.23% awarded to companies from another Country.

A growing number of European Parliament resolutions and Council conclusions (incl. the Spring 2012 Council conclusions)[5], encouraged the European Commission to reinforce public procurement (in particular PCP) as a main driver of Europe's research and innovation policy. The previous CIP and FP7 Programs and the current HORIZON 2020 program include calls that enable since 2011 consortia of public authorities from different EU Member States to apply for EU funding for jointly undertaking PCPs[6].

Demand-side innovation policy was put in the spotlight again to achieve the goals of the Europe 2020 strategy in the above mentioned "Innovation Union" Communication (EC 2010). In short, the Communication called on Member States to dedicate a budget for pre-commercial procurements (PCP) and public procurements of innovative products and services (PPI).

[5] EP resolution promoting PCP: EP 2006/2084(INI), EP resolution promoting PCP & PPI: EP 2009/2175(INI). 2769th EU Competitiveness Council conclusions (4/12/06), European Council conclusions (29/5/2018), 3016th EU Competitiveness Council conclusions (26/5/2010), European Council conclusion (1-2/3/2012)

[6] The on-going cross-border European funded pilots are: SILVER, DECIPHER, THALEA, UNWIRED Health, NYMPHA-MD, ENIGMA, CHARM, SMART@FIRE , V-CON, PRACE 3IP, PREFORMA, IMAILE, ENIGMA….

The EU public sector spends less than 5.5 B € per year on ICT R&D, far below the levels of competing economies. Public policies should be creating the right conditions to explore the yet untapped opportunities such as public procurement that can be an important driver for radical improvements to public sector services and mobilizing new financial resources for ICT R&D. It can act as leverage factor for private R&D spending and help accelerate time-to-market and open up new markets for ICT solutions across the EU. One third of all Europe's ICT business investment in ICT R&D in the EU, by 2020, should come from companies created within the last two decades.

To ensure Europe remains a leader in ICT innovation, the Digital Agenda for Europe (DAE) action 55 identified PCP as a cornerstone measure needed to achieve the target to double Member States annual public spending on ICT research and development from €5.5bn to €11bn (which includes EU programs), in ways that leverage an equivalent increase in private spending from € 35 billion to € 70 billion.

The emerging linkage between innovation policies and the attention to public budgets has been growing during the recent sovereign debt crisis. Over the last four years, European institutions have pointed out how public policies for innovation should be pursued at a minimum expense for the public balance sheets.

As the 2011 OECD report on "demand side innovation policies" noted, the existing lack in assessment practices in the European experience is remarkable, and this is in part due to the difficulty encountered in the implementation of demand-side programs.

As a result, despite the growing attention on public budgets, R&D investments should not be stopped but encouraged and pushed up toward higher efficiency levels. On this path, innovation cannot be fragmented and innovative firms should meet and cooperate.

The elimination of Europe's fragmented efforts and the improvement of Europe's competitive edge are also the basis of the Digital Agenda for Europe (DAE). To achieve its objective, a competitive-based funding is crucial. The best research ideas must be turned into marketable products and services. Currently, EU investment in ICT research is still less than half US levels.

In the light of the problems and limitations emerged in the application of the Public Procurement Directives, the entire EU discipline of public procurement has been recently the object of a complex reform trend.

In 2014 new EU public procurement directives on Public Procurement and Concession Contracts and new EU R&D&I State aid rules and a new WTO Government Procurement Agreement were adopted. These revisions introduce many innovation related provisions, which are summarized as follows.

Joint procurement
The Procurement Directives clarifies the legal base for joint procurement between contracting authorities from different Member States.

Intellectual Property Rights

The Procurement Directives clarifies that contracting authorities are not obliged to acquire all IPRs and can chose or not to transfer some IPRs to companies in procurements and that this is part of the subject-matter of the contract and shall be clearly specified in the tender specifications. The R&D&I State aid rules clarifies that the distribution of IPR related rights used in PCP does not constitute State aid and reiterates the PCP communication that the distribution of IPR rights needs to be specified up front in the tender specs without later renegotiation to avoid State aid.

Pre-commercial Procurement

The exemption for procuring R&D services other than those where "the benefits accrue exclusively to the contracting authority for its use in the conduct of its own affairs on condition that the service provided is wholly remunerated by the contracting authority" is maintained and clarified in the new 2014 public procurement directives. An explicit reference to PCP and the PCP Communication COM (2007) 799 as a procedure that makes use of this exemption is included in the Directives. The R&D&I State aid rules defines which R&D can be covered by PCPs and reaffirms the characteristics from the PCP communication that make that PCPs are considered not to involve State aid. The exemption of R&D services from the WTO Government Procurement Agreement was also maintained in the revised 2014 WTO GPA.

Innovation Partnership Procedure

A new procurement procedure that introduces the possibility to implement a long term procurement partnership combining purchase of R&D services and the subsequent supply of commercial volumes of the end-products or services. As already pointed out by experts[7], the lack of definition and the legal uncertainty around this new procedure could make room to possible distortions of competition and discrimination against the participation of SMEs. The innovation partnership procedure could, if improperly implemented, introduce anti-competitive impact on the market, stimulating a lock in to a single supplier for the procurement of an unlimited volume of products during an unlimited time period, favoring large-scale firms against SMEs, closing off the procurement market and foreclosing competition at a point where there is no proof that the preferred supplier will be able to develop a better solution than other vendors in the market. Innovation partnership could, in some respect, present other two types of potential problems regarding competition: crowding out of the existing R&D investments in Europe (discouraging companies not selected for an innovation partnership procedure from applying for a public R&D grant or procurement or dedicating own investments to R&D, knowing in advance that they have already lost the market to sell to) and reinforcement of the established providers, i.e. of major national companies, to the detriment of innovative SMEs and new players around Europe. These aspects have been taken into consideration in the new 2014 State Aid framework for R&D&I which limits the exclusion of State aid through the use of the innovation partnership procedure only to the exceptional case of unique/highly specialized products, i.e. products for which the procurer is the only potential

[7] Sara Bedin (2014), Contribution to the public consultation on the draft R&D&I-Framework, Section 2.3. Public procurement of research services.

customer and for which there are no other potential providers on the market outside of the innovation partnership.

MEAT as (standard) award criteria

The new Public Procurement Directives are aimed to achieve better value for money for procurers by widening the use of the MEAT award criteria as standard practice. This will reduce the current use of the lowest price only award criterion as dominant practice in Europe, making quality a central issue and leaving more space for environmental, social-welfare and innovation considerations.

The legal certainty for applying PCP is now ascertained by the 2014 R&D&I State Aid Framework. It describes the conditions for PCPs not to be considered State aid, previously only explained in the PCP communication, into the State Aid framework. This measure is necessary to underline the clear separation between pre-commercial public procurement (onerous bilateral contracts) and State Aid (concessionary of funding schemes)[8]. In general, in order for PCP not to involve State Aid, the contracting authority must procure the R&D services at a market price. By so doing, the contracting authority does not provide an un-warranted advantage to certain economic operators and, thus, does not distort competition[9].

The adopted R&D&I State aid Framework mentioned above confirms that alike any public procurement pre-commercial procurement is subject to the European competition rules and, by assigning an explicit responsibility to the contracting authority in the planning of the tender, it aims to prevent the distortion of competition (on a regional and local basis) and allows for the reinforcement of a single European market.

The clarification is definitely important because it makes it possible to confirm that the legitimacy of the measures contained in the pre-commercial procurement call for tenders and of the clauses governing the substantial and formal requisites for

[8] Sara Bedin (2012), PCP Italian Guide-line "Gli appalti pre-commerciali. Istruzioni per l'uso", Digital Agenda Italia, Pre-print version.

[9] The conditions that, when not fulfilled, reveal that the contracting authority is not paying a market price for the R&D services, but is granting a State Aid to undertakings and, consequently, has an obligation to notify R&D&I aid pursuant to Article 108(3) of the Treaty are (in brief):

(a) the selection procedure is open, transparent, non-discriminatory and unconditional and is based on objective selection and award criteria specified in advance of the bidding procedure,

(b) the envisaged contractual arrangements describing all rights and obligations of the parties, including also regarding the IPR rights, are made available to all interested bidders in advance of the bidding procedure,

(c) the pre-commercial procurement does not give any of the participating providers of R&D services any preferential treatment in the supply of commercial volumes of the final products or services,

(d) all results which do not give rise to IPR may be widely disseminated, for example through publication, teaching or contribution to standardisation bodies in a way that allows other undertakings to reproduce them, and any IPR are fully allocated to the public purchaser,

(e) any R&D service provider to which results giving rise to IPR are allocated is obliged to grant the public purchaser unlimited access to those results free of charge, and has the right to grant access to third parties to those results under fair and reasonable conditions for example by way of non-exclusive licenses, under market conditions.

participation must be verified in accordance with the general principles regarding the contractual activity of the administration and in compliance with the exemption for R&D services in the Public Procurement Directives[10].

The contractual activity of a public administration also remains subject to compliance with the general principles of the Treaty of the European Union, specifically with the principles regarding the free circulation of goods, right of establishment, freedom to provide services, non-discrimination, equal treatment, mutual recognition, proportionality regarding the applicability of said general principles also to tenders that do not fall within the scope of application of the Directives 2004/18/EC and 2004/17/EC (cf. Commission interpretative communication 2006/C-179/02).

Demand-side innovation policies have been receiving increasing interest from a number of countries, as witnessed by the "OECD Project on Demand-Side Innovation Policies" launched in 2008. Overall, it can be stated that in a number of countries (like Italy, Spain, Norway, Sweden, Netherlands, UK, Belgium, Austria, Denmark and others) demand-side innovation policy has become an explicit part of recent innovation strategies. However, a majority of Countries still largely focus on supply-side instruments and do not sufficiently take into account the demand-side innovation policy issue.

To date, the discussion shows how innovation policy, and in particular PCP policy, is seen as key for the future development of Europe, and that there is a clear economic rationale to move in this direction.

[10] Sara Bedin (2014), contribution to the public consultation on the draft R&D&I-Framework, Section 2.3. Public procurement of research services.

4. REVIEW OF THE LITERATURE

This Section provides information from literature review about impacts on the nine research questions that were observed in other PCP like procurements that were not used for the empirical analysis in section 7 in this study.

4.1. Improvements in the quality and/or efficiency of the public services achieved by deploying the innovative solutions developed as a result of the PCP

Geroski (1990, 1992) was among the first to highlight how governments are often very large purchasers in the many sectors in which they operate and this makes public procurement a potentially very valuable lever to use in stimulating innovation. He argued that early innovations designed to cater to the needs of the public sector can help crystallize private sector demand, subsequently stimulating a larger and somewhat different set of innovation.

An early example of PCP-like procurement is the procurement of **supercomputing** technology in the US, dating back to the 60's. The Department of Energy (DOE) procured R&D services to address some performance problems of the most advanced computing systems available. As reported in **Rambøll (2008)**, the supercomputing R&D procurements lead to an improvement of the quality and effectiveness of a number of public service applications which required high-performance computing power, and stimulated industrial innovation in the computing sector at large. The supercomputers that followed were produced in very limited numbers and delivered primarily to government users, but the technology pioneered in these systems set the basis for industrial mainstream and commercial PCs.

As reported in **Rambøll (2008),** the cost / performance improvements that have been achieved in over 60 years of supercomputing procurements were significant. Sustained public demand for ever more performing computing power has reduced the cost per unit of computing power a trillion times over 60 year time. This has brought enormous cost savings to computing intensive government departments, as well as large spill-over effects to the affordability of personal computers for the private consumer segment.

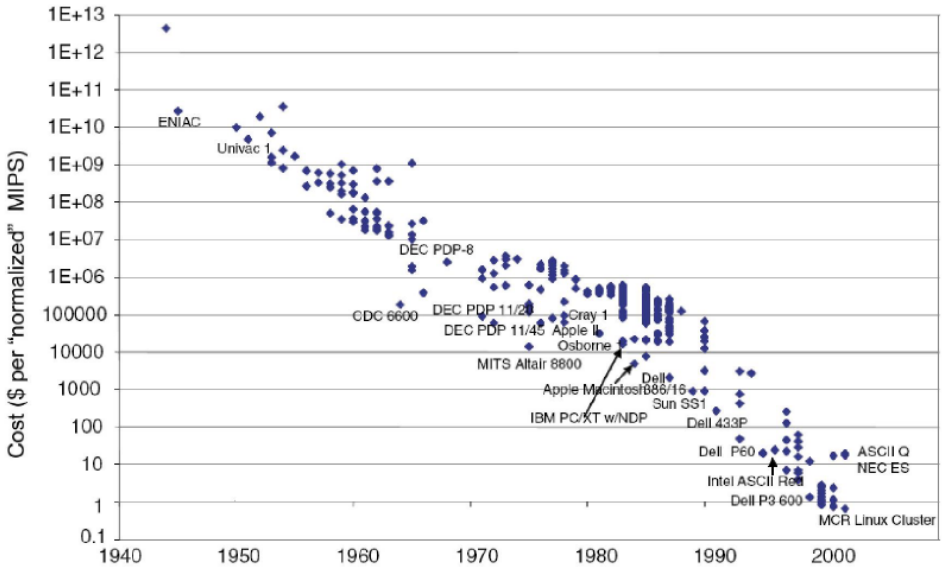


Figure 4.3: 'Getting up to speed: the future of supercomputing', Committee on the future of supercomputing', US National Research Council, 2004

These efficiency/performance improvements are attributed to the fact supercomputing R&D projects are implemented by DOE as demand-driven / public procurement R&D projects: the tender specifications are set by a public procurer that represents the real demand side. This ensures that industry developments converge to deliver new functionalities and performance / cost improvements that meet actual user needs and operational realities of the customer environment in which solutions will need to be used.

Other initiatives undertaken by the Defense Advanced Research Projects Agency (DARPA) that used a supply-side government funding approach to stimulate supercomputer development (funding of development not driven by concrete user needs) failed to develop technology, products, or lasting companies; e.g. in the DARPA Strategic Computing Initiative (SCI) in the 80s and the High Performance Computer and Communications Initiative (HPCC) in the early 90s all of the 20 DARPA HPCC projects were unsuccessful.

Also in other sectors of public interest, PCP like R&D procurements created significant quality / efficiency improvements in public services: e.g. the efficiency improvements on inter-department data exchange delivered by the TCP/IP Internet protocol R&D procurements, in aircraft/aviation, various public sector applications that make use of GPS, fuel cells, nanotechnology, etc. In particular, **Geroski (1990)** reports how Governmental procurement of Semi-conductors is largely considered one of the most successful stories. Quality and standard setting for these projects proved to be more important than favorable purchasing prices for the final outcome. The large public demand, as well as well-established long-run contracts, supported the firms in the development phase, allowing projects to be profitable from the beginning, even before entering private market during the commercialization phase. This enabled the firms to

establish a manufacturing expertise, very much needed to the following commercialization phase. The projects also forced contractors to share information and stimulate entries of newcomers which favoured the rapid diffusion of know-how and manufacturing expertise.

4.2. Increase in quality and decrease in prices of products resulting from the highly competitive multi- sourcing, phased procurement approach that distinguishes PCP from other procurement approaches.

Most of the existing economic literature on innovation policy analyses supply side R&D programs, while, for the remaining demand side policy instruments, like PCPs, there are only few evaluations (see **Tassey 2003, OECD 2012** for a discussion). However, some insights on the potential impact of PCP on quality/price of resulting products can be gained considering a characterizing feature of PCP procurement, namely the presence of dual or multiple awardees, which is a feature analysed by the economic literature under the terms "dual sourcing" or "multiple-sourcing".

1) Use of multiple sourcing at the R&D stage - PCP

Starting from the work of **Anton and Yao (1989, 1992)** and **Dana and Spier (1994),** economists have recognized that awarding contracts to multiple firms may maximize the long-term benefits of procurement. Multiple sourcing is beneficial to reduce procurer's lock-in and help to develop a more competitive market. This is relevant to R&D procurement: if there is only a single contractor during the R&D phase, the production contract may have to be negotiated in a sole-source environment with the contractor that completed the initial development. This generates lock-in: once the pressure of the competitive environment subsides, the awardee may have little incentive to strive to improve performance. Low quality, time overruns and cost overruns may then be observed. Multiple sourcing during the R&D phase helps to mitigate the adverse consequences associated with bilateral monopoly.

Another benefit of multiple sourcing is that it may incentivize more pre-auction cost-reducing investment compared to winner take all auctions, as more firms may choose to invest to reduce their cost if they expect to be able to secure one of the multiple contracts (**Anton and Yao 1989**).

Gansler, Lucyshyn and Arendt (2009) consider US Defence programs, with and without multiple-sourcing, to study the impact of multi-sourcing in procurement programs (see also **RAND 1996**). In the US Defence industry, barriers to entry are high and, for national security, there is a limit to the threat of substitutes from foreign companies. Given the need to have performing solutions and the most advanced technology, it is thus critical for there to be two or more viable competitive suppliers for each product or service, so that the government can balance their power.

Comparing single and multiple sourcing, **Gansler, Lucyshyn and Arendt** find that competition during research and development reduced development time by 33 percent, development cost by 42 percent, and average per-unit cost of more than 50 percent. Furthermore, maintaining competition during the provision of the final end-solution (products/services) results in further positive effects. They observed that competition during sustainment operations has established dramatic improvements in material availability (above 95 percent), world class response times (2-4 days), significant reductions in inventory, and savings of 17 percent over the historic support methods. Finally, they argued that early competition in the system lifecycle is desirable, as sponsoring the concurrent development of two or more competing weapon systems represent potential substitutes for filling a presumed military need, the government can hedge against uncertainties. This reduces the risk of being committed to an unsatisfactory approach and increases the probability of obtaining an acceptable end product

The Joint Direct Attack Munition (JDAM) is an example of the advantages from competition during the development stage. In this case, two prime contractors (Martin Marietta and McDonnell Douglas) competed against each other during development. This competition lead to a reduction in development time by 33 percent, in development cost by 42 percent, and an average per-unit cost reduction of more than 50 percent.

Learning effects reinforce the benefit of multiple sourcing. The evidence collected by Gansler, Lucyshyn and Arendt shows that the second supplier/source achieves a steeper learning curve: learning by the second source is between 2 percent to 9 percent greater than for the first source (see figure 4.2). The steeper second-source learning curve exerts price pressure on the original firm, whose learning curve becomes steeper because of the competitive pressure. Thus, competition drives both firms to more efficient pricing.

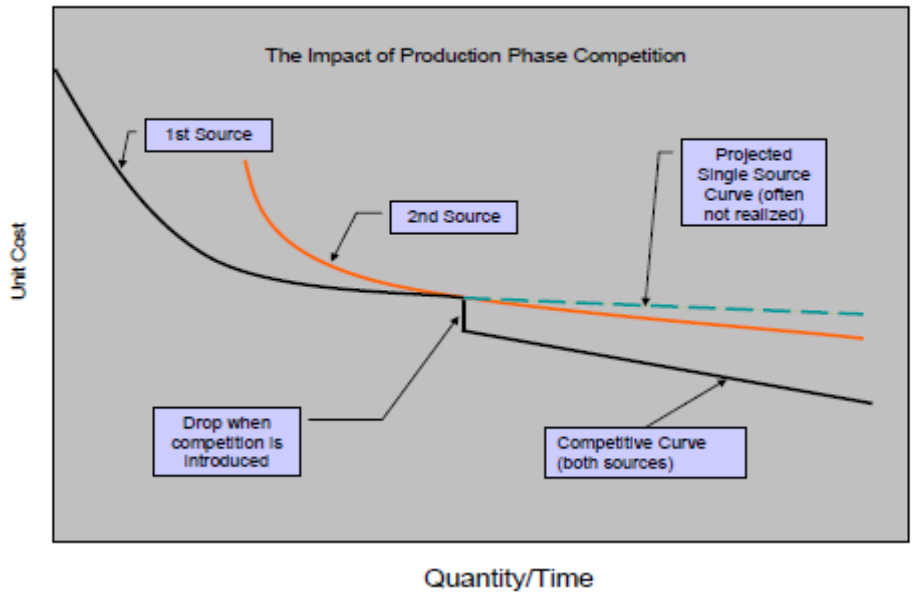


Figure 4.1: Gansler, Lucyshyn and Arendt (2009): Learning Curbe

Gansler, Lucyshyn and Arendt also find that competition during production helped the DoD to improve weapon system quality and reliability. They report the case of the U.S. Navy's Sidewinder guidance which was provided by Raytheon and Ford Aerospace producers, whose items met reliability goals in full.

Competition is also found to lead to a lower cost growth of DoD programs. The cost growth factors on the programs with no production competition (based on actual cost incurred vs. program baseline) increased by 46 percent, on average. Of the 10 programs studied, most showed an increase between 25 percent and 104 percent. Instead, the cost-growth factors for commercial aircraft produced in a competitive environment showed a decrease of between 2 percent and 27 percent.

Dual-sourcing also increased the availability of supplier information between competitive suppliers that resulted in more aggressive bidding and gave the government more leverage on quality aspects that had not been specified in the contract because difficult to contract upon **(Lyon 2006).**

A number of other studies, cited in Gansler, Lucyshyn and Arendt (2009), have confirmed the cost saving of dual sourcing. Savings from dual sourcing in electronic programs have also been observed (see **Birkler et. al. 2001**).

Grimm, Pacini, Spagnolo and Zanza (2006) summarize the benefit from dual or multiple sourcing as

- Simultaneously allows both winning firms to learn and to gain experience, resulting in a steeper overall product-specific learning curve.
- Produces procurement cost savings to the government when it is followed by a winner-take-all tendering process, but this involves the danger of lock-in which increases cost in the future. Reducing long-term costs can thus make it optimal to allow for multiple awardees also in the final round of the tendering stage.
- Reduces informational asymmetries between suppliers, which can lower procurement cost by inducing more aggressive bidding in subsequent tendering processes.
- Gives the buyer more leverage over non-contractible dimensions of product quality: the buyer has additional disciplinary power with respect to product attributes that are difficult to specify in a contract.

2) Use of multiple sourcing at the deployment stage - PPI

The use of multiple sourcing, which requires investments in production, distribution and supply of commercial volumes of end-products, requires more careful consideration to ensure costs do not outweigh benefits.

First, production of goods or services by dual or multiple sourcing involves duplication

of the initial investment or effort, as each source must incur the initial fixed costs. If these fixed costs are sunk, that is irreversible, the cost of procurement may raise with multiple sourcing. However, this problem is likely to be more sever when multiple sourcing is used at the deployment stage beyond R&D, rather than at R&D stage, as the capital cost for large scale production is likely to be more significant than the one required for the R&D service.

Second, scale economies have a strong effect on the bidding equilibrium as they make the award choice depend crucially on the aggregation of the privately observed cost information held by the individual suppliers (**Anton, Brusco and Lopomo**, 2010), increasing uncertainty for bidders at bidding stage. This in turn can lead to higher priced bids.

For example, the DoD made the decision to dual-source the production engines and the major avionics elements, but cost pressures led to an initial sole-sourcing of the avionics (with the option of introducing competition later), and in 2004, the DoD decided to drop the engine second source. Even if they expected dual-sourcing of the engines during production to result in significant cost savings, the initial investment of nearly $2.7 billion was viewed as too high. **Beltramo** (**1983**) for example shows that multiple sourcing can lead to higher costs. The paper collect empirical data on competition in US defence, identifying ten cases where multiple sourcing had been used, 7 of which were considered suitable in terms of cost savings analysis but 4 of those cases showed increasing costs.

Third, compared to winner-take-all auctions, where there is only one awardee, it has been noted how multiple sourcing may make it easier to sustain bid rigging at procurement stage (see for example **Anton and Yao, 1992** and **Grimm, Pacini, Spagnolo and Zanza, 2006**). Intuitively, this may occur because the presence of multiple awardees may make it unnecessary for conspirators to pay illegal side transfers to sustain the collusive agreement and share the benefit across the cartel members. This argument however has been made with regard to multiple sourcing of production contracts, where the object of the tender is relatively homogenous and the benefit from the award of the contract is solely given by the monetary compensation received by the procurement authority. For R&D contracts, the case for multiple souring to raise the risk of bid rigging at procurement stage is weaker. This is because the benefit for a firm from the award of the contract is not constituted solely by the monetary compensation but also by the IPR obtained on the solution proposed. Such IPRs provide incentives for firms to compete fiercely against their competitor so as to improve their position in the market.

We note, further, that with R&D services, bidders face more uncertainty on each other's costs, than they do in the production of homogeneous and non-complex products. This cost uncertainty makes it difficult for bidders to agree on a coordinated collusive conduct. For this reason, we should expect greater potential gains from multiple sourcing in markets were multiple awardees are used for R&D services rather than for contracts for the supply/production of goods.

An implication of this literature is that for contracts for both R&D and for commercial deployment/supply of end-products the final number of awardees should not be fully fixed in stone a priori, but a minimum expected number of awardees could be set allowing still for the final number to be chosen with some degree of endogeneity, as function of the quality/price of the bids placed by the firms, so as to optimally trade off the various factors (**Dana and Spier, 1994**). The maximum budget available for each of the phases of the procurement process should then be chosen appropriately so as to optimally trade off the need to provide incentives to bidders and the need to reduce any unsuitable coordinated action.

4.3. Reduction in the risk of failure in large scale follow-up PPI procurements

A PCP can significantly reduce the risk of failure of follow-up large deployment contracts (PPI). There are a number of risk reduction techniques used in PCP: (1) splitting the R&D (PCP) off from contracting for large scale deployment (PPI), (2) comparing/learning from several alternative solutions approaches in parallel before fixing the requirements/tender specs for deployment, (3) splitting the R&D in phases with evaluations after each PCP phase that stops further investment in non-viable solution approaches, (4) sharing the benefits/risks of commercialization/IPRs with the PCP vendors (5) reducing the perceived risks to buy from SMEs (6) encouraging the development of open interoperable solutions.

Regarding (1) there is a vast economic literature on the benefit and cost of bundling different stages of procurement. Public Private Partnerships (PPP) are long term contracts that typically involve the bundling of the design, building, finance, and operation of a project, which are contracted out to a consortium of private firms. The benefit of such bundling have been argued to be given by the extra-contractual incentives for the service provider to invest in better quality project designs so as to reduce the cost of the project implementation. This has been shown to be typically associated with lower cost and time renegotiations and with higher project quality (see **Iossa and Martimort, 2015** for a discussion). Bundling however has generally resulted unsuitable in fast moving sectors like ICT. In ICT, procurers have found it difficult to adapt the contract to chances in user needs or to benefit from the fast changing technologies. Suppliers have used inefficient technologies and managed to lock themselves into the long-term PPP contracts and procurers have been left to undertake expensive negotiations to renegotiate contract terms. PCP can prevent these risks by splitting the development phase (PCP) from the large scale deployment phase (PPI).

Furthermore, a recent study by **Che, Iossa and Rey (2015)** on procurement of innovation has shown that the prospect to be awarded the implementation contract for large scale deployment can be an important leaver for incentivizing R&D effort, especially for projects which have little market value. However, full bundling of R&D and large scale development is generally inefficient, as it grants the innovating firm a

lucrative implementation contracts even when its R&D effort has resulted in low value projects. Unconditional bundling can thus reduce rather than increase effort by the provider and result in low value projects being implemented. These arguments against bundling are even more likely to hold if we consider that PCP projects have typically market value and are thus not specific to a procurer. Leaving IPRs to the firm can play a crucial role at motivating research effort under unbundling. An additional argument refers to the impact of unbundling on the research effort and participation of SMEs (see below).

Unbundling development and large scale deployment can also help to reduce the risk of failure in large scale follow-up PPI procurements, because of the presence of agency problems within public organizations. Under bundling, agency problems within governmental organizations may impede the stopping of low-value projects: risk adverse officials may fear that there will be a judicial challenge from the firm, and they may be perceived as responsible. They may also fear that stopping a project will be viewed as admitting a mistake at tender stage, and fear a reputational loss. When there the R&D phase is highly risky, or when it is difficult to verify objectively the project value, this agency problem provides an important argument in favour of separation of R&D and implementation. We shall come back to this point below.

Regarding (2), according to pyramid research around 70 percent of public procurements for deployments of commercial solutions in the e-health sector, where ICT solutions for healthcare are developed, do not achieve the expected results. Reasons quoted are that procurers run out of budget because of vendors with monopoly position charging too high prices and stalling project duration, or procurers wrongly specifying PPI tender specs because of lack of knowledge on pros and cons of different competing solutions[11]. In the UK, the extensive renegotiations that characterized the public private partnerships for the joint development of IT infrastructures and their management lead the government to recommend against the use of these contractual agreements in the ICT sector (HMT 2008).

It is obvious that procurement risk cannot be completely eliminated. Today procurers mainly use market studies, information, sharing of best practice and hiring of expertise to help reduce this risk. Undertaking a PCP before launching a PPI deployment tender can reduce this risk of procurement failure and the loss that arises when PPI procurements are unsuccessful or inefficient even further, not only by gaining a deeper understanding of pros and cons of alternative solution approaches, but by actively filtering out technology risks and steering R&D to meet user needs etc.

The information accumulated through the PCP may point at the need to acquire additional more accurate knowledge to further reduce risks, before undertaking the PPI Furthermore, the information accumulated through the PCP may reveal that it is not worth pursuing further towards PPI/deployment or that large scale production of the developed solutions is not economically convenient. Even in these cases, the PCP

[11] Sara Bedin (2014), extract from the speech in "Innovative tools for regional 2014-2020 R&D policies" workshop, Brussels

will have been beneficial in terms of increasing procurement efficiency by reducing the risk that unsuitable projects go ahead.

Regarding (3), the phased approach used in PCP is already today reducing the risk of failure for potential future follow-up PPIs. In most finished and ongoing PCPs at national and European level, there are vendors that drop out after the solution design or prototyping stages. Although their solution looked viable initially on paper when they submitted a bid for the PCP, in reality it turns out to be either not technically feasible or too costly to implement. If those procurers had started a PPI or a combined R&D-deployment procurement right away without doing a PCP first, it could have been more difficult to interrupt the project and therefore there would have been the risk of awarding large deployment (PPI) to a vendor unable to deliver within the promised quality / price / timeframe.

Regarding (4) in PCPs the procurers leave IPR ownership rights, and thus also the costs to maintain those IPRs, with the vendors in the PCP. The maximum price for each PCP phase is fixed in advance by the procurer so that cost overruns due to unexpected higher development efforts are not born by the procurers. Not a single EU funded PCP project for example has incurred PCP budget overruns. Leaving IPR ownership with companies encourages them to pursue wider commercialization (see also section 4.9), which in turn offers extra contractual incentives to undertake R&D effort. Furthermore, the anticipating of the potential benefits from commercialization and the subsequent profits from large scale production makes firms willing to bid more aggressively at procurement stage, which helps to bring prices down for the procurer

(5) The fact that PCP is split from potential follow-up large scale deployment contract and the R&D is split in phases, reduces also the risks for the procurer to start buying from SMEs by giving SMEs a chance to show that their solutions are able to compete against larger vendors during the PCP (more info in section 4.5). Furthermore, bundling also makes it more difficult for SMEs to be competitive, which may discourage their participation and reduce incentives to innovation. As shown also in **Che, Iossa and Rey (2015),** to the extent that SMEs may be in a difficult position to handle complex and long term procurement contracts with an integrated commercialization phase, the unbundling that characterize PCP is crucial for inducing participation from SMEs and motivating efficient research effort. In markets were SMEs have a significant potential role, the separation of PCP from the potential follow-up of large scale deployment contract is therefore crucial.

(6) The use of performance based specifications for the PCP that encourage the development of open, interoperable solutions further reduces the risk of supplier lock-in and associated price increases and/or interoperability problems.

Given the high amount of public procurements that does not achieve their goals and the public sector often pays far too much for suboptimal products in Europe today, the

risk of not doing a PCP is actually higher than the risk of doing a PCP to de-risk a PPI. The cost of a PCP is indeed only a fraction of the cost/risk of failure of the follow-up large scale deployment PPI contract and the cost of a PCP can easily win itself back multiple times via the cost savings on the resulting products achieved by the PCP (see section 4.2).

4.4. Increase in the efficiency/intensity of R&D expenditures

(1) Impact of demand/user driven nature of a procurement project on R&D efficiency.

Hippel (2005) finds that user driven innovation improves the success rates of innovations. He reports the outcome of a number of studies that show that supply side R&D programs have a large probability of commercial failures for most new products developed and introduced to the market by manufacturers. In particular, the overall probability of commercialization success for new industrial products is found to be only 27 percent; the overall probability of success for consumer products is found to be 26 percent, and similarly high failure rates are observed in new products commercialized. The author argues that, although there clearly is some recycling of knowledge from failed projects to successful ones, much of the investment in product development is highly specific, and therefore is sunk. High failure rates therefore represent a large inefficiency in the conversion of R&D investment to useful output, and a corresponding reduction in social welfare. Hippel argues that the main reason for the high commercialization failure rates of manufacturers in supply side R&D programs was the inadequate understanding of user needs.

In the supercomputing case discussed in Section 4.1 (**Ramboll, 2008**), the demand driven approach[12] was a key success factor also for optimizing the efficiency and effectiveness of R&D expenditure, as it helped to ensure that developments immediately addressed concrete user needs which created significant cost reductions for the procurers and lead markets for vendors involved. Under supply side driven R&D approaches, instead the development efforts may be decoupled from concrete customer needs and not result in successful products (see info on DARPA supercomputing in section 4.1).

(2) Impact of innovation procurement on R&D expenditure and sales results of firms

Earlier studies, summarized in **Edler and Georgiou (2007),** discuss the impact of procurement of innovation compared to other R&D policies. Notably **Rothwell and Zegveld** (1981) compared R&D subsidies and state procurement contracts without direct R&D procurement. They concluded that, over longer time periods, state procurement triggered greater innovation impulses in more areas than did R&D subsidies. **Geroski (1990)** theoretically discusses alternative policies and concludes that procurement policy can be a more efficient instrument to use in stimulating innovation than any of a wide range of frequently used R&D subsidies.

[12] Innovation procurement requires intelligent customers and these customers need to be involved in the process and to develop new ways of working together. Studies reported in **Proehealth (2012)** reveal how lack of knowledge of user needs is one of the main barriers to innovation procurement.

However, as recently recalled by **Guerzoni e Raiteri (2012),** the empirical evidence about the effect of innovation procurement on innovation output (such as, innovative turnover - which is defined as the share of turnover generated by firms with market novelties, the introduction of a new product, process, or service) in Europe is rather fragmented and mostly limited to case studies (see references therein). In their paper they try to overcome this gap by studying the impact of innovation procurement and R&D subsidies on firms' private R&D investments and innovative output.

They adopt a boarder definition of innovation procurement than the one defined in **Edquist and Hommen (2000).** They consider all "purchasing activities carried out by public agencies that lead to innovation, even if indirectly or as a by-product"; this allows them to take into account also indirect impacts of procurement policies (e.g. even before a formal public tender process has been issued).

They use a multi-treatment, quasi-experimental setting using data from Innobarometer 2006-2008, a survey for DG Enterprise conducted in April 2009 in 27 EU countries, Norway and Switzerland to 5238 companies, which provides information on R&D private investment and on innovativeness (Innovative turnover). Beside usual information about firms' innovation activities, firms have been expressly asked about what the effects of innovation procurements they were involved in had on firm innovativeness, i.e. whether the participation to these procurements increased their sales coming from innovative products/services (i.e. new or significantly improved products or services). Firms were divided into four groups: (i) firms receiving only R&D grants, (ii) firms only winning innovative public procurement contracts, (iii) firms receiving both R&D grants and innovative procurement contracts and, finally, (iv) firms that are not involved at all in any of these programs. In this way the author are able to estimate complementarity effects between R&D subsides (control group) and innovation procurement (treatment group).

Investigating the difference in indicators between treated firms and the control group, they measure the propensity score which consists of a measure of the probability for an individual to be treated conditional to a set of relevant characteristics, as we do in our analysis.

Their main findings can be summarized as follows.

With regard to the impact of Innovation Procurement on private R&D expenditure and innovativeness, compared to the impact of R&D subsidies on private R&D expenditure and firm innovativeness (measured by the innovation output), they find that:

- There is a positive and significant impact of innovation procurement on private expenditure on R&D: 12 percent more firms have increased their R&D expenditure in the treated group than in the control group. Instead, R&D subsidies incentivise only small amounts of additional firms' private expenses in R&D. Only 6.5 percent

more firms increased their R&D expense in the treated group than in the control group.[13]

- There is also a positive significant effect of innovation procurement on firm innovativeness: 9.3 percent more firms in the treated group than in the control group report that most of their sales are coming from innovative product or service. Instead, there is no evidence of R&D subsidies creating any significant impact on firm innovativeness (the effect on firm sales coming from innovative products/services).

Furthermore, when they isolate the effect of each policy, the impact of R&D subsidies on private R&D investment is no longer significant. The impact of innovation procurement on private R&D investment remains significant.

Interestingly, in their analysis they also investigate whether R&D subsidies displace private efforts or, on the contrary, favour them. Their findings reveal the presence of hidden correlation and reinforcing effects between R&D subsidy programs and innovation procurement. In particular, they find a positive significant impact on both indicators of receiving simultaneously R&D subsidies and winning innovation procurement contracts. First, 20 percent more firms in the treated group than in the control group have increased their private R&D investment. Second, 8 percent more firms in the treated than in the control group have reported an increase in their innovativeness due to their participation in their respective program.

These findings highlight the importance of considering policy interactions when evaluating the impact of supply side or demand side policies.

More generally, until recently, the academic debate on the impact of government purchases on firms' economic activity, employment, and innovation, had provided mixed results. In models with firm-level heterogeneity, the aggregate effects of government purchases was shown to depend on which firms are most affected (i.e. young versus old), how incumbent firms respond to competition, and whether government policies affect entry and exit (see **Ramsey, 2011**, for a review).

Recently, however, **Ferraz, Finan, and Szerman (2015**) have found significant empirical evidence of the positive impact of public procurement on firm's growth, both during the quarter in which they win, as well as over the medium horizon. They analyse a comprehensive data set of formal firms in Brazil and the universe of Brazilian federal government procurement contracts over the period of 2004 to 2010. Their data include firm size, the age of the firm, the characteristics of all of the firms' workers, and the exact date workers are hired and fired. Combining these data they estimate the effects of winning government contracts on firm growth for over 47,000

[13] The possibility that R&D subsidies mainly substitute ("crowd out") private funds is an issue that has been largely analysed by the economic literature. We recall **David et al. (2000)** who review 35 years of econometric evidence on the impact of public R&D on private R&D. They find that 1/3 of studies report public R&D funding are substitute for private R&D funding: 5/6 of studies based on data of countries other than US report overall complementarity, while only 4/7 of studies based on US data report complementarity.

firms that participated in over 6.5 million lots auctioned off by Brazil's federal government during this period.

Their findings show that firms that win government procurement contracts grow more compared to firms that compete for these contracts but do not win. In particular, winning at least one contract in a given quarter increases firm growth by 2.2 percentage points over that quarter, with 93% of the new hires coming from either unemployment or the informal sector. These effects also persist well beyond the length of the contracts. Part of this persistence comes from firms participating and wining more future auctions, as well as penetrating other markets.

Furthermore, winning government contracts change firms' behaviour both in terms of which markets firms enter and in terms of which product they supply. Winners are more likely to participate in auctions where the buyer is located outside of their municipality and increase the number of products they compete for in auctions. These findings suggest that winning government contracts through auctions increase firm growth not only because firms are more likely to get more contracts in the future, but also because they enter more valuable auctions, penetrate more markets, and also increase the variety of products they sell.

4.5. Speeding up time-to-market for firms and facilitating the access of SMEs to the procurement market

Uyarra and Edler (2014) investigate what prevents suppliers from proposing innovative solutions, using a dedicated survey of 4043 suppliers to public sector organisations in the UK. The main barriers reported by firms refer to the lack of interaction with procuring organisations, the use of over-specified tenders as opposed to outcome based specifications, low competences of procurers and a poor management of risk by procurers in procurements.

Additional key concerns include lack of feedback from unsuccessful bids, a low appreciation of unsolicited ideas and consideration of the private sector delivery history, and, especially for SMEs, the difficulties for participation posed by pre-qualification procedures and conditions. Their results also suggest that SMEs perceive certain procurement practices as disadvantageous. Their incentives to participate are lowered when the size of contracts is higher, there is lack of useful feedback and the pre-qualification requirements are stringent.

By challenging companies to develop breakthrough innovations for public sector challenges for which there are no solutions on the market yet and by making development efforts on the supply side converge faster towards solution requirements on the demand side through early customer feedback, PCP can reduce the time-to-market for companies to gain first mover advantage and gain leadership in new markets.

The phased PCP approach with gradually growing contract sizes that follow the natural growth path of innovative start-up companies can facilitate the access of small innovative firms / SMEs to the (procurement) market. This is evidenced by PCP-like R&D procurements in the US that have nurtured small companies into major market leaders across different industry sectors such as computing, telecommunications, aviation and bio/nano technology. Companies like IBM, HP, Dell, Cray, Intel, Qualcomm all developed their first block buster products in R&D procurements.

In Europe, SMEs are also very active in PCPs both at national[14] and European[15] level. In the EU funded PCPs[16] so far 75,5 % of PCP contracts were won by SMEs (SME bidding alone or SME as lead bidder together with other partners). When comparing to 29% of public procurement contracts that are typically won by SMEs in Europe, it's clear that the PCPs funded by the EU FP7 program are facilitating the access of SMEs to the European procurement market. Interestingly, the type of SMEs in the EU funded PCPs are mostly small young SMEs: 34,5% below 10 people, 81% below 50 people, 56% less than 10 years old.

4.6. Attracting financial investors to Europe

We have discussed above that agency problems within public organization may prevent failing projects from being discontinued, because of lack of incentives and fear of reputational loss. The same agency problems also exist at the higher tier of governments. Politicians and high government officials may finance poorly design project because of their mere private interest (see **Flyvbjerg, Bruzelius, and Rothengatter, 2003** for empirical evidence). Unsurprisingly, these poor projects will receive little interest from the private sector. The availability of private finance for project financing is often an important signalling device of the quality of the investment.

Geroski (1990) notes how government subsidies (tax incentives or grants supporting R&D activities) have often financed second-best projects and failed to attract private capitals. Poor projects were conceived and implemented, even when they lacked any tangible benefit, and they have been justified by governments in the name of national pride and prestige and subsidized from the public purse. Some case studies are reported in the early work by **Rothwell and Zegveld (1981).** Public Procurement of innovation should suffer less from these problems when it is undertaken by the authority that will be responsible for delivering the public service requiring innovative effort. In this case, it can be the expression of a clear, consistent set of needs towards which innovative effort is needed and it will constitute a credible signal to private financiers that the innovation is worth pursuing.

[14] http://ec.europa.eu/digital-agenda/en/news/innovation-procurement-initiatives-around-europe
[15] http://ec.europa.eu/digital-agenda/eu-funded-projects
[16] Overview results first EU funded PCPs: https://ec.europa.eu/digital-agenda/news-redirect/21250

Financial investors have pointed out[17] that public procurers in PCPs can successfully act as a seal of approval, confirming the market potential of new emerging technological developments, thereby attracting new investors for the highly innovative companies in the PCP.

However, there have not been a sufficient number of completed PCP cases in Europe to enable significant impacts to be observed or not at this point. It will be interesting in particular to follow whether, alike in classical R&D grant projects, companies in PCPs that aim at dual-use technology (for which market take-up is not limited by public sector speed of adoption alone) will attract more Venture Capital investments than companies in PCPs for which the only customer is the public sector.

4.7. Increased interoperability / impact on standardization / reduction of supplier lock-in

1) Interoperability/standardization/supplier lock-in at the R&D stage (PCP)

Streamlining desired product specifications amongst suppliers and procurers at the stage when products are still under development empowers procurers to foster the necessary degree of standardisation amongst suppliers to guarantee economies of scale and interoperability. There is a clear link between PCP and standardisation:

PCP can be clearly used by the public sector to reach de facto standardisation in a fragmented sector. By setting requirements for interoperability etc at the start of the R&D, PCP (especially when executed by a critical mass of procurers in cooperation) can enable procurers to drive industrial developments in the PCP to become the de facto standard in the sector. Clearly GPS, TCP/IP (Internet Protocol) etc are examples of solutions developed during competitive R&D procurements in the US that have become de facto standards in entire sectors afterwards. A number of EU funded PCP projects (e.g. CHARM on traffic management and SMART@FIRE on smart textiles for fire brigades) have foreseen regular interaction with their professional network of other procurers around Europe to foster de facto standardisation by interaction with them in preparing the tender specs and following up the vendors during the PCP.

Procurers also have the possibility to align the PCP development process with the official standardisation process of standardisation bodies, driving therefore the creation of de jure standards out of industrial developments in the PCP. Security, cloud computing are typical US examples where the government itself is driving de jure standardisation itself to align procurement needs with ongoing industrial developments. In Europe similar is possible. The three phase PCP process aligns with the three phase standardisation process of typical European standardisation bodies such as ETSI. De jure standards are typically also created in three phases: first a requirements specification / standard is created, afterwards an architecture specification / standard, and last the detailed protocol / conformance testing

[17] http://cordis.europa.eu/fp7/ict/pcp/reportpcp2011event.pdf

specifications / standards. Public procurers can therefore alike private procurers (e.g. telecom operators) feed the outcomes / results of the PCP, phase by phase, into the European standardisation process: typically after phase 1 of a PCP (design phase), procurers have confirmation about the feasibility of their requirements and a first version of requirements standards can be created; typically after phase 2 of a PCP (prototyping), procurers have confirmation about the system architecture and a first version of architecture standards can be created; typically after phase 3 of a PCP (development and testing of small quantity of first products), procurers have confirmation about conformity with detailed operational implementation issues and detailed protocol/conformance testing standards can be created.

The EU funded PCP project V-CON (on virtual road infrastructure modelling) for example is aiming to create new de jure standards through their PCP project.

2) Interoperability/standardization/supplier lock-in at deployment stage (PPI)

Interoperability/standardization can be handled in PPI procurements by avoiding to refer to existing standards/brand names etc, whenever it is not necessary. This allows the awardees of PCP contracts to all be competitive with their developed solutions and participate at PPI stage. Non-PCP firms can also participate.

This approach helps to avoid long term supplier's lock in. Supplier's lock in reduces the incentives of vendors to provide non-verifiable and contractible quality because the vendor is protected by the threat of being replaced with an alternative supplier, raises the cost of the locked-in products or service by reducing competition. Many innovative goods and services exhibit network effects: the value of a technology for a user is greater the higher is the number of other users of the same technology. Strong network effects can potentially lead to market failures: users remain locked into a technology even if a superior technology is available. They do not switch technology because they fear that other users will not switch. This is a result of coordination failure by users. Historical examples include the aborted attempt at switching from AM to FM radio broadcasting in the 1950s.

Lock-in happens when an organization cannot easily change a supplier after the expiration of his contract, because not all essential information or technologies for production is available for efficient takeover by another provider. The Digital Agenda for Europe identified lock-in as a problem. Building open ICT systems by making better use of standards in public procurement is seen as a way to prevent lock-in.[18] European Commission reports how many organizations are 'locked' into their ICT systems because detailed knowledge about how the system works is available only to the provider, so that when they need to buy new components or licenses only that provider can deliver. The lack of competition is reported to lead to higher prices and some € 1.1 billion per year lost unnecessarily in the public sector alone.

[18] http://ec.europa.eu/digital-agenda/en/open-standards.

They report the results of a survey carried out in 2011 among public procurement officials in the European Union Member States which surveyed 244 procuring authorities.[19] At least 40 percent of them considered that changing their existing ICT solution would be too costly because it would involve changing many other systems that use the data of the system that they would like to change. Of those surveyed, 25 percent felt they would not be able to change their ICT solutions for fear that their information would not be transferable.[20] 59 percent of the respondents report that the interoperability of new software, which makes it compatible with software from other producers and product families, is most important, whilst 33 percent found that the software compatibility from other producers and product families was most important (8 percent said they did not know). This shows that a significant share of public administrations in practice lock themselves into proprietary technologies.

Using ICT systems based on standards instead of proprietary technology can help to open up restrictive public procurement practices, because standards make essential knowledge about a system available to anyone, implying that other potential suppliers could maintain or evolve the system under more competitive terms and conditions

Public procurement can help alleviate network effects and reduce users' lock in. By purchasing sizeable amounts of innovative goods and services, procurers may signal that they attach high value to the technology and help to create a sufficient demand for the product. By requiring open, standardized, interoperable solutions for the public sector, public procurement can thus stimulate demand for more open solutions through the reduction of the risk of isolation, coordinating users and avoiding lock-in.

Cabral, Cozzi, Denicolò, Spagnolo and Zanza (2006) reports a number of examples where government procurement had an influence in the direction of the standard setting processes, reducing supplier lock-in. During the mid-1970s, the McDonnell Douglas DC-10 was in danger of being taken over by the Boeing 747 (and, to some extent, the Lockheed 1011). However, when the US Air Force ordered sixty units of the KC-10 (the military version of the DC-10), the company was given a new life and was able to compete for a few more years. This avoided the lock-in that could have resulted from the incentives of airlines to buy the same type of aircraft as other buyers, thus resulting in a reduction in maintenance and other complementary services.

Public Procurement however can also cause inefficient lock-in, when ill directed. Nuclear power reactors is one such example discussed in **Cowan (1990).** By the late 1950s, there were about a dozen relevant alternative technologies considered superior to "light water" which was nevertheless the dominant technology in the market for nuclear reactors. This was largely due to a large procurement by the U.S. Navy of light water for submarine propulsion. When a market for civilian power emerged, light water had a large head start, and by the time other technologies were ready to enter the market, light water was entrenched.

[19] http://cordis.europa.eu/fp7/ict/ssai/docs/study-action23/study44-survey1results.pdf.
[20] http://cordis.europa.eu/fp7/ict/ssai/docs/study-action23/study44-survey1results.pdf.

Ghosh (2005) and other studies cited in the paper find an extensive use of brand names in procurement documents. Between 16 percent and 36 percent of invitations to tender refer to brand names, depending on the sample used. Doubling the number of bidders lowered the contract value by around 9 percent. Given this ratio of increased bidders to reduced costs and given a reference to brand names in 16 percent of the EU ICT public procurement (estimated at € 78 billion), public authorities are estimated to be spending unnecessarily some € 1,1 billion per year as a result of the restricted number of bidders caused by the reference to brand names.

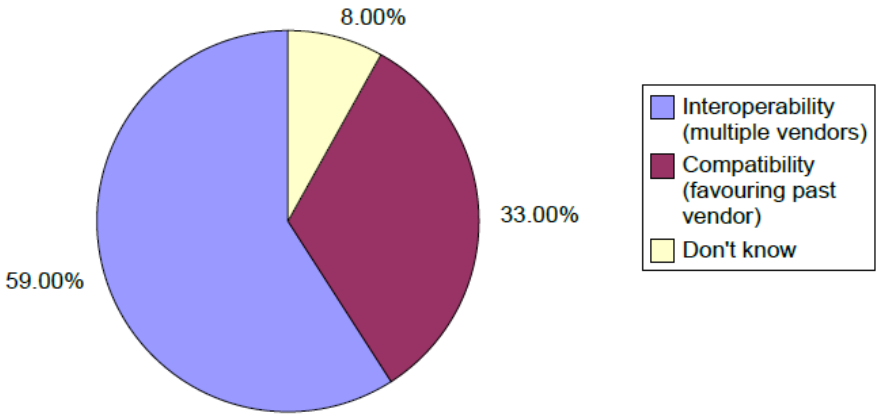


Figure 2.5: Ghosh (2005): Selection Criteria for New Software Purchases.

4.8. Impacts on competition structure in the market

PCP can provide a way to facilitate the entrance of new small innovative companies into the procurement market and reduce suppliers lock-in via standardization. This may help reduce the dominant firms market share and create a more innovative and competitive market.

The supercomputing demand side approach provides some evidence of this positive impact of public procurement on competition structure.

The **Rambøll study (2008)** reports how supercomputing R&D procurements were clearly effective at stimulating industrial innovation in the computing sector at large. It triggered further industry R&D investments to bring technological innovations originally developed for supercomputers to the commercial PC market. It is estimated that sales to US universities accounted for 80 percent of SUN Microsystems revenues in its first years of business. By imposing demanding performance requirements universities effectively influenced technological advances in timesharing, computer graphics and artificial intelligence. Out of these efforts companies such as Silicon Graphics Inc (SGI) emerged.

The R&D supercomputing procurements undertaken by the DoD and the Department of Energy (DoE) have actively increased competition in the market by calling for PCPs with a higher number of suppliers (to give chances to new entrants) in times when small amount of firms started dominating the market. In 1970s IBM retreated from the supercomputer market to commercialize its newly developed technologies in commercial computer business. CDC and Cray then started to dominate the supercomputing industry, which induced the DoD and DoE to attract more companies to their computer related R&D procurements. Many of the commercial array processor companies that emerged in the late 1970s were spinoffs of these efforts, such as Digital Equipment Corporation (DEC). It produced the most popular minicomputers for the engineering communities in the 70s and 80s. DEC was acquired by Compaq in 1998, which later merged with Hewlett Packard in 2002. As of 2007 its product lines are still produced under the HP name.

The EU funded PCPs[21] also show a clear effect on unlocking the internal market. The effect of joint cross-border PCP procurement is that 25% times more contracts (33%) than typically in national procurement (1,23%) are awarded to companies that are not from countries of the procurers. The PCPs are opening up the single market and contributing directly to creating a Digital Single Market in Europe by offering concrete cross-border market/growth opportunities to companies.

Whether a more competitive market structure will result in yet more innovation in the long term is still an open issue, but we can expect that the reduction in supply lock in and increase in service quality following useful innovation will indeed lead to improvement in the provision of public services as the market develops and innovative approaches are adopted.[22]

4.9. Increased exploitation of IPRs and R&D results (IPR protected or not) in general

PCP is expected to lead to an increase in the exploitation of IPRs. Anticipating the potential benefits from commercialization of their developed solution, firms participating to PCP projects have additional incentives to exert research effort in order to develop solutions that have great potential in terms of subsequent commercialization. Compared to traditional innovation procurement, where IPRs are fully retained by the public contracting authority, allocating IPRs to the firm (with the

[21] Overview results first EU funded PCPs: https://ec.europa.eu/digital-agenda/news-redirect/21250

[22] There is evidence that R&D and technological change are directed toward more profitable areas. For example, Linn and Acemoglu (2004) consider data from the pharmaceutical industry and find that a 1 percent increase in the potential market size following a successful innovation is associated with a 4–6 percent increase in innovation rates (measured by the number of new molecular entities). However, whether current competition is associated with higher or lower profitability of innovations depends on a number of factors. On the one hand, the prospect of gaining a technological market leadership and large market shares by developing a successful solution and retaining property rights, suggests that current competition can be good at incentivizing innovation (see Cabral, 2006). On the other hand, current competition may translate into a perception that gaining a stable technological market leadership will be difficult because there may be an expectation that other competitive products will soon be developed by the competitors, in which case incentives to innovate of individual firms may decrease with competition.

public contracting authority for example retaining a licence of use) should therefore be associated with greater exploitation of R&D results.

To our knowledge however the impact of IPRs on the commercial exploitation of R&D results is an issue that has not yet been investigated by the empirical literature, possibly due to the limited number of cases and data. Furthermore, as reported by **Lynn and Write (2015),** there is lack of empirical evidence on the determinants of the success/failure of publicly-funded R&D projects, and thus on whether exclusive development of R&D results could explain lower success and commercialization compared to the case where the IPRs are in part retained by the firm. Existing evidence must therefore rely on few case studies.

The **Rambøll** study (2008), for example, reports that the supercomputing procurement program lead to the development of the first processor on a chip which set the basis for personal computers. Intel, for example, owes its success today to a procurement funded development in which Intel retained IPRs. In 1969 Intel financed the development of the world's first single chip microprocessor with a $60,000 contract from the Nippon Calculating Corporation. Intel's engineers come up with the revolutionary design for the Intel 4004, the first programmable chip on the market for use in a variety of products.

We mentioned how **Geroski (1992)** discusses early evidence on how procurement policy favoured exploitation and commercialization of R&D results, although it is not clear what role IPRs had on this. A study of 50 major clusters of innovations introduced in a number of countries over 1950-1990 finds that procurement policy had a 'very big' or 'major' effect on the emergence of at least 25,50% of the total sample of innovation clusters. The effect of procurement policy was felt in nuclear power, in the development of electronic devices and systems, synthetic materials and new chemical products, and, less strongly, engines and transport equipment. He concludes that procurement policy can be very successful in stimulating both the generation of new technology and its commercialization which favors rapid diffusion across a wide range of users.

5. SUMMARY OF RESPONSES TO PCP QUESTIONNAIRE

In this section, we briefly summarize the eight PCP cases and report in depth descriptive statistics obtained from analysing the responses of the public procurers and the awardees of the PCP cases examined.

5.1. PCP cases description

Case	Country	Year and status	Object
a) Asfinag/FFG	Austria	2011 (completed)	Mobile traffic management system for road work areas and major incidents
b) Lombardy Region and Niguarda Hospital	Italy	2013 (on-going)	Automated universal system for moving hospital beds that is easy to use, equipped with all anti-collision and safety systems, which does not need tracks or guide lines and which can also be used on non rectilinear routes
c) Statoil[23]	Norway	2011 (completed)	CO2 capture plant technology qualification and engineering services
d) City of Stockholm	Sweden	2012 (completed)	ICT solutions to make transportation and travelling more efficient
e) 4S/Norrvatten	Sweden	2013 (completed)	New Technologies for secure joining of PE-pipes
f) AQUAS	Spain	2014 (on-going)	R&D to integrate cross-border PHR services
g) European Space Agency (ESA)	EU	2014 (on-going)	Developing innovative Earth Observation products and services in response to authoritative end-user requirements.

[23] Classified information

a) Asfinag/FFG

In 2011, the Austrian Ministry of Transport, Innovation and Technology, the Austrian Federal Railways (OBB-Infrastructure) and the Austrian Motorway Operator (ASFINAG) agreed to co-finance a pilot project, that have seen the participation of a variety of entities (universities, SMEs, industry and research institutes), aimed to develop a new self-functioning, simple and quick de-installable, mobile traffic management system for road work areas and major incidents. The ambition is to support ASFINAG's vision to become one of the Europe's leading motorway operators. The competitive procedures have been articulated in two-stages, consisting in the project development and feasibility study and, secondly, the prototype development and testing.

b) Lombardy Region and Niguarda Hospital

The PCP has been used to solve the problem of high accidents rate and functional limitations of socio-health workers tasked with moving, via manual pushing and pulling, the hospital beds, as well as the long transport times. The desired innovative solution is a new and cost-effective automated universal medical device for moving hospital beds (and possibly also gurneys), that is easy to use and to manoeuvre for a single operator, equipped with all anti-collision and safety systems, reduced in size, which does not need tracks or guide lines and which can also be used on non rectilinear routes and in all hospital spaces (rooms, lifts, corridors and diagnostic ward spaces), which result in a significant advance in terms of technology and performance and, at the same time, cost reduction.

The multiplier effect of the impacts on efficiency for the regional procurer stems from the fact that the number of hospital beds in Lombardy is roughly 40,000 units, of which around 70% are public beds, and it is estimated that 40% of beds could need a universal movement device. The required solution was identified following a structured state of the art investigation, by means of an open technical dialogue with the market (conducted through public hearings, advertised explorative calls for tender and an in-depth world-wide patents analysis) that had displayed the non-existence on the market of commercialized products complying with the requirements and shortcomings which require new R&D.

The designed competitive procurement results in the most fit-for-purpose and cost-effective solution and it avoids single-supplier lock-in. The PCP implementation consists in a multiple-sourcing procurement of R&D services involving risk-benefit sharing with a competitive procedure in phases.

The on-going PCP contract results in three R&D phases (1. Feasibility study, 2. Technical design, 3. Prototyping & testing & experimentation), awarding parallel contract to a number of competing companies, keeping competition going between companies with evaluations of each company's performance after each project

milestone, retaining at least 2 companies at the end, and assigning IPR ownership rights and leaving the opportunity to resell developed solutions to other markets afterwards to participating companies, in return for a financial compensation (royalties) linked to sales.

c) Statoil

On October 2006, Statoil (now StatoilHydro) and the Norwegian State agreed on the implementation of CO2 Capture and Storage (CCS) at the Mongstad refinery located north of Bergen. The agreement required a two-stage implementation of CCS. The first stage is the European CO2 Test Centre Mongstad (TCM) with a design capacity of 100 000 tonnes of CO2 /year. The second stage is full scale implementation. The TCM partners are Gassnova SF (representing the Norwegian State), DONG Energy, Shell, StatoilHydro, and Vattenfall. The partners are operators from both oil & gas and power industry, and participate actively in the development of CO2 Capture and Storage. The purpose of the test centre is to identify, test, develop and qualify CO2 capture technologies, and to reduce cost and financial, technical and environmental risk connected to the construction and operation of a full scale CO2 capture plant. Based on the result of the technology qualification program, the CCM project will determine the requirements to be set for the next phase. This phase will be subject to a new procurement process where vendors capable of supplying a qualified technology that meets the project's requirements may seek to participate. In 2013 Norwegian government announced termination of full-scale carbon capture project. As affirmed by the Executive Vice President Eldar Sætre the project carried out gave them new knowledge of capture technology. Moreover, they had the opportunity to develop a toolbox for measuring and analysing emissions.

d) City of Stockholm

In 2012, the City of Stockholm with the Swedish Transport Administration, the Swedish ITS-Council and Kista Science City agreed to stimulate scalable innovation for more effective travels and transports to and from Kista, both during the congested traffic situations that the on-going infrastructural projects give rise to, but also after project completions. Being a "catalytic" procurement, it is not the intention to de-risk a follow-up PPI, but to encourage citizens of the larger Stockholm region to use the solution. The underlying objective of this R&D service procurement is to avoid lock-in effects and enable competitors to think outside the box, stimulating development of solutions that the competition organisers would never have been able to come up with themselves. Competitors have been allowed to use any data they want in order to develop their solutions, but in order to facilitate competitors' access to and management of data, the public procurers have provided free access to approximately forty data sets. The procurement has been articulated in two-stages. In Phase 1, competitors had four months at their disposal to develop a prototype of their solution,

a development process. The submitting of the Phase 1-Reports were followed by the competitors presenting their prototypes and intended solutions for an expert panel, consisting of people with deep and wide knowledge of ITS, business trustworthiness, telecom and innovation. The presentation in front of the expert panel, from who the contestants received feedback, was followed by possible negotiations between the competitor and competition organisers. The Updated Phase 1-Reports were evaluated on the in advance determined criteria, after which the competition's up to six winners were appointed.

The winners, whose contractual agreements from Phase 1 were prolonged to also cover Phase 2, will in Phase 2 further develop their prototypes into functioning and introducible solutions. During Phase 2, the contestants' developmental progress will be monitored and evaluated by the competition organisers prior to each payment. The aim of the competition is that the solutions are to be commercialised and brought to market after the end of Phase 2.

e) 4S/Norrvatten

The 4S group, a cooperative of municipality water boards, has decided to initiate a R&D services procurement with the aim of stimulating suppliers of PE pipes and joint techniques to tailor improvements to the group's requirements. Norrvatten's task is to produce and distribute drinking water of the highest quality and ensure that the water reaches the customer in a secure and efficient manner at the lowest possible cost. Norrvatten is a municipal council owned by 14 different urban municipalities in the northeast sector of Stockholm. They are the following: Danderyd, Järfälla, Knivsta, Norrtälje, Sigtuna, Sollentuna, Solna, Sundbyberg, Täby, Upplands-Bro, Upplands Väsby, Vallentuna, Vaxholm and Österåker.
Norrvatten's highest authoritative organ, the federation's council, determines the price of the water every year payable to the municipal alliance upon delivery from the federation's pipelines. During 2010, Norrvatten delivered approximately 43 million cubic metres of water. The main pipeline is about 260 km long and has six pumping stations and eight reservoirs. In order to guarantee that the water delivery is constant, there is a circular feeding of the water. This means that if Norrvatten is forced to turn off the water in one pipeline, water can be pumped from another. Norrvatten has its own laboratory, accredited by SWEDAC, the board of accreditation and technical control, in 1994. The standard set by "Livsmedelsverket" – the National Food Department – stipulates that an authorised laboratory has to be able to undertake examinations of its own drinking water. The authorisation ensures that the laboratory is impartial in regards to the production and distribution department of Norrvatten. This makes the analytical reports from the laboratory more accurate and trustworthy for the authorities.
Due to urban change, however, large parts of the water supply networks need to be substituted every year. The cost for this is substantial. Today, PE-pipes are largely used. To join these pipes two different methods are used: welding and mechanical joints. These traditional methods present some cons (pipe and joint tolerance does not fit, mechanical damages on welded joints, difficulty to test quality of joints, quality

defects in approved joints). To address this process problem, 4S has launched a two-stage procedure to develop and prototype new methods for securing the joints of PE-pipes.

f) AquAS

DECIPHER PCP Project, funded under the European Commission 7th Framework Programme for research and technological development (FP7), is an ongoing project and challenges the industry to develop mobile solutions that enables secure cross-border access to existing patient healthcare portals and efficient and safe medical care of mobile patients in EU member states. These solutions (the DECIPHER Service) shall be of special interest in the management of patients with chronic diseases or unplanned care episodes. Most importantly, the DECIPHER Service requires access to Personal Health Record (PHR) data residing in national health-data repositories. There are many challenges – both technical and privacy-related – in accessing the PHRs by other applications. Therefore applications accessing PHR systems are typically tethered – e.g. solutions provided by the national authorities and bound to particular I systems. The Procuring Entity is the Agència de Qualitat I Avaluació Sanitàries de Catalunya (AquAS), a public agency attached to the Health Department of the Regional Government of Catalonia (SPAIN).
Before launching the call for tender, the state-of-the-art study has provided technical background information for the development and procurement of the DECIPHER Service. Prior to the technical dialogue, an Horizon Scan was carried out, which consisted of a review of the Literature of scientific, technical publications and patent search to guarantee that the technological solutions developed during the project are innovative and can be protected by IPR.
The DECIPHER PCP Procedure will be divided into 3 phases, after an initial selection based on a preliminary project definition. Each phase will result in a competition between the bidders in such a way that the number of bidders will decrease from one Phase to the next one to ensure selecting those that best address the technical challenge on which this PCP is based:

- Phase 1: Solution Design Selection. A maximum of 9 Bidders awarded with the Phase 1 will be entitled to submit a final design for an innovative solution.
- Phase 2: Prototype Development Selection.- A maximum of 6 Bidders awarded with the Phase 2 will be entitled to develop prototypes on the basis of the final innovative solutions selected at the end of Phase 1.
- Phase 3: Proof of Concept.- A maximum of 3 Bidders awarded with the Phase 3 will be entitled to produce and test a small scale products on the basis of the prototypes finally selected at the end of Phase 2.

g) ESA – European Space Agency.

The DUE INNOVATOR III consists in a suite of projects of maximum two year time duration and of value up to 200,000 euro each. The INNOVATOR III projects give to the end-users, industry and research communities, the opportunity to develop and demonstrate innovative Earth Observation (EO) services and products using existing

ESA, ESA third-party mission and other EO datasets. The procurement concern the execution of R&D services articulated in phases. These INNOVATORS III projects will constitute the base for future large scale activities within the Agency's Data User Element (DUE) programme. The INNOVATOR III application areas and service themes require a targeted end-user community that will directly benefit from these new services and products. As first but not exclusive priority, the INNOVATOR III projects shall respond to the R&D agenda of major international initiative such as GEO and perform the necessary R&D preparatory activities for a large scale exploitation of the most innovative aspects of Sentinels 1 and 2. At least one end-user entity has been actively involved in each project and has been responsible for providing the detailed service and product requirements, as well as support the interpretation and validation of the service products, and asses the adequacy of and benefits of the service. The INNOVATORS III complements rather than overlap the R&D projects funded under the major European Earth Observation application programs such the ESA DUP/DUE, EOMD/VAE, SEOM, STSE. GSE, the EU Research Framework Programmes or National EO programmes.

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We include also a description of NHS case, while not fully fitting the PCP classification share with it relevant features for our analysis, with particular reference to multiple stage and source contracting.

h) NHS Blood and Transplant	United Kingdom	2009 (completed)	To obtain a suitable design of blood donning chair which would be able to cope with patients who faint during the donation process

h) NHS Blood and Transplant

NHS Blood & Transplant (BT) had identified a process problem which disrupted the workflow of taking blood from members of the public.
For years they had been aware that donors who either felt faint, or who actually fainted, during the blood donation process decreased donor throughput as the donor turned into a patient and had to be attended and to be given recovery support. This occurred some 300 times per day in total across all of the donating centres in England. Not only did these donors-to-patients events decrease throughput and disrupt blood collection, but it was disturbing for the donors awaiting their turn and often triggered them to leave, causing further loss of blood collection.
NHS BT attempted to solve the problem, via R&D services procurement, by seeking a different type of chair or bed which the donor would use. With the advice and support of the NHS National Innovation Centre they published a call for tender for new designs and prototypes which would enable the donor position to be adjusted according to whether they reported feeling faint or not.
This was addressed by describing the operational problem NHS BT were experiencing and requesting outline designs which would solve the problem without adversely

affecting the key functional parameters of the existing unit currently in use.
Four companies responded to the Call by providing paper descriptions and drawings of outline designs for a new Donor Chair. Two of those designs were taken forward to provide detail designs presented as 3D-CAD drawings. Both companies were commissioned to create fully-working prototypes, which were tested in a mock-up donation centre to simulate real-world storage, transport, set-up and use, including ease of cleaning.
As a result of the simulated in-use trials, a follow-up PPI has been launched and one design was selected to be taken forward and 1000 of the units were ordered and are now in use.

5.2. Responses from public procurers

We provide below some descriptive statistics obtained from our questionnaire.

a) Public Procurer overview

The seven PCP case plus the NHS case (for brevity, from now onwards we shall simply refer to the same as the "eight PCP cases") examined have been implemented in Italy, Sweden, Spain, Austria, Norway and United Kingdom.

PCP is used in **different sectors**. The eight cases examined refer to water, transport, space, energy and health-care sectors.

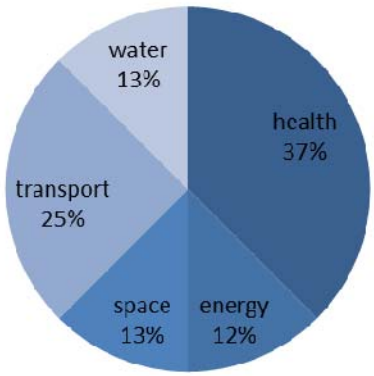

Figure 5.1: Sector of Public Intervention of PCP

50% of public procurers involved in the PCPs are **responsible** for the regulation of the public service that motivated the procurement, the 62.5% is responsible for the acquisition strategy of the new solutions and for the delivery of the public services motivating the procurement; 75% are (also) responsible for the use of the innovation resulting from the PCP.

b) Experience on PCP

The 85.7% of respondents have not long **experience** with the PCP, as they started only one PCP in the last three years. The remaining 14.3% started 5 PCP in the last three years.

Only 50% of the public procures have an internal **department or team dedicated** to help them with the PCP.

The public procurers involved in the PCP invest between 150K and 20ML euros per year in **R&D**.

c) Background information on the market

The market where the analysed PCPs have taken place is mainly characterized by **many non-dominant competitors** (66.6% of respondents), but there are also cases where the market is characterized by a few dominant firms (16.7% of respondents) or where there is some but limited competition (16.7% of respondents).

Most of public procurers reported that the typical R&D procurement in their country is characterized by **exclusive development** (83.3% of respondents) **and sole sourcing** (66.7% of respondents).

d) Project data

There is some **joint procurement** in the PCP cases analysed. In 50% of cases, the PCP was launched by a group of procurers. These procurers were mainly operating in the same region, with each of them in charge of different aspects of the procurement; three out of eight PCPs (37.5% of respondents) were also **transnational**, that is they involved procurers from different countries.

The **procurement value** of the PCPs analysed ranges from 340,000 to 1,256,000 Euros.

The **number of initial bidders** is between 4 and 90, with an average of about 18 bidders per tender. However, there is an outlier: a tender with 90 initial bidders. If we take this case out of the sample, then the average changes to 8 bidders per tender.

All PCPs have been organized in **multiple-phases**: four of the PCPs are characterized by two phases and four by three phases. The awardees have been on average 5.57 in phase 1, 4.28 in phase 2, 3.25 in phase 3.

e) PCP Examined

Multiple **motivations** explain the choice of the public procurers to engage in the PCP. In particular, 62.5% of respondents launched the PCP to **resolve a mission-related technologically demanding problem that impacted negatively on the quality and/or cost of the public services offered.** 62.5% launched the PCP also to fulfil problem in operational service production and delivery, leading to

productivity/ performance gap. Another 37.5% were motivated by the need to face a grand societal challenge without having a direct internal procurement need for the solutions. 25% of respondents launched the PCP to filter out technological risk related to a planned large-scale commercial procurement and another 25% launched the PCP to reduce whole-life costing of a product/service; other only 12.5% of respondents indicated the need to anticipate an investment, either for new systems and assets or for replacement at the end of the life-cycle. No respondent indicated among their motivations the one related to the need to meet an up-coming (new or more stringent) regulatory change.

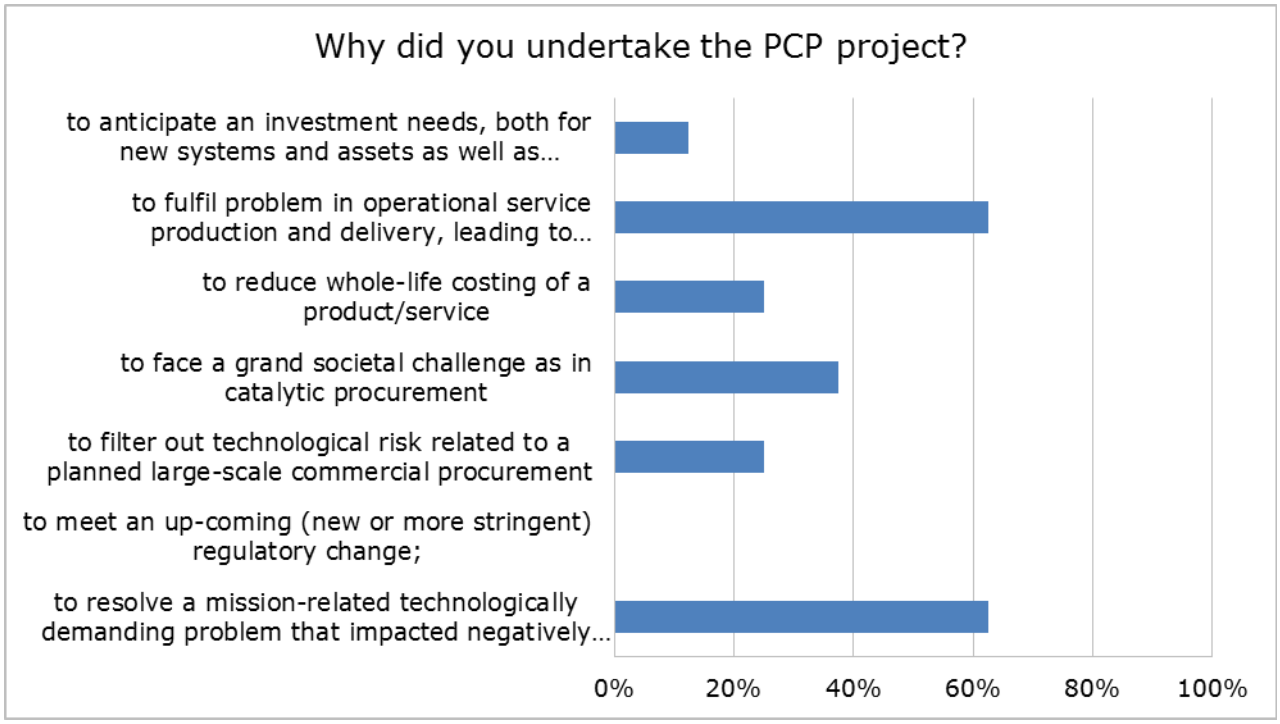

Figure 5.2: multiple motivations explaining the choice of the public procurers to engage in the PCP

The majority of public procurers use the PCP to create a **significantly new product/service/technology** (85.7% of respondents) rather than to incrementally improve/adapt an already existing one (14.3% of respondents) or to create a completely new product/service/technology (0% of respondents). This suggests that PCP has been used neither for radical innovation nor for simple adaptions.

Respondents report that **users are involved** in 66.7% of the cases. **Internal assessment** has always been undertaken by the public procurers to assess the technology state of the art before launching the PCP. However, 62.5% of respondents also have also undertaken a market study or patent search & analysis, an explorative call (37.5%), a public hearing (12.5%), a one-to-one meeting with vendors (37.5%), an open meet-the-market event or multilateral meeting (25%) and/or technical dialogue (12.5%).

The result of this assessment is as follows: In 25% of cases, the public procurer has observed the presence of **exiting solutions in the same sector that exhibited shortcomings.** In another 25% of cases, the market-assessment has revealed the existence of solutions that are not quite ready. In 37.5% of cases no suitable solution is found in the market. Finally for the remaining 12.5% the question does not apply.

57% of respondent have developed a **business case analysis**, planning the likely results and other consequences of their action. This has helped them supporting their decision to start the PCP examined.

86% of the respondents have **shared information** with other contracting authorities, which suggests that there is cooperation within the public sector.

The majority of public procurers (85.7% of respondents, 6 out of 7) anticipate that **other public administrations, both in their country and abroad, may need, a lot or on average, the solution developed from the PCP.**

57% of public procurers (4 out of 7 respondents) believe that there will be also a significant **private market** for the solutions developed under the PCP. The other 43% indicates that there will not be such private market.

Finally, 42.8% of the respondents have used **key performance indicators** (KPIs) to define the goals to be achieved by the PCP**.**

f) Role of the PCP examined

50% of respondents have described their **needs** in the tender, **specifying functional or performance requirements**, while 37.5% of respondents have described their needs in general terms. The remaining 12.5% of respondents have specified the functional or performance requirements in a technical prescriptive way. It is important to note that the majority of procurers avoided a technical specification, which would have limited the flexibility necessary for firms to explore possible solutions.

When applicable, the majority of respondents have set **interoperability** (75% of respondents) **and scalability requirements** (66.7% of respondents).

None of the respondents have asked bidders for **provisional deposit** for the initial PCP phase or for the subsequent phases, nor have they required a minimum general **company turnover** or specific turnover.

In 80% of cases the contract has been awarded through a **MEAT criterion**. The respondents however have not reported the weights used in the tender.

Three different ways have been used to identify the **procurement value** (i.e., the maximum value that can be paid to awardees): (i) budget available (57.1% of

respondents); (ii) as percentage of the cost of the problem addressed (28.6% of respondents); (iii) value of R&D services needed to have a (min/expected) alternative projects (14.3% of respondents).

All respondents (8 out of 8 public procurers) have set **IPR**s arrangement at the beginning in the tender documents and 6 out of 8 admitted no negotiation. In particular, in 75% of eight PCP examined the IPR ownership rights are 100% assigned to the awardees; in 12.5% of cases (one respondent) they are instead shared between the procurer and the awardee and the remaining respondent have kept 100% IPRs ownership rights. Only one PCP procurer includes **additional IPR arrangements** in favour of the public procurer, who obtains royalties on the sales.

All PCP cases see a **participation of SMEs**. However, possibly due to the phased approach (sequence of small gradually growing contracts/assignments per phase) and the non-stringent qualification and financial requirements set by procurers (none of the respondents asked bidders for provisional deposit nor did they require a minimum general company turnover or specific turnover). Further, in the 87.5% of cases (i.e. 7 out of 8 examined tenders), SMEs have also been awarded the PCP contract as single bidder or as lead partner in consortium/entity grouping.

In only three PCP cases there is **sub-contracting**.

The information available on the **tender's performance** in terms **of time and cost overruns** is difficult to obtain because the information is classified or because some tenders are still on-going. We notice that in the 50% of cases there was no time overruns, in the 25% the tender is still going, and in the remaining 25% there was time overrun. In particular, in one case this time overrun has been more than 60% of the planned project completion date.

Three public procurers have answered the question on cost overrun, reporting none.

In all PCPs examined), the project was not (intentionally) co-financed by another funding program aimed to support business growth.

With regard to the perception of the public procurers as to what is the percentage of the awardees' **development costs** effectively covered by the price paid, in one case this is less than 60%, in another case between 60-80% and in yet two cases between 80-100% of development costs. In two cases, 100% development costs are covered by the price paid. These amounts confirm the perception that in practice projects are not wholly remunerated by the public sector and able to stimulate additional investments from the supply-side.

g) Results, impact and characteristics of the PPI that followed up, if any.

No public procurer reports the final discount of the winning bids. In two cases this is because the information is considered as classified.

Little information is obtained on how many **PPIs have followed the PCPs**. In one case there was no PPI after the PCP because the public procurer decided to

discontinue the project. This public procurer however finds that the information provided by the PCP helped it in de-risking the project. In two cases there has been a PPI, one adjudicated to a firm that won the original PCP and one to others. In other two cases, it is too early for procurers to decide on launching a PPI as the PCP projects are still on-going or just completed.

85.7% of respondents agree (of which 50% strongly agree) that being better informed through a PCP about pros and cons of competing solutions before launching the PPI helps **de-risking a PPI**. The remaining 14.3% has no opinion.

Overall, 100% of public procurers are at least "**Satisfied**" with the innovation level achieved with PCP in particular, 62.5% is **very satisfied**. The majority of respondents (85.7%) also believe that, as a result of this PCP, the **quality and efficiency of the public services will improve substantially**.

For two public procurers the PCP has led to a reduction in the **cost of the developed solutions, in one case by more than 20% and in the other between 5-10%.** Three procurers haven't answer as the PCPs are still on-going or just completed. For other three public procurers the PCP has had no impact, but two procurement of those are catalytic, meaning that the solution will be used and acquired by private end-users.

In one PCP case, the respondent reports that the developed solution meets the **targets** expressed in terms of Key Performance Indicator (KPIs). In the other cases, no response is given.

Two out of eight respondents (25% of cases) agree that the PCP has resulted in **new procurement channels** being opened and that this has helped to avoid single supplier lock-in. Four out of eight respondents (50% of cases) strongly agree with the previous statement whilst one respondent (12.5%) disagrees, and one other respondent (12.5%) has no opinion on this point.

Compared to other procurement procedures, all respondents are **at least satisfied** with the PCP, and three are **very satisfied**. One public procurer could not respond as the tender is on-going.

The respondents also evidence one or more of the following **non-commercial benefits** resulting from the project: (i) we obtained useful information (50%), (ii) the firm improved its knowledge of this technology (38%), (iii) the firm hired or retained one or more valuable employees (25%), (iv) the public (users, customers) directly benefited or will benefit from the results of this project (50%).

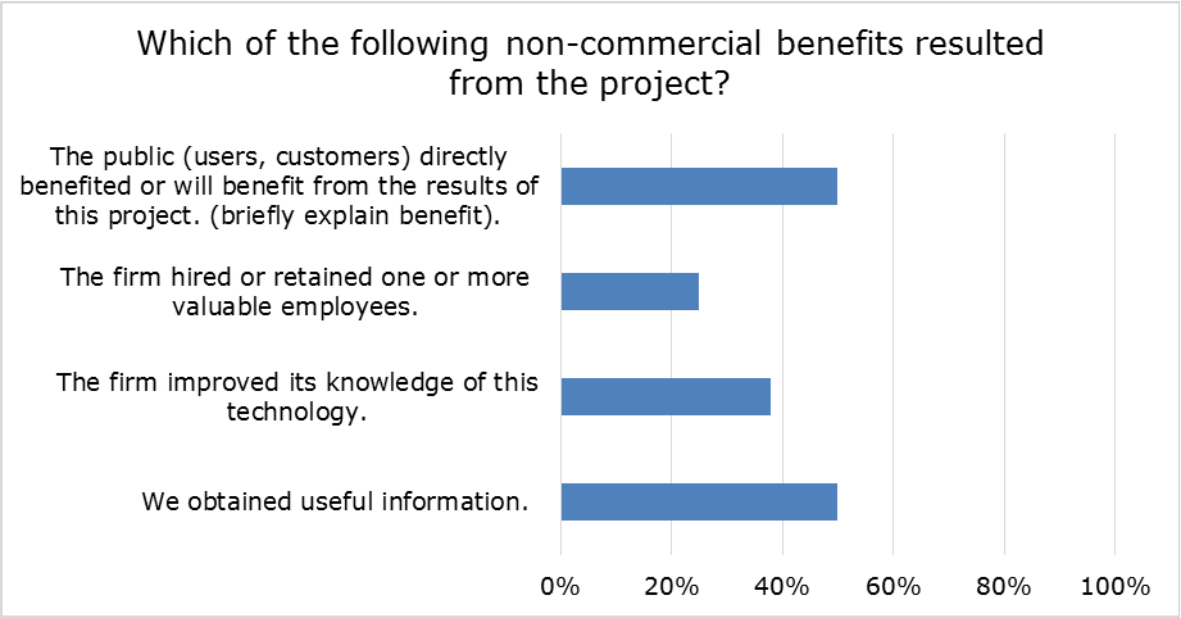

Figure 5.3: non-commercial benefits resulting from the project

Overall the public procurers recommend that the European Union make **supporting funding** available for PCP actions which do not have to be linked to specific sectors or disciplines and which do not have to be internationally collaborative, due to the coordination costs involved. Also, more knowledge sharing would help to build a common understanding of handling IPRs in the context of PCP.

5.3. Responses from awardees

a) Awardee overview

Three of the seven companies that replied to the questionnaire were **founded** after 2010. One of the companies was founded thanks to the PCP.

Awardees with varying **annual sales** participated to the different PCPs. The annual sales of awardees range from less than 35000 Euros to approximately 80 million Euros. Thus, PCP awardees are either SMEs or established companies.

Following the previous points, also the number of **employees varies** across the sample, from 1 to 100.

The PCPs awardees operate in **different sectors**, such as chemical industry, civil infrastructure, water, sewage and gas applications, health technology, tourism and heritage.

The seven awardees are of different types too: industrial, technology, limited liability partnership and commercial companies.

b) Project data

Four out of seven awardees report their perception of **market conditions** prior to the PCP. According to 50% of respondents, the market where the PCP has taken place was characterized by few dominant firms; for 25% of respondents, it is characterized by many non-dominant competitors, and for the remaining 25% there is some but limited competition.

Project **total price offered** ranges from 30,000 Euros to 5 million Euros.

All PCPs are **multi-phased** with at least 2 phases.

c) Awardee's experience on PCP

In terms of **prior experience in PCP**, seven out of seven awardees have already participated at least to one procurement in the last year.

None of the awardees have **an internal office** or team **dedicated** to help them with the PCP.

d) Role of PCP examined

All awardees believe that **quality improvement** is the most important benefit which is brought about by their developed solutions. In addition, for 43% of awardees **life-cycle cost saving** is another important benefit and for 14% of them **price saving** is also important.

A number of factors have **motivated** the awardees to participate to the PCP: (i) volume of potential demand: 71% (5 respondents), (ii) access to potential key clients: 71% (5 respondents), (iii) access to financing resources: 43% (3 respondents), (iv) desire to gain competitive advantage: 43% (3 respondents), (v) desire to define a new standard: 29% (2 respondents), (vi) possibility to enter in a new strategic sector 14% (1 respondents).

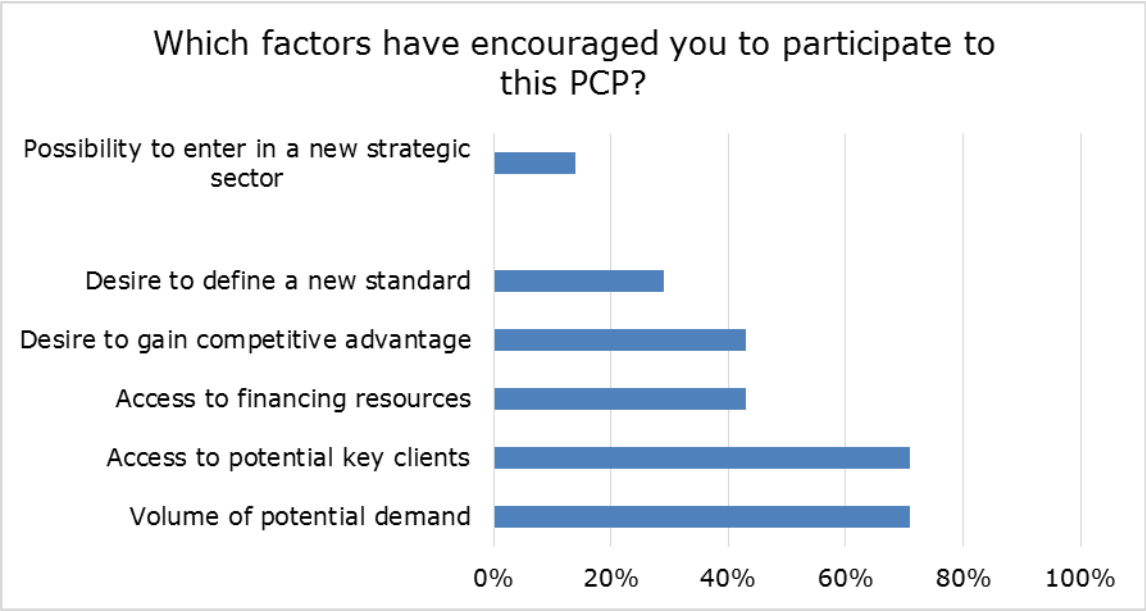

Figure 5.4: multiple motivations explaining the choice of the awardees to participate in the PCP

For 17% of respondents, the public sector is their most important potential client for the innovative solution resulting from the PCP, while for 83% of respondents the public sector is only of medium importance as potential client. Large companies are key potential clients for 50% of respondents; the other 50% attributes to large company medium importance.

SMEs have little importance as potential clients for 33.3% of respondents and they have medium importance for another 33.3%. 33.33% of respondents indicate that SMEs are key potential clients for the resulted solution. Finally, 50% of respondents indicate that citizens as direct users have little importance as potential clients, another 33% attributes medium importance to citizens and the remaining 17% believes that citizens are key potential clients.

e) Execution of PCP examined

We obtained only two responses with regard to the **final rebate**, which is defined as the discount offered by the bidders compared to the procurement (maximum) value. One firm has offered a discount of less than 10%; the other one between 10-30%. Further, in one PCP, companies have also asked for a 1% royalty on the future sales of the developed solutions.

The price paid by the public procurers has covered a percentage of **the cost of R&D activities** undertaken by the respondents that has been: (i) less than 60%, for one firm, (ii) between 60-80% for two firms, and (iii) between 80-100% for two firm; for yet another firm (iv) it has been 100%.

The four firms that have made **additional R&D investments** reported that they have covered these costs through their own funding or through external private funding, which however are neither from venture capitalists nor from debt capital or bank loans. There has been no funding from non-European investors.

The PCP has had a positive **impact on the level of R&D investment** of the awardees in the sample. Before the PCP, the R&D investment of respondents was on average 23% of the awardees' total revenues.

The **R&D expenditure** at present of the awardees in the sample is on average 55% of total revenues. There is an outlier: a firm that has R&D expenditure equals to 90% of total revenues. If we take this firm out of the sample, the mean changes to 44.2%.

When compared to previous R&D expenditure, it is found that 80% of respondents have increased their R&D investment. In particular, 33% of respondents by 10%, 33% of respondents by more than 20% and 17% of respondents (one out of six) have decreased their level of investments in R&D.

In 80% of cases (4 out of 5) the respondents would not have undertaken this project in the absence of the PCP. Only one respondent would probably have made the investment anyway.

As reported in the table below, there are a number of **factors which have contributed to the success of the PCP.**

- 71.4%% of awardees consider the **tender focus on technical quality** (and not on price) and the **outcome and performance based specification** as a crucial success factors and for the remaining 28.6% are factors of medium importance.
- The **interaction with final users** is considered a crucial factor by the majority (66.7%) of awardees. 33.3% of awardees attribute medium importance to these success factors.
- 57.1% of awardees consider the **absence of pre-qualification requirements** or the **use of non-stringent ones**, and the **adoption of life-cycle cost criteria**, as two crucial factors while 28.6% consider these as factors of medium importance. For the remaining 14.3% the mentioned success factors have little importance.
- **Access to an operational context** to test and the assignment and possibility to exploit IPRs are considered crucial factors by 57.1% of awardees, the remaining 42.9% believe that these factors have medium importance.
- The majority of awardees (71.4%) attribute medium importance to the **competitive pressure** to deliver best value for money. The remaining 28.6% considers this factor as crucial to the success of PCP.
- The **development in phases** is considered crucial success factors by 42.9% of awardees, while the other 57.1% attributes to this factors medium importance.
- The majority of awardees (71.4%) considers the **competence of the public procurer** as a factor of medium importance. Only 14.3% of them believe that this is a crucial factor, and for another 14.3% the competence of public procurer

has little importance for the success of the PCP.

- 42.8% of awardees believe that the **percentage of performance risk assigned (to awardee)** is a factor of medium importance. For 28.6% of awardees this factor crucially contributes to the success of the PCP while for another 28.6% of respondents the percentage of performance risk assigned has little importance.
- The **separation of the R&D phase** from the deployment of commercial volumes of end-products is a crucial success factor for 42.8% of awardees, another 28.6% of respondents believe that it has medium importance and the remaining 28.6% of respondents attribute little importance to this factor.
- 71.4% of awardees believe that the **value of contract awarded** is a factor of medium importance. For the remaining 28.6% of awardees this factor crucially contributes to the success of the PCP.
- **Low tender preparation costs** is considered crucial success factor by 33% of awardees. The 50% of respondents attribute medium importance to this factor and in the remaining 17% this factor does not apply.
- The **companies' performance in past contracts,** meaning in similar R&D experiences, is seen as having little importance as success factor by 71.4% of awardees. 14.3% of them attribute medium importance to this factor and another 14.3% believe that this factor is crucial.

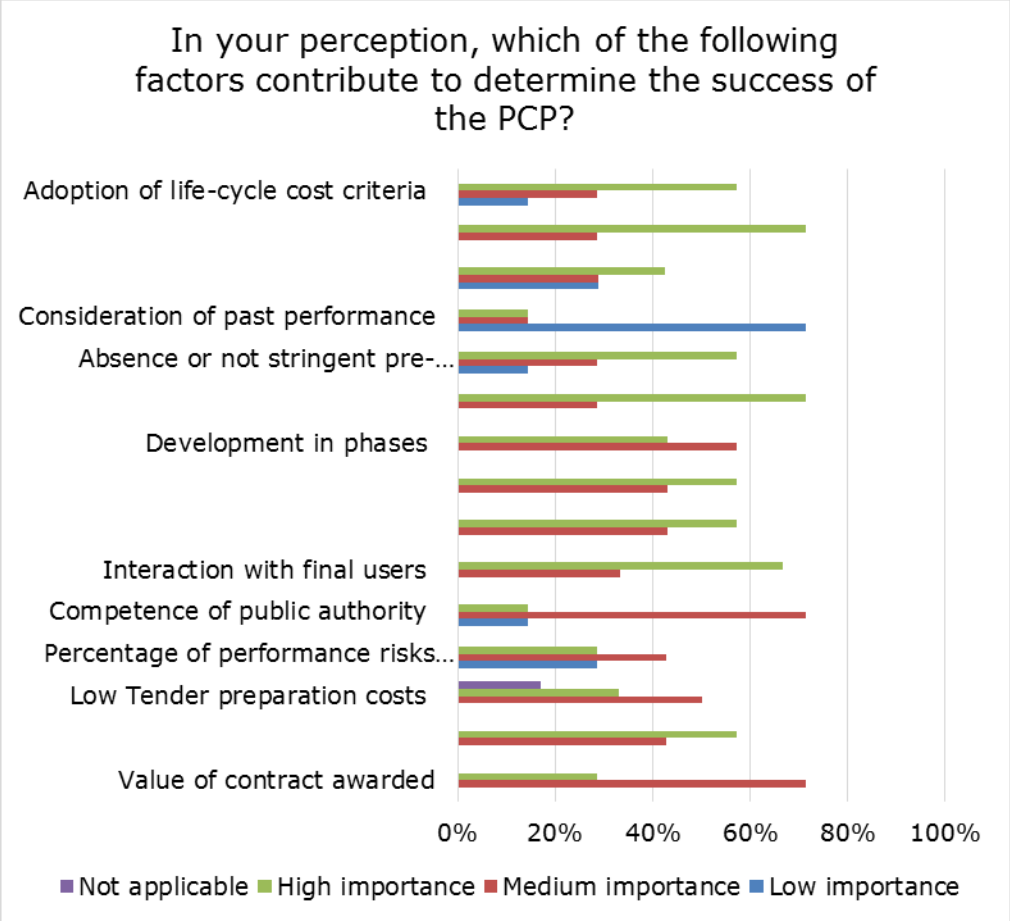

Figure 5.5: factors which have contributed to the success of the PCP

All respondents consider **interoperability and scalability requirements** in their developments.

When applicable (57% of the cases) and answered (6 out of 7 awardees), it is found that 100% of PCPs contributed to the **development of open and widely usable solutions or new common standards**.

Five of the six respondents (83.3%) report that the **technical requirements** in the tender have been very detailed; one reports instead that they have been broad.

In terms of **technological impact**, the respondents finds that the PCP has led to the (i) development of a completely new technology: 20% (1 respondent); (ii) the incremental adaptation of an already existing technology: 40% (2 respondents); (iii) the transposition of an existing technology in a different context: 40% (2 respondents).

f) Post-PCP impact

In the sample, the PCP has a positive impact on the **awardees' number of employees**. In particular, in one company (a SME) the number of employees has increased from 2 to 8 (200% increase), in the company set-up thanks to the PCP, the number of employees is now 1. In the other companies (which are larger, i.e. with more than 10 employees) the number of employees has remained the same. On average, the number of employees has increased.

The solutions developed under the PCPs have had a positive **impact on the total revenues** of the awardees, beyond the amount provided by the PCP contract, especially for SMEs and start-ups. The total revenues of an SME have increased by 600% (from 50K to 350K). A large company that has been awarded a PCP also exhibited a positive impact of 2%. There is also a case where no impact is observed.

There is a positive impact of PCP on all of the five respondents' **market shares**. In particular, the market share of two firms has increased by around 1%, in another case the PCP is on-going and therefore the data is not available, though the awardee reports that it expects a big impact of the PCP on its market share. In one case, a start-up has managed to capture 80% of the market thanks to the PCP. In yet another case there is no change.

For 75% of the respondents, the PCP has had no **impact on the company's technology focus**, which has remained the same as the one before the PCP. Only 25% (one company) have widened their technology focus.

The **impact of PCP on commercialization activities** is positive. Four awardees report that they have made an additional investment in the commercialization and industrialization of their proposed solutions. The percentage of the contract value invested in these activities varies significantly from less than 10% to more than 75%. For one awardee, the question is not applicable as the PCP is on-going.

66.67% of respondents have **financed the commercialization/industrialization of the product with their own funds**. The remaining 33.3% with other private funds. There has been no funding coming from a PPI award or a venture capitalist.

The role of the **PCP as facilitator to access the procurement market** is very positive. All awardees agree that PCP has been helpful, and 57% of awardees strongly agree.

The graph below shows the **factors that have crucially contributed to the effectiveness and efficiency of the solutions resulting from the PCP award**: the volume of potential demand is the most important factor, followed by the selection criteria and by the competitive phased development.

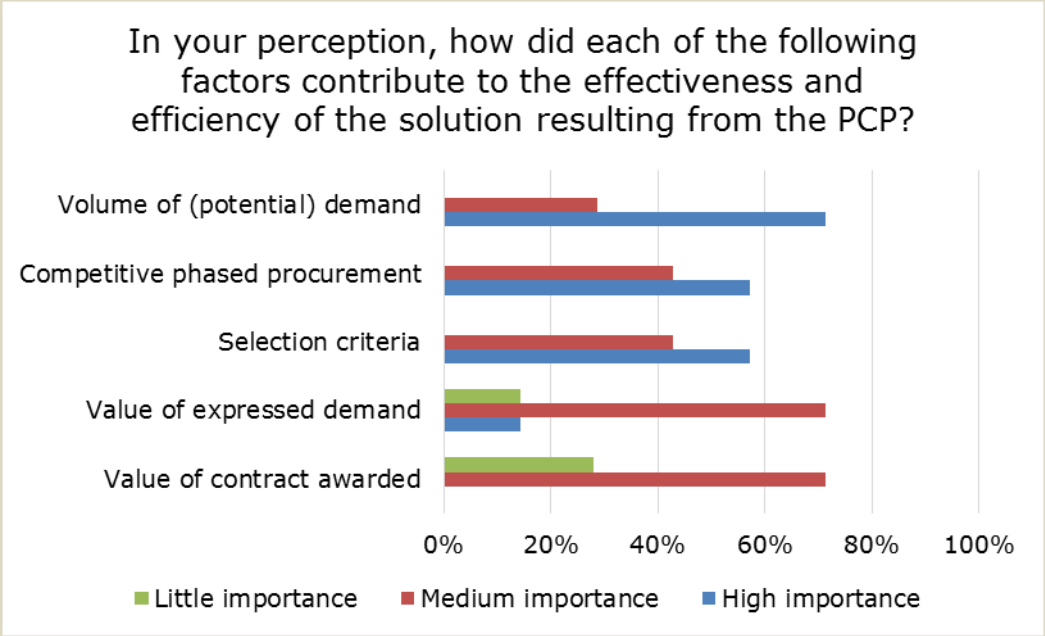

Figure 5.6: factors which have contributed to the effectiveness and efficiency of the solutions resulting from the PCP award

100% of respondents (6 out of 7 awardees) have started the **commercialization phase**.

80% of respondents expect to obtain an increment in their **annual sales** from the product commercialization. 50% of these respondents expect an increase in their annual sales of less than 10%. Another 25% expects an increase of more than 75% and the remaining 25% between 50-75%.

A number of **patents have resulted from the PCP** award: in one case, even if the PCP is still on-going, one patent has already resulted. In another case, where the PCP is completed, two patents have resulted and finally in three cases no patent has resulted from the PCP award. On average, 0.6 patents per awardee have resulted from the PCP. In addition, one awardee reports that a "reasonable number" of additional patents have resulted from its R&D activity.

20% of awardees who completed the PCP have sold 10 **licenses from the product developed during the PCP**, the 20% has sold 4 licenses while the remaining 60% of completed cases have sold none. On average, considering only those awardees who have provided the data, 3.5 licences per awardee have resulted from the PCP.

For 75% of respondents, the **public sector is the main market for all of the products developed due to the PCP**. In particular, 50% of this market is made of the public authorities awarding PCP, the other 25% is made by other public authorities. 25% of respondents have not specified which is their main market.

The respondents have made **some recommendations for future actions**, which can be summarized as follows. (i) They find the procurement process to be quick and efficient in terms of timescales and that being judged by a panel of industry experts is helpful, (ii) the PCP is a very rational and good approach that can be beneficial especially for SMEs and start-up participation, (iii) more effort is needed for the commercialization phase, (iv) there needs to be a clear goal at the end of the procurement process, as this would help attracting more companies, (v) it would be important to have more certainty on the PCP implementation strategy and to make it systematic and independent of political contingencies.

5.4. Main statistic comparative analysis between PCP and non-PCP cases

With reference to the type of contracting authority that conducted the procurement, the PCP and non-PCP samples show similar features. Indeed, in both samples there is a clear prevalence of public procurers. The term "public procurer" is here used to refer to public entities involved in the public services delivery chain and/or in the definition of the procurement strategy and in the use of the resulting innovation. Thus, public procurers are able to leverage the power of the public pursue to deploy innovations. However, there is a minority of policy makers (such as innovation agencies) conducting both PCP and non PCP cases, with a mandate to support innovation in their sector and to shorten time to market for innovations, via R&D procurement.

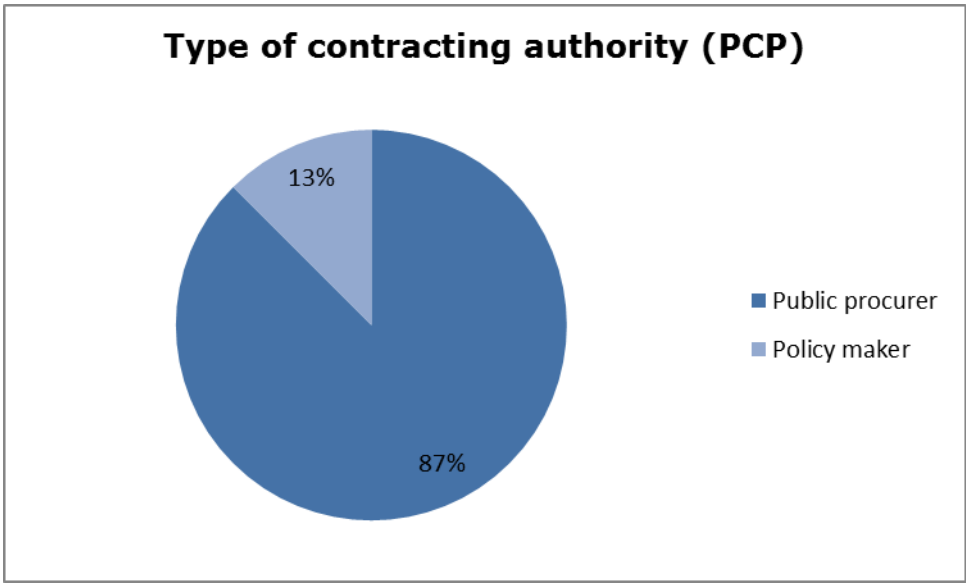

Figure 5.7: Type of contracting authority (PCP)

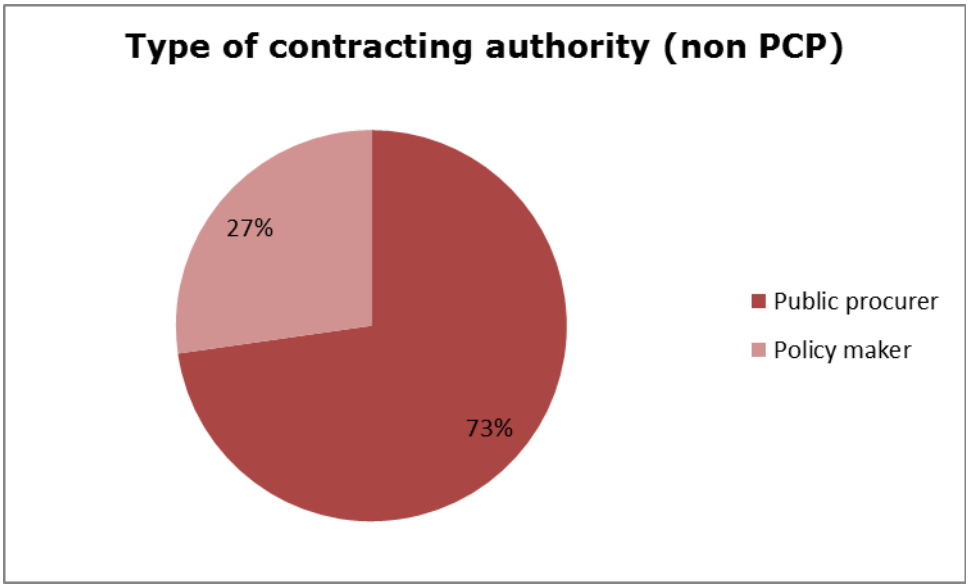

Figure 5.8: Type of contracting authority (non PCP)

Concerning the type of procurement analysed, the samples reveal a clear prevalence of direct procurement, which is when the contracting authority undertakes a procurement to fulfill an unmet need of its own. Within the PCP sample there are two catalytic procurements, that identify a situation where the resulting solution is used exclusively by private end-users.

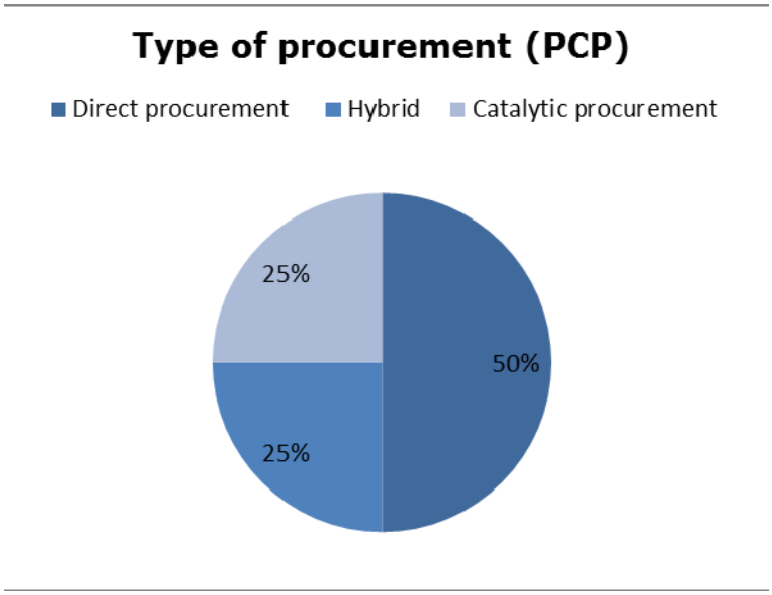

Figure 5.9: Type of procurement (PCP)

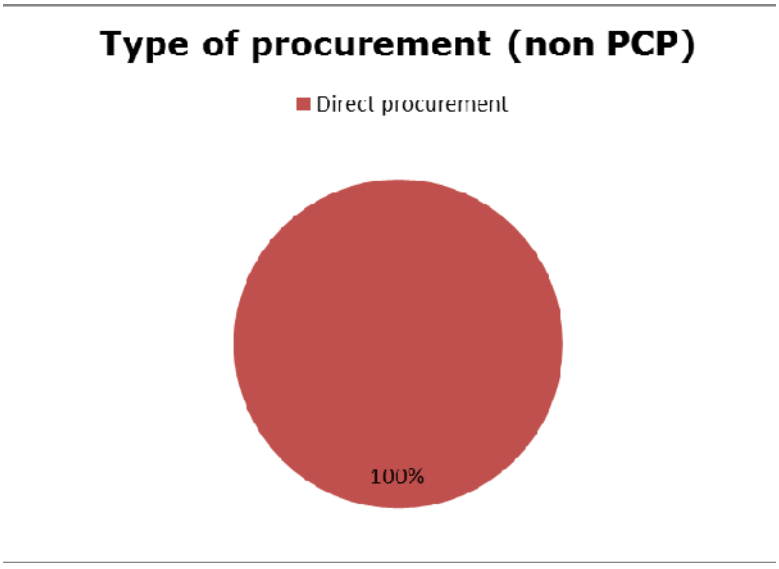

Figure 5.10: Type of procurement (non PCP)

Concerning the responsibilities assumed by the public entities that conducted the procurements, the 62.5% of public procurers involved in the PCPs (and the 83% in the non PCP cases) are responsible for the acquisition strategy of the new solutions and for the delivery of the public services motivating the procurement (in the non PCP cases the latter percentage is 55%); 50% of public procurers involved in the PCPs (and 40% of those involved in non PCPs) are **responsible** for the regulation of the public service that motivated the procurement; finally, 75% conducting the PCPs (and 70% involved in non PCPs) are (also) responsible for the use of the innovation resulting from the procurement.

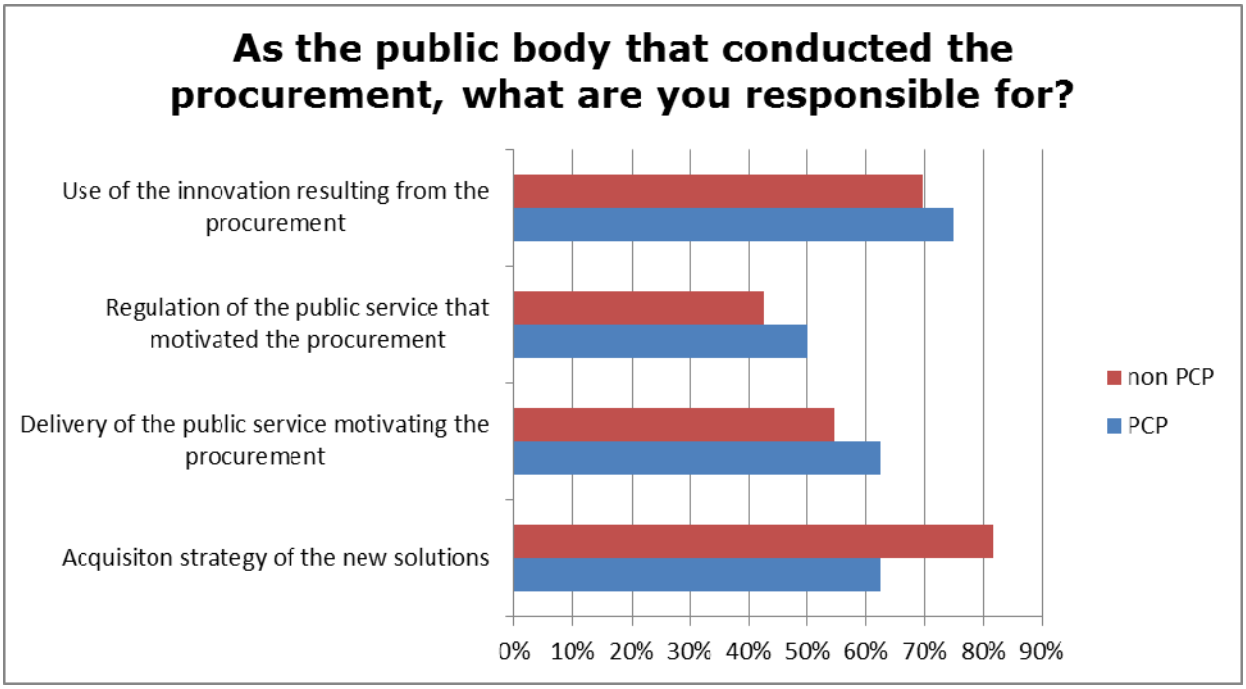

Figure 5.11: Task for which the public body that conducted the procurement is responsible.

The main sectors of public intervention interested by PCPs are health-care and transport and as regards to non PCPs cases, they are related also to the education and "pure" ICT sectors, as shown below.

Sector of public intervention		
	PCP	**non PCP**
Education	0%	15%
Health	37%	24%
Environment & Energy	25%	12%
Space & Defence	13%	9%
Transport	25%	15%
ICT	0%	24%

Table 5.12: Sector of public intervention (PCP and non PCP)

The chart below shows which factors motivated the public procurer to undertake the project. For both samples, but to a greater extent for the PCPs, principal motivations have been the need to fulfil a problem in operational service production and delivery and to resolve a mission related technologically demanding problem.

Also the need to face a societal challenge highly motivated public procurers to undertake the PCP project, while this motivation is not that important for the control sample. This latter result reflects the nature of the two catalytic procurements sampled.

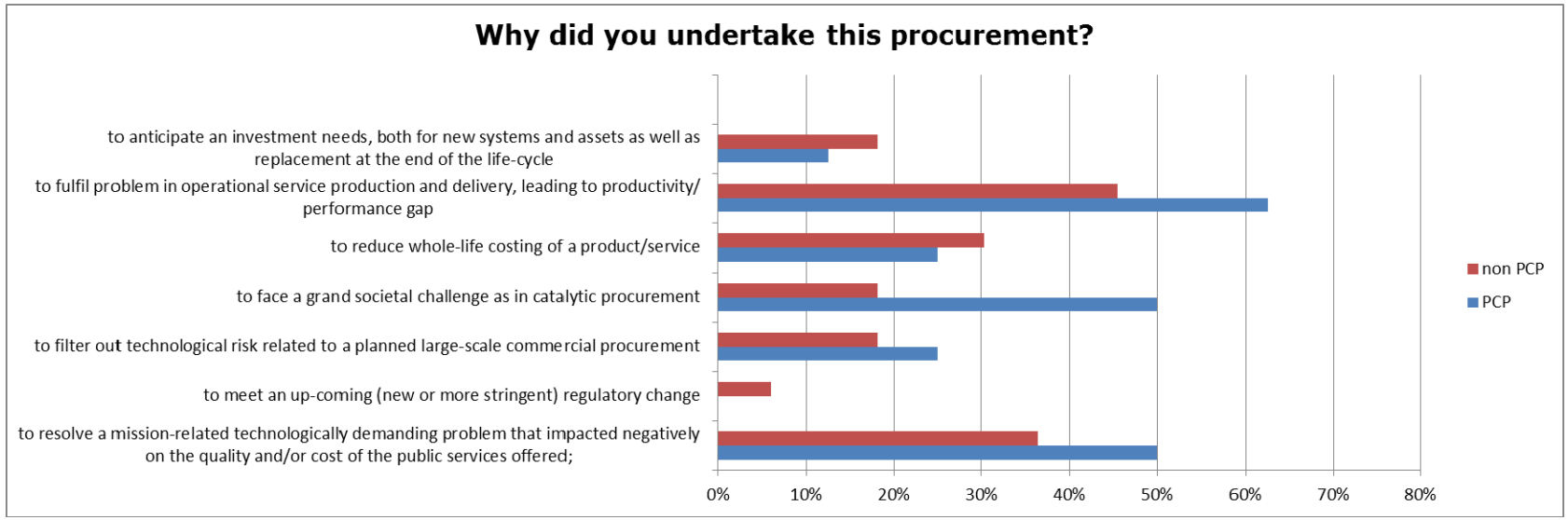

Figure 5.13: Factors that motivated the public procurer to undertake the procurement (PCP and non PCP)

In 57% of PCP cases, the decision maker has undertaken a business case, while this happened only in 19% of control cases.

In 86% of PCP cases there was information sharing about the innovation need, which highlights collaboration and public demand lever use. The result is slightly different for the control group: only in 39% of non PCP cases there was information sharing.

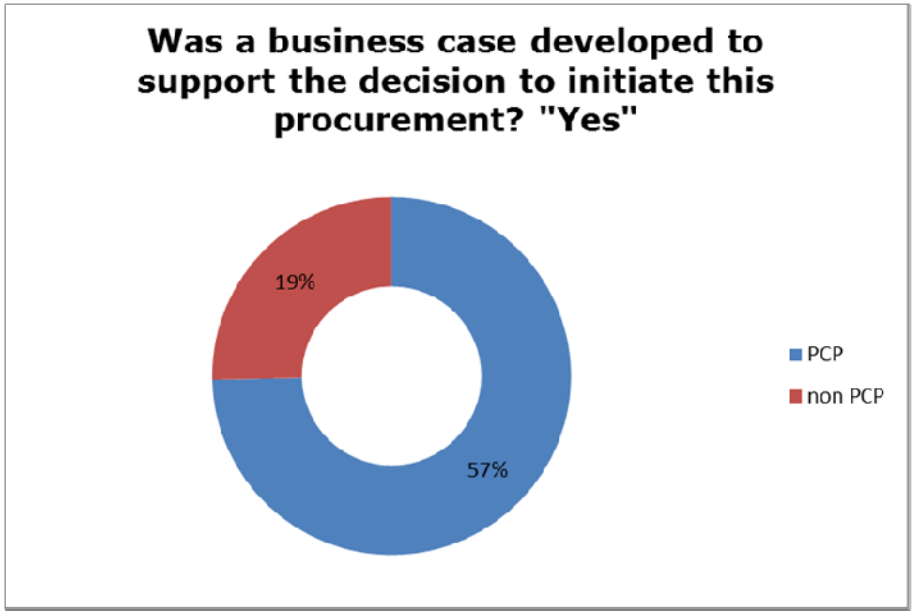

Figure 5.14: Development of a business case supporting the decision to initiate the procurement (PCP and non PCP)

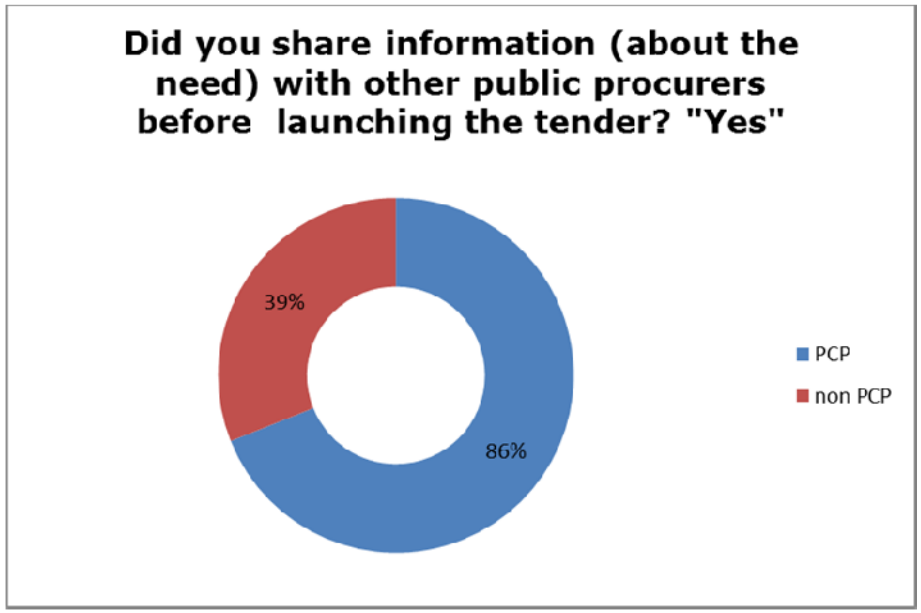

Figure 5.15: Sharing of information before launching the tender (PCP and non PCP)

The following charts show which methods have been used by public procurers to assess the technology state-of-the art before launching the procurement. In 100% of PCPs an internal assessment was done. Generally speaking, public procurers of PCPs conducted more extensive analysis, adopting multiple instruments, than non PCP cases.

Figure 18 shows a comparison between PCPs and the single-sourcing procurement of R&D services.

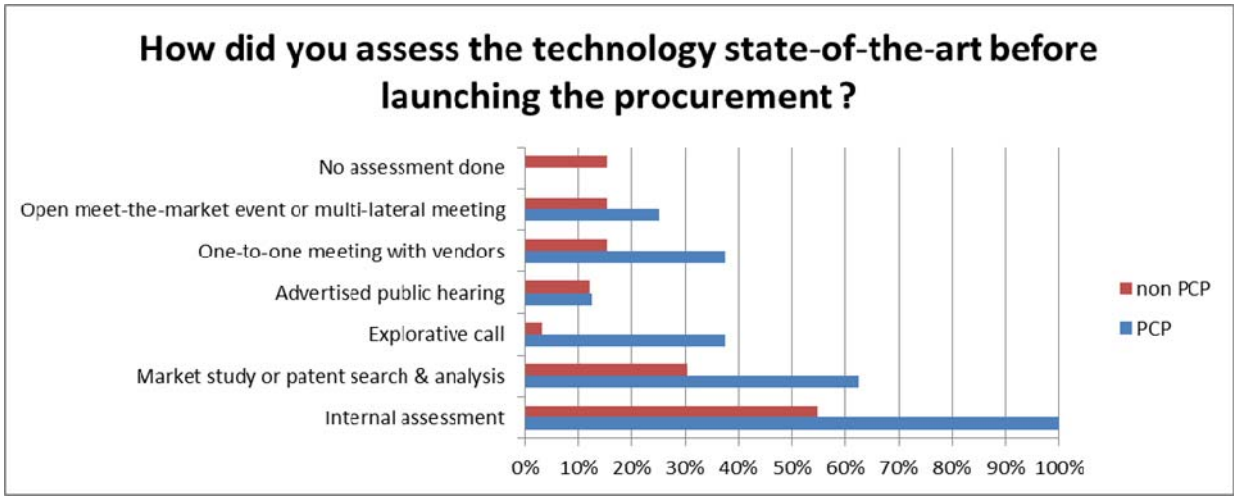

Figure 5.16: Different methods used by the public procurers to assess the technology state-of-the-art before launching the procurement (PCP and non PCP)

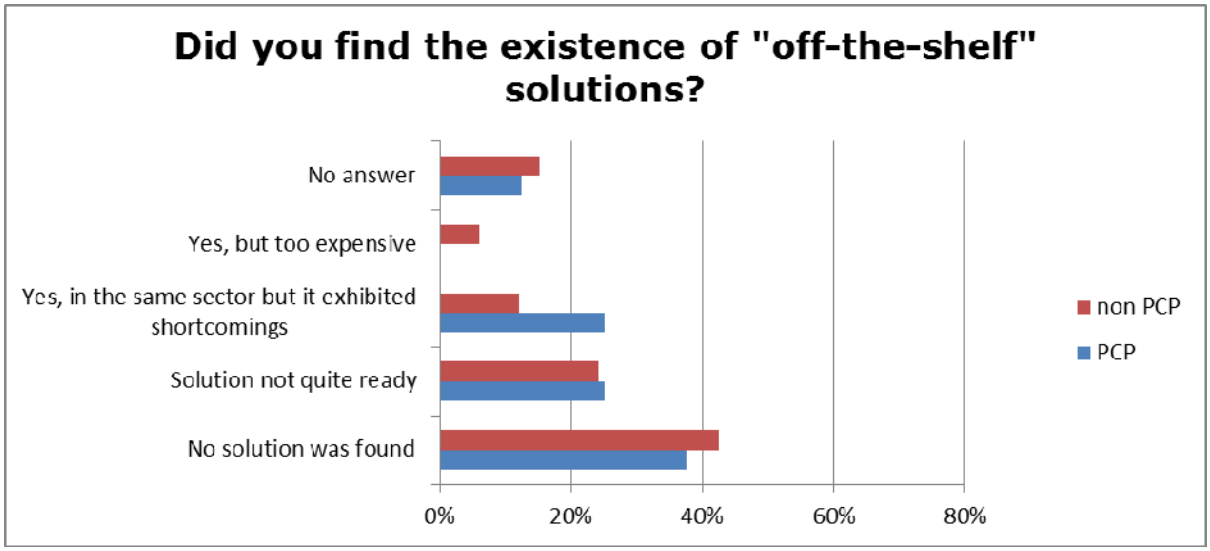

Figure 5.17: Existence of "off-the-shelf" solutions (PCP and non PCP)

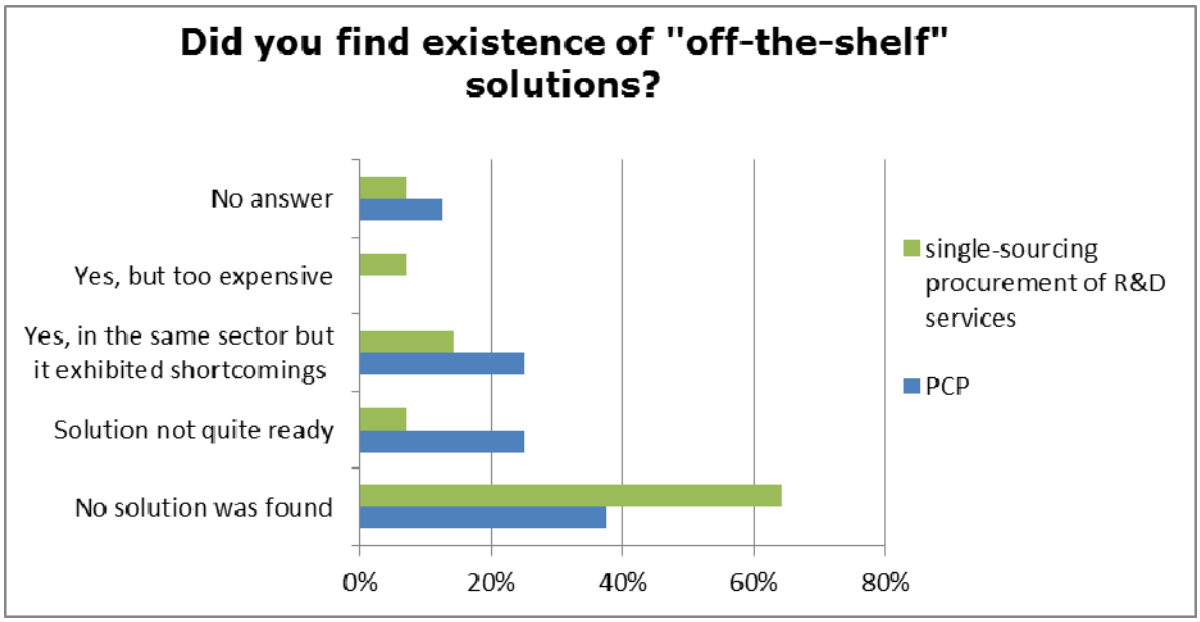

Figure 5.18: Existence of "off-the-shelf" solutions (Single-sourcing procurement of R&D services and PCP)

IPRs contractual arrangements are always fixed for PCPs and sometimes they remain indeterminate in non PCPs cases.

As shown in the graph below, in PCPs sample the IPRs contractual agreements are always defined beforehand and in the majority of cases a renegotiation is not allowed.

In the control group sample, the agreements definition is postponed and defined during the procedure. In several cases the advanced definition of IPRs contractual arrangements occurs because of a negotiation.

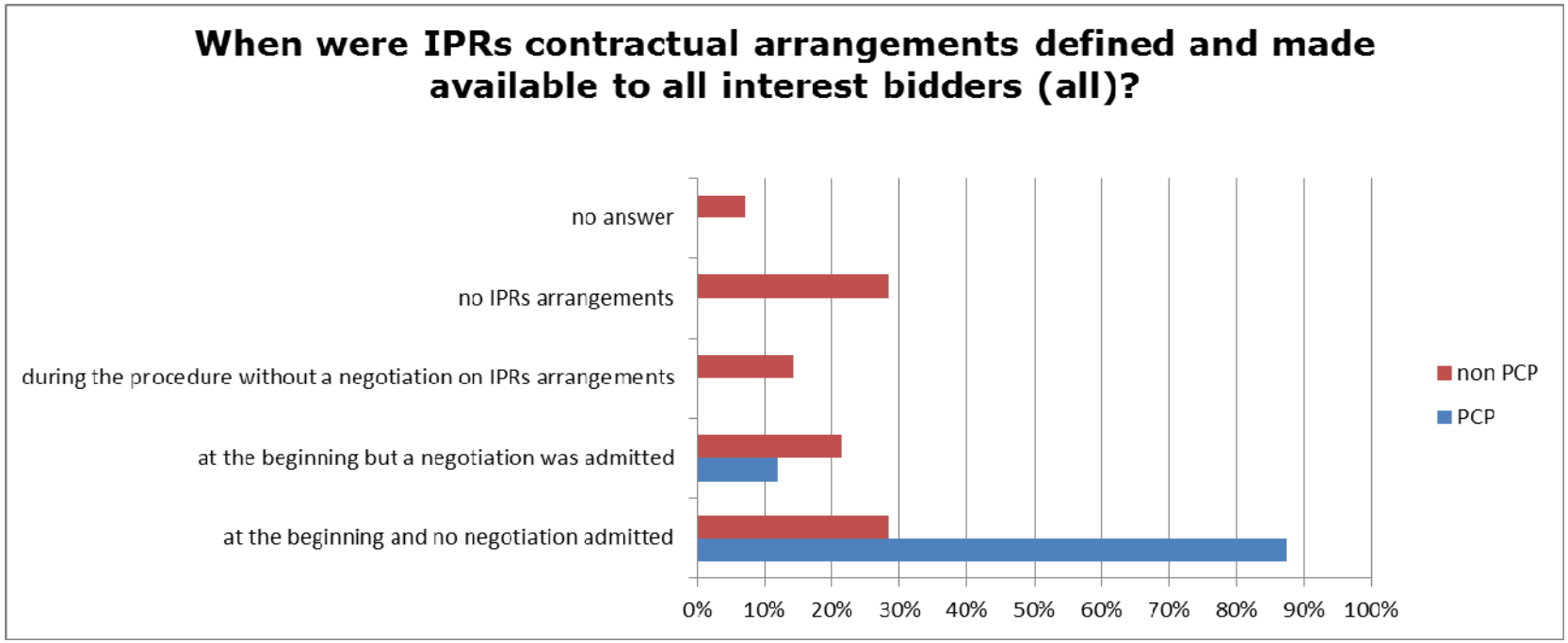

Figure 5.19: Definition and availability of IPRs contractual arrangements to all interest bidders (PCP and non PCP)

Regarding the use of the sub-contracting, this is slightly greater in the non PCPs cases and, in turn, in the sub-group of joint procurements.

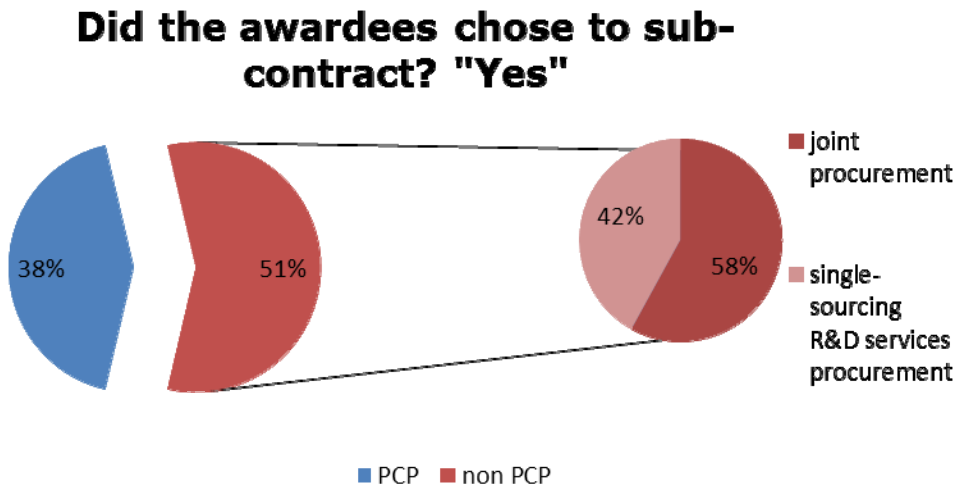

Figure 5.20: Sub-contracting in PCP and non PCP cases

6. THE METHODOLOGY FOR PCP IMPACT ASSESSMENT

This section describes the empirical methodology that we followed to assess the effectiveness of PCP using the survey data described in the previous section. The main goal of the proposed methodology is to allow us to evaluate the merits of PCP relative to other related procurement methods and to offer a series of recommendations for new actions to be undertaken in Europe to encourage the use of PCP. In so doing, this methodology has to balance a series of different tasks: it has to be general enough to allow us to address all the 9 research questions, but also specific enough to exploit in the best possible way what the data can reveal about each individual research question. Moreover, it has to be applicable to the small dataset that it was collected through our survey analysis, but also to a potentially substantially larger dataset that will be collected once more PCP cases will become available as procurement agencies expand their usage of this instrument. Finally, the methodology should ideally be also informative about how to refine the data collection process by disentangling which variables were found to be relevant for our initial assessment of PCP.

It is evident that balancing all these tasks is an extremely hard methodological problem. In practice, this means that for none of the 9 research questions our methodology should be considered ideal when focusing on one single task (for instance, the ideal methodology for an environment with a large dataset). Nevertheless, we believe that the proposed methodology successfully achieves a reasonable balance between each one of the tasks mentioned above. We foresee for future potential replications of our methodology with different datasets that certain tasks that our current methodology sought to achieve might become less relevant. In particular, once a large dataset will be obtained, the attention to the problems caused by the small size of the data will be less relevant and potentially different methods will become preferable. We mention a specific instance of this fact in subsection 6.3 below and return on this issue in our final recommendations.

The remaining part of this section is articulated as follows: 6.1 presents our general approach, 6.2 describes the balancing between generality and specificity in addressing the 9 questions, 6.3 describes the balancing between applicability in our small sample and in potential future larger samples, 6.4 illustrates how the methodology is informative about the data collection process.

6.1. The general approach

The main goal of the methodology is to assess PCP procurements relative to other procurement approaches that differ in the key characteristics from PCP. Therefore, the key input into the methodology is a dataset of procurements for which we have a variable indicating whether each procurement is a PCP or not. Moreover, for the analysis to be informative, for all those procurements that are not PCP the dataset must allow the researcher to observe what kind of alternative procurement method was used. As illustrated in the previous section, both the procurer and awardee

survey-based datasets contain this information. In particular, the procurer dataset contains: 7 cases of PCP, 1 case "similar" to PCP (NHS) and 33 cases of non-PCP procurements (divided between **14** cases of single sourcing procurement of R&D services (panel 2) and **19** cases of conventional joint procurement of R&D services and supply (panel 3)).

The second essential element of the dataset is a collection of variables measuring the outcomes corresponding to the 9 research questions. These **outcome variables** (or "dependent variables") will be described in detail in the next section in relation to each one of the 9 questions. Some of these outcome variables are **numerical**. This is, for instance, the case of the number of SMEs applying and winning. Other variables, instead, are **ordinal**. This is, for instance, the case of those outcome variables produced from responses to survey questions asking whether the respondent agreed with a certain statement in full, partially or not at all. We discuss in section 6.2 how we deal with these different types of outcome variables.

Finally, the third key element of the data is a rich set of **control variables** that should allow us to isolate the causal effect produced by the usage of PCP, conditional on other forces that concur to determine such outcomes. For instance, when analyzing the impact of PCP on a certain outcome, it might be important to control the effects that features of the procurer/awardee (or of the contract) could have on this outcome. Given the inherent complexity of measuring all the possible determinants of the outcome variables, we cannot be confident that our datasets contain all of them. However, it is important to remark that our choice of administering surveys with a long list of question was intended to try to capture all such determinants.

The empirical strategy that we followed, pools together the three data elements described above to estimate the effect of PCP on outcomes through a regression approach via **Ordinary Least Squares (OLS)** and **Nearest Neighbor Matching (NNM)** estimators. While the exact description of these methods requires some formal mathematical notation, their functioning is rather intuitive. Therefore, we relegated the more technical description in a box at the end of this subsection and present below the intuitive discussion.

The idea behind the OLS method is to evaluate how an outcome variable moves in response to changes in the type of procurement varying between PCP and non-PCP, conditional on other possible determinants of the outcome variable. In even simpler words, the idea behind the OLS method is to evaluate how an outcome variable changes when there is a change in the type of procurement from non-PCP to PCP, holding as fixed all the other possible determinants of the outcome variable, so as to isolate the impact of the type of procurement from the impact of other variables.

For simplicity, consider a case where the PCP nature of the procurement is the only (potential) determinant of the outcome. The OLS estimate of the effect of PCP on Y is equivalent to: *i)* partitioning the data sample in two groups depending on the PCP or non-PCP nature of the procurement, *ii)* calculating the mean of the outcome variable

in each of the two subsamples and *iii)* taking the difference between the mean for the PCP sample and that for the non-PCP sample. The OLS estimate equals this difference in the means. Its interpretation, hence, is that of the effect on the mean of the outcome variable that we observe in association with switching from zero to 1 an indicator for the PCP nature of the procurement.

When additional control variables are included in the regression model, then the interpretation is nearly identical. The only difference is that the OLS estimate of the effect of PCP becomes equal to the difference between *conditional* means, where the conditioning is upon the set of control variables included.

As regards the matching estimator, its logic is closely related although not identical to that of the OLS. Since there exist a vast class of matching estimators, we focus on one of them that we consider appropriate for the purpose of this study: the k^{th}-Nearest Neighbor Matching (NNM) estimator. From now onward, it will be convenient to refer to PCP procurements as the "**treated group**" and to non-PCP procurements as the "control group." Our goal in testing the effect of PCP is similar to that of testing the effect of a new medical therapy on a treatment group relative to a control group receiving a placebo therapy. This treatment effect (more formally known as the *Average Treatment Effect of the Treated*, ATET) is what we have loosely been discussing for the OLS as the average difference in outcomes due to different assignment to PCP and non-PCP procurement methods.

A matching model asserts that the treatment effect is an average of the differences between outcomes for a treated observation and a weighted average outcomes for similar observations from the control group based observed characteristics of the procurement (and/or of the procurer). Therefore a main difference between the OLS and the NNM estimators is how they use the control variables included in the model to calculate the weighted averages forming the estimate. In particular, Nearest Neighbor matches each treated observation to the control group observation with the minimum distance between their relevant characteristics. k^{th} Nearest Neighbor matches each treated observation to a distance weighted average of the k closest control observations. The formulas for the calculation of the estimators are presented in the box at the end of this section. Further details on these methods as well as on other types of matching estimators can be found in **Angrist and Pischke (2009).**[24]

Up until this point, we have described our control group as composed by non-PCP procurements. Therefore, the interpretation of the OLS or NNM estimate is that of switching to PCP from generic non-PCP procurements. However, to better evaluate the effect of PCP relative to alternative methods, we conduct all regressions on three

[24] The method of weighting determines the specific matching estimator. Propensity Score matching compares treatment observations to control observations based distance between propensity scores over the distribution of covariates rather than matching on the covariate themselves. Alternatively, Kernel Matching estimators consider several control group observations for each treated group observation, and take a weighted average of the outcomes of the matched control group observations, placing more weight on observations with propensity scores closest to that of the treated. Different kernels will weigh the observations differently and constitute unique kernel matching estimators.

samples that differ in terms of the non-PCP procurement included: the first sample includes all non-PCP cases (we refer to this as Control Group 1), the second includes only single sourcing procurement of R&D services (we refer to this as Control Group 2) and the third includes only cases of conventional joint procurement of R&D services and supply (we refer to this as Control Group 3). Thus, the interpretation of the PCP estimate will change depending on what set of non-PCP procurements are included in the sample and, under ideal conditions described below, will be the effect on the outcome of switching the procurement method from those of the non-PCP cases in the sample to PCP.

Below we will discuss some more technical requirements on the data in order to implement our estimators, that illustrate the assumptions needed to ensure the reliability of the estimates. As shown in the following section, due to differing response rates to the various questions in the survey, the regressions for different outcome variables are based on samples of different sizes. Although both OLS and NNM estimates will be consistent with appropriately large samples, **we believe that, given the small size of the current dataset, the best approach is to report estimates from multiple estimators (i.e., both OLS and NNM) and to look at them jointly for a tentative assessment of the effect of PCP.**[25]

In particular, to emphasize this aspect we will report confidence interval estimates instead of point estimates. A point estimate is a single number that, loosely said, provides the best guess of the effect of PCP (under either the OLS or NNM estimation methods). This point estimate is associated with a standard error that represents a **measure of its precision** and that, in turn, directly depends on the sample size (as well as on the variability in the data). As regards the confidence interval (CI), its definition in statistics is as follows:

*In statistics, a **confidence interval (CI)** is a type of interval estimate of a population parameter. It is an observed interval (i.e., it is calculated from the observations), in principle different from sample to sample, that frequently includes the parameter of interest if the experiment is repeated. How frequently the observed interval contains the parameter is determined by the confidence level or confidence coefficient. More specifically, the meaning of the term "confidence level" is that, if CI are constructed across many separate data analyses of replicated (and possibly different) experiments, the proportion of such intervals that contain the true value of the parameter will match the given confidence level. (…) So when we say, "we are 99% confident that the true value of the parameter is in our confidence interval", we*

[25] A more technical issue regards how the two methodologies differ with regard to small samples. Angrist and Hahn (2004) show that under random assignment propensity score matching out performs covariate matching with high dimensional desecrate or continuous covariates, when covariates have little influence on the treatment effect conditional on the propensity score, or when the proportion treated is close to 0 or 1. Rosenbaum and Rubin (1985a) show that in finite samples, when exact matching is infeasible, propensity score methods have less bias then matching estimators. Unfortunately imposing exact matching, restricting analysis to observations that have perfect matches, can also induce bias. Frolich (2004) compares propensity-score, matching and weighting estimators finding ridged matching preformed best in small samples with kernel matching coming in second and weighting estimator performing the worst. Though each of these papers compare finite sample characteristics under limited data they all require data richness assumptions that in very small samples are likely to fail.

express that 99% of the hypothetically observed confidence intervals will hold the true value of the parameter. After any particular sample is taken, the population parameter is either in the interval realized or not; it is not a matter of chance. The desired level of confidence is set by the researcher (not determined by data). (…) In applied practice, confidence intervals are typically stated at the 95% confidence level, meaning that the confidence interval will contain the true parameter value 95% of the times. (…) Certain factors may affect the confidence interval size including size of sample, level of confidence, and population variability. A larger sample size normally will lead to a better estimate of the population parameter.[26]

This definition makes clear that an advantage of focusing on confidence interval estimates is that of directly providing a sense of the variability of the estimates, with more precise estimate reflected by narrower bands. This variability will be inversely proportional to the sample size available in the data. **In this way, one can determine an estimate's statistically significant difference from zero and precision of the estimates, whose precision should increase in later periods with the number of contracts under the various procurement mechanisms increases.**

The next section will report a series of tables containing 95% confidence interval estimates of the effect of PCP on the different outcome variables. An interval that does not include zero is interpreted as a finding of an effect of PCP on the outcome: a positive effect if the interval is to the right of zero or a negative effect if the interval is to the left of zero. The remaining part of this sections offers a more technical discussion of our methodology and describes how it balances the different goals of the analysis. Less technically inclined readers can skip the following sub-sections and move directly to the descriptions of the regression findings in section 7.

6.2. Technical assumptions

There is a long literature on the development and refinement of the type of estimators described above and their successful implementation in policy evaluation.[27] Importantly, these methods have been applied to public procurement environments to address the same type of questions that we will address in the next section with regard to PCP.[28]

[26] The definition presented is an elaboration made by the authors of the Wikipedia entry for "Confidence Interval", accessed on June 1, 2015.

[27] Important early examples include Card and Sullivan (1988), Heckman, Ichimura and Todd (1998), Angrist (1998), Dehejia and Wahba (1999) and, more recently, Lechner (2002) and Angrist and Hahn (2004).

[28] In particular, in a recently published study by one of the members of this team, Decarolis (2014), the author uses both differences in difference and matching methods to compare the effect of different awarding rules (first price versus average bid) used to allocate public work contracts on three main outcomes: the winning price, the ex post performance (in terms of both cost overruns and delays) and the amount of time to evaluate the reliability of the bids received. In a related study, Branzoli and Decarolis (2013), use these same methods to analyze participations into public procurement auctions and subcontracting decisions under first price auctions compared to average bid auctions.

The reason for the success of these estimators is that under ideal data conditions, both the OLS and matching estimators are able to produce estimates of the effect of PCP that can be legitimately interpreted as the causal effect of PCP. The two estimators share that among the most important set of conditions for the validity of the estimates there is a large enough data and that a more technical condition, known as the conditional independence assumption, is satisfied.

We discuss issues related to the first condition – a large enough sample size - in subsection 6.3 where we describe how this matters when balancing the possibility of analyzing the current data with the need for an ideal method for larger datasets. As regards the conditional independence assumption, this condition requires assignment between PCP and non-PCP groups is as good as random after accounting for observable characteristics. Intuitively, this means that once we control for observable characteristics, the assignment of procurements to PCP or non-PCP should be essentially random. The logic of this requirement is obvious if one considers again the analogy with the evaluation of a medical treatment: if, even after controlling for observable differences (like gender, age, etc.), the groups of people receiving the treatment are not comparable to those receiving the placebo, then the estimate of the effect of the treatment will be biased. A clear instance of this occurs when the treated group differs along one characteristic (say, health status) that matters to assess the effect of the treatment, but is not observable to the researcher. The estimate of the treatment will then be plagued by an omitted variable bias. For both the OLS and the NNM methods a major threat to the identification of a causal effect of PCP is thus the presence of omitted variables.[29]

Below we will discuss some additional requirements on the data needed to implement our estimators in a way that produces reliable estimates.

Technical Box: Details on the OLS and NNM Estimators

For the OLS strategy, the model to be estimated is:

$$Y = \beta PCP + X\gamma + \varepsilon$$

Where Y is outcome variable, PCP is a dummy variable equal to 1 if the procurement is a PCP and zero otherwise, X is a matrix of covariates and epsilon is an error term. We are especially interested in the estimate of β since this quantifies the effect of PCP on the outcome.

For the NNM strategy, we employ the following k^{th} Nearest Neighbor estimator. This estimator matches every sealed bid auction with the k^{th} "closest" open auctions and vice versa, with closeness being measured as a weighted distance between

Similar techniques have been successfully applied in the context of US public procurement by a few important studies including Bajari and Lewis (2011) and Marion (2009).

29 For the NNM estimator, an additional key assumption is known as the support condition. It requires that there is a chance of an individual being assigned to either the treatment or control group for every characteristic. Thus, no particular characteristic and preclude being assigned to treatment (or control) with certainty. For a more complete description of the set of conditions required for a causal interpretation see Angrist and Pischke (2009).

procurement characteristics. It then compares the outcome of each procurement t, Y_t, with the average outcome of the matched procurement $\hat{Y}_t$, and estimates the average effect of PCP as the average of these comparisons:

$$\hat{\tau}_Y = \frac{1}{T^s} \sum_{t:PCP} \left(Y_t - \hat{Y}_t \right) + \frac{1}{T^o} \sum_{t:Other} \left(\hat{Y}_t - Y_t \right)$$

where T^s and T^o are the number of PCP and non-PCP procurements. In practice, due to data limitations we implement this estimator setting $k = 1$ and compute robust standard errors following Abadie and Imbens (2004). An higher k could be set in the future if more data will be collected.[30]

6.3. Balancing generality versus specificity

The previous discussion defines a general methodology that is applicable to answer each one of the nine research questions. However, it is crucial to appreciate the implications for our methodology of the differences between the 9 research questions. In particular, there are at least three aspects in which the need for differentiation among the methods used for the 9 questions is evident: inclusion in the set of covariates, inclusion in the sample and choice of the functional form.

The first dimension along which our methodology differentiates between the 9 research question is by evaluating for each of the outcome variables what is the most appropriate set of covariates to be included in X. Given the discussion about the OVB above, it is not surprising that a key aspect for the reliability of the estimates is the choice of X. This translates into ad-hoc model specifications for each one of the outcome variables that we analyze, (i.e., the set of variables in X might differ depending on whether Y is a measure for the risk of lock-in or for the capacity of attracting non-EU financing). The exact set of controls will be described in the next section together with the findings. Our approach to the choice of controls was based on to what indicated by the literature and by our understanding of the market. However, the way in which we organized the Stata codes will make trivial to repeat the analysis with different model specifications.

The second dimension along which our method is specific for each question is that for each regression we allow for the possibility of excluding a subset of the procurement cases. To make a specific example, for a case where the project has been interrupted it would not make sense to use the survey answers on the outcomes that followed the completion of the contract (like the follow up commercialization), but it still makes sense to include this cases when evaluating outcomes concerning the awarding of the

[30] As stated above there are many other matching estimators that could be applied and that share the same basic principle of the NNM. For instance, match on the basis of the propensity score: P(X) = Pr (PCP=1|X) instead of matching on each covariate. Attempting to create a match for each procurement with controls having the same or very similar value of X in small data is often infeasible; we can instead match control observations to treatment observations based similarities in likelihood of covariate composition.

contract, for instance the participation of SMEs. A point worth stressing is that the importance of these case-by-case restrictions is exacerbated by the small size of the sample: While in a larger sample one might hope that some sources of noise in the data cancel out on average, this is not feasible in our small data and, hence, requires careful attention regarding the cases to include.

A third aspect where analysis requires foregoing generality in favor of specificity regards attention to the nature of the data. The answers to the surveys produce nominal, ordinal and interval data, with the latter in the form of both continuous and discrete variables. Since accurately accounting for the nature of each variable would have caused a substantial fragmentation of the methodological analysis without, in our opinion, a substantial improvement in its quality, we decided to analyze only interval data, transforming ordinal data into interval data whenever possible. Therefore, for questions requesting for instance to what extent the respondent agreed with a certain statement, we created an interval dummy variable taking the value of 1 in case of agreement (typically regardless of the intensity of the agreement) and zero otherwise. In the next section we document exactly all these transformations. With larger data sets our methodology can be extended to finer interval measures. Finally, even within interval data it might be advisable to use different functional forms to account for their specificity. Here again we decided that the benefits from using, for instance, a Probit instead of the linear OLS model were not sufficient to justify abandoning the unified framework through which we present our analysis in the next section. Nevertheless, the Stata codes implementing our methods have been prepared having in mind the possibility of making it trivial for the user to replicate the analysis with models like Probit or Logit (that by constraining the outcome variable to range between zero and one are often the most appropriate for outcomes measured via indicator variables), or models like the Negative Binomial (that by taking positive integer values are often the most appropriate for outcomes like the number of SMEs participating).

6.4. Balancing applicability in the current sample and in follow up studies

Many aspects of our methodology reflect the tension between having a method useful for our small sample and offering to the DG Connect a methodology useful for future implementations in larger datasets. This tension is indeed evident in the attempt to maximize the set of usable cases, but at the same time selectively excluding some of them when they would likely bias the analysis (as for a case[31] mentioned above). The focus on confidence intervals instead of point estimates was also driven by this tension. Similarly, the choice of covariates, X, that we present in the next section needs to account for that with our small data the inclusion of each additional covariate imposes a high cost in terms of performance of the estimator.

[31] Classified information

Therefore, a feature of our methodology that we consider very relevant for the current small sample is that together with the OLS and matching estimates, we also always present simple Wilcokson Rank Sum (RS) tests. This nonparametric test has the advantage that by not relying on the applicability of the Central Limit Theorem, is useful even for small samples. Therefore, for each one of the 9 research questions, the OLS and matching findings will be preceded by the results of the Rank Sum test. Indeed, while to take as valid our OLS estimates based on very small samples of 10 observations on average, one would need to embrace the full set of stringent assumptions of the Classical Linear Model (to avoid relying on asymptotic results), the RS test gives perfectly legitimate inference statements even in small samples. Specifically, for each outcome variable we report the p-value of the RS test that the effect of PCP is zero, where the definition of p-value is as follows:

The p-value is a function of the observed sample results (a statistic) that is used for testing a statistical hypothesis. Before the test is performed, a threshold value is chosen, called the significance level of the test, traditionally 5%. If the p-value is equal to or smaller than the significance level, it suggests that the observed data are inconsistent with the assumption that the null hypothesis is true and thus that hypothesis must be rejected (but this does not automatically mean the alternative hypothesis can be accepted as true). An equivalent interpretation is that p-value is the probability of obtaining the observed sample results, or "more extreme" results, when the null hypothesis is actually true (here, "more extreme" is dependent on the way the hypothesis is tested).[32]

When a larger dataset will be available, we foresee that the relevance of the RS test will decline while that of the matching estimators will increase. Nevertheless, we also remark that large datasets might contain features in the data that could allow for even more reliable methodologies than the matching ones. For instance, the presence of a subset of procurers observed using both PCP and non-PCP methods might allow for the implementation of a Difference-in-differences (DD) analysis. The data requirements for this methodology are more stringent in that observations must be observed in at least two time periods, with selection into a particular contract group differing in one time period.[33] In our dataset, two procurers exhibit this feature, but the scarcity of usable data induced us to leave out the DD from our analysis, not excluding it could nevertheless become more relevant with a larger dataset.

Finally, the applicability of our methodology in both the current small sample and future larger samples is enhanced by the use of a flexible Stata code. A user manual is presented along this document to assist in properly understanding, implementing and modifying the codes.

[32] The definition presented is an elaboration made by the authors of the Wikipedia entry for "P-value", accessed on June 1, 2015.

[33] From the example above, suppose we saw contracts awarded across time, and that the contracts in the healthcare sector after some date were exclusively assigned with a PCP mechanism while other sectors remained unchanged. Further, these contracts could be linked between time periods in some way, so that you saw the outcome of "the same contract" in the period before the policy switch and after. Then, by differencing first within the contracts you could eliminate any unobservable contract specific trait contributing to time-to-completion, then the difference between the healthcare sector and the other sectors could be interpreted as the effect of assigning the PCP mechanism. One can also estimate a DD model, where differences across time with respect to the matching estimator for each time period.

6.5. Learning about relevant variables

The last task that our methodology accomplishes is that of being a learning tool to understand the relevance of the various variables that can be collected. Given the cost of administering and managing the data collection process we see this as a relevant side benefit of our work. In particular, one can see our study as suggestive of at least three types of data issues that future replications of the data collection process should carefully address. First, we found the presence of a few questions to which all procurers and/or awardees surveyed responded in an identical way. This implies that the resulting measure is a constant and no statistical analysis can be conducted on such degenerate random variables. Depending on the variables, one might consider omitting them from future iterations of the survey if they are likely to be constant not only in our sample but more generally in the population of procurements. Second, we find that for some questions we received no or very few answers. Our analysis in the following section highlights all the cases in which this happens. It is clearly important that, especially for the subset of questions that became part of the empirical analysis presented in the next section any future repetition of the data collection aims to obtain all answers. Finally, our analysis below indicates that some covariates enter the regressions in a non-statistically significant way. Although this might imply the possibility of excluding them from the analysis, we do not suggest taking this interpretation, as larger samples would be required to establish this conclusion.

7. EMPIRICAL FINDINGS ON THE 9 AREAS OF RESEARCH

This section is divided into 11 sub-sections, one for each of the research questions plus two final sub-sections. For each research question, we report:

i) the outcome variable (or variables) and how it is derived from the survey question that most closely corresponds to the research question (i.e., how the survey questions were transformed it into a new variable usable for the empirical analysis),

ii) the outcomes of the estimates,

iii) a discussion of the findings. The discussion at the end of the first two tables, Table 7.1.a-b, is particularly detailed and explains how all the remaining tables in this sections shall be read and interpreted.

7.1. Improvements in the quality and/or efficiency of the public services achieved by deploying the innovative solutions developed through PCP.

Dependent variable: The outcome variables used to study the first question posed by the DG Connect are derived from the answers of the following questions posed in the procurer survey:

1) *Quality Improvement*: "Do you believe that, as a result of the tender, the quality/efficiency of the service will: improve substantially; improve; stay the same; worsen; have no impact"

2) *Satisfaction:* "Are you satisfied with the innovation level of the product/technology/service resulted from the tender?"

For the analysis, in both cases we employ indicator variables: from the answers to the first question we create a dummy variable equal to 1 if the response was improve (substantially or not) and zero otherwise. For the second question, we create a dummy variable equal to 0 if the answer is "Not satisfied," and 1 otherwise. We exclude the Statoil case from the analysis since its premature ending would not make it appropriate to assess the type of outcomes analysed for this first research question.

Results: We report the results in the two tables below. Each table has three rows corresponding to the three sets of non-PCP procurements included. The first row includes all non-PCP cases (Control Group 1), the second includes only single sourcing procurement of R&D services (Control Group 2) and the third includes only cases of conventional joint procurement of R&D services and supply (Control Group 3).

The first column reports the p-value of a Rank Sum test (RS, see definition in sub-section 6.4): The null hypothesis is that the outcome variable has the same distribution under PCP and non-PCP cases.

Therefore, when in column (1) we report a number equal or lower than 5%, that means that the data rejects at the 5% level that the two distributions are the same.

The following column (2) reports the 95% confidence interval (CI, see definition in sub-section 6.1) estimates of an OLS regression where in addition to PCP the only other control is a constant. Column (3) differs from (2) in that here we add to the set of control what we consider to be relevant covariates. For all variables derived from responses to the procurer dataset, column (3) always includes exclusively the contract starting value. This variable is then the one used as matching variable for the NNM estimates in column (4). The column heading "Obs." means that the column reports the number of observations used in the regression described in the preceding column.

Columns (5) and (6) will typically differ across the outcome variables that we analyze in that they report estimates of OLS and NNM respectively where, in addition to the starting value, we include variables that we consider the most relevant specifically for the outcome variable considered. Here, however, there is an evident trade-off between adding more controls to limit the omitted variable bias and limiting the number of variables to preserve degrees of freedom in the small dataset. For the two outcome variables analysed below, columns (5) and (6) use as additional variable a dummy variable for whether the procurer shared information about its procurement needs with other procurers.

The relevance of including this specific variable derives from the fact that we expect that, due to the IPRs allocation under PCP, having a procurer that shares its needs makes more appealing for the firms to deliver higher quality since a profitable market is more likely to emerge for its innovation. Moreover, sharing information likely also proxies for a type of procurer that is directly concerned for the quality of the innovation it procurers. To address more explicitly this latter aspect, we also add a dummy variable for the type of procurer by including a dummy variable for whether the procurer is a *policy maker*. Procurers that are policy makers, indeed, potentially have a negative impact on quality improvements naturally being less concerned with them.

Table 7.1.a - *Quality Improvement*

	-1 RS	-2 OLS	Obs.	-3 OLS	-4 NNM	Obs.	-5 OLS	-6 NNM	Obs.
Control Group 1	**0.04**	**[0.02 - 0.80]**	36	**[0.01 - 0.81]**	**[0.07 - 0.65]**	32	[-0.21 - 0.50]	**[0.03 - 0.64]**	31
Control Group 2	**0.04**	**[0.03 - 0.88]**	18	[-0.02 - 0.81]	**[0.13 - 0.85]**	17	[-0.15 - 0.64]	[-0.03 - 0.65]	16
Control Group 3	0.06	[-0.01 - 0.79]	25	[-0.03 - 0.84]	**[0.06 - 0.71]**	22	[-0.26 - 0.61]	**[0.01 - 0.66]**	21

Table 7.1.b - *Satisfaction with Innovation*

	-1	-2		-3	-4		-5	-6	
	RS	OLS	Obs.	OLS	NNM	Obs.	OLS	NNM	Obs.
Control Group 1	0.09	[-0.06 - 0.68]	36	[-0.06 - 0.67]	[-0.02 - 0.50]	32	[-0.27 - 0.49]	[-0.04 - 0.50]	31
Control Group 2	0.09	[-0.06 - 0.73]	19	[-0.11 - 0.66]	[-0.04 - 0.61]	18	[-0.29 - 0.61]	[-0.12 - 0.51]	17
Control Group 3	0.14	[-0.08 - 0.67]	24	[-0.07 - 0.71]	[-0.02 - 0.55]	21	[-0.26 - 0.61]	[-0.06 - 0.56]	20

Discussion: Each table reports multiple results about the effect of PCP on the outcome variable. These differences are driven by the different methods used (RS, OLS and NNM), by the different control groups (control groups 1, 2 and 3), by the different set of control variables included in the regressions (columns 3-4 vs. columns 5-6) and for the different sample sizes.

As regards this latter aspect, the comparison between the number of observations appearing in the different columns of each table shows that we are not using the same sample to compute all estimates. The reason is that once we introduce control variables, we might run into cases where not all subjects answered (properly) the survey question. The presence of missing data makes the samples used across the different model specifications (i.e., across the different columns of the table) not homogenous. Although our approach implies that any difference in the estimates performed using different model specifications is due either to the specification itself or to the sample composition, we considered that, given the small size of our sample, the benefit of using the largest possible sample far exceed the cost caused by this ambiguity. Similarly, the difference in the number of observations across different outcome variables is due to the presence of missing or incomplete survey answers. Based on the same logic exposed above, instead of forcing a unique sample to study all the outcome variables, we decide to always use the largest sample of data available.

In terms of the interpretation of the findings in the two tables above, overall the estimates show that the data indicate a positive and statistically significant effect of PCP on quality improvements. Recall that for OLS and NNM estimates we report 95 percent confidence interval estimates. We mark in bold all those intervals that do not include zero and, hence, that imply we can reject at the 5 percent significance level that there is no difference between PCP and non-PCP. Similarly, in the first column we report in bold the instances where the rank sum test indicates a difference of PCP relative to non-PCP that is significant at the 5 percent level. For the quality improvement outcome, the positive effect of PCP emerges for most of the estimates. In particular, it emerges always when the control group is composed by all the non-PCP cases jointly. It is also statistically significant when the control group is that composed of conventional joint procurements (last row), although in column (2) the

significance is only at the 10 percent. Notice that there is a clear tendency for the estimates to achieve statistical significance when the sample sizes are larger. Therefore, our assessment is that a positive effect of PCP on quality is present in the data and it is also likely to emerge more strongly with larger datasets.

As regards the satisfaction with innovation, the table reveals the lack of a statistically significant effect at the 5 percent level. This means that **we fail to reject a null hypothesis of no effect of the PCP relative to non-PCP on the outcome variable.** Nevertheless, we shall point out that most of the estimates in the table are significant at the 10 percent level and that all estimates agree on the positive sign of the coefficient on PCP. Therefore, we consider the case of the satisfaction with innovation as one where some evidence in favor of a positive effect of PCP is present, but this evidence is not fully conclusive.

As regards the role of covariates, although for ease of exposition we do not report for the OLS regression the whole set of estimates for all the covariates, it is potentially interesting the fact that for both outcome variables the coefficient on a dummy **for the procurer sharing information on its procurement needs always has a positive and, in most cases, statistically significant effect.** When controlling for other potentially relevant variables, like an indicator for whether the procurement is direct or catalytic, we do not observe any relevant changes to either the magnitude or the significance of the main estimates presented in the tables above. Note that our survey did not contain a direct question on whether the procurement was catalytic or direct, so we integrated ex post the dataset with this information in order to quantify its role.

Finally, the estimates in Table 7.1.a-b include the NHS case among the sample of PCPs. Given the peculiarities of this case discussed in section 5, however, in section 7.11 we will explore the robustness of our estimates to the exclusion of the NHS case from the analysis sample. As shown there, the estimates presented above are not affected by this change in the sample composition.

7.2. Increase in quality and decrease in prices of products resulting from PCP.

Dependent variable: The outcome variable used to study the second question posed by the DG is derived from the answers of the following question posed in the procurer survey:

1) *Cost Decline*: "In your perception, what was the impact of the tender on the cost of solution resulted (end product)?"

For the analysis, we employ an indicator variable: from the answers to this question we create a dummy variable equal to 1 if the response entailed mentioning a cost decline (regardless of the magnitude of this decline). The Stata code documents the specific subsample used, which takes into account the specificities of two cases that

suggest excluding them from this analysis. We exclude the Statoil and NHS cases from the analysis since they are inappropriate (the first one due to its premature ending and the second due to the legal suite that followed its conclusion) to assess the type of outcomes analysed for this second research question.

Results: We report the results in the table below. The structure of the table is identical to that of the previous two tables. In particular, columns (5) and (6) use as additional variable a dummy variable for whether the procurer shared information about its procurement needs with other procurers. The logic is analogous to that illustrated above for the first research question. Relative to the previous tables, the lower number of observations derives from some of the procurers not answering the survey question.

Table 7.2.a - *Cost Decline*

	-1 RS	-2 OLS	Obs.	-3 OLS	-4 NNM	Obs.	-5 OLS	-6 NNM	Obs.
Control Group 1	0.31	[-0.17 - 0.51]	29	[-0.24 - 0.54]	[-6.09 – 3.12]	25	[-0.42 - 0.53]	[-13.63 - 7.53]	24
Control Group 2	0.54	[-0.37 - 0.65]	13	[-0.37 - 0.55]	[-1.40 – 2.13]	12	[-0.59 - 0.83]	[-2.92 - 4.47]	11
Control Group 3	0.28	[-0.17 - 0.55]	20	[-0.29 - 0.58]	[-8.16 – 3.41]	17	[-0.50 - 0.63]	[-17.85 - 7.38]	16

Discussion: Contrary to what discussed before for the quality and satisfaction measures, **all the estimates show that for this specific question the data does not indicate any significant difference between PCP and non-PCP procurements**. The additional specifications included in the Stata codes that include also additional control variables confirm the same finding. Finally, repeating the estimates including the two excluded cases (Statoil and NHS) does not change this findings. This latter aspect is explored further in sub-section 7.11.

7.3. Reduction in the risk of failure in large scale follow-up PPI procurements.

Dependent variable: The outcome variable used to study the third question posed by the DG is derived from the answers of the following question posed in the procurer survey:

1) *Reduced Risk of Failure in PPI*: ""Do you agree with the following statement: "being better informed through a PCP about pros and cons of competing solutions before launching the PPI reduced the risk of failure in PPIs"?"

For the analysis, we employ an indicator variable: from the answers to the question above we create a dummy variable equal to 1 if the respondent agreed with the statement (regardless of the intensity of the agreement) and zero otherwise. This is the question that was asked to procurers concerning PCP cases. For procurers involved in non-PCP cases we do not have an exactly equivalent question in the

survey. However, since all our non-PCP cases occurred well before our survey, we believe that it is reasonable to proxy for the risk of failure of the follow-up PPI by looking (within such cases) at whether a PPI indeed occurred or not. Therefore, for the non-PCP cases we set the indicator variable used to measure the reduced risk of failure of PPI as 1 if the procurer reported that a follow up PPI occurred. [34]

Results: We report the results in the table below. This table has the same structure of the previous ones. The additional control included in the last two models of column (5) and (6) is a variable measuring the presence of an explicit intent to filter out technical risk, as stated by the procurer among its goals for the tender.

Table 7.3.a - *Reduced Risk of Failure in PPI*

	-1 RS	-2 OLS	Obs.	-3 OLS	-4 NNM	Obs.	-5 OLS	-6 NNM	Obs.
Control Group 1	0.21	[-0.17 - 0.69]	21	**[0.13 - 1.08]**	[-0.03 - 0.88]	19	**[0.12 - 1.07]**	**[0.00 - 0.87]**	19
Control Group 2	0.08	[-0.07 - 1.02]	13	**[0.22 - 1.42]**	**[0.43 - 1.24]**	12	**[0.17 - 1.47]**	**[0.33 - 1.17]**	12
Control Group 3	0.54	[-0.32 - 0.57]	16	[-0.01 - 0.88]	[-0.14 - 0.72]	14	[-0.01 - 0.86]	[-0.14 - 0.76]	14

Discussion: The OLS and NNM estimates suggest a **positive association between PCP and a decline in the risk of failure of follow-up PPI**. The relationship is statistically significant at the 5% level when using the control groups 1 and 2, but it is nearly so when using control group 3 as well (the estimates in the last row are significant at the 10 percent level for the models in columns (3-5)). Furthermore, results not reported above confirm the robustness of this positive association across different model specifications that include procurer characteristics.

7.4. Increase in the efficiency of R&D expenditures.

Dependent variable: The outcome variables used to study the fourth question posed by the DG are derived from the answers of the following questions posed in the awardee survey:

1) *No Project Absent Tender*: "In your opinion, in the absence of this tender, would your company have undertaken this project?"

2) *R&D Investment after Tender*: "(If applicable) As a consequence of this tender, your R&D&I investment."

[34] More precisely, for the non-PCP cases the indicator variable is set to 1 whenever the respondent answered "yes" to the question: "After the tender, was there a public procurement of the resulting innovation (PPI)?" or if it indicated that at least one firm attended the follow-up PPI when answering the question: "How many firms, participated to the PPI? - Open-Ended Response."

3) *Project Investment after Award*: "After the award of the tender, did you invest other funds in one or more of the following activities related to the tender project? - Other (please specify)"

For the analysis, we employ three indicator variables: for *No Project Development Absent Tender,* the dummy variable equals 1 if the respondent answered "No" and zero otherwise. We exclude the case ANM2 awardee from this analysis given its specificities relative to this question. For *R&D Investment after Tender,* the dummy equals 1 if the answer contained the word "increase" and zero otherwise. For *Project Investment after Award,* the dummy equals 1 if the answer contains the word "yes." We excluded the case of "ANM1 awardee" from this analysis given its specificities relative to this question. We exclude the Statoil and Tour Talk LLP cases from the analysis since they are inappropriate to assess the type of outcomes analysed given the nature of the object procured.

Results: The structure of the table below is identical to that used for the previous research questions where the data sample was based on the procurer data. The main difference in the analyses involving awardee and procurer data is that while for the latter the regression specifications reported in column (2-6) control for the contract starting price, for the former we include the awardee annual sales. Furthermore, as regards the three outcome variables analysed below, the additional control variable included is an indicator variable for whether the awardee answered positively to the question: "Did a commercial product/technology result from the tender project?"

Table 7.4.a - *No Project Absent Tender*

	-1 RS	-2 OLS	Obs.	-3 OLS	-4 NNM	Obs.	-5 OLS	-6 NNM	Obs.
Control Group 1	0.40	[-0.26 - 0.59]	16	[-0.20 - 0.70]	[-0.25 - 0.53]	16	[-0.23 - 0.99]	[-1.23 - 2.71]	15
Control Group 2	0.37	[-0.34 - 0.74]	9	[-0.42 - 0.83]	[-0.22 - 0.44]	9	[-0.21 - 1.24]	[-1.85 - 4.09]	9
Control Group 3	0.45	[-0.30 - 0.58]	11	[-0.17 - 0.84]	[-6.49 - 12.74]	11	[-0.76 - 1.17]	[-0.23 - 0.43]	10

Table 7.4.b - *R&D Investment after Tender*

	-1 RS	-2 OLS	Obs.	-3 OLS	-4 NNM	Obs.	-5 OLS	-6 NNM	Obs.
Control Group 1	**0.00**	**[0.58 - 1.24]**	15	**[0.51 - 1.23]**	**[0.55 - 1.22]**	15	**[0.18 - 1.11]**	**[0.22 - 1.21]**	14
Control Group 2	**0.02**	**[0.26 - 1.34]**	9	**[0.02 - 1.21]**	**[0.16 - 1.17]**	9	**[-0.41 - 1.27]**	**[-0.09 - 1.09]**	8
Control Group 3	**0.00**	**[1 - 1]**	10	**[1 - 1]**	**[1 - 1]**	10	**[1 - 1]**	**[1 - 1]**	9

Table 7.4.c - *Project Investment after Award*

	-1 RS	-2 OLS	Obs.	-3 OLS	-4 NNM	Obs.	-5 OLS	-6 NNM	Obs.
Control Group 1	**0.04**	**[0.03 - 0.64]**	18	[-0.01 - 0.68]	[-0.22 - 0.49]	18	[-0.11 - 0.91]	[-0.42 - 2.10]	16
Control Group 2	0.17	[-0.19 - 0.86]	11	[-0.31 - 1.04]	[-0.21 - 0.57]	11	[-0.52 - 1.36]	[-0.26 - 0.66]	10
Control Group 3	0.11	[-0.09 - 0.76]	13	[-0.25 - 0.91]	[-27.51 - 5.59]	13	[-0.79 - 1.59]	[-17.21 - 5.03]	11

Discussion: The estimates indicate that the PCP effect differs among the three outcome variables analysed above. There is overwhelming evidence in support of a positive and statistically significant effect on PCP on an increase of R&D investments after the tender. This result is confirmed across all estimation methods and for all the comparison groups considered, as indeed we stress with bold character. On the contrary, there is no evidence in the data of any association between PCP and whether the company would have started the project absent the procurement. Finally, some weak evidence in favor of a positive effect of PCP emerges for the third outcome variable regarding investments after the contract award. In this case, the 5% statistical significance of the estimates is achieved only when control group 1 is used and no covariates are included in the regression.

7.5. Speeding up time-to-market for firms and facilitating the access of SMEs to the procurement market.

The outcome variable used to study the fifth question posed by the DG are derived from the answers of the following questions posed in the awardee procurer:

1) *Number SMEs Applied*: "How many SMEs or start-up applied to the tender? - Open-Ended Response"

2) *Number SMEs Awarded*: "How many SMEs or start-up were awarded the tender? - Open-Ended Response"

3) *Number Initial Bidders*: "Number of initial bidders - Open-Ended Response"

4) *Number Awardees*: "Phase 1 - Number of awardees"

For the analysis, we employ four variables. *Share SME Applying* is the percentage of applicants that are SMEs. *Share SME Winning*: is the percentage of winners of that are SMEs.

We complement the list of outcome variables described above with an additional variable derived from the answers to the awardee survey:

5*) Access to Market*: " How much do you agree with the following statement: "the participation in the tender has facilitated my access to the procurement market"?"

For the analysis, we employ an indicator variable: from the answers to the question above we create a dummy variable equal to 1 if the respondent answered "Strongly agree" and zero otherwise. We foresee that in the future another question contained in our survey ("Did a commercial product/technology result from the tender project?") might be useful to address the DG question, but at this stage the PCP cases are too recent to allow us to evaluate PCP along this dimension.

Results: We report our findings below in three different tables: the first two regard the outcomes based on the procurer data, while the latter regards the outcome variable from the awardee data. The tables have the usual structure of the previous tables. The estimates in the last column of the procurer-based data include as additional controls an indicator variable for whether the response to the question regarding the timing of IPR allocation was "at the beginning, in the tender documents and no negotiation admitted." For the awardee-based data, the additional control variable included in the model shown in the third column is an indicator variable for whether the company has a tender dedicated office.

Table 7.5.a - *Share SME Applying*

	-1 RS	-2 OLS	Obs.	-3 OLS	-4 NNM	Obs.	-5 OLS	-6 NNM	Obs.
Control Group 1	**0.01**	**[10.04 - 70.96]**	37	**[9.17 - 75.75]**	**[13.19 - 93.41]**	32	**[1.09 - 73.79]**	**[22.42 - 94.67]**	32
Control Group 2	**0.04**	[-3.97 - 75.74]	21	[-0.69 - 85.58]	**[23.98 - 101.8]**	19	[-20.31 - 83.56]	**[22.39 - 101.2]**	19
Control Group 3	**0.01**	**[13.16 - 75.34]**	24	**[7.07 - 76.07]**	**[7.46 - 93.64]**	20	**[3.87 - 81.37]**	**[31.04 - 99.27]**	20

Table 7.5.b - *Share SME Winning*

	-1 RS	-2 OLS	Obs.	-3 OLS	-4 NNM	Obs.	-5 OLS	-6 NNM	Obs.
Control Group 1	**0.00**	**[17.12 - 82.49]**	36	**[16.89 - 88.46]**	**[7.84 - 95.03]**	31	**[6.36 - 82.89]**	**[26.57 - 100.80]**	31
Control Group 2	**0.01**	**[13.83 - 91.72]**	20	**[20.37 - 102.2]**	**[42.37 - 110.70]**	18	[-0.74 - 92.62]	**[41.05 - 112.00]**	18
Control Group 3	**0.01**	**[10.31 - 84.83]**	24	**[1.50 - 82.78]**	[-4.64 - 91.76]	20	[-1.02 - 90.10]	**[24.02 - 104.10]**	20

Table 7.5.c - *Tender Facilitated Access to Market*

	-1 RS	-2 OLS	Obs.	-3 OLS	-4 NNM	Obs.	-5 OLS	-6 NNM	Obs.
Control Group 1	**0.00**	**[0.25 - 0.89]**	19	**[0.21 - 0.93]**	[-8.45 - 2.48]	19	[-0.02 - 1.02]	[-6.92 - 2.64]	17
Control Group 2	**0.01**	**[0.03 - 1.11]**	12	**[0.09 - 1.13]**	**[0.34 - 1.16]**	12	[-0.13 - 1.30]	**[0.29 - 1.16]**	11
Control Group 3	**0.01**	**[0.13 - 1.01]**	14	[-0.04 - 1.16]	[-7.08 - 2.17]	14	[-0.17 - 1.15]	[-5.88 - 2.08]	12

Discussion: As regards *Share SME Applying* and *Share SME Winning,* the estimates indicate similar results: **there is clear evidence in favor of PCP increasing both the participation and the awarding of SMEs.**

For the first outcome variable, this results appears more evidently when the only comparison group is that of conventional joint procurement of R&D services and supply (control group 3).

The estimates concerning the effects of the tender on facilitating the access to market show some significant difference between PCP and non-PCP procurements. Most of the estimates reported in the table are significant at the 5 percent level and, among the remaining ones, many are significant at the 10 percent level. The additional specifications included in the Stata codes confirm the same finding.

7.6. Attracting financial investors to Europe.

The outcome variables used to study the sixth question posed by the DG are derived from the answers of the following questions posed in the procurer survey:

1) *Attract Founds through Tender*: "Did you obtain / attract (other) R&D&I investment because of this tender?"

2) *Attract non-EU Funds*: "If you received any form of financing for the industrialization/commercialization of the project, did you attract any funds from non-European investors?"

For the analysis, we employ indicator variables equal to 1 if the answer contained the word "yes" and zero otherwise. In both cases, we exclude ANM2 awardee from this analysis given its specificities relative to this question.

Results and Discussion: We do not report statistical evidence to analyze this DG question because all respondents answered "No." So, **the different procurement mechanisms do not seem to create any differential condition in terms of attracting outside investments.** We experiment with and without the inclusion of the Tour Talk LLP case that might be different to all other cases with respect to this research question given the nature of the project, but the results are qualitatively the same with and without this case included in the analysis.

7.7. Increased interoperability, impact on standardization and reduction of supplier lock-in.

The outcome variables used to study the seventh question posed by the DG are derived from the answers of the following questions posed in the procurer survey:

1*) Interoperability Requirements:* "Did you explicitly set interoperability requirements in the tender requirements?"

2) *Reduced Lock-in*: "Do you agree with the following statement: "the PCP has resulted in new procurement channels being open, which helps to avoid single supplier lock-in)"

For the analysis, we employee indicator variables: for *Interoperability Requirements,* the dummy equals 1 if the answer is "yes" and zero otherwise. For *Lock-in,* the dummy equals 1 if the answer contains the word "agree" and zero otherwise. For both variables we implement some consistency checks using additional information: in particular, for *Interoperability Requirements,* the Stata codes document how we ensured the outcome variable matches special features of three cases, while for *Lock-in* the same codes document the use the *Cost Decline* variable (see question 2 above) to cross-check the reasonableness of the answer on lock-in.

Results: We report the result for the two outcome variables in the two tables below. The table structure is the usual one for outcome variables originating from the procurer data. For models (5) and (6), the additional control included is a dummy for weather the IPR are fully allocated to the awardee. In the Stata code we explore different model specifications that control for the motives behind the tender (i.e., we use dummy variables to categorize the different answers to the question: "Why did you undertake this PCP?").

Table 7.7.a - *Interoperability Requirement*

	-1	-2		-3	-4		-5	-6	
	RS	OLS	Obs.	OLS	NNM	Obs.	OLS	NNM	Obs.
Control Group 1	0.36	[-0.23 - 0.60]	31	[-0.31 - 0.62]	[-0.25 - 0.75]	27	[-0.44 - 0.57]	[-1.49 - 3.61]	27
Control Group 2	0.60	[-0.40 - 0.65]	16	[-0.47 - 0.72]	[-0.47 - 0.71]	15	[-0.47 - 0.88]	[-0.53 - 1.34]	15
Control Group 3	0.32	[-0.24 - 0.67]	23	[-0.34 - 0.73]	[-0.36 - 0.76]	19	[-0.77 - 0.51]	[-9.08 - 22.72]	19

Table 7.7.b – *Reduced Lock-in*

	-1	-2		-3	-4		-5	-6	
	RS	OLS	Obs.	OLS	NNM	Obs.	OLS	NNM	Obs.
Control Group 1	**0.00**	**[0.20 - 0.88]**	41	**[0.33 - 1.04]**	[-2.57 - 1.62]	34	**[0.33 - 1.06]**	[-3.73 - 2.51]	34
Control Group 2	**0.00**	**[0.36 - 1.00]**	22	**[0.44 - 1.11]**	[-0.32 - 1.06]	19	**[0.45 - 1.17]**	[-0.10 - 1.63]	19
Control Group 3	**0.04**	**[0.02 - 0.85]**	27	**[0.14 - 1.05]**	[-3.57 - 1.49]	22	[-0.02 - 0.98]	**[0.05 - 0.95]**	22

Discussion: As regards *Interoperability Requirements,* the evidence indicates the lack of any statistical association with PCP. **However, the sign of the mean effect of PCP is always positive and we observe a tendency for the statistical significance of such positive effect to increase in response to an increase in the sample size. Thus, in this case we see some evidence suggestive that a**

larger dataset could lead to detect a positive association between PCP and *Interoperability Requirements.*

Convincing evidence in favor of a positive association between PCP and the reduced lock-in is reported in the relative table.

There we show that most of the reported confidence interval estimates, as well as all the rank sum tests, all indicate that PCP is associated with less lock-in.

As above, the fact that this effect tends to disappear in estimates based on models with less degrees of freedom (because of the combination of data and parameters to estimate) is suggestive that when we find the lack of any statistical effect this might be mostly driven by the small size of the dataset and not by the PCP not having any effects on lock-in.

7.8. Impacts on competition structure in the market.

The outcome variables used to study the eight question posed by the DG are derived from the answers of the following questions posed in the procurer survey:

1) *Subcontracting*: "Did the awardee choose to sub-contract?"

Subcontracting is an indicator variables equal to 1 if the answer to the subcontracting question does not contain the word "no" and zero otherwise.

We complement the list of outcome variables described above with an additional variable derived from the answers to the awardee survey:

3) *Revenues Before Tender*: "Total Revenues before tender participation (please specify currency) - Open-Ended Response"

4) *Revenue at Present*: "Total Revenue at present - Open-Ended Response"

5) *Market Share before Tender*: "Market share before tender - Open-Ended Response"

6) *Market Share Current*: "Market share at present - Open-Ended Response"

7) *Number Employees before Tender*: "Number of employees before participation to this tender - Open-Ended Response"

8) *Number Employees Current*: "Number of employees at present - Open-Ended Response

For the analysis, we calculate whether there are increases in revenues, number of employees and market shares by checking whether the values reported as current values exceed those reported with regard to the pre-tender period.

Results: We report our findings below in two different tables: the first regards the outcome based on the procurer data, while the latter regards the only outcome variable from the awardee data (the change in market shares) for which we have enough responses to perform the analysis. The tables have the usual structure of the previous tables. The estimates in the last column of the procurer-based data include as additional controls an indicator variable for the timing of IPR allocation. For the awardee-based data, the additional control is the indicator for the presence of a tender dedicated office.

Table 7.8.a - *Subcontracting*

	-1 RS	-2 OLS	Obs.	-3 OLS	-4 NNM	Obs.	-5 OLS	-6 NNM	Obs.
Control Group 1	0.64	[-0.42 - 0.66]	31	[-0.37 - 0.79]	[-3.36 - 1.54]	27	[-0.32 - 0.90]	[-3.36 - 1.56]	27
Control Group 2	0.40	[-0.39 - 0.89]	16	[-0.39 - 0.97]	[-0.88 - 1.09]	15	[-0.32 - 1.21]	[-0.95 - 1.12]	15
Control Group 3	0.95	[-0.54 - 0.57]	19	[-0.56 - 0.76]	[-4.83 - 1.45]	16	[-0.52 - 0.89]	[-4.81 - 1.53]	16

Table 7.8.b - *Market Share Increase*

	-1 RS	-2 OLS	Obs.	-3 OLS	-4 NNM	Obs.	-5 OLS	-6 NNM	Obs.
Control Group 1	0.69	[-0.56 - 0.78]	12	[-0.59 - 0.96]	[-10.07 - 3.61]	12	[-1.01 - 1.81]	[-11.03 - 4.57]	12
Control Group 2	0.33	[-0.65 - 1.45]	7	[-0.72 - 1.66]	[-0.05- 1.19]	7	[-1.57 - 2.57]	[-0.11 - 1.25]	7
Control Group 3	0.99	[-0.80 - 0.80]	10	[-1.02 - 1.08]	[-12.34 - 4.21]	10	[-1.02 - 1.08]	[-12.34 - 4.21]	10

Discussion: As regards *Subcontracting* and *Market Share Increase,* **the estimates indicate a lack of significant association with PCP.** The additional specifications included in the Stata codes confirm the same finding.

7.9. Increased exploitation of IPRs and R&D results.

The outcome variable used to study the ninth question posed by the DG is derived from the answers of the following question posed in the awardee survey:

1*) Effectiveness through Potential Demand*: "In your perception, how did each of the following factors contribute to the effectiveness and efficiency of the solution resulting from the tender? - Volume of (potential) demand"

For the analysis, we employ an indicator variable that equals 1 if the answer is "Crucial importance" and zero otherwise. Although no single question perfectly captures the whole idea of the DG's ninth question, we believe that the survey question above is able to capture its essential element by focusing on the potential

future exploitation of the solution resulting from the tender. Indeed, this question can be contrasted with the one regarding exploitation based on the current tender: "In your perception, how did each of the following factors contribute to the effectiveness and efficiency of the solution resulting from the tender? - Value of contract awarded."

Results: We report the results in the table below. Its structure is the usual one for awardee-based data. The additional control used in the model reported in the last column is a dummy equal to 1 when the awardee reported that the value of contract awarded was a contributing factor to the effectiveness and efficiency of the solution resulting from the tender.

Table 7.9 - *Effectiveness through Potential Demand*

	-1 RS	-2 OLS	Obs.	-3 OLS	-4 NNM	Obs.	-5 OLS	-6 NNM	Obs.
Control Group 1	**0.01**	**[0.26 - 1.00]**	19	**[0.17 - 1.01]**	**[-0.48 - 5.57]**	19	**[0.03 - 1.30]**	[-0.73 - 5.87]	19
Control Group 2	**0.02**	**[0.22 - 1.21]**	12	**[0.18 - 1.20]**	**[0.05 - 2.21]**	12	[-0.30 - 1.69]	[-0.16 - 2.43]	12
Control Group 3	**0.04**	**[0.06 - 1.08]**	14	[-0.28 - 1.04]	[-3.01 - 14.14]	14	[-0.54 - 1.51]	[-1.51 - 8.57]	14

Discussion: Most of the estimates **indicate a significant positive effect of PCP, although this is not confirmed for all specifications**. Thus, **we tentatively conclude that there is some evidence of a positive association between PCP and the outcome variable.**

7.10. Effects of the PCP Features: The IPRs Allocation

The analysis thus far has considered the effect of PCP relative to non-PCP procurements. An additional element of interest is, however, how the distinguishing features that define the PCP nature of procurements individually affect outcomes. More in details, we have discussed earlier how PCP is characterized by an IPR allocation that gives some, if not all the IPRs to the awardee.

Table 7.10 below shows the allocation of IPRs in the PCP and non-PCP cases in our procurer data. Although most of the PCP cases entail some IPRs for the awardee, there is one case of PCP – the NHS case – where 100 percent of the IPR went to the procurer. The allocation in full to the procurer is the modal case for non-PCP procurements. However, among the non-PCP cases we observe that 6 out of 40 cases for which we were able to assess the allocation of the IPR have them allocated to the awardees. Furthermore, for both PCP and non-PCP cases we observe instances of shared IPRs. Overall, this variation across PCP and non-PCP cases in the allocation of the IPRs suggest that a fruitful extension of our analysis can entail looking at the effects of the IPRs allocation, independently of the PCP or non-PCP nature of the procurement. This type of analysis could thus potentially reveal the importance of one

of the characterizing elements of PCP in isolation form the other PCP distinguishing features.

Table 7.10.a – *IPRs Allocation and PCP Procurements*

	PCP	Non-PCP
100% to Awardees	6	6
Shared	1	6
100% to Procurer	1	18

Our approach to analyze the effect of the IPRs allocation consists in using the same type of OLS regressions described above with one main difference: the key independent variable is now not the PCP indicator, but a dummy variable for whether 100 percent of the IPR are allocated to the awardee. The table below reports the OLS estimates of the effect of this IPRs allocation indicator on four outcome variables: quality improvements (see 7.1.a), satisfaction for innovation (see 7.1.b), cost decline (see 7.2) and lock-in reduction (see 7.7). For each one of these outcome variables we consider two model specifications: the first one includes exclusively the IPRs allocation indicator as independent variable (together with a constant). The second specification includes the PCP dummy. The interest in this second specification derives from the possibility of assessing to what extent the IPRs allocation indicator is able to capture the effect of the PCP dummy on the outcome variable.

Table 7.10.b – *Effects of the IPRs Allocation*

	Quality Improv.	Quality Improv.	Satisfact. Innovat.	Satisfact. Innovat.	Cost Decline	Cost Decline	Avoids Lock-in	Avoids Lock-in
IPR to Awardee	**[0.15 - 0.79]**	**[0.04 - 0.80]**	**[0.03 - 0.59]**	[-0.09 - 0.60]	[-0.05 - 0.31]	[-0.09 - 0.42]	**[0.16 - 0.60]**	[-0.01 - 0.27]
PCP		[-0.18 - 0.68]		[-0.23 - 0.55]		[-0.31 - 0.27]		**[0.63 - 0.95]**
Observations	41	34	41	34	41	34	41	34
R-squared	0.19	0.27	0.12	0.16	0.05	0.07	0.24	0.85

Discussion: Focusing on the regressions where PCP is not included, the estimates in the table above indicate that the IPRs allocation has no effect on cost reductions, while it is positively and statistically significantly associated with quality improvements, satisfaction with the innovation procured and reduction in lock-in. Interestingly, for these latter three outcomes the inclusion of the PCP dummy has qualitatively the same effect: it reduces the magnitude of the estimated effect and

moves the confidence interval toward zero. For the cases of the satisfaction with innovation and lock-in reduction the effect is sufficiently pronounced to make the interval include zero and, hence, imply a lack of statistical significance at 5 percent level. Nevertheless, while for the case of lock-in the PCP dummy is itself significant, this is not the case for the satisfaction with innovation. An interpretation of these finding is, therefore, that the IPRs allocation is particularly relevant by itself for quality improvements and, although to a lesser extent, for satisfaction with the innovation. Instead, for the reduction of lock-in the combined effect of all the characteristics determining a PCP is more relevant than the IPRs allocation by itself.[35]

7.11. Robustness: inclusion of the NHS case

In the previous sections, the NHS case was included within the sample of PCPs for the estimates presented in tables: 7.1.a-b, 7.3.a, 7.5.a-b, 7.7.a-b, 7.8.a. As discussed earlier, the motivation is that this case, while not fully fitting the PCP classification shares with PCP features such that they make it useful to assess the effects of PCP on the outcomes analysed in those tables. The peculiarities of this case discussed in section 5, however, suggest that an important robustness check for our analysis consists in repeating all this estimates excluding the NHS data from the analysis sample. Table 7.11.a reports these results.[36]

The various blocks in which the table is divided indicate the outcome variable to which the estimates are related, as well as the corresponding table in the previous sub-sections. For instance, as regards the first two blocks of Table 7.11.a, they are the analogue of the OLS and NNM estimates presented in Table 7.1.a-b of sub-section 7.1. The only difference between these two sets of results is that, relative to the estimates in Table 7.1.a-b, those in Table 7.11.a exclude the NHS data from the sample. This is indeed indicated by the fact that, for all regressions, Table 7.11.a reports one less observation relative to the corresponding regressions in Table 7.1.a-b.

Table 7.11.a – *Effects when Excluding the NHS Case*

(1) Table	(2) OLS	Obs.	(3) OLS	(4) NNM	Obs.	(5) OLS	(6) NNM	Obs.
Quality Improvement **(Table 7.1.a)**								
C.Gr.1	[-0.01 - 0.84]	35	[-0.03 - 0.85]	**[0.06 - 0.66]**	31	[-0.40 - 0.37]	[-0.01 - 0.67]	30
C.Gr.2	[-0.01 - 0.92]	17	[-0.05 - 0.86]	**[0.12 - 0.87]**	16	[-0.36 - 0.40]	[-0.08 - 0.62]	15
C.Gr.3	[-0.04 - 0.82]	24	[-0.07 - 0.88]	**[0.04 - 0.71]**	21	[-0.50 - 0.50]	[-0.02 - 0.72]	20
Satisfaction with Innovation **(Table 7.1.b)**								
C.Gr.1	[-0.09 - 0.71]	35	[-0.09 - 0.70]	[-0.03 - 0.52]	31	[-0.43 - 0.43]	[-0.07 - 0.54]	30

[35] This interpretation is further supported by looking at the changes in the R-squared at the bottom of the table. This quantity measures how well the regression model explains the variation of the outcome variable. The table reveals that the inclusion of PCP leads to a major improvement in the R-squared for the lock-in dummy: form 24 percent to 85 percent.

[36] The abbreviation "C.Gr." stands for Control Group.

C.Gr.2	[-0.10 - 0.77]	18	[-0.14 - 0.70]	[-0.05- 0.61]	17	[-0.50 - 0.55]	[-0.12 - 0.49]	16
C.Gr.3	[-0.11 - 0.70]	23	[-0.12 - 0.75]	[-0.02 - 0.56]	20	[-0.46 - 0.58]	[-0.08 - 0.61]	19
Reduced Risk of Failure in PPI **(Table 7.3.a)**								
C.Gr.1	[-0.22 - 0.70]	20	**[0.10 - 1.08]**	[-0.05 - 0.86]	18	**[0.08 - 1.08]**	[-0.03 - 0.82]	18
C.Gr.2	[-0.14 - 1.05]	12	**[0.20 - 1.47]**	**[0.40 - 1.24]**	11	**[0.14 - 1.53]**	**[0.29 - 1.16]**	11
C.Gr.3	[-0.37 - 0.58]	15	[-0.04 - 0.90]	[-0.17 - 0.69]	13	[-0.05 - 0.88]	[-0.15 - 0.61]	13
Share SME Applying **(Table 7.5.a)**								
C.Gr.1	**[2.83 - 66.88]**	36	**[1.42 - 72.50]**	[-248.4 - 152]	31	[-6.38 - 70.53]	[-246 - 160.5]	31
C.Gr.2	[-11.51 - 71.1]	20	[-8.89 - 83.51]	[-43.22 - 114]	18	[-29.61 - 80.9]	[-43.2 - 114.5]	18
C.Gr.3	**[6.36 - 70.85]**	23	[-0.39 - 72.22]	[-338.4 - 144]	19	[-3.27 - 77.61]	[-322.7 - 158]	19
Share SME Winning **(Table 7.5.b)**								
C.Gr.1	**[10.77 - 80.1]**	35	**[10.35 - 87.4]**	[-271.6 - 153]	30	**[0.14 - 81.88]**	[-265.6 - 171]	30
C.Gr.2	**[7.24 - 89.59]**	19	**[13.7 - 102.5]**	[-40.14 - 132]	17	[-8.28 - 92.41]	[-40.14 - 132]	17
C.Gr.3	**[3.75 - 82.66]**	23	[-5.58 - 81.88]	[-361.1 - 140]	19	[-7.97 - 89.26]	[-342.3 - 162]	19
Interoperability Requirements **(Table 7.7.a)**								
C.Gr.1	[-0.30 - 0.59]	30	[-0.39 - 0.61]	[-0.29 - 0.75]	26	[-0.52 - 0.57]	[-7.32 - 19.12]	26
C.Gr.2	[-0.47 - 0.65]	15	[-0.58 - 0.73]	[-0.52 - 0.67]	14	[-0.63 - 0.97]	[-2.76 - 1.32]	14
C.Gr.3	[-0.30 - 0.67]	22	[-0.43 - 0.72]	[-0.39 - 0.72]	18	[-0.84 - 0.53]	[-9.93 - 24.04]	18
Reduced Lock-in **(Table 7.7.b)**								
C.Gr.1	**[0.30 - 0.99]**	40	**[0.48 - 1.18]**	**[0.23 - 1.09]**	33	**[0.44 - 1.18]**	**[0.34 - 1.04]**	33
C.Gr.2	**[0.49 - 1.08]**	21	**[0.65 - 1.18]**	**[0.31 - 1.10]**	18	**[0.68 - 1.25]**	**[0.78 - 1.11]**	18
C.Gr.3	**[0.13 - 0.96]**	26	**[0.31 - 1.18]**	**[0.05 - 0.98]**	21	**[0.07 - 1.04]**	**[0.11 - 1.04]**	21
Subcontracting **(Table 7.8.a)**								
C.Gr.1	[-0.22 - 0.96]	30	[-0.16 - 1.09]	[-0.10 - 0.87]	26	[-0.11 - 1.19]	[-0.10 - 0.87]	26
C.Gr.2	[-0.17 - 1.17]	15	[-0.16 - 1.25]	[-0.02 - 1.01]	14	[-0.04 - 1.50]	[-0.02 - 1.01]	14
C.Gr.3	[-0.31 - 0.84]	18	[-0.33 - 1.04]	[-0.20 - 0.73]	15	[-0.29 - 1.15]	[-0.17 - 0.80]	15

Discussion: For most of the results, eliminating the NHS case has qualitatively no impact on the estimates. In the case of quality improvements and satisfaction with the innovation, for instance, the estimates remain nearly identical to those presented in sub-section 7.1 both in terms of magnitudes and in terms of significance. Hence, the estimates confirm the presence of a positive effect of PCP on quality improvement, but the lack of any statistically significant effect on satisfaction with the innovation.

The lack of relevant changes after excluding the NHS case is true for all outcome variables with the exception of those concerning the SMEs (participation and awarding) and the reduced lock-in. As regards the outcomes concerning SMEs, eliminating the NHS case reduces the number of instances when the PCP estimate is significant at the 5% level.
This is more evident for the case of the SMEs applying variable while the difference with the results in section 7.5 is less pronounced in the case of the SMEs winning variable. Despite the reduced magnitude and significance of the estimates, however, the average effect remains positive for both outcome variables and the statistical significance is lost for some, but not all of the estimates. Therefore, although these results suggest a lower strength of the effect of PCP on the SMEs outcomes, they do

not contradict that PCP seems to be associated with more participation by SMEs and more contracts awarded to SMEs.

Finally, as regards the reduced lock-in, the results obtained by excluding the NHS data document a substantially more pronounced positive effect of PCP in achieving a reduced lock-in.
This is evident from Table 7.11 above where all the estimates associated with the reduced lock-in are significant (and so reported in bold). Relative to the estimates in sub-section 7.7, we have that all NNM estimates achieve statistical significance at the 5% level and that the effect of PCP appears positive for all the three control groups.

8. RECOMMENDATIONS

As shown in sections 4, 5 and 7, this study has found quantitative evidence on the economic impact of PCP compared to other procurement approaches. The evidence shows particularly positive impacts of PCP on improving the quality and/or efficiency of the public services, reducing vendor lock-in and facilitating the access of SMEs to the public procurement market. PCP is therefore a particularly useful mechanism to develop and reinforce a strong European home market for innovative products and services and speed up time-to-market for innovative companies including SMEs.

This section provides a set of recommendations based on the findings of this study and the experience in the field of public procurement implementation.

8.1 Recommendations for actions to be taken by the EU

<u>Recommendation 1</u> – Economic semester and structural reforms

The study evidence shows measurable positive impacts of PCP compared to other public procurement approaches on modernizing public services (improved efficiency and effectiveness of public service) and opening up the EU internal market (increased cross-border award of public contracts, interoperability and reduced supplier lock-in). The study evidence (section 4 literature review) also shows that compared to R&D subsidies/grants, public procurement is more effective in encouraging private investment in R&D and increasing company sales.

PCP is thus an instrument that can drive more efficient government spending whilst creating economic/company growth, which is of key importance in times of austerity. The Council conclusions on 2014 European Semester emphasize that more attention should be paid to the implementation of structural reforms, notably through competitiveness and competition-enhancing reforms.

Therefore recommendation 1 is for the European Commission to promote PCP actively to Member States as an instrument to achieve the economic semesters' priority on government modernization.
Member States should be encouraged to integrate PCP visibly and prominently in economic planning when undertaking structural reforms. Alike is the case for other R&D/innovation policy instruments (R&D subsidies, tax incentives), the Commission is also encouraged to facilitate the long term monitoring of the impacts of PCP on structural reforms, by building the models to monitor the macroeconomic impacts of PCP/R&D procurement based on the lesson learnt from the microeconomic evidence collected by this study.

Recommendation 1 (Actions):

1. Build the models to monitor the macro-economic impacts of PCP/R&D procurement in a way that allows comparing its impacts with other public R&D interventions such as R&D grants and R&D tax incentives.
2. Integrate innovation procurement in the annual economic semester exercise of structural reform planning with Member States.

<u>Recommendation 2</u> – Policy framework: targets and action plans

Since 2007 the EC demonstrated that compared to other parts of the world there is a major underutilization of R&D procurement in Europe (5Bn in Europe versus 50Bn in US). It was made clear that this is the reason for half of the R&D investment gap: Europe is still lagging 1% behind to reach the 3% Lisbon target on R&D expenditure. Bell's innovation curve clearly shows that in a normally functioning market 2.5% of 'innovator' type customers (that buy R&D - PCP) are needed to convince the majority of more risk averse customers to adopt innovative solutions afterwards (PPI).[37].

Seven years later it is clear that awareness raising alone about these facts is not triggering enough PCP procurement investments in Member States. The study had a difficult time to find cases of real R&D procurement in Europe, due to the fact that in most European countries there is still a serious lack of strategic foundation and forward planning for innovation in public services.

Recommendation 2 is therefore for the EU to take the lead to create an EU wide agreed policy framework with targets and action plans for PCP and PPI:

- A European wide target needs to be set to dedicate 2,5% of public procurement expenditure to R&D procurement/PCP (€50Bn). Given the minimum volume of PCPs required to trigger PPIs (Bell's curve), if it is considered to set an overall target for innovation procurement, then this overall target needs to split up in one sub-target for PCP/ procurement of R&D (that needs to be min. 2,5%) and one sub-target for PPI/ procurement of innovative solutions (that needs to be min. 12,5% - Bell's curve). Up to now some Member States have confused this and set too low targets of 2,5% for innovation procurement in total (e.g. Germany is already at 10% for PPI).

- Lessons learnt from countries around Europe that have already set targets for innovation procurement show that a target does not reach the desired effect when it is not accompanied with an action plan agreed per sector of public interest of

[37] Lieve Bos, European Commission, FAQ Document published in CORDIS website.

how to set the priorities to reach the target. Qualitative Key Performance Indicators (KPIs) should be set per sector (e.g. target to modernize water treatment processes with innovative solutions to increase the water quality by x percent by 2020).
The EC shall request each Member State to report annually on its action plan and the progress towards the target as a part of the annual national research and innovation plans.

- The evidence of this study clearly shows that PCP achieves the positive economic impacts found, when it is implemented by public procurers that represent the real demand side for the innovative solutions. The reason for this is the customer drive to steer the PCP to solving a well-defined procurement need to improve the quality or operational delivery of the public service the procurer is responsible for (as expressed by 87,5% of the cases interviewed). Targets and action plans shall thus focus on mobilizing those procurers that are responsible for the acquisition and/or regulatory strategy of the innovative solutions to execute more R&D procurements/PCPs.

Recommendation 2 (Actions):

1. Set at European level a target, as a percentage of public procurement expenditure in Member States to be dedicated to PCP.
2. Complement targets with qualitative KPIs for the respective public sector domains.
3. Ensure that MS create an action plan on innovation procurement (with actions across the respective public sector domains) and integrate the monitoring of this in the annual reporting exercise on the national action plans for R&D&I to the EC.

<u>Recommendation 3</u> – Reinforced dedicated EU funding program for PCP/PPI

EU funding for PCP has been instrumental in triggering PCP activity in Europe. The number of countries in which there are now procurers involved in PCPs and in which PCP became part of the national R&D&I strategy has increased from 2 to 14 between 2009 and 2014 thanks to EU funding for PCP. The FP7 and Horizon 2020 funded PCPs are also the trailblazers for joint cross-border public procurement around Europe.

Section 4 reports on the impacts that can already be observed from this first wave of ongoing FP7 funded PCP projects. Clearly, FP7 funded projects achieve additional impacts compared to national procurement projects: 25 times more contracts (33% compared to 1,23%) are awarded to companies that are not from a country of the procurers and 2,5 times more contracts are awarded to SMEs (75,5% compared to 29%). EU funded PCPs are thus contributing directly to creating a "Single" Market in Europe by opening up concrete cross-border market and growth opportunities to

companies, including to innovative SMEs. These effects on the single market are not found in structural funds funded PCPs.

It is thus essential for Horizon 2020, and the EU R&D&I funding programs to come after Horizon 2020, to continue and reinforce the support to "joint" cross-border PCP/PPI procurement to unlock the single market. As the relevant impacts of such a policy occur only in the mid-to-long-term, any slowdown or a loss of momentum of the EU funding for PCP/PPI would be destructive.
However, a number of improvements are recommended in the EU funding approach as the first PCP projects were not easy to start:

- As there is often national pressure on public procurers to buy nationally, FP7/Horizon 2020 funded PCPs need not only financial support but also tailored practical/legal EC support to remove barriers to cross-border procurement. Clearly, without EU co-financing combined with "strategic" EU project management support, there are no incentives for procurers to start joint cross-border PCPs/PPIs. It has to be recognized that EU funded PCP/PPI projects need EU project managers that are specialized in PCP/PPI and master also the legal (public procurement, state aid rules) and innovation policy skills (connection between procurement and IPR management, SME support) to make such projects a success. This is currently not the case, leading to incoherent project management of EU PCP/PPI projects across different EC units/DGs.

- As cross-border procurement requires extra effort from procurers, the EU funding rate for cross-border PCPs/PPIs needs to be higher than the funding rates of national support programs for PCPs/PPIs across Europe. The 70% funding rate for PCP co-fund actions in Horizon 2020 came under pressure because over the last years, national funding rates have increased to 100% in most countries with PCP support programs: in ongoing PCPs in DK, NO, IT, ES, BE, DE, AT the budget to finance the procurement cost for the PCPs is not paid by the procurers (public hospitals, cities etc.) that need the innovative solutions but by national or regional ministries supporting them. In countries that are working on new PCP support programs (HU, GR) the same habit exists for national ministries to finance local procurements 100% (e.g. with the help of structural funds). The proposed increase to 90% for the funding rate for Horizon 2020 funded PCPs in 2016-17 is an improvement, but may still restrict participation in projects to large procurers from richer Member States that can pay 10% co-financing.

- Current misalignment of the topic scope of Horizon 2020 PCP/PPI calls with actual procurement needs of public procurers also needs to be better tackled. Most breakthrough innovation takes place at the crossroads between different and unpredictable technologies. To get the best value for money solutions for PCPs and PPIs, procurers need to compare and leave companies the freedom to come with different technological solution approaches. The topic/budget and timing alignment

of most Horizon 2020 PCP&PPI calls with traditional supply / research / technology driven EU research priorities represents a significant barrier for procurers to submit PCP/PPI proposals. These often do not fully match the procurement need.
To ensure that H2020 PCP and PPI calls are effectively targeted, aligned and synchronized with real priorities, EC should launch periodically larger "open[38]" PCP and follow-up PPI calls, dedicated to a specific type of contracting authorities, aimed to call for proposals in specific public sectors (health, environment, transport, education etc.). Public procurers from all over Europe should be consulted in the preparation of such calls, to ensure that calls match procurement needs for which concrete investments are planned in the yearly national procurement budget preparation cycles.

Thus, to mainstream PCP funding across the EU R&D&I program, recommendation 3 proposes a more efficient and coordinated implementation approach based on:

- a system shift, away from a fragmented funding and project management approach to a specific funding program for PCP with a dedicated budget and coordinated by a centralized service with specialized strategic project management and legal/IPR skills that manages all funded PCP projects (alike for the SME instrument),
- continued CSA support (for groups of procurers to prepare the ground for future PCPs/PPIs) and PCP actions (co-financing the procurement cost for joint PCPs),
- mainly "open" calls for PCP (alike for the SME instrument),
- time synchronization of PCP/PPI calls (to ensure continuation to deployment/PPI),
- regular cut off dates (today the call mechanism is too dispersed and requires public procurers to pool their demand in too short time),
- dedicated consultation meetings with public procurers per sector in the preparation of the work program, to ensure WP priorities match real procurement needs/planning.

Recommendation 3 (Actions):

1. Increase the EU funding support to PCP, in particular through Horizon 2020.
2. Define a specific EU PCP/PPI program funding with dedicated budget managed by a central service with specialized legal/IPR/strategic project management skills.
3. Offer mainly open calls with regular cut-off dates.
4. Offer both coordination grants to support networking of procurers to prepare PCPs/PPI and grants that co-finance the PCP/PPI procurement cost.
5. Assure regular, dedicated consultation of public procurers in preparation of WPs.

[38] The concept of "open" refers to the area of innovation need, but not to the specific field of public intervention and / or the specific type of public procurers solicited by the call (eg. open call for procurers in the rail transport sector, open call for the procurers in the field of clinical devices, open call for primary and secondary schools). This mechanism could facilitate the demand pooling.

<u>Recommendation 4</u> – Measurement and impact evaluation

Developing effective innovation procurement policies requires an EU wide agreed measurement system to track and compare in a uniform way the amount of R&D procured across all Member States.
In addition, a systematic ex-post evaluation of the economic impacts of those R&D expenditures in Member States is also needed.

To facilitate tracking the amount of PCP procurement that takes place around Europe and to make the implementation of such procurements more transparent to interested companies, we recommend including PCP in the list of public procurement procedures that can be chosen by public procurers to publish their PCP call for tenders at EU level (in TED) and at national level (in national public procurement portals).
Also we recommend the EU to provide a PIN form (public information notice) specifically for announcing open market consultations that precede PCPs/PPIs in TED.
The process in TED and national procurement portals to submit contract (award) notices should become web-based so that procurers can only submit well filled-in notices that contain all the data for measuring the amount of R&D procured and for impact evaluation.
As there is a substantial amount of R&D procurements that are exempted from publication obligations, the EU wide measurement system to track the amount of R&D procured across all Member States should not be based solely on the amounts of R&D procurements published in TED and national procurement portals, but should be complemented with data collected from surveys of procurers and suppliers about non-published R&D procurements.

Based on this study, the following impact indicators can be used for ex-post evaluation of the long term impacts of PCP, and R&D procurements at large. An EU wide agreed set of impact indicators would facilitate benchmarking the performance of PCP implementation across different European countries (and for EU funded projects).

- *Impact on the demand side: public sector modernization, efficiency and effectiveness*
  - improvement in quality and/or efficiency of public services,
  - (for PCP focusing on creating efficiency gains/cost reduction) level of re-investment of efficiency gains in the economy,
  - reduction of technology lock-in (e.g. higher interoperability, interconnectability, new open EU standardization of solutions in the sector),
  - impact of lessons learnt from PCP on future procurements (e.g. reduction of the risk of failure and/or cost savings for follow-up PPI procurements, new innovation procurements or procurement collaborations triggered by the PCP),
  - other measurable impacts on procurers that performed the PCP.

- *Impact on the supply side:*
  - increase in sales resulting from the PCP (sales to public and private sector, from

new products developed during the PCP or extensions to existing products sold as a result of the PCP or from licensing income etc. resulting from the PCP),
- personnel increase resulting from the PCP (split up in inside and outside EU),
- additional financial investments attracted by the supplier as a result of the PCP
- new patents created (value of future market opportunities),
- mergers, acquisitions, IPO, increase in stock value as a result of the PCP,
- new or intensified investments by the supplier in R&D and/or innovation (internal investments or partnerships with other actors on the market) resulting from the PCP (split up between inside and outside EU),
- other measurable benefits/impacts on the suppliers that participated to the PCP.

- *Wider impact on the market and on society as a whole:*
  - improved access to the procurement market for new players, including SMEs, reduction rate of dominant market positions,
  - contribution to opening the internal market – increase in cross-border growth/sales opportunities for companies (amount of PCP contracts awarded to suppliers from other countries than those of the procurers),
  - (re)use of PCP tender specifications by other procurers on the market, impact of the PCP tender specifications on standardization, certification, regulation,
  - other measurable benefits on the market and society as a result of the PCP.

Recommendation 4 (Actions):
1. (The EU should) take the lead to develop, in cooperation with Member States, a set of consistent metrics to measure on regular basis: a) the amount of R&D procurement expenditure, as well as b) the long term economic impacts of those investments on the supply side, demand side and society/the economy as a whole across the different public sector domains across Europe. 2. (The EU should) increase the transparency of open market consultations and PCPs: a) make available a PCP contract notice form in TED to include PCP in the list of public procurement procedures to enable procurers to publish their PCP call for tenders, b) make available an open market consultation PIN form in TED to enable procurers to publish open market consultations in preparation of PCPs or PPIs in TED.

<u>Recommendation 5</u> – Training, assistance and awareness raising

The study observations indicate that wider PCP implementation is held back in Europe due to lack of awareness among public procurers about the benefits of PCP and lack of skills and resources to implement PCP. Indeed a combination of technical, economic and legal expertise is needed to implement PCP and often procurers lack this.

The study interviews with procurers also identified widespread misunderstandings among public procurers about the purpose and correct implementation of PCP and PPI. Such misunderstandings are fueled by organizations that are providing awareness raising and training around Europe – often even on request of national ministries – that focuses on how to (ab)use PCP/PPI to "not" identify the best value for money innovative solutions on the market but to favor national/local industry at all cost.
In order to foster innovation procurement learning and implementation in a coherent and legally compliant way across Europe, it is recommended that the EU itself sets up a rigorous high-value capacity building, coaching and mentoring program, of which the quality level is controlled and certified by the European Commission.

Recommendation 5 (Actions):

1. (The EC should) set-up a certification program for PCP/PPI that lists EU certified experts per country that provide local training and assistance that correctly position PCP/PPI as tools to maximize the economic impacts on modernization of public services and the single market in compliance with EU procurement and state aid rules.
2. (The EC should) set-up an excellence / competence center on PCP/PPI run by the Commission itself that: (i) coordinates wider dissemination and specialized training courses across the EU on the economic benefits and specialized implementation aspects of PCP e.g. regarding IPRs, using the previous list of EU certified PCP/PPI experts (ii) disseminates best practices (identified based on rigorous criteria in compliance with the Public Procurement Directives, COM (2007) 799 and State Aid rules requirements); (iii) provides an EU approved tool-kit for public procurers to implement PCP in all EU languages, iv) monitors PCP implementation and impact across the EU.

8.2 Recommendations for actions to be taken by the Member States

The implement the actions recommended by our study findings at EU level, the following complementary actions need to be undertaken by the Member States.

<u>Recommendation 1</u> – Political commitment for structural reforms
Member States should integrate PCP visibly and prominently in economic planning when undertaking structural reforms. Priority areas where government modernization could have the largest economic impact should be identified in each country across different sectors of public interest and based on that political commitment should be assured of where to use PCP to drive public sector modernization proactively.

Recommendation 1 (Actions):

National political commitment is needed to:
1. Integrate PCP in economic planning when undertaking structural reforms.

2. Identify priority areas per sector of public interest with largest potential economic impact on public sector modernization where PCP will be used.

<u>Recommendation 2</u> –Policy framework: targets and action plans

Each Member State should commit itself to a concrete action plan for mainstreaming PCP. The action plans should go beyond the current initiatives in Member States that are piloting PCPs mostly as an instrument to support innovation, but don't fully leverage yet its impact by using it structurally inside top level priority areas to be modernized (health, transport, education, environment etc.) and especially in large network infrastructures (e.g. transport). The action plan should provide priorities, strategic policy goals and targets of public spending to be dedicated to PCP.

Recommendation 2 (Actions):

Member States should define action plans and targets for PCP:

1. (Member States should) set a national target for public procurement expenditure on R&D/PCP to contribute to the EU target for PCP.
2. The action plan should prioritize areas of public intervention with a clear plan to deploy the final solutions.
3. The action plan should be coordinated at national level and define clear mandates (roles, responsibilities and governance model) for PCP implementation to those entities responsible for deploying the solutions and optimization of public spending.
4. In the action plan, procurement actions should be complemented by actions needed to remove barriers for deployment of innovative solutions (e.g. regulation, product certification/labelling, standardization, deployment subsidies/tax incentives).
5. The action plan needs annual-based mapping/revision of promising procurement opportunities, linked to structural reforms in the economic semester, with forecast and/or targets and strategic and political decisions for intervention.
6. The action plan should foresee priority areas for bundling demand for PCP and identify priorities that could be better addressed at transnational level.
7. The innovation procurement priorities, procurement plans and targets should be published well in advance to enable companies to identify promising future market.

<u>Recommendation 3</u> – Reinforced incentives

National support programs for R&D&I and national/regional planning for the use of ESIF funds focus traditionally in Europe on supporting supply side innovation (via grants, loans for industry and researchers). As a result, current PCP pilots in Member States are too often associated with R&D/innovation agencies and not driven by a concrete procurement need.

The results of this and other studies show that PCP achieves higher positive economic impacts when properly implemented by those public procurers that are directly responsible for the modernization and transformation of public services. The evidence confirms that a key factor is "who" execute the PCP, the procurer that knows and represents the real end-user needs: the one responsible for buying the ultimate end-solutions or the ministry responsible for specific public sector domain that represents the interests of the end-users on the market and can mobilize other demand side instruments, such as regulation, to speed up time-to-market for innovations.

Recommendation 3 (Actions):
National /regional/local authorities should foresee incentives schemes to encourage public procurers in the country/region/city to undertake PCPs: 1. Incentives should be targeted only to procurers that represent the real demand side for the solutions. 2. A combination of financial and other incentives could be used (e.g. reward schemes such as PCP prizes, bonuses for public servants that work on PCPs). 3. Financial incentives should focus on lowering the risk for procurers to undertake PCPs and leverage national and EU funding where suitable for this (e.g. Horizon 2020, ESIF funds, EIB loans etc.).

<u>Recommendation 4</u> – Measurement and impact evaluation

This study encountered difficulties to find R&D procurement and PCP cases across Europe, because in practice many tenders labeled by the public authorities as R&D procurements or PCPs in fact are not that.

To enabling better tracking of the amount of R&D procured and the amount of PCP procurements in each country, Member States should create a national measurement system for R&D and PCP procurements. In addition, a systematic ex-post evaluation of the results and economic impacts of those R&D expenditures is also needed. This should be done in coordination with other Member States to arrive to an agreed EU wide measurement and impact evaluation system (see recommendation 3 at EU level).

Recommendation 4 (Actions):
Member States should set-up national systems for: 1. Measuring the amount of R&D procurements, in particular PCPs. 2. Monitor the impact of those R&D expenditures in coordination with other Member States and the EC to arrive to an EU wide agreed measurement and impact evaluation system.

<u>Recommendation 5</u> – Training / competence centers

The study had difficulties to find legally correct implemented PCP cases and noticed a proliferation of interpretations on PCP that are not compliant with the EU Treaty principles, competition/State aid and public procurement rules.

There is a need for clear national guidelines on when to use PCP versus innovation partnerships, in a way that is compliant with the R&D&I State aid framework provisions on this point. To assure a correct legal implementation, Member States should provide national guidelines.

The study found also that public authorities lack know-how, skills and resources to implement PCP. There is a clear need for national competence centers on PCP that provide training, assistance and awareness raising based on good and certified practices. Where possible, capability building on PCP/PPI implementation could be co-financed by ESIF (e.g. by Thematic Objective 11 for enhancing the administrative capacity).

Recommendation 5 (Actions):
Member States should create: 1. National guidelines for PCP implementation. 2. National competence centres, with specific competences in vertical domains. 3. Training and awareness raising programs to public procurers in their country.

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