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Public Procurement for Innovation (PPI) as Mission-oriented Innovation Policy

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Abstract

This article focuses on public procurement for innovation as a relevant demand-side instrument to be exploited in the mitigation of grand challenges. It intends to provide some clarification on what should (and what should not) be regarded as innovation procurement. It defines what is meant by public procurement for innovation and categorizes it according to three dimensions: (i) the user of the purchased good; (ii) the character of the procurement process; and (iii) the cooperative or non-cooperative nature of the process. In addition, it illustrates the main stages in innovation procurement processes and exemplifies them with six cases to provide evidence that public procurement for innovation can contribute to satisfying unsatisfied human needs and solving societal problems.

Keywords: Public procurement for innovation (PPI); innovation policy; functional specification; interactive learning; cooperation; competition.

1. Introduction

Public organizations may place an order for something (normally a product or a system) that does not exist; hence, this "something" has to be developed by the supplier before it can be delivered. In other words, innovations are needed before delivery can take place. Until about 10 years ago this phenomenon was called "public technology procurement" (Edquist et al., 2000a). Since then, this vocabulary of the 1990s and earlier has changed. The concept of "technology" has been replaced by the concept of "innovation", reflecting a widening of the content of the notion. It is a matter of using public demand (or similar) to trigger innovation. We will use the term "Public Procurement for Innovation" (PPI) to denote this phenomenon.

However, the (non-existing) product ordered in the process of PPI is not the beginning of the process or its objective. Instead, the rationale for PPI is:

- To satisfy human needs, and/or
- To solve societal problems.

This is why PPI is so relevant in the context of grand challenges, the idea being to mitigate these challenges through the kind of innovation policy instrument that we call PPI. However, the nature of grand challenges such as global warming, tightening supplies of energy, water and food, ageing societies, public health, pandemics or security (Lund Declaration, 2009) does not allow defining policies to target them as a whole, at the same time and with only one policy instrument. As it is simply not possible to work at such levels of aggregation, policies need to address narrower targets and partial problems linked to those grand challenges. This is in fact reflected in the use of PPI for meeting human needs and mitigating societal problems, where more limited goals are set for those programs (e.g. energy saving of a certain kind, improving mobility with regard to passenger transport, increasing security in a specific field). We would argue that most mission-oriented policy mitigation of grand challenges has - and must have - a narrower focus as compared to the grand challenges as such, simply because they are so "grand". It should be added that PPI certainly includes innovations intended to meet needs ('missions') of public agencies themselves, if they are related to general human needs or societal problems (see direct PPI in Section 3 and four of the cases in Section 5).

Needless to say, grand challenges can also be mitigated through other means and instruments, for example R&D funding, tax credits, environmentally motivated regulations and standards (e.g. mileage standards for automobiles), creation of markets for innovative ideas, support for education and training or enhancing capacities for knowledge exchange (OECD, 2011). Nonetheless, instruments other than PPI will not be addressed here, except for brief references in cases when they are closely combined with PPI in the "policy-mix" (Flanagan et al., 2011).

A new interest, at the European level, has recently emerged with regard to demand-side approaches to innovation policy (Edquist and Hommen, 1999) and, more specifically, the use of public demand as an engine for the development and diffusion of innovations. In early 2004 three governments issued a position paper to the European Council calling for the use of public procurement across Europe to spur innovation (Edler and Georghiou, 2007; French/German/UK Governments, 2004). This development continued and was manifested in various reports, including the Aho Group Report (Aho et al., 2006). The Aho Group identified several application areas – or grand challenges - where demand-side policies could be used to a larger extent: e-Health, Pharmaceuticals, Energy, Environment, Transport and Logistics, Security and Digital Content (Edler and Georghiou, 2007, p. 951). There seems to be much less talk about innovation procurement in the US than in Europe (Vonortas et al., 2011). We suspect, however, that other fields of US government policy involving "mission agencies", such as defense or energy, incorporate elements of PPI. Discussion of the differences between European and US practices regarding PPI seems to conflate the use of procurement to meet societal challenges with the use of procurement to meet mission-agency needs. PPI in the US has often been used for the latter and less frequently for the former (Thai, 2001). It has also been used for mission-agency needs in Europe and elsewhere.

The aim of this article is to contribute to clarifying the characteristics of (different kinds of) PPI, how PPI has been used, as well as, briefly, its relationship to other public innovation policy instruments. We have therefore decided to base this article firmly on empirical experiences by using a number of examples of PPI. Section 5 contains six case descriptions of PPI. Before that, the context for PPI is presented in Section 2. A few definitions that are necessary to structure and characterize the cases are introduced in Section 3. The methodology and the dimensions of the cases are found in Section 4, as is a detailed summary of the case descriptions (Table 2). The conclusions and policy implications are addressed in Section 6.

2. Interaction in innovation systems

Innovation processes occur over time and are influenced by many factors. Because of this complexity, firms almost never innovate in isolation, but interact with other organizations to gain, develop, and exchange various kinds of knowledge, information and other resources.

These interactions among organizations (players) operating in different institutional contexts are important for innovation processes (Edquist, 2011). What we call 'activities' in the Systems of Innovation (SI) are the determinants of the development and diffusion of innovations. Examples of activities are Research and Development (R&D), the financing of the commercialization of such knowledge, or demand-side activities such as the formation of new product markets or the articulation of new product quality requirements.

Hence, the development and diffusion of innovations are highly influenced by demand that may emanate from either private or public organizations (players).[1] This article will disregard the influence from private organizations (e.g. demand from customer firms or individual consumers) and only address the demand from public organizations.

PPI is an important demand-side innovation policy instrument (Dalpé, 1994; Edler and Georghiou, 2007; Geroski, 1990; Rothwell and Zegveld, 1981), and from now on this article will concentrate on PPI. Hence, it is generic with regard to research areas or grand challenges; it deals with one innovation policy instrument that can potentially be used to mitigate many different challenges. As we have seen, and will see, PPI is one example of interaction between organizations (procurers and suppliers), which is strongly stressed as a source of innovation in the SI approach.

3. Defining and classifying innovation procurement

Innovations are new creations of economic or societal significance mainly carried out by firms (but not in isolation). They may be new products or new processes. New products may be material goods or intangible services; it is a matter of what is produced. New processes may be technological or organisational; it is a matter of how the products are produced.

Non-firm public organizations do not normally take part directly in the innovation processes, although they certainly are important organizations participating in the research and invention activities that influence innovation. They affect (change, reinforce, improve) the context in which the innovating firms operate. As indicated in Section 2, this context includes all the determinants of innovation processes. *Innovation policy* may thus be understood as actions by public organisations that influence innovation processes, i.e. the development and diffusion of innovations (Edquist, 2011).[2]

Public procurement means that a public organization buys a product (a good or a service or a combination of the two, which might be called a system). *Public Procurement for Innovation* (PPI) occurs when a public organization places an order for the fulfillment of certain functions within a reasonable period of time (through a new product).[3] Hence, the objective (purpose,

[1] Public means that the activity is performed by an agency or organization (player) that is a part of the local or municipal authorities, the regional authorities, the national state, or supranational bodies.
[2] This implies that innovation policy also includes actions by public organizations that unintentionally affect innovation.
[3] The public organization may also financially contribute directly to the R&D leading to the development of the product. However, such contributions are not intrinsic parts of the PPI as such. Public R&D funding is a different - complementary - policy instrument in the policy-mix, one which is not in focus here. The purchase of a non-existing product is the central element of PPI. However, the development costs of the new product are, of course, indirectly supported by the procurer by (initially) paying a high price for the product. This is part of the very idea of PPI, but since the procurers’ commitment is only to buy a number of units of the product at a certain price, this support of the

rationale) of PPI is not primarily to enhance the development of new products, but to target functions that satisfy human needs or solve societal problems. We must point out here that the diffusion of the product from the procuring organizations is not always among the major objectives of this type of program. However, there are cases in which diffusion of the new product is aimed at from the very start of the procurement process. This difference reflects the distinction between PPI carried out mainly for the missions or needs of the procuring agency and PPI to support economy-wide innovation. Be that as it may, innovation is needed in all PPI before delivery can take place. In contrast to PPI, *regular procurement* occurs when public agencies buy ready-made products such as pens and paper "off-the-shelf", where no innovation is involved. Only the price and quality of the (existing) product are taken into consideration when the supplier is selected.

We will now present a taxonomy of different phenomena that are, or should be, labeled PPI or innovation procurement (Edler, 2009; Edquist et al., 2000a; Hommen and Rolfstam, 2009; Uyarra and Flanagan, 2010). The taxonomy will be used to classify the cases presented later. The first dimension refers to whom the *user* of the resulting product (good, service, system, etc.) is, which we can then use to identify two different categories of PPI: Direct and Catalytic.

- *Direct PPI* is when the procuring organization is also the end-user of the product resulting from the procurement. The buying agency simply uses its own demand or need to influence or induce innovation; this type of PPI includes the procurement undertaken to meet the ('mission') needs of the public agencies themselves. However the resulting product is often also diffused to other users. Hence, innovations resulting from PPI can be useful for the performing agencies, as well as for society as a whole.
- *Catalytic PPI* is when the procuring agency serves as a catalyst, coordinator and technical resource for the benefit of end-users. The needs are located 'outside' the public agency acting as the 'buyer'. Hence, the public agency aims to procure new products on behalf of other actors. It acts to catalyze the development of innovations for broader public use and not for directly supporting the mission of the agency.

The second dimension refers to the character of the result of the procurement process, i.e. the character of the innovation (if any) embedded in the resulting product, according to which three types may be distinguished: Pre-commercial, Adaptive and Developmental procurement.

- *Pre-commercial procurement (PCP)* refers to the procurement of (expected) research results and is a matter of direct public R&D investments, but no actual product development. Moreover, it does not involve the purchase of a (non-existing) product, and no buyer of such a product is therefore involved. This type of procurement may

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development cost is brought about through the product price mechanism and cannot be regarded as direct public R&D funding.

also be labeled "contract" research, and may include development of a product prototype.

- *Adaptive PPI* is when the product or system procured is incremental and new only to the country (or region) of procurement. Hence, innovation is required in order to adapt the product to specific national or local conditions. It may also be labeled 'diffusion oriented' or 'absorption oriented' PPI.
- *Developmental PPI* implies that completely new-to-the-world products and/or systems are created as a result of the procurement process. It can be regarded as 'creation oriented' PPI and involves radical innovation.

Let us initially focus on the first of these types of procurement. A recent communication from the European Commission addresses the concept of PCP, which concerns the acquisition of expected research results, i.e. an R&D phase that may precede commercialization (European Commission, 2008, p. 6). However, the commercial development of new products is not part of the PCP as such (see Art 16f of 2004/18/EC). Accordingly, no actual product development and no buyer of such a product are involved in PCP. The product prototype that may result, may be possible to commercialize or not. It is a matter of R&D funding; i.e. it is a *supply*-side policy instrument in relation to innovation. Hence PCP is something very different from PPI, which is a dedicated *demand*-side policy instrument in relation to innovation. Therefore, PCP cannot be considered as PPI in our sense of this term, since PPI largely includes instruments other than public R&D funding. PPI and PCP may thus supplement each other as parts of a policy-mix, but they should not be mixed up. A PCP may be an important preparation and specification phase before a PPI process is started.

Table 1 classifies the six cases to be presented in the next two sections by using the previous concepts. As the reader will know, direct PPI has historically been a much more commonly used instrument than catalytic PPI. We believe that this can be seen as an indication that catalytic PPI is an underused innovation policy instrument. Hence, we would like to open up for a much wider use of this instrument in order to contribute to the mitigation of various grand challenges.

Table 1: Overall summary of cases

Character of the Procurement Process / User	Adaptive Procurement	Developmental Procurement
Direct Procurement	X2000 (Case 1) NødNett Norge (Case 5)	AXE Telephone Switch (Case 2) ADS-B (Case 6)

Catalytic Procurement	Light corridors (Case 3) Swedish refrigerator (Case 4)	[4]

In addition, it is important to add a third dimension to the classification, i.e. the fact that PPI can be performed in a more or less cooperative and interactive way. All the five categories discussed above may be more or less cooperative. Cooperation implies that the (public) procurer and the potential (private) supplier(s) communicate and/or collaborate for the purpose of learning in the procurement process, sometimes over a long period of time. By definition and by design, there is always some cooperation between procurers and (potential) suppliers in PPI. Cooperation between the procurer and the (potential) supplier may concern the whole process of procurement, but can also apply to only one or more of the stages it consists of (see below). Such cooperation is obviously related to the degree of competition between potential suppliers. Cooperation is a matter of degrees, not a dichotomous variable. As we know, interactive learning is a key dimension of innovation (see Section 2) and – even more – of PPI, as the cases addressed illustrate.

The typical PPI process can be divided into the following stages (adapted from Edler et al., 2005; Expert Group Report, 2005):

1. Identification of a grand challenge (or a public agency/mission need), and its formulation in terms of a lack of satisfaction of a human need or an unsolved societal problem.

2. Translation of the identified challenge into functional specifications.

3. Tendering process:

    a) Opening of the bidding process through a tender.

    b) Translation of the functional specification into technical specifications by potential suppliers.

    c) Submission of formal bids by potential suppliers.

4. Assessment of tenders and awarding of contracts.

5. Delivery process:

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[4] The fact that we could not find any cases for this box is significant, which relates to the statement we have made on the underutilization to date and the future potential of catalytic procurement.

a) Product development.

b) Production of the product.

c) Final delivery to the purchasing agency.

This general structure does not imply by any means that the PPI process is of a linear nature. As we will see in the six cases below, these general steps are very much interrelated and intertwined.

4. Summary of case descriptions

The cases emanate from three countries, although Sweden dominates with four well-documented cases. The other two cases represent Norway and the USA, and are of more recent origin. The bias towards Sweden is explained by its long history with regard to innovation procurement (Edquist et al., 2000a). However, the Swedish extensive tradition does not imply that many new PPI initiatives have been undertaken since the end of the 1990s. The lack of examples thus represents the momentum that PPI policies have lost during the last couple of decades. However, this situation appears to be changing (see Section 1).

The methodological approach followed is exploratory. Information about each case has been complied by accessing relevant documents such as tender calls, scientific literature, policy documents and evaluations and other written materials and reports.

Table 2 provides a detailed summary of the six cases described according to the following dimensions:

1. PPI process
    a. Challenge/need: illustrates the point of departure of the policy. What was the challenge/problem/unsatisfied need? Was it carried out to meet the (mission) needs of the public agency?
    b. Result of the procurement process: describes whether a product (material good or intangible service) or system was the intended result in order to mitigate the challenge.[5]
    c. Degree of cooperation and type of call: Was there an open call where potential suppliers could "bid" in competition or was the call restricted to selected suppliers? This dimension also captures the degree to which the procurer cooperated with the supplier(s) during (some stages of) the PPI process.
    d. Type of PPI: as specified in Section 3 (Table 1).

[5] Cases where R&D results were the intended output, e.g. cases of Pre-Competitive Procurement (PCP), were excluded from this article. We will address PCP in a later article (Edquist and Zabala-Iturriagagoitia, forthcoming).

    e. Other intended consequences that the results had on the identified challenge/need/problem.
    f. Other unintended consequences of the policy (e.g. regarding profits, exports, etc.).
    g. Type of subsidy (incentive): shows how the PPI process was funded, promising the purchase of a future order, offering economic rewards, etc.
    h. Policy-mix: illustrates whether other supplementary policy instruments were also used as a complement to the PPI process.
2. Procurer
    a. Who was the procurer: identifies the organization acting as a procurer of the intended result.
    b. Functional/Technical specifications: illustrates whether the procurer had developed functional or technical specifications, or both, prior to launching the PPI process. How did the procurer develop the specifications?
    c. End-user: identifies who was the end-user of the (intended) result of the PPI.
3. Supplier
    a. Who was the supplier: identifies the organization/firm acting as the supplier of the intended result.
    b. Award criteria: defines the criteria by which the supplier was awarded the contract.

Following the previous dimensions, Section 5 contains more thorough descriptions for each of the six cases.

Table 2: Detailed summary of case descriptions

	1. PPI process							
	A. Challenge/ Need	B. Results	C. Cooperation and type of call- Consultation / dialogue / partnerships	D. Type of procurement	E. Intended consequences	F. Unintended consequences	G. Type of subsidy	H. Policy-mix
1. X2000	Human mobility as a challenge Faster and reliable passenger transport on existing tracks	High Speed Train (rapid passenger traffic)	Open Call Continuous dialogue, “development partners”	Direct Adaptive Cooperative	Reduced journey times Industrial development Reduced infrastructure costs	Delay Lack of exports Innovation in some components Knowledge transfer	-	Industrial Policy Innovation Policy Legislation
2.AXE Telephone Switch	Communication as a challenge Introduce new services for subscribers Improvements in efficiency, capacity and maintenance costs	Construction and development of equipment for electronic switching	Closed call (fixed switch) Continuous dialogue of the 3 parties during the entire process Exchange of employees	Direct Developmental Cooperative	Computerized switching technology stations Change from electro-mechanic to electronic technologies Exports (40% of world market)	National digital coverage Low telephone fees Adaptability to mobile telephony	Procurement contract (including R&D funding)	Industrial policy Joint R&D (public-private) funding
3.Light corridor	Energy efficiency as a challenge Stimulate the development of energy-efficient products Make the results marketable	Stimulate the market Improve the efficiency of lighting	Restricted call (light corridor) Open call (HF ballasts) Pre-procurement discussions Dialogue with largest Swedish manufacturers Agreements with several organizations	Catalytic Adaptive Cooperative (in early stages)	Introduction of more efficient technology Development of requirements for lighting power density	Use of Life-cycle cost estimation Development of testing methods Standard setting	Subsidy per kWh saved	Energy policy Fiscal instruments Regulations Financial instruments
4.Swedish refrigerator	Energy efficiency as a challenge Produce market transformations toward more energy-efficient technologies	Reduce energy consumption and environmental impact of refrigerators/ freezers	Open call Consultation with experts and key purchasers	Catalytic Adaptive Cooperative (in early stages)	Efficiency improvements Energy-efficient labeling Products sold after STPP	Growing market share Exports Energy savings Follow-up by other manufacturers Adaptation to other kitchen appliances	Subsidized purchase STPP covered a portion of the buyers´ cost	Energy policy Innovation policy Industrial policy
5. NødNett Norge	Security as a challenge but also mission-oriented Coordinate independent analogue mobile radio networks Enable interdepartmental communication	Development of a digital mobile radio system	Open call Continuous dialogue and cooperation during the pre-procurement and procurement phases	Direct Adaptive Cooperative	Single nationwide digital radio system Cost savings Technical improvements Efficiency gains Higher security	Employment creation Potential commercialization to other countries	Investments granted in the national budget	R&D policy Defense
6. ADS-B	Security as a major challenge but also	Constant broadcast of the precise	Open call Continuous dialogue -	Direct Developmental	Replace ground-based radar systems	Improve accuracy, integrity and	Cost-plus incentive fee	Defense policy

	mission-oriented Transform air traffic control systems from a radar-based system to a satellite-based one	location of all aircraft to/from other aircraft and traffic controllers	before, during and after the bidding process, with industry representatives, service providers and experts		for air-traffic control Lower Cost Full airspace coverage Improved safety	reliability of satellite signals Reduce separation between aircraft	in phase 1 Fixed-price arrangement in phase 2	

Table 2: Detailed summary of case descriptions (cont.)

	2. Procurer			3. Supplier	
	A. Who was the procurer	B. Functional/Technical specifications	C. End-user	A. Who was the supplier	B. Award criteria
1. X2000	SJ, Swedish State Railway Company	Functional and technical requirements	SJ	ASEA (now wholly owned by Daimler-Chrysler)	Trust Long-term costs
2.AXE Telephone Switch	Swedish Telecommunications Administration - Televerket	Functional	Televerket in Sweden and foreign telephone operators	Ellemtel (jointly owned by STA and LM Ericsson)	Joint-venture between procurer and supplier
3.Light corridor	NUTEK Swedish Council for Building Research	Functional Technical	Energy utilities and real estate companies (as energy providers)	13 large Swedish real estate management companies and owners of public and commercial buildings Helvar Oy (Finland)	Ease of arranging the funding of their own share of costs (light corridor) Technical expertise (HF ballasts)
4.Swedish refrigerator	Purchaser group: HBV, NUTEK, etc.	Functional 40-50% more efficient than existing products on the market 1.0-0.9 kWh/liter	Individuals	Electrolux AB	Price Use of standard and established technology
5. NødNett Norge	Norwegian Ministry of Justice and the Police (in cooperation with other national organizations)	Functional	Several public organizations (mostly related to Fire, Police and Health brigades)	Siemens Norway	Price Requirements
6. ADS-B	Federal Aviation Administration (FAA)	Performance-based	FAA UPS (outcome)	ITT Corp.	Best value and least risk in the implementation

5. Detailed case study descriptions[6]

5.1. X2000 High Speed Train

The first case deals with the procurement of the X2000 high-speed train in Sweden (Edquist et al., 2000b), one where the only existing user, the Swedish State Railway Company (SJ), represented the final demand for the trains. Hence, it constitutes a case of direct procurement which faced human mobility as a major social need. The entire process of bidding was open to foreign firms, through several rounds occurring between the first tender request in 1982 and the final contract negotiation in 1986.

One of the most notable aspects of the X2000 procurement was the length of time required for its completion. An insufficient level of competence on the procurer´s side was one of the primary reasons for this slow process. A technical requirement demanded by SJ at the time was that of a "single-locomotive, tiltable train" (Edquist et al., 2000b, p. 86). The problem of defining (realistic) requirements took some years and it was finally solved in 1985 when SJ sent out a supplementary request for a second round of tenders. ASEA (later AD Tranz, now wholly owned by Daimler) was then awarded the contract in summer 1986 as a "development partner". Development partner is here understood as the blending that allows the involved actors (purchaser and supplier) to develop a high level of competence through interactive learning (Fridlund, 2000, p. 147). Accordingly, we may also deem this case a cooperative procurement process.

The requirement that it had to be locomotive-drawn not only resulted in the X2000 losing the international technological competition; it also made success in export markets impossible, and it did not become the dominant design. In the competing Italian Pendolino,[7] every wagon had its own engine, while X2000 necessarily had to consist of one single locomotive and a fixed number of wagons. This made Pendolino much more flexible in terms of demand requirements and maintenance, reflecting the lack of competence of SJ as a procurer at the time, and the devastating influence that having too specific and strong technical requirements (instead of only functional ones) can have on innovation outputs.

The X2000 resulted in significant improvements to the infrastructure and thereby conditions for economic growth. These included increased commercial profitability for SJ, reduced infrastructure costs for building traffic routes, lower energy consumption costs from decreased use of automobiles, shorter travel times and reduction of accidents and pollution due to highway traffic.

[6] A considerably longer version of this article, where the case descriptions are much more detailed, is available as Edquist and Zabala-Iturriagagoitia (2012).

[7] The Pendolino had already been developed and came into full operation in 1976 (Giuntini, 1993), so Swedish public procurers should have been aware of this technical development by the time the X2000 procurement process started officially in 1982, even if the whole discussion of developing a high speed train in Sweden started in 1969.

The procurement of the X2000 can thus be regarded as a case of adaptive public procurement; it was not the first high speed train to be developed, nor has it come to be widely used outside Sweden.[8] In fact it did not result in any radical change in the speed or direction of technical change, as most of the elements in the train system had existed previously and a high-speed train with similar functions (the Italian Pendolino) had appeared well before. Thus, the procurement was not that successful from an innovation policy point of view. Nonetheless, the X2000 case can be deemed to have had limited success in terms of industrial policy.

5.2. AXE Switching Technology

The second case concerns the procurement of the AXE telephone switch (Fridlund, 2000), where the Swedish Telecommunications Administration (STA) as a user - also known as Televerket (nowadays Telia Inc.), and the private manufacturer LM Ericsson (LME, today Ericsson) as a producer were the main actors involved. The goal was the creation of a computerized switching telephone network that would meet the social demands related to communication needs. AXE was developed by the semi-public company Ellemtel, which was jointly owned by Televerket and LME.[9] Consequently, we can talk about a procurement process that was cooperative to a very large degree, in which a separate joint organization was created as a result of a public-private partnership, without a previous bidding process, in order to deal with the challenge.

The first stage of the PPI process focused mainly on developing functional specifications, with Ellemtel assessing the proposals Televerket and LME had elaborated in terms of potential computerized switching systems. The main problem of the AXE project was to come up with a solution to meet the demands of both Ellemtel's shareholders. While Telerveket was interested in a switch to fulfill the needs of the Swedish telephone system, LME was export oriented and required a switch fitting as many systems as possible. Ellemtel finished the study by proposing two versions of a switching technology: one for local switches and up to 20000 subscribers (for the domestic market), and one for larger switches (foreign markets).[10] The functional requirements to be met by the AXE system were agreed upon by the three parties in 1972.

The next stage in the PPI process implied the development/production of the new switching technology. Coordinating committees, product and function committees, including expert groups and steering committees, had members from all levels in the three organizations. This involved an important mobility of employees among the three partners, which facilitated the transfer of

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[8] Despite SJ's belief there could be an enormous export opportunity for the high speed train (e.g. Norway, Finland, Germany, Austria, France, Portugal, China, Australia, USA), only one train set was sold to China. Between 1998 and 2010, a trainset called Xinshisu 新时速 was in traffic between Hong Kong, Shenzhen and Guangzhou.

[9] The contract creating Ellemtel was signed in 1970 with the objective of developing strategic telecommunications technologies in general and the AXE electronic switch in particular. The procurement contract stated that the major advantages of the new telecommunication technology (the societal needs it had to meet) were, in addition to increasing operational reliability and reducing maintenance costs, the adaptation of the new switches to the varying conditions and the provision of new services to customers.

[10] For a complete list of the functional requirements agreed on, see Fridlund (2000, p. 157), Vedin (1982, p. 138) and Meurling and Jeans (1995, p. 38).

knowledge among them. We can thus say that this procurement case included all the three stages that a cooperative procurement policy should have: consultation, demonstration and coordination (Gavras et al., 2005). The first test of the AXE technology was carried out in 1976 in a Televerket switching station in Södertälje, which had 3000 subscribers and was regarded as a suitable first trial for the new technology.

The next steps were oriented towards increasing the scale of operation of the stations and selling the AXE system in foreign markets. As was noted above, LME viewed exports as an intended and desirable consequence of this PPI. During the following years, Televerket received orders for 10 new AXE stations in Sweden (up to 240000 subscriber lines), which were manufactured by LME after knowledge had been transferred from Ellemtel to LME. This made Sweden the first country in the world to offer national digital coverage which also led to lower telephone fees. At about the same time, LME received requests for new stations in Finland, France, Denmark, Mexico, Brazil, Australia and Saudi-Arabia, which gave LME a share of 40% of the world market in 1992.[11] Accordingly, we may conclude that the AXE case was certainly a direct and developmental PPI, as a new-to-the-world digital switch was introduced in the market and directly purchased by Televerket.

5.3. Light corridor

In 1988 the Swedish Government decided to establish a new energy-efficiency program which included a sub-program for technology procurement, managed by the Department of Energy Efficiency at NUTEK (Swedish National Board for Industrial and Technical Development).[12] One of these projects for increasing energy-efficiency was the light corridor project, initiated jointly by NUTEK and the Swedish Council for Building Research (BFR). Since NUTEK initiated this project on behalf of private companies included in the BFR, this can be categorized as a catalytic case.

The objectives of the program were to stimulate the development of energy-efficient products, systems and processes, to demonstrate their function, to stimulate market penetration and to commercialize the results in residential and commercial buildings and in industry (Stillesjö, 1993, p. 219; Suvilehto and Öfverholm, 1998).

The project started with the appointment of a reference group that included representatives from the authorities, users, consumers, real estate owners and managers, energy utilities, lighting manufacturers, scientists and lighting consultants to discuss strategies for achieving more

[11] Most of these buyers were also public agencies, so they also constitute new cases of innovation procurement – of an adaptive kind.

[12] In 1988, the Department of Energy Efficiency was located at STEV (the Swedish National Energy Administration). In 1991, STEV and three other governmental departments were merged into NUTEK. As of January 1st 1998, NUTEK´s activities in the energy field were taken over by the Swedish National Energy Administration.

efficient use of electricity in buildings. As a result, the functional specifications for lighting systems were published in order to guide bids.

In order to spread the previous specifications so that efficiency gains (i.e. savings) would be as large as possible, NUTEK invited the largest energy utilities and real estate companies to sign an agreement to participate in the procurement program.[13] NUTEK funded the initiative through entering into agreements with BFR and providing it with financial incentives to stimulate the purchase of more efficient equipment (Stillesjö, 1993). Agreements were signed with thirteen of Sweden's largest real estate management companies and owners of public and commercial buildings (representing 30% of the total floor space of such buildings). The participants' involvement was governed, among others, by the following clauses (Stillesjö, 1993, p. 221):

a) participants will receive an investment bonus of SEK 1.5 for every kWh of electricity per year saved compared to conventional design, up to a ceiling of SEK 2.5 million;
b) participants will try to meet the minimum efficiency standard of 10 W/m^2 in new or retrofit lighting design;
c) if participants are successful and implement the new standards throughout their whole organization, the ceiling may be lifted to SEK 5 million;

In order to get the previous subsidies, the program requirements of 10 and 5 W/m^2 installed had to be met, which was achievable only when High-Frequency (HF) lighting was installed. However, property owners did not show any commitment to invest in HF lighting, partly due to the economic recession in the early 1990s, but also because some uncertainty remained about the durability of the new electronic ballasts in this technology and their high price.

In an attempt to tackle these problems, an invitation for tenders was sent by NUTEK to the major manufacturers of HF-electronic ballasts for fluorescent lighting in the fall 1991. The technical specifications were based on experience from the lighting systems of the previous procurement project. The buyers' group for the HF-ballast procurement program was composed of leading industrial companies whose choices had a strong influence on the market. An expert panel developed the specifications after consultations with manufacturers, customers, and lighting specialists (Suvilehto and Öfverholm, 1998).[14]

The winning manufacturer was Helvar Oy, from Helsinki (Finland). The purchasers' group had guaranteed 20000 and 6000 ballasts intended for 36W and 58W fluorescent tubes, respectively, which represented one third of the annual sales in Sweden, and was about five times greater than the yearly sales of HF-ballasts prior to the procurement (Ottosson and Stillesjö, not dated; Stillesjö, 1993). This first batch saw an enormous increase in the domestic sales of HF-ballasts, which were approximately constant between 1985 and 1991 (Neij and Öfverholm, 2001),

[13] Those who were most active and could most quickly arrange for financing of their own portion of the costs won the agreements (Stillesjö, 1993, p. 220).

[14] Since communication and consultation among different actors existed to a certain extent (mostly in requirement setting), we can talk about a cooperative PPI during the early phases of the process.

causing their price to drop by approximately 25% from 1992 to 1995. Two years later, Helvar produced more than 400000 ballasts for the Swedish market alone, which was 80% of the total market in Sweden, and 6 years after the completion of the project, Helvar started to export the product to several European countries (Sylvest, 2008, p. 60)

Summing up, we can conclude that the lighting program led to two complementary procurement initiatives; the first establishing new standards and the second fostering the development of new products. The procurement process was combined with several co-ordinated support activities, such as educational programmes in cooperation with the electrical installer's association or concurrent demonstration projects, which illustrates that PPI is another instrument in a wider policy-mix.

5.4. Swedish refrigerator procurement

In 1988, the Swedish Government launched the Swedish Technology Procurement Program (STPP) to exploit Sweden's potential for energy-efficiency and to counter increases in electricity use where this could be done cost effectively. The STPP aimed to reduce national demand for electricity by 10 TWh by the year 2000. This implied replacing 15% of the 60-70 TWh that Sweden was generating with nuclear power by a more efficient use of electricity (Lewald and Bowie, 1993, p. 82). Of the several energy-efficient technologies supported to fulfill this target (Neij, 2001), this case focuses on energy-efficient refrigerators.

Refrigerators/freezers consume 30% of residential appliance consumption. The market for refrigerator/freezers in Sweden is divided equally between the managed rental properties and the private sector (Lewald and Bowie, 1993). Husbyggnadsvaror (HBV)[15], which purchased appliances for a large portion of the publicly owned multi-family housing in Sweden, formed, along with NUTEK, the purchaser group which included representatives from the energy supply authorities, Hyresgästernas Sparkasse och Byggnadsförening (HSB, the association of housing cooperatives), Skandia (an insurance and real estate company), the Swedish National Board for Consumer Policies, and the Swedish National Energy Administration (The results center, not dated, p. 8).[16] Thus, the public sector facilitated the PPI process, not as a buyer but as a catalyzer. Experts provided by the STPP, together with organizations included in this purchaser group, set as a major goal the development of a product which was 40-50% more efficient than existing products on the market (The results center, not dated; Westling, 1991).[17]

[15] HBV is a business association of building enterprises whose members are mainly Swedish municipal housing companies. The association was founded in 1952 and has approximately 310 members who together own and manage approximately 900000 apartments.

[16] The dialogue among the partners integrating the purchaser group took place mostly during the requirement setting stages, so this phase can be regarded as cooperative. However, we cannot conclude that the whole case constitutes a cooperative practice.

[17] A level was set at 1.0kWh/liter/year and another at 0.9 Kwh/liter/year (Lewald and Bowie, 1993, p. 85).

The average electrical consumption of all brands of new refrigerator/freezers in Sweden was 1.4 kWh/l/year, and of these the most efficient on the market used 1.2 kWh/l/year before the procurement program. It was estimated that the average consumption of refrigerator/freezers already installed and operating in Swedish households was higher than 2.0 kWh/l/year (The results center, not dated, p. 8).

A request for proposals was circulated internationally, followed by a declaration from the purchaser group guaranteeing the acquisition of 500 units for rental properties and the commitment to continue buying the product. The first purchase, subsidized by the STPP, covered a portion of the buyers´ cost. Manufacturers who met the required technical specifications of the purchaser group, but were not finally selected, were to be awarded 100000 SEK (The results center, not dated, p. 9).

Five manufacturers submitted proposals of which three were accepted for evaluation in June 1990. A Danish consortium, viz. Gram and Osby/AEG presented proposals that met the efficiency requirements, but both companies were unable to improve the environmental aspects of their current technologies. The winning company, Electrolux AB, had two proposals, one with an efficiency of 0.79 kWh/liter/ year and another with 0.53 (Lewald and Bowie, 1993, p. 85). The purchaser group selected the first design due to its price and the use of more standard and established technology (The results center, not dated, p. 9).

In December 1990 a prototype called the TR 1060-LE was tested and by September 1991 it was available on the market. The prototype used conventional technology and was 33% more efficient than the most efficient model available, 44% more efficient than the most popular model, and 60% more efficient than the average model in use in Swedish households (The results center, not dated, p. 9). Not only did the purchaser group's order amount finally to 632 units, but 3350 Electrolux TR 1066s were also sold between 1991 and 1994, highlighting the immediate impact the original purchase created in the domestic market. Exports to Germany also started with this increasing market. Furthermore, the market share for efficient refrigerator/freezers increased from less than 1% to 5% in a few years. Cumulative savings through 1994 for the Electrolux model alone were more than 1 GWh, and NUTEK estimated that annual savings from all of its market transformation initiatives could be 1 TWh by 2010, all at a cost to NUTEK of significantly less than half a million dollars (The results center, not dated, p. 1).

5.5. Public Safety Radio Network – NødNett Norge

This case deals with the procurement of a shared digital mobile radio system (safety network) for emergency and alert situations in Norway. The project was based on the need for a digital radio network that coordinates the independent analogue mobile radio communication networks in use by organizations such as the fire departments, health services, police forces and other emergency services. It was a cooperative mission-oriented procurement initiative to meet the needs of a set of public agencies, all concerned with public safety and security. The Norwegian Ministry of Justice and the Police were appointed as the main purchasing bodies.[18]

Before the procurement process itself started (Hommen and Rolfstam, 2005), a pre-procurement phase took place from 1995 to 2004, and three distinct activities were carried out during this period: a pre-study in 1995-1996, a feasibility study in 1998-2001 and a pilot study in 2000-2004. It was concluded that the radio systems of the fire departments, the police and the health sector (i.e. Public Safety Agencies) no longer met the requirements for functional and reliable communications. Cooperation and interactive learning among them to consider the possibility of a future shared radio system was recommended.[19] The three agencies combined their demand and the European TETRA standard (TErrestrial Trunked RAdio) was selected as the preferred technology for the digital network. Several Schengen countries had already implemented the technology, so Norway could also benefit from previous experiences in the field, implying that the project may be regarded as adaptive (Hommen, 2005). During the pilot study, an experimental installation was approved and located in the Trondheim area in July 2000, integrating the TETRA network with existing radio and telephone networks used by the Public Safety Agencies.[20] The system became operational in June 2003.

The procurement process itself began on November 5th 2004, when the Norwegian Government presented a NOK 3.6 billion project for establishing a nationwide digital radio network for the fire department, the police and the health services (Directorate for Emergency Communication, 2004). The Ministry of Justice invited potential suppliers to bid for a nation-wide system, and to sign a contract for the first roll-out phase covering 54 municipalities in the Norwegian south-east. The process was financed entirely by investments granted in the national budget and the Government would become the owner of all the required equipment for the system. The main users would belong to fire, police and health departments, including other emergency preparedness organizations such as defense, customs, prisons and some Non-Governmental Organizations.

The specification for the public safety radio network was technologically neutral; in other words, the specifications only described how the radio network should function from an end-user perspective (i.e. functional requirements). However, the functional requirements of the agencies were too detailed. In fact, there were over 4000 demands as to how the system should operate, which left limited interpretation space for the potential suppliers (Sylvest, 2008).

A call for tenders was issued in December 2005, and five proposals were received, three including radio networks and control rooms, and two tenders only for control rooms. After the

[18] They did, however, actively collaborate with a number of other agents such as the Defence Logistics Organisation, Sor-Trondelag Police district, the fire departments of Trondheim, Klaebu, Malvik and Melhus, St. Olav’s Hospital and Telenor (Lyngstøl, 2004).

[19] http://www.dinkom.no/default.asp?pubid=620&sub=34&pub=1&labb=no

[20] http://www.dinkom.no/FILES/Trondheim_Pilot_engelsk.pdf

evaluation of the proposals and the subsequent negotiation with the prioritized candidates, the selection of the supplier was announced in 2006. The chosen provider was Siemens Networks Norway AS, with price being one of the most important selection criteria (Sylvest, 2008).[21] The contract between the parties was signed in March 2007.

The development of the coverage and implementation of the system was carried out in two stages. In the first one, the Eastern part of Norway, including Oslo and surroundings would be integrated, while in the second stage the rest of the country would also be included (Directorate for Emergency Communication, 2007). The project also aspired to sell this publicly owned safety radio concept to other European countries. In 2007, Denmark was also involved in the development of a public safety network based on the TETRA-technology (SINE – Sikkerheds NEttet), which was supplied and operated by Dansk Beredskabskommunikation (a Danish communications service provider). The project yielded other positive impacts for Norway in the areas of employment, efficiency and public safety.

5.6. Automatic Dependent Surveillance-Broadcast program (ADS-B)

This last case illustrates an example of direct and developmental procurement in the US. The Federal Aviation Administration (FAA) oversaw an effortto develop an Automatic Dependent Surveillance-Broadcast (ADS-B) system that would eventually replace existing ground-based radars (Vonortas et al., 2011, p. 36). This case brings to the fore another example in which direct PPI can be used to cover agency mission-needs, in this case related to public safety and transportation efficiency. The ADS-B system will allow aircraft to constantly broadcast their position, which improves the security of pilots and the accuracy and reliability of the information received by air traffic controllers. The FAA purchased the system developed as a result of the PPI process, which did not exist before (developmental), and started using it in several key air traffic control facilities.

The FAA went through a multi-stage contracting process to select the final supplier. Numerous "Industry Days" took place, which allowed interested businesses to present their thoughts and ideas on the system. Their contributions influenced the definition of the requirements to be met by the system. The specifications for the ADS-B were based on performance criteria, in order to grant greater flexibility to potential suppliers. This performance specification allowed potential suppliers to present designs, manufacture, test, and deliver equipment to the FAA without any major limitations, while increasing competition by creating the conditions for innovative ideas to come to the forefront.

The FAA issued a screening information request in November 2006, which allowed bidders to submit their proposals. Three vendors (ITT Corp., Lockheed Martin and Raytheon) were

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[21] Although the TETRA-based system offered by Siemens Networks Norway AS was preferred, one of the suppliers (EADS Secure Networks OY) presented an alternative solution, based on a different technology (Tetrapol), to meet these demands.

preliminarily chosen. During the entire process, FAA remained in direct communication with the vendors and the industry, hence there was some cooperation. The agency issued a request for offers in March 2007, officially asking the three companies to submit their proposals for the provision of ADS-B services. A team of experts in technical, business, and cost areas evaluated each proposal. Finally, in August 2007 the FAA awarded the contract to the team headed by ITT Corp. as it combined the least risk and best prospects for a successful implementation. The nationwide ADS-B ground infrastructure was expected to be completed by 2013, and the FAA has already issued the ADS-B Out mandate by which aircraft broadcast will need to be ADS-B equipped by 2020.[22]

The ADS-B was implemented in two segments[23]: (i) establishment of ground infrastructure in key sites (Gulf of Mexico, Louisville, Philadelphia, South Florida); and (ii) development of the equipment needed to deploy ADS-B nationwide. Segment 1 was contracted under a cost-plus incentive fee agreement in which the FAA covered the cost of any additional requirements. Segment 2 was contracted under a fixed-price arrangement in which ITT covered the cost of deploying enough radios to meet requirements. The procurement contract established that ITT had to install and maintain the ground-station equipment, while the FAA had to pay for the surveillance and broadcast services and the subscription charges for ADS-B broadcasts transmitted to adequately equipped aircraft and air traffic control facilities.

According to the FAA, ADS-B provides greater coverage, since its ground stations are easier to place than radar-based ones. Additionally, ADS-B results in more direct routings and optimized departures and approaches, which will increase capacity and save time and fuel (McCallie et al., 2011). ADS-B has since become one of the key technologies in the FAA´s plan to transform air traffic control. United Parcel Service (UPS), seeing the benefits, contacted the FAA to test the ADS-B technology in trials at its hub in Louisville, Kentucky. The FAA approved the proposal, so UPS equipped approximately 100 of its aircraft with the ADS-B, knowing that it will recoup its investment by saving time and money.[24]

6. Conclusions and policy implications

Using Public Procurement for Innovation (PPI) is to a large extent a matter of identifying human needs and societal problems that are not solved at the present time. These problems are often related to "grand challenges" where costs are very large. Addressing a "whole" grand challenge by a single instrument is normally impossible. Therefore, making the mitigation of those grand challenges manageable requires them to be reflected in more delimited policies. The cases

[22] http://www.faa.gov/nextgen/media/ng2011_implementation_plan.pdf

[23] For a more detailed schedule and the planning for the full operation of the ADS-B system nationwide see: http://www.oig.dot.gov/sites/dot/files/pdfdocs/ADS-B_Testimony.pdf
http://www.oig.dot.gov/sites/dot/files/ADS-B_Oct%202010.pdf

[24] http://www.faa.gov/news/fact_sheets/news_story.cfm?newsid=7131

included here are just a few examples of how these grand challenges can be translated into demand-driven policies, and how PPI policies can partially help to mitigate them.

In this article we have defined PPI, shown the main stages in which PPI occurs, introduced a classification of different types of PPI and illustrated them with six cases. We now present the conclusions and policy implications emanating from the case studies in combination with the conceptual framework.

6.1. Different kinds of PPI

PPI is a demand-side policy instrument influencing innovation. It has been defined as the process by which public organizations place an order for the fulfillment of certain functions by a new product (good, service, system) that does not yet exist, and whose development and diffusion will influence the direction and rate of technological change and other innovation processes. PPI is divided into four categories: Direct, Catalytic, Adaptive and Developmental.

The simple and classical example is *direct PPI*. Starting from a challenge (problem/need), the procurer specifies the functional requirements of a non-existing product, the procurement process is performed, the product delivered and finally used and diffused by the procurer. In this type of PPI the procurer uses its own demand to trigger innovation through PPI. These examples are often related to infrastructure development (e.g. Case 1, Case 2, Case 5) or to support the missions of the public agencies themselves (Case 6).[25]

Catalytic PPI occurs when the procuring agency is not the final user of the resulting product. This is a very important difference as compared to direct PPI. The public agency identifies the challenge and then operates as a catalyst “on behalf of” the potential users. This can be seen as a way of supporting “infant” products or industries (e.g. Cases 3 and 4). In all these cases, public agencies appear as the buyer, but the real market penetration is achieved by subsequent private demand (Edler and Georghiou, 2007).

From a policy point of view, catalytic PPI can pave the way for market penetration from two different (but complementary) directions. First, it can be oriented to mitigate those needs that cannot be satisfied/solved by private firms. Private actors involved in the previous two examples (Cases 3 and 4) would not have been capable of developing such initiatives without public subsidies covering the procurement costs. Second, catalytic PPI can transform into effective demand those needs that cannot (easily) be articulated through market exchange signals (supply/demand/price).

We believe that strenuous efforts should be made to further *develop experiences and procedures for using catalytic PPI* extensively as a policy instrument in the context of grand challenges. In

[25] It should not be ignored that besides satisfying human needs and solving societal problems, PPI may substantially contribute (directly or indirectly) to the consolidation and the global success of companies involved as suppliers (e.g. Case 2).

particular, we believe in the potential of this instrument for public bodies such as the European Commission, which is not often the main end-user of new products that may emanate from catalytic PPI. The Commission could still have a great influence on its development and exploitation in other organizations, opening up for the creation of new markets. Such catalytic policies can have a great impact, but they also require additional organizational skills and efforts, since they demand the coordination of public agencies and innovator-suppliers with end-users.

6.2. Problems/needs/effective demand vs. functional and technical specifications

The end-result of a PPI process is the mitigation of a challenge through a new product or system, i.e. an innovation. Nonetheless, the technical characteristics of this product should not be specified by the procurer. Cases show that excessively detailed specifications set by the procuring agency limit the ability and creativity of potential suppliers to provide innovative solutions to the challenge (e.g. Case 1, Case 5).

The procuring organization should only specify the functional requirements or specifications that can satisfy the human needs or solve the societal problems constituting the grand challenge. These requirements should describe the desired performance characteristics of the product the procurer is ready to buy, but should not include any specific, or basic, design of the product. For the procurer it is irrelevant how the product mitigates the challenge. That must be left to the potential suppliers.

The “translation” of needs/problems/challenges into functional requirements requires highly developed competences on the part of the procuring organization. The functional specifications must constitute solutions to the challenges, but at the same time they must be achievable given the state of the art at the time. In the procurement of the Swedish high speed train (Case 1), we described how the lack of experience and flexibility of the procurer led it to demand a locomotive-drawn train. Excessively detailed technical specifications from the procurer (SJ) prevented ASEA/ABB from developing a non-locomotive drawn train system (which FIAT did at about the same time). The more flexible design of the FIAT solution (Pendolino) won the world market. Hence SJ´s technical specification had a devastating influence on the later competitiveness of the Swedish solution. Two products resulting from two different procurement processes trying to fulfill similar functional requirements turned out very different, and one outcompeted the other. Similarly, the requirements for the NødNett public safety radio network (Case 5) were too detailed. Despite the fact that the purchasing bodies had “only” included specifications as to how the system should operate, the more than 4000 demands identified did not leave much scope for originality for potential suppliers. Hence, the main conclusion is that the targets in requirement specifications should not be the products, but the challenges.

In addition, the “translation” of functional requirements into technical specifications requires sophisticated competence, this time on the side of the suppliers. Both “translations” will together determine the future technological and product trajectories of the innovations.

6.3. Interactive learning and regulation: cooperation vs. competition

Both empirical knowledge and innovation theory strongly indicate that interactive learning between organizations is extremely important for innovations to emerge. Those organizations operate on the demand/pull side as well as the supply/push side. Despite the relevance of demand-side organizations (and individual consumers), they have for long been neglected in innovation studies and innovation policy.

Interaction leading to learning is to a large extent the same as communication and cooperation outside the market (demand/supply/price). The procurer may work hand in hand with one company from the start (e.g. Case 1, Case 2, Case 5). If both are competent, it might maximize interactive learning. If this is not the case, it may lead to a failed process of procurement, and at times to inefficiencies and corruption. Moreover, it might also be the case that the parties involved cooperate intimately in some stages of the procurement process (e.g. Cases 3 and 4), but not in others (see stages of PPI processes in Section 3).

The descriptions of the six cases in Section 5, summarized in column 1C in Table 2, include a discussion of the degree and character of cooperation among relevant actors. One conclusion from the cases is that cooperation between procurers and potential suppliers is more common and more productive in the early stages of the PPI process. There is some degree of cooperation in all cases, but only a few were cooperative in all stages of the PPI process. This reflects the fact that cooperation is a matter of degrees, not a dichotomy.

One way to enhance/achieve interactive learning (between organizations) through PPI, may be the organization of "focus groups" - or "task forces"- within certain need/problem/challenge/procurement areas in the early stages of the PPI process. The "industry days" organized in the US (Case 6) clearly show how consultation and dialogue between buyer and supplier can directly influence the requirement setting stages. The focus groups should involve potential users, politicians, policymakers, researchers, firm representatives, etc. Researchers should belong to relevant fields of science and technology, but also come from economics, psychology, political science, etc., while firm representatives should come from different divisions of firms: R&D, marketing, strategic leadership, etc. *Diversity is the key* in such focus groups and research projects. They would be the basis for "new combinations" of knowledge - to refer to the way Schumpeter characterized innovations. We deem this open dialogue scheme as an interesting example of how interaction and mutual learning among purchasing agencies and relevant stakeholders can be at the core of the PPI process. This directly leads us to emphasize cooperation as a key determinant of the development of effective PPI policies.

In procurement processes the issue of cooperation (interactive learning) is closely related to competition between potential suppliers. Obviously, a very tight cooperation between a procurer and a potential supplier excludes competition between suppliers. What are the advantages and disadvantages of each of these in processes of innovation? We believe that cooperation should also be a guiding principle in procurement policies, rather than solely ideas of perfect competition. However, promotion of cooperation alone would not be beneficial for either the procuring agency or the potential supplier. How this balance between cooperation and competition should be struck is an important - and complicated - issue for further analysis. So is the analysis of the stages of PPI in which cooperation is more or less effective.

The EU regulation of public procurement has been an important obstacle to PPI. The procurement rules and their enforcement by the EU and member states have been ideologically charged to some extent. Generally speaking, two ideologies have been counterposed to one another: a 'free market' orientation which "emphasizes the need to exclusively apply commercial criteria when awarding the contract", and an 'interventionist' orientation which "regards public procurement as an instrument to realize social and economic objectives wider than mere efficiency in the use of public money" (Martin 1996, p. 41). It is evident that the EU procurement rules have inhibited collaboration and interaction for innovation in PPI processes for a long time. Policies to maximize competition have been governing the design of the rules to a much larger extent than policies to enhance innovation (e.g. through interactive learning). Stringent competition regulations across the EU have developed into a major obstacle to the use of this instrument (Edquist et al., 2000a). Therefore, ways should be found to get around these rules, and further actions to have them changed should also be taken.

As a response to earlier critiques (e.g. Edquist et al., 2000a), new EU directives concerning procurement regulations some years ago have opened up opportunities for public authorities to purchase innovative solutions. For example, some dialogue was made possible between purchaser and supplier, which is a prerequisite if one side is to understand the other (Edler and Georghiou, 2007, p. 960). Yet another new set of new EU directives was proposed in December 2011. Among others, some of the proposed changes include increasing the flexibility and simplification of the procedures, the possibility to use life-cycle costing as an assessment criteria, the clarification on when cooperation between public bodies is subject to public procurement rules, or the possibility to conduct market consultations prior to the launch of the formal procurement procedure (COM 2011, 896).

The issue of what should be the most appropriate rules to enhance innovation by means of procurement remains to be analyzed. Such an analysis should be based more upon innovation theory than on competition theory, the reason being that cooperation is an important ingredient of PPI processes (as the cases have shown) and in innovation processes in general. Obviously, communication, interactive learning and cooperation should not be prohibited by regulations. On this basis, attempts should be made to further revise EU rules with regard to PPI. This is an important implication of this study for the regulation of PPI.[26] One way to secure this would be

[26] However, we do not focus in any detail upon regulation of public procurement in this article, although it is certainly justified. A detailed investigation of the role of the EU PPI institutions (the rules of the game) would be an

to create separate regulations for regular procurement and for PPI – something which is highly motivated.[27]

6.4. Transforming regular procurement into PPI

We have argued that regular procurement has nothing to do with innovation; that is, it is not an innovation policy instrument. In 2009, 19.4 % of European GDP was public procurement, i.e. the enormous sum of 2.3 trillion Euros. Procurement represents a key source of demand for firms in sectors such as construction, health care, defense material, energy and transport. However, the vast majority of the 2.3 trillion Euros is a matter of regular procurement, i.e. standard products bought off-the-shelf. An interesting issue is whether a part of this regular procurement can be transformed into PPI? In which areas? And how?[28]

The administrators in charge of procurement are often "normal" purchasing managers who are inclined to procure off-the-shelf products. The procurement of existing products should be partly replaced by the procurement of *results* in terms of societal problem solving and needs´ satisfaction. In the short run this might be incompatible with the objectives of various agencies and budget constraints, but in the longer run it might lead to large cost savings. Hence, PPI could make costs go down, as we have seen in the examples of the market-oriented energy-efficiency programs implemented in Sweden. In order to achieve this, it would be important to make the individuals and organizations that are involved in regular procurement more inclined to use their resources for innovative purposes. Further training of purchasing managers in issues related to PPI might be instrumental in this context.

6.5. Policy-mix

As we have seen, PPI is a powerful demand-side innovation policy instrument to meet grand challenges. Nonetheless, grand challenges can also be mitigated through means and instruments other than PPI – alone or in combination with PPI. PPI should be used in combination with other innovation policy instruments, including supply-side ones. There should be a "policy-mix" (Flanagan et al., 2011). Other instruments have not been systematically addressed here and only briefly mentioned in those cases when they have been closely combined with PPI. One of these supplementary instruments is public funding of R&D. Other examples of supplementary instruments to PPI policies include tax incentives, demand-based foresight,

interesting exercise. A comparison of the rules in different countries and regions is called for, e.g. a comparison of the EU, the USA and some Asian countries.

[27] A guiding principle in the creation and revision of procurement rules should be that the rules are analytically based on actual knowledge about the dynamics of procurement processes of different kinds – also other than only regular procurement versus PPI. Conceptual specification should be the basis for designing the legal framework. Different sets of rules for regular procurement and PPI, of course, presupposes that a clear delineation between the two is made – which is not an unsurmountable problem. It is also interesting to note that the Swedish Government Inquiry on Innovation Procurement (Innovationsupphandling 2010) proposed a separate law for Pre-Commercial Procurement (PCP).

[28] An interesting contribution to such an analysis is Valovirta 2012.

development/modification of regulations and norms, standard setting or innovation vouchers to mention a few (Edler, 2009; Flanagan et al., 2011). Which of these are used will depend to a great extent on the specific character of the grand challenge that is addressed. PPI should be part of a policy mix to mitigate Grand Challenges – but the different instruments should not be mixed up.

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