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Rationales of public procurement of innovation: When demand-side instruments address supply-side gaps.

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Abstract

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State-of-the-art: Public procurement of innovation (PPI) has recently gained a renewed impetus and interest in most OECD countries as well as in the academic literature[1]. A number of scholarly typologies of PPI instruments has been elaborated to understand better their nature and impacts.

Research gap: In spite of this renewed interest, no unified framework that would help understanding and justifying their variety has been provided in the academic literature on PPI, and their economic justification is rather weak[2]. Moreover, the broader literature on innovation policy rationales has put a higher emphasis on supply-side instruments to the detriment of demand-side ones such as PPI. Consequently, our overall research question is the following: How could we build an analytical framework unifying the existing literature in terms of economic justification?

Research method: Our research methodology consists in a two-step literature review: a first review of the general literature on innovation policy rationales in order to identify the theoretical justifications of PPI instruments and to

elaborate an analytical framework; second, an analysis of the specific literature on PPI through this analytical framework.

Theoretical arguments: Our first hypothesis is that a comprehensive approach is required for elaborating our analytical framework. We assume that the various sets of failures identified by economic theories to justify public interventions must be complementarily used[3], i.e. we need to consider market failures as well as evolutionary gaps, systemic traps and failures related to the transformation of systems. Our second hypothesis is that some PPI instruments could be considered hybrid and be justified by both supply- and demand-side rationales.

Results: Based on our review of the literature on innovation policy justifications, we elaborate an analytical framework distinguishing two levels of failures on which PPI instruments may act. First, PPI instruments might impact individual producers and users e.g. by improving the innovation capacities of the former and the acceptability of innovations of the latter. At a meso level, PPI instruments could reduce two types of coordination gaps[4]. They may address "deep coordination failure", i.e. the lack of match between demand and supply, by acting simultaneously on both sides of the market. They may also provide the required "experimental space" to foster the coordination of actors on the demand side towards the adoption of novelties, i.e. to solve a "surface coordination failure". This analytical framework highlights a set of demand-side failures not so often considered in the literature on policy rationales, and suggests that a demand-side instrument might also address failures on the supply side. Our framework allows to transversally reconsider the various typologies and case studies in the literature on PPI in terms of rationales, which are a key element in the appropriate design of any policy instrument[5]. The main result of confronting our theoretical framework with the more empirical literature on PPI instruments is to be able to link design concerns to economic and political rationales. We also confirm, from an empirical view point, that some PPI instruments might be hybrid.

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Rationales of public procurement of innovation

When demand-side instruments address supply-side gaps

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Abstract

Public procurement of innovation (PPI) has recently gained a renewed impetus and interest in most OECD countries as well as in the academic literature. A number of scholarly typologies of PPI instruments has been elaborated to understand better their nature and impacts. However, no unified framework that would help understanding and justifying their variety has been provided in the academic literature on PPI, and their economic justification is rather weak. Consequently, our research question is the following: how could an analytical framework unifying the existing literature in terms of economic justification be built? The research methodology consists in a two-step literature survey: first, a comprehensive review of the general literature on innovation policy in order to identify the various theoretical justifications of PPI instruments and to elaborate an analytical framework; second, an analysis of the specific literature on PPI through this analytical framework. Based on the literature survey, the paper considers three groups of rationales for PPI instruments: those respectively on the demand and supply sides, and those relating to traps in users-producers interactions. By combining them, four justification-based categories of PPI instruments and eight subcategories are defined. This framework allows to unify the various typologies in the literature on PPI, and to link design concerns to economic rationales. Moreover, some PPI instruments appear to be hybrid, i.e. justified by both supply- and demand-side rationales

Keywords

Public procurement; Innovation policy; Rationale; Market failure; Evolutionary failure; Systemic failure; Transformational failure.

1. Introduction

Even though the primary objective of public procurement is to provide public administrations with goods and services necessary for performing and delivering public services, governments and other public authorities have been also using their purchasing power to achieve a number of additional economic and social goals. Its specific inclusion into national and regional innovation policy mixes have only recently gained a renewed interest and impetus. In 2011, policies and/or strategies for supporting the procurement of innovative goods and services had been implemented in more than half OECD countries (OECD, 2013, p. 133).

The use of public procurement as an innovation policy instrument is encouraged at the international level. For instance, the OECD highlights its positive impact and sets the objective “to leverage public procurement to foster innovation” in its innovation strategy (OECD, 2010, p. 118). The European Commission is particularly active in the promotion of public procurement of innovation (PPI) as well (Edler & Georghiou, 2007; Rolfstam, 2009; Uyarra, 2012). PPI is identified as an instrument to leverage R&D expenditures to the 3% Barcelona target (European Commission, 2003). A second major step in the rise of public procurement on the European innovation policy agenda is the release of the Aho Group Report (2006), which calls for creating an innovation-friendly environment notably through the use of public procurement.

The academic literature on economics of innovation is increasingly concerned by the heterogeneity of PPI instruments and their impacts on innovation. Considerations for their actual justifications is marginal. Moreover, the academic literature has elaborated a number of typologies defining PPI instruments based on various criteria

such as the degree of maturity and nature of the market, the type of social needs, design issues, users-producers interaction, geographical aspects and contracting modes. However, the literature does not provide a unified framework that would help understanding and justifying the variety of PPI instruments. None of the elaborated typologies has included justification considerations, even though the nature of the rationales for public procurement of innovation is a question that should be raised and carefully addressed by policy-makers prior adopting and implementing related instruments.

The innovation policy toolkit includes a large number of instruments with various impacts (Box, 2009). However, the choice for the inadequate instruments may lead to counterproductive effects. In order to avoid such government failures, policy-makers must carefully consider “the nature of the problem to be solved as well as its causes” (Borrás & Edquist, 2013, p. 1518), and then accordingly choose and design innovation policy instruments. The choice of the most suitable instruments and their design according to the context are key in the successful formulation of innovation policy instruments. Therefore, the weak consideration of rationales for PPI instruments is a gap that must be addressed for the sake of intelligent policy design. In this respect, the research question of this paper is as follows: how could an analytical framework unifying the existing literature in terms of economic justifications be built?

The paper aims to contribute to a better understanding of PPI instruments, of their justifications and their features that directly relate to their rationales by a two-step literature survey. First, a review of the literature on innovation policy will enable to elaborate an analytical framework of rationales for PPI instruments. Due to the objective of policy analysis, this review must be comprehensive, i.e. different theories and concepts of economics of innovation are considered to build the framework. It encompasses the market failure literature as well as the evolutionary theory, the innovation systems approach and the recently developed notion of transformation of systems. These various approaches of innovation policy rationales have generally put a higher emphasis on supply-side instruments to the detriment of demand-side ones such as PPI instruments. However, justifications for the latter are assumed to be possibly found. The analytical framework is subsequently used to analyse the specific literature on PPI instruments, which in turn enables to refine the categories of PPI instruments and whose review aims at linking existing typologies to our rationale-based PPI categories.

We consider that PPI can be justified by three broad categories of failures: demand-side failures, demand-supply interactions traps and supply-side failures. PPI instruments are demand-side innovation policies whose objective is primarily to foster innovation by encouraging their uptake (Edler, 2009). They essentially consist in the purchase or order by a public authority of a novelty to address a need. Procured products and innovation could be new to the whole market or to the sole purchaser. The needs addressed can be those of public purchasers as well as the needs of external users. In line with evolutionary and systemic approaches, PPI instruments are also considered instances of interactions between innovations users and producers. Asymmetries of information between the demand and the supply sides and loose collective learning abilities of both sides could hinder the success of innovation processes. Finally, PPI instruments are justified in some instances by failures on the supply side (i.e. innovation producers). They are able to improve incentives to invest in R&D and capabilities of firms to innovate by acting directly on these firms. Taking account of this last category of failures, the paper questions and explores the possibility of PPI to be a hybrid policy instruments addressing in some cases demand- and supply-side failures. By combining the three sets of failures, four justification-based categories of PPI instruments and eight subcategories are defined. Moreover, attention is paid to make links with typologies previously elaborated in order to provide with a comprehensive approach of PPI instruments instead of an additional typology thereof.

The paper process as follows. Section 2 describes the methodology of the two-step literature survey and its justifications. Each of the three following sections is dedicated to one group of rationales for PPI instruments. Section 3 develops failures on the demand side by distinguishing the different end-users of procured products and services. Section 4 introduces the traps in users-producers interactions that can be solved by PPI instruments. Finally, the fifth section is dedicated to failures related to innovation producers, which may encourage the adoption and implementation of PPI instruments. Eight subcategories of PPI instruments (grouped in four categories) are then elaborated based on these different justifications. Their respective description is provided in section 6. Features of each categories are derived from typologies previously elaborated in the academic literature. Finally, our results are discussed in the conclusive section.

2. Methodology

Prior to searching for the rationales for PPI instruments, the role of academic theories in the justification of public interventions should be briefly explored. Laranja *et al.* define rationales as “more or less formalised models implicitly or explicitly drawing upon academic theories or concepts that could inform policy design, implementation and evaluation” (2008, p. 823). This definition underlines that a link exists between the justification of public interventions and academic theories, but also that this link is not straightforward. Indeed, the formulation of a policy is a complex process shaped by a number of factors and contingencies, which are not restricted to recommendations derived by academics from theories (Laranja *et al.*, 2008). Public policies are adopted and implemented subsequent to the identification of a problem to be solved. And this problem is considered a social construct involving a number of actors, cognitive processes and the translation of this problem in political and administrative terms (Sheppard, 2006). In consequence, policy instruments are seldom the direct translation from a single academic theory. Policy-makers instead cherry-pick various elements in scholarly recommendations, whose theoretical bases are different and rival to some extent in order to justify their intervention.

The role of academic theories should be considered to be in the provision of analytical frameworks for assessing the appropriateness of specific policy instruments according to their objectives and in regard with the economic context in which they are implemented (Guellec, 2001). Therefore, our search for rationales for PPI instruments must not disregard academic theories, but not overestimate their contribution to the overall policy-making process.

Due to this distinction between the rationales directly derived from academic theories and those actually used by policy-makers, our literature survey focusing on the justifications of PPI instruments must be comprehensive. In other words, it must encompass main academic theories providing with rationales for innovation policy: the neo-classical literature complemented by the new growth theory, the evolutionary approach of technological development, the concept of systems of innovation, and the new approach focusing on the transformation of system.

The neo-classical theory assimilates knowledge with information, i.e. a commodity generic, codified, freely accessible and context-independent (Smith, 1996). Because of this nature, it shares characteristics with public goods: it is indivisible, inappropriable and uncertain. In a free market, these public-good attributes “create a negative gap between private and social returns to R&D and hence reduce the incentive for firms to invest in R&D” (Montmartin & Massard, 2014). This gap prevents from reaching a social optimum and is thus referred to as “market failure”. The general neo-classical literature has generally considered that this failure to achieve an optimal resources allocation (Arrow, 1962) translates into corporate under-investment in R&D (Nelson, 1959). Based on the R&D-based growth literature, Montmartin and Massard have extended the list of market failures with the concepts of knowledge externalities, surplus appropriability, duplication, rent transfer and location externalities. They thus demonstrate that market failures may also mean an overinvestment in R&D (2014). In any case, market failures are the rationales for specific innovation policies, whose objective is then to achieve a second-best optimum.

The concept of innovation systems (Lundvall, 2005) has been built on the idea that innovation is the outcome of an interactive, cumulative and context-dependent learning process, which involves a number of organisations whose interactions are themselves influenced by institutions. Systemic analysis of innovation puts emphasis on both market and non-market actors and how they “influence the direction and speed of innovation and technology diffusion in a country and the knowledge flows that move between these institutions” (Box, 2009, p. 14). In this perspective, innovation policies are justified by any bottleneck in organisations’ interactions affecting innovation performance. These systemic traps relate to infrastructures, institutions, interaction of organisations and capabilities of innovation producers (Klein Woolthuis, Lankhuizen, & Gilsing, 2005).

In a historical perspective, the concept of innovation systems actually draws on the evolutionary approach of innovation, which puts emphasis on the complexity of the creation and diffusion of technologies considered to be “a mix of tacit and explicit knowledge that cannot simply be reduced to pieces of information” (Laranja *et al.*, 2008, p. 829). Evolutionary analyses consider innovation to be a dynamic industry evolution, whose most important engine is learning (Malerba, 1996). In this perspective, public intervention is justified by bottlenecks in industry evolution processes that negatively impact innovation and its diffusion, i.e. learning failures, inappropriate balance between exploration and exploitation, lack of dynamic complementarities, and an impairing appropriability regime (Malerba, 1996).

Because systemic approaches justify the adoption and implementation of policy instruments aiming at increasing innovation performance within a system, they have paid little attention to the actual transformations of systems. On the contrary, the newly developed concept of system transformation focuses on “novel configurations of actors, institutions and practices that bring about a new mode of operation of entire sectors or systems of production and consumption” (Weber & Rohracher, 2012, p. 1037). In this perspective, public policy intervention is justified by any burden on system transformation processes, the so-called “transformational system failures” which include the deficient definition of the transformation direction, lack of demand articulation, impairing policy coordination and insufficient reflexivity of transformation process (Weber & Rohracher, 2012).

These four main paradigms of economics of innovation have been built in opposition to each other to some extent (Lundvall, 2005; Weber & Rohracher, 2012). However, as stated previously, policy-makers go beyond these theoretical debates and freely cherry-pick various elements in these academic theories to build the justification of their policy instruments. A question can then be raised: is a comprehensive approach of academic theories (as policy-makers do) appropriate? We contend that it is a relevant approach: focusing on a single theory and excluding the rival ones would not reflect actual policy-making and would then mislead our policy analysis. Secondly, the differences of focus among academic theories should be perceived as potential complementarities instead of radical oppositions preventing comprehensive analysis (Bach & Matt, 2005).

3. Demand-side failures

The justification of the implementation of PPI instruments with demand-side failures may seem to be the most obvious one. Public procurement of innovation indeed essentially consists in the *purchase* of a novelty by public administrations. We suggest dividing the effects of PPI instruments into three broad categories according to the identity of targeted demand-side actors: those in charge of or participating to public services missions; other users or consumers who are not part of the purchasing public administration; and, a mix of these two groups of users (see Table 1).

3.1. *Improvement of public services*

In public procurement of innovation, two broad groups may be distinguished. The first one consists of public procurement where innovation is a by-product necessary for achieving public services missions. And the other one encompasses public procurement where innovation is the very objective of the public purchaser (Cave & Frinking, 2003). According to Edquist and Zabala-Iturriagoitia, the primary objective of PPI is to “target functions that satisfy human needs or solve societal problems” (2012, p. 1758). They assume that public procurement is oriented toward innovative product or service mostly for the sake of the quality of public services. It can also be used to accelerate the diffusion of products or services, but this objective is deemed not to be always among the major ones.

PPI instruments justified by the improvement of public services essentially consist in the translation of public sector’s needs into demand on a concomitantly created market. They carry out a demand-pull effect (Cave & Frinking, 2003; Mowery & Rosenberg, 1979): public procuring organisations issuing a call for tenders **create a market for a product or service** by expressing a demand, which had not existed until then. The implementation of PPI instruments is academically justified by their role on market formation (Box, 2009; Chaminade & Edquist, 2005).

Created markets are however of restricted size because products or services are supposed to be procured for the sole account of the public sector. Therefore, this group of PPI instruments is equivalent to those addressing **niche/dedicated market** in Uyarra and Flanagan’s (2010) product-focused typology of PPI instruments. Moreover, a link could also be made with the so-called Hommen matrix, which distinguishes PPI instruments according to the need and the stage of market development. PPI instruments related only to the delivery of public services are equivalent to “**direct procurements**” where procuring organisations are also end-users of products and services resulting from the procurement (Edler & Georghiou, 2007; Edquist & Hommen, 2000; Edquist & Zabala-Iturriagoitia, 2012; Fraunhofer Institute Systems and Innovation Research, 2005; Hommen & Rolfstam, 2009; Rolfstam, 2013; Uyarra, 2012). We extend the definition of this group of PPI instruments to those where end-users are not only procuring organisations, but also all actors involved in the performance and the delivery of concerned public services.

3.2. *Promotion and diffusion of innovation to private demand agents*

The primary objective of some PPI instruments is to encourage and accelerate innovation. The decision to use public purchasing power to foster innovation, i.e. to carry out a direct demand-pull effect (Cave & Frinking, 2003), can be justified by demand-side failures that essentially relate to diffusion issue.

Diffusion as a rationale for PPI instruments must be understood in the sense of adoption of an innovation by a new population of users (Geroski, 2000): policies relevant in this regard aim at orienting consumers' preferences toward specific new products and services and explicitly include public procurement. The public sector is traditionally a large user of new products and services (Ergas, 1987), which is all the more able to ease their adoption by larger groups of users and consumers since it is less price sensitive and it brings the novelties that it procures in the public domain (Geroski, 2000).

In their evolutionary approach of market formation, Bleda and del Río conceptualise the diffusion of new products and or services as a “process of coordination among the agents that are adopting this new knowledge (or new rule complex) during the second stage of market formation at a generic surface level” (Bleda & del Río, 2013, p. 1045). They hence identify a related category of failure called “**surface coordination failure**” which is the result of agents' inertia and lack of adaptive skills.

The need to **increase return to adoption** is a rationale for PPI instruments (Mangematin & Callon, 1995). They can indeed reduce **switching costs**, which consist of **transaction and learning costs** plus **costs related to the adoption of complementary equipment**. Too high switching costs may lock agents into existing products and services. Through an initial mass purchase, PPI may create network externalities: by enlarging the installed base of an innovation, it makes it more attractive in comparison with other product and service (Geroski, 2000). This effect can be key for the diffusion of products or services, “whose value rises with the units sold in the market” (Edler & Georghiou, 2007, p. 956). The public sector acting as an early-user through PPI may also create an “information cascade” (Geroski, 2000): it experiments an innovation and then provides other agents with information on it, which will **reduce their learning gap** and hasten their adoption decision (Steinmueller, 2010).

The public sector may also act **on preferences of consumers** by orienting them towards innovative products and services. This is a factor necessary to the emergence of demand for innovation (Saviotti & Pyka, 2013). PPI instruments can indeed contribute to the elaboration of standards for some products and services (Uyarra, 2012), towards which demand is consequently oriented. Based on Schumpeter's understanding of innovation as a “creative destruction” process (1976), Rolfstam claims that the role of public procurement may be to end a product's life cycle to be replaced by another one (Rolfstam, 2013). In fact, public procurement essentially consists in a choice among different options to satisfy a need and consequently in diverting demand from other products and services. Therefore, in cases of PPI, the public sector prefers innovative solutions to others, for which demand decreases and may eventually cease.

Consumers' preferences can be oriented through PPI instruments by creating a space where external users may experiment and adapt to innovations put in the public domain. For instance, in Italy, public procurement for school meals has been used as an instrument to promote healthy eating habits and the consumption of locally produced food (Morgan & Sonnino, 2007). Consumers' preferences is thus oriented through education instead of standards. These efforts by policy-makers aims at enabling demand articulation and then the uptake of innovations that are key for the transformation of system. Therefore, the literature based on this concept identifies “**demand articulation failures**” as a rationale for PPI instruments (Weber & Rohracher, 2012).

Because the primary objective is to act on the private demand, whose agents will ultimately be the exclusive end-users of purchased innovation, these PPI instruments are assumed to be instances of **catalytic procurement** (Edler & Georghiou, 2007; Edquist & Hommen, 2000; Edquist & Zabala-Iturriagoitia, 2012; Fraunhofer Institute Systems and Innovation Research, 2005; Hommen & Rolfstam, 2009; OECD, 2014a; Rolfstam, 2013; Uyarra, 2012). Moreover, it is assumed to be equivalent to PPI instruments targeting a **generic market** in Uyarra and Flanagan's product-based typology (2010).

3.3. *Procuring public administrations as lead-users*

Between these two groups, a third one can be identified. It consists of PPI instruments whose objective is to improve the quality of public services via new products and services that are diffused throughout the market. However, this market is not restricted to those in charge of public services, but encompasses private demand agents. In this regard,

public procuring organisations act as **lead users** (von Hippel, 1986). Multiple authors have highlighted that the public sector can use its large purchasing power to early adopt an innovation in order to spread it on other markets (Box, 2009; Dalpé, 1994; Edler & Georghiou, 2007; OECD, 2014a; Phillips, Knight, Caldwell, & Warrington, 2007; Uyerra, 2012; Uyerra & Flanagan, 2010).

These PPI instruments are justified by a combination of the rationales of those whose objective is to improve public services and those that aim at diffusing innovations to external users. They translate a need shared by public administrations and other actors into a demand on a large market. Moreover, they ease the diffusion of innovations by addressing related barriers such as switching costs and by oriented consumers’ preferences.

For these PPI instruments, public purchasers must accept to bear risks related to any novelty. Efforts must be consequently done to transform public administrations into “intelligent customers”. Moreover, such diffusion-oriented policy requires a representative first user. It means that public procuring organisations must share sufficient similarities with other users and be part of the same social networks to be able to influence their own adoption decisions (Mangematin & Callon, 1995).

Because this group of PPI instruments aims at addressing needs shared by the public sector (and other actors involved in the performance and delivery of public services) with other actors, they are defined as “**co-operative**” PPI instruments (Edler & Georghiou, 2007; Fraunhofer Institute Systems and Innovation Research, 2005; Hommen & Rolfstam, 2009; Rolfstam, 2013). However, the distinction between direct, catalytic and cooperative PPI instruments is not systematically made: some authors make the difference only between the first two (Edquist & Zabala-Iturriagoitia, 2012; Uyerra, 2012).

In co-operative PPI instruments, the public sector uses its purchasing power to create a market through a demand-pull effect. On the other hand, in catalytic PPI instruments, the public sector acts rather as an interface between innovation producers and users (Taylor, 2008). However, these both sub-groups of diffusion-oriented PPI instruments share the characteristics to target products and services whose **market is generic** (Uyerra & Flanagan, 2010).

Table 1. Demand-side rationales of public procurement of innovation

Overall objectives	Improvement of public services	Diffusion of innovation	
		Diffusion of innovation to external users	Public administrations as lead users
Rationale for public procurement of innovation	Market creation to fulfil a need (demand)	Surface coordination failure Transition failure transaction costs, consumers’ learning and preferences Demand articulation failure	Market creation to fulfil a need (demand) Surface coordination failure Transition failure transaction costs, consumers’ learning and preferences Demand articulation failure
Features of PPI (related to the location of needs)	Direct procurement	Co-operative procurement	Catalytic procurement
Nature of the market of procured products and services	Demand: Niche/dedicated market	Demand: Generic market	Demand: Generic market

4. Demand-supply interactions traps

The most basic effect of any public procurement is to create an interface between demand (procurers and end-users) and supply (innovation producers). The actors of both sides can interact with each other throughout the whole procurement process. For these reasons, public procurement must be considered “a special case of users-producers interaction” (Rolfstam, 2009, p. 349).

We distinguish two groups of PPI instruments according to the intensity of demand-supply interactions failures they address: those where information asymmetry are solved solely by signalling the state of demand, and those requiring the implementation of an interactive learning space between both sides of the market (see Table 2).

4.1 *Need to signal the state of demand*

The first of these groups of PPI instruments assumes that calls for tenders are sufficient to create demand-pull effect. They provide firms with information and then reduce part of uncertainties on the outcome of corporate R&D investments. Therefore, PPI instruments are justified by market failures (Arrow, 1962; Nelson, 1959) related to a lack of firms' knowledge of demand (**asymmetry of information**).

Almost no reference to this rationale has been found in the academic literature on PPI instruments. In fact, we assume that public purchasers can drive innovation only through their call of tenders. This implies that they exactly know which innovative products and/or services are required to solve their needs, and consequently that these innovative products and/or services most often already exist. In consequence, PPI instruments consist in the introduction of products and services already available on the market into the public sector. This extended definition questions the distinction commonly made between regular public procurement and public procurement of innovation. The former is the purchase of off-the-shelf products and services, whereas the latter is often defined as the procurement of products and services that do not exist yet (Edquist & Hommen, 2000). However, several authors claim that the innovation impact of public procurement cannot be restricted to the purchase of novelties (Uyarra & Flanagan, 2010). Such approaches advocate for extending the conventional definition of innovation by further taking into account the point of view of users (Appelt & Gualindo-Rueda, 2014).

PPI instruments, whose rationale is the need for signalling the state of demand, require public purchasers, which have first clearly identified their needs and, most importantly, identified precisely new solutions to them. This has consequences in terms of modalities of interactions between users and producers of procured innovation. First, the fact that the sole signal of the nature and state of demand is sufficient to pull innovation means that none of the parties believes that their cooperation is required. Such PPI instruments are then characterized by **low “collaborative norms”** (Wang & Bunn, 2004). Moreover, the level of technological knowledge of policy-makers is a key determinant in the nature of coordination between policy-makers and target population in mission-oriented technology policies (Foray & Llerena, 1996). This category of policies is characterized by a centralized governance and targets “big science deployed to meet big problems” (Ergas, 1987, p. 193). They are assumed to include PPI instruments since the latter consist in the choice of a restricted number of suppliers for the provision of innovations whose objective is to solve identified needs. In consequence, PPI instruments in this category are mission-oriented technology policies implemented by policy-makers with high technological knowledge, which means that they should be implemented through a model of **vertical coordination** (Foray & Llerena, 1996): policy-makers identify the needs and the technical solutions that firms must provide to address them.

4.2 *Public procurement as an interactive learning space*

Evolutionary and systemic approach of innovation highlight the key role of the iterative interactions between users and suppliers, where the former contribute to innovation processes by their feedbacks and by their use thereof. In this regard, PPI instruments consist in opportunities for these interactions to occur and can be then conceptualised as **interactive learning spaces**. The rationale for their implementation is **the lack of “dynamic complementarities”** between suppliers and users (Malerba, 1996), which prevents virtuous cycles of interactions and mutual learning. The role of public procurement is to transform public administrations into users who can then contribute to develop and improve products and services through their “co-investments and feedbacks” (Malerba, 1996, p. 19). The evolutionary concept of “dynamic complementarities failures” has been translated into “**weak network failure**” (Klein Woolthuis et al., 2005) in systemic approach of innovation.

Users-suppliers interactive learning places contribute to the first phase of market formation in an evolutionary perspective: the knowledge coordination at deep level (Bleda & del Río, 2013). It consists in connecting all categories of knowledge (technical, social, behavioural and cognitive) in order to transform inventions into proper innovations. The typical situation of **deep coordination failure** is an inappropriate timing of introduction of an innovation relative to the then state of demand: either it is “ahead of its time” and would need a very different knowledge structure (including a revision of demand patterns), or it is “behind its time”. PPI instruments may help to build a new knowledge complex by facilitating the exchange of information between producers and user/consumers, i.e. improving the match between supply and demand.

PPI instruments whose rationale is to improve users-suppliers interactions must be combined with measures to address information asymmetries, i.e. make purchasers more aware about what product and service the market can offer them, and suppliers of potential innovation more knowledgeable on what customers wants

(Edler & Georghiou, 2007). Prior to the formal issue of calls for tenders, purchasing public administration can conduct or commission market and technology studies as well as organise meetings with potential suppliers in order to improve their knowledge of the potentialities of the business sector. Other instruments to achieve this purpose include the competitive dialogue procedure and foresight exercises (Edler & Georghiou, 2007; Vecchiato & Roveda, 2013).

In all these modes of interactive learning spaces, government agencies and suppliers essentially share **high “collaborative norms”** (Wang & Bunn, 2004), i.e. they must be aware that their collaboration is key to the success of PPI instruments.

Table 2. Rationales for public procurement of innovation related to users-suppliers interactions traps

Overall objectives	Signal to the business sector the state and nature of demand	Match demand and supply through an interactive learning space
Rationales for public procurement of innovation	Reduction of one-side information asymmetry and uncertainty	Dynamic complementarities failure Weak network failure Deep coordination failure
Features of users-suppliers interactions	Low collaborative norms Vertical coordination	High collaborative norms

5. Supply-side failures

Even though public procurement is commonly defined as a demand-side innovation policy instrument, its implementation can be justified by failures on the side of innovation producers. We distinguish two groups thereof: those that can be solved by improving firms’ incentives to innovate, and those related to producers’ capabilities failures (see Table 3).

Failures on the supply-side occur mainly for complex products, for which uncertainty is higher and which require high-level and specialised inputs (Uyarra & Flanagan, 2010). Moreover, the flow of information exchanged between both procurement parties is assumed to be all the more important that products and services procured are complex (Uyarra & Flanagan, 2010). Therefore, PPI instruments justified by supply-side failures target **complex products or services and require high information exchange**, and the other way round for PPI instruments whose rationale is not on the supply side.

5.1 Inadequate firms’ incentives to innovate

The demand-pull effect literature assumes that the size and sophistication of demand are key factors in firms’ decision to introduce new products or services (Guerzoni, 2010). An existing demand for specific innovations **reduces the uncertainty on outcomes** of R&D activities, which makes firms reluctant to perform them otherwise (Arrow, 1962). PPI instruments act then as insurance devices guaranteeing a minimum amount of demand for new products or services and a level of purchase over a pre-determined period of time (Cave & Frinking, 2003; OECD, 2014a). They cannot reduce risks essentially related to any R&D activity but the uncertainty on their outcomes and on the period between their performance and the purchase of their results. Such incentive for firms to innovate is all the more effective that the demand is large. In this regard, public procurement has a significant potential impact. Public administrations can influence the demand size and reach critical mass by aggregating demand notably through central purchasing organisations (Edler & Georghiou, 2007; Fraunhofer Institute Systems and Innovation Research, 2005; Uyarra, 2012).

Based on the literature on R&D-based growth, Montmartin and Massard (2014) highlight that public procurement is an appropriate policy instrument to solve surplus appropriability problems, which refers to the fact that firms can hardly appropriate the full benefits from the commercialization of their innovation (Smith, 1996). In fact, innovative firms are assumed to adopt a monopolistic behaviour by setting a selling price for their innovation superior to what the price would have been in a competitive market. This decision creates a downward distortion in the quantity of innovations produced relative again to a situation of pure and perfect competition. In such circumstances, innovation producers gain profits, but fail to appropriate the consumer surplus and the so-called “static inefficiency” or “deadweight loss”, which is the reduction in demand and consequently in production

resulting from prices superior to marginal production cost. In a dynamic perspective, firms' profit is the measure of the profitability of innovation. However, the increase of welfare includes additionally the consumer surplus and the static inefficiency. In consequence, the private welfare is inferior to the social one, which leads to corporate R&D underinvestment. In response to this market failure, Montmartin and Massard recommend demand-oriented policy instruments. The direct effect of public procurement is to increase the demand for differentiated and innovative goods. In consequence, the static inefficiency is corrected and the profitability of innovation increases, so that the business sector has more incentives to invest in R&D (Montmartin & Massard, 2014).

5.2 Capabilities failure and inappropriate market structure

An overall rationale for public procurement may also be "to strengthen key suppliers" (Laranja et al., 2008, p. 829). In this regard, the evolutionary approach innovation puts emphasis on learning. Related failures impairing innovation performance are a level of R&D insufficient to start a process of competencies accumulation, an inadequate level of human capital, and a limited knowledge diffusion throughout the business sector (Malerba, 1996). Malerba explicitly identifies public procurement as a tool to **improve firms' learning process**. Through public procurement, selected suppliers indeed accumulate knowledge and capabilities that will be useful for their future innovation activities.

By their purchasing power, public administrations are also able to favour experimentation of alternatives to dominant technologies by orienting suppliers' innovation activities. PPI instruments can **break path dependencies** by requiring the supply of solutions based on technologies considered not sufficiently explored (Chaminade & Edquist, 2005; Malerba, 1996). Moreover, Ergas states the success of products and services emergence phase requires "the proximity to a pool of sophisticated customers, who can rapidly distinguish promising and less promising alternatives" (1987, p. 227). Public procurement is the adequate instrument in this regard, public procuring organisation playing the role of these "sophisticated customers". These two categories of rationales for PPI instruments (**learning failures** and **lock-in situation or transition failures**) are identified as "**capabilities failures**" by Klein Woolthuis et al. (2005, p. 2005) in their system failure framework.

Another category of firms' capacities is likely to be improved by public procurement: the capacities to diffuse innovation throughout markets. This diffusion is two-fold. First, PPI instruments can encourage suppliers to collaborate and organize themselves in consortia to bid. Secondly, the fact to be selected in a call for tenders helps then to get additional public aids (Guerzoni & Raiteri, 2014) and to enter into new market, because of a signalling effect of public procurement (Mangematin & Callon, 1995).

Finally, innovation producers may not suffer from any capabilities failure and have all resources needed to supply with new products or services, but be prevented from doing so because of **inappropriate market structure**. The primary objective of procuring organisations is to be supplied with the best solution to the needs they have identified. In consequence, in most cases, they should favour competition by facilitating bidding by a maximum population of firms (Uyarra & Flanagan, 2010). For instance, the access of SMEs to calls for tenders may be eased by unbundling demand. Allotting calls for tenders may help to by-pass oligopolistic firms, which attempt imposing their own products and service in spite of set specifications, and to favour bidding by small competitors which are less likely to have such power (Knutsson & Thomasson, 2014).

Table 3. Supply-side rationales for public procurement of innovation

Overall objectives	Improve firms' incentives to innovation	Improve innovation producers' capabilities
Rationales for public procurement of innovation	Reduction of uncertainties Appropriability surplus failure	Learning failure / Capabilities failure Lock-in situation Inappropriate competition
Features of users-suppliers interactions	High information exchange	
Nature of procured products and services	Complex	

6. Rationale-based category of PPI instruments

The analytical framework of rationales for PPI instruments, which is built based on the respective reviews of the literatures on innovation policy and on PPI, permits the identification of categories thereof. A basic and significant assumption is that each PPI instrument is simultaneously justified by failures on the demand side and on users-suppliers interactions. They can have additionally rationales related to the supply side. In this respect, we assume that the distinction between the two categories of supply-side failures is mostly a theoretical and intellectual construct because it focuses on channels used by demand to act on the supply side. In fact, a single PPI instrument may use both channels or be not actually justified by any supply-side failure. In our attempt to identify rationales for PPI instruments, we then distinguish rather the following two configurations: either PPI instruments are justified by supply-side rationales, or they are not.

In consequence, four categories of PPI instruments are identified (see Table 4). Each of them have two subcategories. Rationales related to the diffusion of innovation among demand agents have been merged in a single group, even though public purchasers' decision to act as lead-users or simple innovation promoters may lead to slightly different implementation modalities. These differences are considered too small to create two groups of rationales.

6.1. Transformational PPI

Transformational PPI instruments are justified by **failures on the supply side** and aim at **diffusing procured innovative solutions**. The leverage effect of public procurement is expected to be large: its objective is to simultaneously improve firms' capacities to innovate and diffuse procured innovation to a maximum demand agents. In consequence, the public sector aims to transform systems by its purchasing power.

These PPI instruments are **co-operative or catalytic** procurements whose purpose is to introduce complex products on **generic markets**. They correspond to **technological PPI** (Uyarra & Flanagan, 2010) and subsequent innovations are considered "**architectural**" (Abernathy & Clark, 1985), i.e. they consist in "adapting and applying latent technologies to previously unarticulated user needs" (Uyarra & Flanagan, 2010, p. 137). This category of PPI instruments requires **high-level of information exchange** between procurers and suppliers.

6.1.1. Industrial PPI

Industrial PPI instruments are those for which the sole signal of the state of demand by public procuring organisation is sufficient to obtain expected innovations, which will smoothly diffuse throughout demand agents. The public sector has then high technological and market knowledge, which allows it to coordinate vertically with potential innovation producers. In other words, it is able to **supervise the innovation production process**: public procuring organisations do not believe that they need to collaborate with suppliers who hold the full responsibility for the success of their public procurement (Wang & Bunn, 2004). However, they provide with frequent and **high flow of information**.

Industrial PPI instruments are assumed inadequate to solve learning and capabilities failures on the supply side. Because they exclusively rely on formal calls for tenders, their demand-pull effect is among the simplest: it consists in improving firms' incentives to innovate.

6.1.2. Systemic PPI

Systemic PPI instruments aim to transform systems by simultaneously acting on the innovation capacities of producers and absorption capabilities of demand agents through the establishment of an **interactive learning space**. In this configuration, public procuring organisations have only identified needs whose effective translation into demand requires a dialogue with potential suppliers.

Users-suppliers interactions involved in systemic PPI instruments are essentially **collaborative** following Wang and Bunn's typology (2004): innovation producers' lack of capabilities require frequent and **rich exchange of information** between both parties and their collaboration is key to achieve the objectives of public procurement.

6.2. Diffusive PPI instruments

The main objective of diffusive PPI instruments is to **accelerate the diffusion** of new products and services, which the business sector is already able to supply. These products are already standardized and the public sector aims to

diffuse them throughout **generic market**, where they are considered not sufficiently used. Uyarra and Flanagan (2010) define this category as “**efficient procurement**” and state that their innovation impact is low. They are reported to lead to “**regular innovation**” (Abernathy & Clark, 1985), which essentially “builds on established technical and production competence applied to existing markets and customers” (Uyarra & Flanagan, 2010, p. 137). They promote alternative use and consumption and can consist in social innovation in some cases (see Table 4).

6.2.1. Non-collaborative diffusive PPI instruments

In the first subcategory of diffusive PPI instruments, the formal call for tenders is sufficient to obtain expected products and services, which are then diffused throughout the market. The leverage of this subcategory of PPI instruments thus consists of the simplest demand-pull effect: a market is created only by **signalling the state of a generic demand**. The production of procured products and services requires **low collaborative norms** and **low flow of information exchange**, so that interactions between procurers and suppliers are **arm’s-length** (Wang & Bunn, 2004). These interactions consist in a **vertical coordination**, which is made possible by the high technological and market knowledge of procuring public administrations (Foray & Llerena, 1996).

6.2.2. Collaborative diffusive PPI instruments

The second subcategory of diffusive PPI instruments consists of those requiring the implementation of an **interactive learning space** in order to define precisely the product or services to be diffused and whose production does not suffer from any burden. These instruments may then solve situations where a deficient match between demand and supply additionally prevents or slows down the diffusion of an innovation. The role of the public sector is larger than in the previous subcategory: prior to attempting at reducing barriers to adoption of new products and service, it must help the coordination between demand and supply agents, so that an invention becomes an innovation ready to be diffused on a large scale. The success of public procurement consequently depends on the **collaborative behaviour** of both parties in their interactions, which are then identified as **recurrent** in Wang and Bunn’s typology (2004). Both parties indeed need to **exchange repeatedly** to effectively match demand and supply, but the flow of information shared can be low because procured products and services are standardized.

6.3. Developmental PPI instruments

Developmental PPI instruments consist of PPI instruments whose objective is to stimulate the development of innovative solutions for improving the **performance of public services**. Procured new products and services are **specialised or complex** and target a **niche market** namely a public administration in charge of public services to be improved. This category of PPI instruments consists in **experimental PPI** instruments (Uyarra & Flanagan, 2010) and is expected to lead to **radical innovations** (Abernathy & Clark, 1985) (see Table 4).

6.3.1. Developmental PPI instruments with the sole public sector’s demand-pull effect

This first subcategory encompasses PPI instruments that aim at improving public services by solving **supply-side failures** through the sole **signal of public sector’s demand** to potential innovation producers. For instance, firms may have all the capabilities needed to develop an innovative solution for the public sector, but be reluctant to do so because they are actually unaware of this public need. The formal issue of calls for tenders is then supposed to be sufficient to inform potential suppliers of the need of public procuring organisation and to encourage consequently them to **undertake R&D** and/or innovation activities required for the production of appropriate products and services. However, supply-side failures are assumed simple enough to be solved by a demand-pull effect.

In order to be able to draft a call for tenders sufficient to solve supply-side failures without any prior interaction with suppliers, public procuring organisations must have good technological and market knowledge. In consequence, the relationships between public procuring organisations and potential innovation producers should consist in **vertical coordination** (Foray & Llerena, 1996) and be **supervisory** (Wang & Bunn, 2004). In fact, the sole need to signal the state of public sector’s need for the success of PPI reflects low collaborative norms, but the complexity of products and services purchased requires repeated, important and open information exchange.

6.3.2. Creative PPI instruments

Creative PPI instruments establish interactive learning spaces between suppliers and users in order to ease the definition of technical specifications of the needed products and services, whose development additionally requires solving supply-side failures. In consequence, they consist in ambitious innovation policy instruments that must be carefully designed to be able to concomitantly act on three levels: identification of public sectors’ need; translation

of this need into a demand relative to the potentialities of innovation producers; making the development and production of identified solutions possible. The success of creative PPI instruments requires **collaborative users-producers interactions** and **repeated flows of information exchange**.

6.4. Adaptive PPI instruments

The last category of PPI instruments encompasses those aiming at **improving public services** through the purchase of products and services, whose production and supply encounter no obstacle. It consists of public procurements of **standardized** products and services for **niche markets** (public administrations). The very basic idea of this category of PPI instruments is to adapt already existing products and services to the public sector (see Table 4).

6.4.1. Non-collaborative adaptive PPI instruments

The first method to adapt existing products and services to the public sector is **to signal to the business sector its particular needs**. Calls for tenders are sufficient to create a demand-pull effect: they reduce information asymmetry on the side of producers, which are then able to supply public procuring organisations with products and services that the latter had specified technically and in details.

Users-producers interactions are **arm’s-length**: none of the two parties need to collaborate, and the level and **frequency of information exchanged are low** because procured products and services are **standardized** (Uyarra & Flanagan, 2010; Wang & Bunn, 2004). Non-collaborative adaptive PPI instruments require public procurers with good technological and market knowledge, so that they can effectively and successfully coordinate **vertically** with suppliers (Foray & Llerena, 1996).

Table 4. Rationale-based categories of PPI instruments

PPI category	Transformational		Diffusive		Developmental		Adaptive	
	Industrial	Systemic	Non-collaborative	Collaborative	Non-collaborative	Creative	Non-collaborative	Collaborative
Supply-side failure	Yes	Yes	No	No	Yes	Yes	No	No
Users-producers interactions traps	One-side information asymmetry	Interactive learning space	One-side information asymmetry	Interactive learning space	One-side information asymmetry	Interactive learning space	One-side information asymmetry	Interactive learning space
Demand-side failure	Diffusion	Diffusion	Diffusion	Diffusion	Improvement of public services			
Product nature	Specialised		Standard		Specialised		Standard	
Market	Generic		Generic		Dedicated		Dedicated	
Product-based PPI category	Technological		Efficient		Experimental		Adapted	
Innovation type	Architectural		Regular		Radical		Market niche	
Cooperative norms	Low	High	Low	High	Low	High	Low	High
Information exchange	High		Low		High		Low	
Users-producers interaction type	Supervisory	Collaborative	Arm's length	Recurrent	Supervisory	Collaborative	Arm's length	Recurrent
Coordination between public procurers and suppliers	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal
Type of PPI based on the location of needs	Direct	Cooperative or catalytic	Direct	Cooperative or catalytic	Direct	Cooperative or catalytic	Direct	Cooperative or catalytic

6.4.2. Collaborative adaptive PPI instruments

Collaborative adaptive PPI instruments require **an interactive learning space** for matching demand and supply. In fact, the improvement of public services requires the supply of products and services whose technical specifications cannot be identified by public procuring organisations alone. Instead, they must create dynamic complementarities to identify with (potential) suppliers the most suitable solution to their needs.

Therefore, collaborative adaptive PPI instruments are configurations where products and services procured are **standardized**, so that they do **not require intense exchange of information** between suppliers and public purchasers. However, their adaptation to the specific needs of the public sector must make both parties aware that

their collaboration is a condition sine qua non of the success of the operation. Collaborative adaptive PPI instruments must consequently be conducted with **recurrent users-suppliers interactions** (Uyarra & Flanagan, 2010; Wang & Bunn, 2004).

7. Conclusion

Public procurement has recently gained a renewed interest and impetus as a means to stimulate innovation. The academic literature on PPI instruments has also recently developed, but a marginal attention has been paid to rationales. They have been roughly identified and not incorporated in the various typologies of PPI instruments, even though they are key to better understand and evaluate them. Intelligent policy design is supposedly based on objectives to be fulfilled that relate in turn to problems to be solved. In consequence, rationales for any policy instrument must be clearly identified in order to adequately design it but also to appropriately evaluate it. The paper aims at contributing to a better understanding of rationales for PPI instruments in this respect.

Both literatures on innovation policy and on PPI instruments have been surveyed for this purpose. The review of the former literature enabled to build an analytical framework of rationales for PPI instruments. The latter literature was analysed based on this analytical framework that has been complemented in turn. Three categories of failures have been consequently identified to justify PPI instruments. On the side of demand, rationales consist in either the sole need to improve the performance and/or delivery of public services, or the diffusion of innovation considered insufficiently used or consumed at the level of the public sector or by external private demand agents. Evolutionary and systemic approach have highlighted the essential role of users-producers interactions in innovation processes and identified public procurement as an instance thereof. In this regard, PPI instruments are justified by the need to improve or create interactions between innovation producers and users of the products and services eventually produced. Two categories of interactions have been identified: those consisting in the sole signal of the nature and state of demand to the business sector, and proper users-suppliers interactive learning spaces. Each of them addresses specific rationales: a one-side information asymmetry, or deep coordination and dynamic complementarities (weak network) failures. The third category of rationales for PPI instruments relates to the supply side. They correspond to inadequate firms' incentives to innovation or learning and capabilities failures.

On the basis of the analytical framework based on rationales, four categories of PPI instruments have been elaborated according to whether they address supply-side failure or not, and to whether the objective is the sole improvement of public services or the diffusion of innovations. These four categories are: transformational (supply-side failure, diffusion of innovations), diffusive (no supply-side failure, diffusion of innovations), developmental (supply-side failure, improvement of public services) and adaptive (no supply-side failure, improvement of public services). Each of these categories is then subdivided into two subcategories depending on the nature of users-producers interactions (see Table 4).

The categories of PPI instruments identified in the paper have incorporated elements from the various typologies of PPI instruments. This comprehensive approach of PPI instruments has enabled to attribute features and design patterns to each of them in regard with the mode of interaction and coordination between public procuring organisations and suppliers.

Finally, the review of rationales has highlighted an additional characteristics of PPI that may improve and/or justify further its attractiveness: it consists in a demand-side innovation policy that can solve supply-side failures. To the best of our knowledge, the academic literature has not considered such hybrid instruments. Supply- and demand-side policy instruments are instead opposed to each other (OECD, 2012, 2014b). Our conclusion is not about the inconsistency of this distinction between supply- and demand-side innovation policy instruments, but it highlights that supply-side failures may also be solved by demand-side instruments. However, PPI instruments are not a panacea: they are not able to solve all kinds of failures and the more they have to address the more carefully they should be designed in order to avoid policy failures.

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