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Innovation, competition and public procurement in the pre-commercial phase

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INNOVATION, COMPETTION AND PUBLIC PROCUREMENT IN THE PRE-COMMERCIAL PHASE

Abstract

Should the supply or the demand side bear the risk connected to innovation? The two polar cases identified in the literature are the supply push and the demand pull. The former is the typical one, with the supplier bearing the costs and obtaining the benefits from innovating. The latter is technology procurement, where the buyer takes the risk, by procuring the innovative good or service. With respect to this, pre-commercial procurement is a peculiar solution that can explain the debate found in the literature relative to its configuration either as a supply-side or a demand-side instrument. The separation from the commercial phase allows the procurer to take only (part of) the risks connected to R&D services. Also, competition among suppliers gives the opportunity of evaluating different solutions and to obtain, in the commercial phase, a lower price for the innovative good. The counterpart of all this is a large portion of risk being left to the supplier. As a consequence, suppliers need to obtain a larger share of the benefits of the innovation process. This economic reason, besides the legal restrictions on State aid, explains the need for a shared risks-shared benefits approach, centred on the agreements on the assignment of IPRs.

Keywords: innovation; competition; public procurement for innovation; pre-commercial procurement.

JEL classification: H57; K21; L16; M38; O34; O38.

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1. Introduction

Innovation as such refers to not yet existing markets and therefore, to interactions among agents not only through price signals.

Under this respect, the fundamental theoretical reference is Schumpeter's (1975) idea of competition: innovation itself is a more decisive instrument than prices in gaining an advantage over rivals. Innovation, in fact, can grant a temporary monopoly power and the resulting extraordinary profits that compensate the costs of research and development (R&D). These include the costs stemming from technological uncertainty, regarding the development cost function, and market uncertainty, on when and if a rival innovation will appear and on the profitability of the innovation (price of substitutes and competing innovations, etc.).

In this perspective, the producer-seller takes the initiative to innovate, while the demand side is characterised by routine behaviour and limited foresight. In particular, demand must be induced externally through the seller's marketing activity. Of course, the innovation will be driven by consumers' (new) needs, but producers have the role to detect and meet them. The reason for this is that information, exclusion and transaction costs hinder the articulation of demand. Thus, market power, not simply in the usual meaning of price fixing, but in the sense of being able to take the initiative to innovate, rests with the supply side. As a consequence, the producer bears the risks and catches the opportunities of innovating.

There are, however, situations in which the above sketched process does not work: the producer does not take the initiative to deliver a potentially Pareto-improving innovation, typically because the market risk is too high. Can consumers substitute in for the sellers? Or should the government intervene because of the hindrances that affect also the demand side?

This paper retraces the literature on innovation to evaluate the theoretical rationales for a particular policy instrument, pre commercial procurement (PCP). Section 2 sketches the main issues of the traditional and of the new market failure perspectives, the former centred on the relationship between innovation and market structure, the latter extending the analysis of a firm's ability to innovate beyond the choice of R&D investment. Sections 3 and 4 analyse the literature on the role of the demand side in general and of innovation procurement in particular, while section 5 the rationales for government intervention in the form of innovation procurement. Section 6 applies the results of the literature to the evaluation of PCP, while section 7 analyses the role of IPRs management in the functioning of this policy instrument, also on the basis of recent experiences. Section 8 summarises the main conclusions of the paper.

2. Innovation and market failure

The traditional market failure perspective is centred on the instances of under-provision of R&D (Arrow, 1962).

The first one is the public good nature of scientific knowledge and the consequent imperfect appropriability of R&D results, together with the non rivalness in the use of knowledge; the positive externality of new knowledge makes social returns from innovating exceed private ones, with the consequence that the market fails to provide the socially optimal level (and direction) of R&D. Then, there are the high fixed costs of R&D and the resulting economies of scale, which create an incentive to monopolise. Finally, investment in R&D presents major sources of technological and market uncertainty, beyond those normally affecting the entrepreneurial activity. The profitability of an innovation depends on technical difficulties, on the nature and timing of competing innovations, etc., which are not known in advance. Reducing or mitigating the effects of uncertainty is costly (for instance, both technical and market uncertainty can be reduced by developing alternative research efforts). Uncertainty can in principle be separated from the profits from innovation by selling shares in the project. However, asymmetric information, especially in the form of moral hazard, can involve under-provision of funds and, as a consequence, of innovative activity.

The market remedy to these problems is a departure from perfect competition, according to Schumpeter's vision: innovation activity is stimulated by the anticipation of monopoly profits for being the unique producer of the good. These can be achieved only by preventing, at least temporarily, imitation, by means of erecting barriers to entry (buy up of raw materials, control of distribution channels, building up of reputation and identity, realisation of economies of scale).

Alternatively, in addressing market failure, the government can grant IPRs (patent, trademark, copyright, etc.). The problem is to design them in such a way as to weigh the short-run efficiency loss from monopoly with the long-run gain from innovation. The way in which the expectation of some extraordinary profits should be preserved in order not to discourage innovation reveals the conflict between individual and collective welfare that is at the heart of the problem. The monopoly profits required to finance innovation activity last until imitation succeeds. Therefore, the innovator's interest is to be the only producer of the new good as long as possible. Society, instead, would benefit from the diffusion of innovation. But imposing to disclose production secrets or barring monopoly could prevent investment in innovation at the detriment of society itself.

In principle, society could obtain the competitive market outcome compensating the monopolist-innovator for the loss of profits. Until exclusion and transaction costs make this solution impossible, one faces a trade-off between short and long-run efficiency. Patent laws accept it by allowing temporary extraordinary profits, not to discourage innovation and loose the increase in welfare that society will experience once its results will be public.

In some sense, the temporal trade-off also marks the nature of the temporary profits from innovation. In fact, in a short-run perspective, they are the result of above marginal cost pricing, and, as such, they are linked to a dead-weight loss. However, in a long-run, backward perspective, they represent the compensation for the uncertainty of the profitability of the innovation. As long as they remunerate this, they are not extra-profits. A deeper insight can be obtained by considering their essentially temporary nature. Profits will attract imitation and competing innovations, which will wipe them away. If this is true in general, it is particularly so in the realm of innovation, where possible rivals can appear from different industries, and against which the barriers erected by the monopolist can be rather weak. One could say that the possibility of innovation makes a market much more contestable than otherwise. Potential competition, as known, will discipline the monopolist's price fixing behaviour. Thus, no extra-revenues beyond those remunerating production costs (inclusive of the remuneration for risk taking) could in principle be obtained. Moreover, innovation can be triggered not just by the allure of monopoly profits, but by the fear that others might displace the firm's present products. From the entrepreneur's perspective, the innovation activity might be just an alternative to imitation not to be excluded from the market.

As noted by Kamien and Schwartz (1982) in their review of the relationship between market structure and innovation, another source of interaction between innovation and market power originates from the possession of monopoly power on present products, which would make it easier to extend it to new products (for instance, through the command over distribution channels, through the firm's unique identity, through the threat of retaliation in the event of innovation from rivals, through other actions made possible by its dominant position). Under this respect, a monopolist should be more willing to innovate than a firm with no market power. Moreover, given the difficulty in finding external financing because of the problem of asymmetric information, monopoly profits could be used as a source of internal financing.

However, if, on the one hand, the possession of monopoly power makes it easier to perform and reap the benefits from innovating, on the other hand, it makes it less necessary. The incentive to innovate can be weakened by the presence of X-inefficiencies (preference for additional leisure with respect to additional profits (Leibenstein, 1966). Moreover, Arrow (1962) and Usher (1964) noted that profits from innovating are only the difference between monopoly profits from current products and perspective profits from the new ones for the incumbent, while they would be the whole amount of the latter for a new entrant.

One can also notice that, in a process of competition through innovation, not just the allure of extraordinary profits, but the fear that rivals could innovate and displace the firm's current product can be an incentive for investing in the development of new goods. This incentive would be weaker for a monopolist, if, as argued by Baldwin and Childs (1969), market power allows the firm to be a "fast second" in imitating a successful product. One can add that the prevision of such a reaction would reduce the incentive to innovate also for the newcomers.[1]

The superiority of monopoly with respect to perfect competition in the provision of innovation does not seem, therefore, theoretically grounded. The same conclusion applies to the hypothesis of a positive relation between innovation and firm size.

Elaborating on Schumpeter's work, Galbraith formulated the hypothesis according to which firm size is positively associated to innovation activity. This is because innovation is expensive and large firms can exploit economies of scale in R&D. Empirical tests have, however, shown that economies of scale are present only within a small scale and that, in

[1] We will return to this point when dealing with the design of IPRs in PCP in relation with the separation between the commercial and pre-commercial phase.

proportional terms, large firms spend less than small ones.

The Schumpeterian hypotheses have stimulated new theories of market structure, that have analysed the factors affecting the speed of innovation in a decision theoretic framework (Kamien and Schwartz, 1982), finding that an intermediate intensity of rivalry yields the fastest pace of innovation. On this basis, the analysis of the relationship between market structure and innovation has been conducted in a game theoretical framework, with the intensity of rivalry an endogenous factor. With respect to social optimality, the result is that market solutions are inefficient.

More recently, new perspectives on innovation have extended the analysis of the determinants of a firm's ability to innovate beyond the amount of investment in R&D. A particular emphasis has been put on systemic and institutional aspects of innovation and on the learning process by firms, giving birth to the national innovation system literature (Lundvall, 1992; Nelson, 1993; Lundvall and Borràs, 1997). Therefore, typologies of market failures other than those related to the properties of scientific knowledge have been identified.

Smith (2000) identifies four types of failure: failures in the provision of infrastructures (underinvestment in physical – e.g., communications and transports – and science-technology infrastructures – e.g., universities, laboratories); transition failures (firms use the technology they know best, but are not competent in technologies applied in related areas); lock-in failures (firms are locked in a particular technological paradigm or trajectory, because of high entry costs connected to the adoption of new technologies when a dominant design exists, of high switching costs for users, etc.; the problem is related to the existence of network externalities); institutional failures (slow changing norms and values on the consumers' side, together with unexpected negative effects of the regulatory context on the innovation system).

Malerba (2002) points at five types of failures: learning failures (firms are unable to learn rapidly and effectively); exploration-exploitation trade-off (firms specialise in either of them, while the two activities should be balanced); variety-selection trade-off (as before); appropriability traps; complementarities failures.

Lundvall and Borràs (1997) reformulate Smith's and Malerba's typologies into three trade-offs: i) the exploration-exploitation dilemma, with firms often pursuing incremental innovation rather than radical one, at the advantage of innovation dissemination, but at the cost of lock-in failures; ii) the integration-flexibility dilemma: integration can avoid transition, complementarities and learning failures, at the cost of being locked in a given trajectory; iii) the diversity-harmonisation dilemma: the incentive for harmonising and standardising technologies and institutions to exploit the economies of scale available in the globalised learning economy is at odds with the importance of diversity as a source of learning.

As issues of system failure become relevant, the role of government widens to include institutional design and firms' ability to learn and connect. Actually, Smith's and Malerba's typologies refer to the aims to be pursued by public policy (Economic Policy Committee, 2002). Thus, failures in infrastructure provision call for incentives and subsidies for private provision or direct public provision; lock-in failures for policies favouring technological alternatives; learning failures for human capital programmes, support for industrial R&D, public procurement, dissemination policies; the exploitation-exploration trade-off for policies keeping technological rivalry open, through public procurement, support to universities, and the like, as well as support of entry and survival of new firms, to allow diversity within the industry, and of variety through a common infrastructure (standardisation) and better dissemination of codified information; the variety-selection trade-off for antitrust, industrial and technological policies to allow market competition; complementarities failure for the provision of connections (R&D networks, industry-university cooperation, etc.).

In synthesis, the system failure literature looks at R&D investment as one of the several activities of the innovation process, which can be performed in various phases. It is a necessary, but not sufficient condition, for the marketing of a new product. Thus, attention is driven to all aspects of the innovation process, emphasising also the role of the users of innovation both in its generation and in its diffusion.

3. Technology push, demand pull and the innovation cycle

The literature on the microeconomics of technical progress has developed the technology-push and the demand-pull hypotheses, based on two different views of the relation between a firm's research department and its marketing department.

According to the technology-push hypothesis, the initiative of the innovation comes from the researchers. This implies that advances in scientific knowledge are the key element of the innovative process.

According to the demand-pull hypothesis (see Godin and Lane, 2013, for a history of the model), instead, the initiative comes from the marketing staff. Innovation is responsive to demand-pull factors (Schmookler, 1996; Griliches and Schmookler, 1963; Mayers and Marquis, 1969), since it depends on profitability that, in turn, depends on market demand and market size.

Even if developed in the attempt to verify Schumpeter's hypotheses, the demand-pull approach appears in contrast with his idea that the demand-side is characterised by routine behaviour and limited foresight, with the consequence that market demand alone has little potential to stimulate innovations unless users' preferences are influenced by the firms.

According to Mowery and Rosenberg (1979), the empirical studies finding that innovation is responsive to demand-pull factors use a too broad definition of demand. The existence of an adequate demand is, of course, necessary, but the role of supply-side factors cannot be overlooked. Technological opportunity and market demand are both necessary for an innovation to result.

The demand-pull hypothesis appears to be a complementary explanation of technological advantage; it has highlighted the role of demand conditions in generating and diffusing innovation. A strong emphasis has been put on the role of early users and sophisticated demand to take up innovation and influence other consumers. In particular, von Hippel

(1986) has introduced the notion of lead users, agents who face needs that will be general in the marketplace time ahead of the rest of the market and who can benefit significantly by obtaining a solution to those needs.

Thus, the positive interaction between innovative customers and innovative users can be said to represent a positive, demand driven effect (Lundvall, 1988; Antonelli e Gehringer, 2015). Also, the relationship between demand and market structure has been analysed (Kamien and Schwartz, 1982; Sutton, 1991 and 1988), as well as the role of communities of practice (Harhoff *et al*., 2003; Franke and Shah, 2003) and of co-invention (Bresnahan and Greenstein, 2001) – for a review, see Malerba, 2007. This literature has provided new insights in the mechanisms of the innovation cycle, which have shed light on the relation between market structure and innovation, on the one hand, and on the role of users in the innovation process, on the other hand.

Utterback and Suarez (1993) consider the two-way causation direction between market structure and technological change: a greater degree of competition implies more rapid rates of technological change, while a rapidly evolving technology attracts new firms into the industry. This link is not in contrast to Schumpeter's view; on the contrary, it is in line with his creative destruction hypothesis.

Utterback and Suarez distinguish three technology phases. The first one, the technology competition phase, precedes the emergence of a dominant design. It starts with the synthesis of a new product by one or a few firms that acquire a temporary monopoly situation in the niches where they possess the most relevant performance advantages. They are followed by a wave of new entrants, each with a variation of the product. These firms are often small and come from outside the industry in question.

In the transitory phase, a dominant design appears and matures as a production concept. Firms, large or small, that succeed in making the transition to product standardisation thanks to process innovation and integration, or that merge with successful firms thanks to some special resources, can compete effectively and acquire dominance.

After the emergence of a dominant design, there is a wave of exits, until a point of stability is reached, with a few firms sharing the market. They are typically large firms, with standardised or slightly differentiated products and relatively stable market shares. Also a few small firms may remain in some particular segments, but they typically display little growth potential.

How are the dimension and number of firms connected to technological advance? Utterback and Suarez (1993) and Muller and Tilton (1969) report that major innovations are not necessarily linked to large absolute size or market power; rather, they are often developed by new entrants in the market or market segment. Moreover, with respect to the innovation phases, the technological process is slow in the very first period, when firms are few, while it speeds up as the number of entrants increases. This feature can be linked to the externalities inherent to scientific knowledge. The increase in the number of firms implies more experimentation, providing feedbacks about products and market requirements.

Along with the emergence of a dominant design, however, research becomes more specialised and the innovation effort concentrates on particular technical aspects.

Technological progress slows down, production techniques become standardised, the cost of production equipment increases with process integration, variable costs decrease, so that firms with large market shares benefit from further expansion. Eventually, a stable condition is reached with a few firms dominating the market.

With reference to the relation between innovation and market structure, the analysis of the innovation process appears to identify two different situations.

In the initial phase, when a major innovation is developed by a firm, this acquires a position of market power, being the unique seller of a product. The profits associated to this monopolistic position are not linked to size and are temporary: firms imitating or introducing variants of the product soon enter the market eroding the initial innovator's position.

This is not, however, the end of the story: the innovation process leads to the emergence of a dominant design; the standardisation of production techniques and the presence of economies of scale, then, typically determines the dominance of a few large firms. Profits in this phase are, therefore, of a different nature with respect to those obtained by initial innovators, deriving from barriers that are other than being the unique producer.

Moreover, the phase in which profits directly derive from the innovative activity does not discourage entry, which is connected to an intense process and product development period. On the contrary, profits in the later phase are connected to a period of slow technological progress. This can be linked to the observation (Arrow, 1962) that the indivisibility of knowledge can be embodied in a factor, for instance, instrumental goods. A monopolist may try to protect the investment in the existing equipment by delaying the introduction of new technologies. In a competitive industry, instead, once a new, superior technology has been adopted by one firm, the other ones are compelled to adopt, if they want to remain in the market.

There seem to be two different market structures, both associated to profits, but of different nature. Firms obtaining profits in the first phase do not necessarily coincide with firms obtaining profits in the second one, even if Utterback and Suarez (1993) note that successful firms usually enter the industry in the early phase. The question is whether the producer is willing to take the risks connected to innovation only in view of the "overall" profits they can gain, including those deriving from the possession of dominance in the last phase. We shall return to this point when dealing with innovation failure and with the role of public procurement and, in particular, PCP in addressing them.

The analysis of the technological phases is also important in better defining the role of the demand side in the innovation process. In particular, during the technology competition phase, the insight into users' needs is the key innovation factor and, on a parallel, the users' lack of perception of the relevance of the innovation can be a major problem. In the transitory phase, a production concept often emerges through the procurement decision of early adopters. In the specific phase, demand selects alternative development trajectories (Kuhn, 1962; Dosi, 1982).

Malerba *et al*. (2007) present a model of the influence of differences in consumers' preferences on the industry life cycle: heterogeneity in demand can break the dominance of an older technology allowing a new, superior technology to win the market. The key hypothesis is that new products must be developed and perfected to meet potential demand. Moreover, there is a direct relationship between the product market share and the likelihood that a consumer will buy it. If a new product reaches the market quality threshold requirements, it competes with old, developed products that are at higher than threshold levels and have a large market share. If consumers are sophisticated, in the sense that they buy the best product available in each period, the new technology does not break in. The lock-in can be broken if there are experimental users, i.e. users who attribute an extrinsic merit to the product just because it is new, or if heterogeneity of preferences exists, that is, some consumers highly value a characteristic at a threshold that is not achievable by the old technology.

This literature helps in analysing the role of demand in the innovation process, as directly addressed in the literature on innovation procurement.

4. The consumer as the active player in the innovation process: innovation procurement

Innovation involves uncertainty, both for producers and consumers. Since a market does not exist, interactions must take place through signals other than prices. The initiative to innovate is generally taken by producers, e.g. through market research. Producers face technical and market uncertainty (on the development cost function, on the time a "rival" innovation will appear, on the profitability of the innovation). Nevertheless, market control is on their side, so that they can more easily overcome information, exclusion and transaction costs. As exposed above, expected profits are the trigger of the process.

There are, however, cases in which uncertainty is too high to rely upon the producer's initiative. In particular, potentially welfare increasing innovation will not be undertaken without the assurance of future demand as an incentive to undertake a sufficient R&D investment level.

In such cases, consumers could take the initiative, typically specifying the requirements of the desired new good and ordering it (innovation procurement). This corresponds to a shift of the risks from the producer to the consumer. The possibility of taking the initiative rests upon the possession of some market control (information, ability of reaping the advantage of innovation, coordination among buyers, etc.). This depends on the users' characteristics (e.g., knowledge and sophistication) and on the structure of the demand side. The two aspects are interrelated in the case of markets with need for a high initial investment level in R&D and production, since the structure of the demand side influences the possibility of articulating demand for a quantity sufficient to encourage investment.[2]

Technology, or, according to the most recent denomination, innovation procurement has

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[2] One can contrast such situations with the cases of open source software or cellular phone applications, with the demand pull taking the form of a direct participation of users in the innovation process as a source of continuous change (for the phenomena of the communities of practice, see Harhoff *et* al., 2003; Franke and Shah, 2003).

been extensively analysed in the literature (see Edquist and Hommen, 1998, for both a review and a systematic treatment of the issue), in the framework of the inability of pure markets to generate product innovation (Lundvall, 1985).

Grandstand (1984) considers the problem of articulating demand within a transaction costs framework. Technology procurement is a special form of buyer-seller interaction, in which the customer takes the active role. This situation is between the two polar cases of a fully integrated organisation and of no integration. In the former, the buyer is integrated backwards into R&D and production for internal use; in the latter, the seller takes the active role within the usual market organisation.

Technology procurement is associated to the specification of technical requirements, which reduces technological and commercial risks for the seller. The most famous example is perhaps the cooperation between Toyota and Nippon Steel (Hellman, 1993; Edquist and Hommen, 1998), which led to an innovation in the steel industry in 1983. Cooperation in R&D started with a simple contract that translated into an agreement on the exploitation of research results before large scale production. According to the agreement, Nippon Steel would license the patent right for its new product to other Japanese steel makers, though remaining the only Toyota's supplier for 18 months. Therefore, Toyota got the long-run benefit of competitive sourcing. Nippon Steel benefited from the growth of the industry stimulated by innovation. Edquist and Hommen (1998) derive two main conclusions from this experience. First, competitive relations between a supplier and a customer are not in contrast with long-run cooperation in R&D.[3] Second, the lack of this kind of relationships may hinder innovation, as in the case of the US car industry that they cite.

The conditions for innovation procurement to be an effective way of stimulating innovation relate to market structure and technology life-cycle.

As for market structure, Arrow (1962) analysed the influence on innovation of the structure of the demand side of the market, stimulating a vast literature (see Kamien and Schwartz, 1982, for a review of the seminal contributions) that developed an alternative version of the demand-pull hypothesis. Rothwell and Zellweg (1982) and Edquist and Hommen (1998) consider three main types of market structure: monopsony, polypsony and oligopsony.

In a monopolistic market, demand pull, or buying power, is potentially at its highest level. There can be, however, two problems for innovation in such a situation. The first one is that the monopsonist chooses only one supplier. This could be the one with an inferior technology and even become a monopolist thanks to the procurement decision. The second problem arises if the monopsonist is a monopolist in another market, when innovation gives the way to product standardization. The most famous example of this is given by AT&T, which dominated the US telecommunication market until the deregulation of the sector.

AT&T's need for smaller and more efficient switches was the demand pull leading to the development of transistors at Bell Laboratories (Kamien and Schwartz, 1982). However, lack of rivalry eventually weakened the need for innovative inputs (Porter, 1990). The

[3] We will return to this issue when dealing with PCP.

tendency was reversed after the break-up of AT&T that followed deregulation.

An assessment of the overall effect of deregulation on innovation should, however, consider the weakening of the demand pull deriving from the loss of monopsonistic power. In Europe, the break-up of old state-monopolies, acting as monopsonists of intermediate goods in the telecommunications, railway and energy sectors, has been considered a potential threat to innovation because of the dissolution of interactions with private suppliers (European Commission, 2006). The issue can be linked to the so called European paradox, that is, the inability of EU countries to deliver marketable innovations despite their technological and scientific excellence.

It should be noted that the negative effect of the lack of rivalry in the final sales market does not exist when the monopsonist is the final user of the good. However, markets for consumer goods usually have a polypsonistic structure, which means that market control, and, with it, the initiative to innovate are with the supply side. The lack of consumer competence is usually a major hindrance.[4] In some cases, this might call for a government representation of users (see below).

The literature (among others, Edquist and Hommen, 1998, and Porter, 1990) identifies in oligopsony the market structure most favourable to innovation procurement, since it avoids the drawbacks of the lack of rivalry, though maintaining high levels of buying power. This is the moral of the Toyota-Nippon Steel story: oligopsonistic relationships allowed the buyer to benefit from competition-driven efficiency gains and avoid lock-in, and the seller to benefit from long-term growth of the industry through patent licensing.[5] In such a situation, Toyota acted as a "quality leader" among the oligopsonists, affecting the direction and the rate of change of innovation.

After market structure, the other element influencing the effectiveness of innovation procurement in stimulating innovation is the phase of the technological life-cycle. As reported in section 3, the procurement decision of early or sophisticated users makes one dominant design mature as a product concept. Innovation procurement guarantees the critical level of demand necessary to encourage investment in R&D and production. Demand pull can also be relevant at a later stage of the technological life-cycle by selecting alternative development trajectories (Kuhn, 1962; Dosi, 1982).

5. Public procurement for innovation

As argued in the previous sections, there are situations in which uncertainty is too high to rely upon the producers' initiative to undertake a welfare increasing innovation without the assurance of a demand level sufficient to recover the costs of R&D and production. In

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[4] Another problem is that of timing, as argued in Nilson (1994): "consumers may also try to seek out better products, but their search will not coincide with that of the manufacturers. Both parties may be aware that technology could be improved, but doing this on a competitive, mass-production basis will depend on this kind of coincidence. The problem is one of timing! (p. 7 and ff.)".

[5] See Kamien and Schwartz (1982) and García-Quevedo *et al*. (2014) for the importance of market growth in stimulating innovation.

such cases, innovation procurement can shift the risk on the buyer, through the specification of functional requirements and the order of the innovative products.

However, the market might fail in providing also the demand side mechanisms. Generally speaking, this will happen if demand cannot be articulated at a sufficient volume level. The possibility for this to occur hinges upon the existence of a buying power that presupposes awareness and the ability to interact, among consumers, on the one hand, and consumers and producers, on the other hand.

Based on the analysis of the previous sections, one can distinguish two categories of innovation failures stemming from hindrances on the demand side: a) a lack of incentives to take the initiative to put an order for innovative products, and b) the failure to reach a critical mass of demand.

An active role of buyers can be hindered by awareness problems, knowledge and adoption externalities (network effects, switching costs, etc.), that cause lock-in failures (Jaffe et al., 2004; OECD, 2014). Lead (von Hippel, 1986) and experimental (Malerba et al., 2007) users can determine the commercial success of new products. Their role is determined by two factors: the new technology has the characteristics of not simultaneously impacting on all potential users (von Hippel, 1986); and some users can benefit more than others from the new products (Schmookler, 1966; Mansfield, 1968; Utterback and Suarez, 1993). It is easy to envisage situations in which no potential adopter has the incentive to switch to a new product. The analysis of the relationship between innovation procurement and market structure has shown that this can easily be the case in polypsonistic markets for consumer goods. A typical example is energy savings technologies (Edquist and Hommen, 1998; Jaffe et al., 2004). Though it could be cheaper to reduce energy consumption than to increase energy supply, the return to suppliers introducing a new technology may be lower than the return to users. The demand side, however, is not organised and cannot articulate a demand for the new technology.

In the case of large scale projects, market demand might not reach the critical level necessary to guarantee the repayment of R&D and production costs.

When also the demand side lacks the incentive to procure innovation, there is scope for government intervention. This is the case when the risks of undertaking the innovation cannot be shifted onto consumers, either because the scale of the project is too large or because of a lack of market generated incentives.

Generally speaking, a welfare improving innovation will not be undertaken if there is a discrepancy between private and social returns.[6] The opportunity and effectiveness of public procurement should be considered along the dimensions used to analyse private procurement (Porter, 1990; Lundvall and Borràs, 1997; Edquist and Hommen, 1998), in particular the structure of the demand side and the phase of technological development.

Public procurement is usually the only case of monopsonistic conditions. As argued above, this structure entails the risk of a technological lock-in, especially if it creates a

[6] One case is the discrepancy between the social discount rate and the private one (De Bonis and Spataro, 2005, 2010; Spataro and De Bonis, 2008).

monopoly on the supply side and if the monopsonist buys intermediate products to be used for production in a nationalised industry (which represents a rationale for deregulation). However, it might be a solution in the case of large scale projects, guaranteeing a critical mass, especially justifiable if a high level of technical risk is associated to a high potential for innovation, especially in an early phase of the technological life cycle. The traditional example of successful public procurement for innovation is the development of the semiconductor industry in the US on impulse from the Department of Defence (Rothwell, 1994).

Oligopsony is a common condition in public procurement: different branches of government can make different procurement decisions and choose different products. Also, a public agency can play the role of “quality leader”, for instance acting as an experimental user in early stages of product cycles, when technical uncertainty is high (Malerba *et al*., 2207; Uyarra and Flanagan, 2009).

The public procurer can take the risk of purchasing a new product, especially if endowed with the necessary technical competence. Under another perspective, government could act as a customer with perfect foresight, willing to incur the costs of buying an inferior good today for the benefit of getting better products tomorrow. The best known example of this is perhaps the role played by the US Department of Defence in the 1960’s and 1970’s in the electronic industry. Under this respect, regulation or state ownership can play a positive role (to be contrasted with the positive potential effect of deregulation in overcoming the drawbacks of monopsonistic power).

Nevertheless, the positive influence of public procurement on innovation might be lost as the product reaches the maturity phase and innovative activity declines, with emphasis shifting to cost saving through large scale production (Utterback and Suarez, 1993; Faucher and Fitzgibbons, 1993). This is the parable of the US Department of Defence intervention in the electronic industry (Kanz, 1993), probably also due to the divergence between military and commercial trajectories, to be found also in the experience of other sectors (Geroski, 1990; Rothwell, 1994). However, besides technical uncertainty, economic uncertainty is also a potential hindrance to innovation, and one should not exclude the importance of public procurement also in later stages of the innovation cycle. As mentioned above, demand pull might be an important factor in determining new evolutionary branches during the diffusion stage (Kuhn, 1962; Dosi, 1982).

Getting back to demand configuration, it has already been noted that in polypsonistic consumer markets the fragmentation of demand involves little incentive for user-producer relationships, so that risk cannot be shifted onto buyers through procurement decisions. Thus, in markets with important societal needs, government might intervene to organise demand, through the specification of requirements based on socially desirable objectives. Successful examples of this have been the activity of the Japan’s Rental Agency (JECC) in the development of the domestic computer market and the NUTEK experience in Sweden, addressing the above mentioned pay-back in the case of energy efficiency.

Again, organising the demand side can represent a more effective policy than deregulation, since this emphasises the profit-maximising role of suppliers (Nilson, 1994; Edquist and Hommen, 1998). In these cases, public procurement has a catalyst nature, the motivation for intervention being stimulating demand rather than improving the provision of a public service.

Of course, public procurement is not the only public measure for innovation operating on the demand side. In the taxonomy proposed by Edler and Gheorgiu (2007), the other measures are: systemic policies, regulation, support of private demand. Actually, for market risk to be shifted from suppliers to buyers, an instrument might be to provide incentives for buyers, particularly in the form of a subsidy to early demand. This might be particularly effective when other forms of intervention risk impairing competition among suppliers.

6. Pre-commercial public procurement

Innovation procurement shifts technological and commercial risks from the seller to the buyer. When the scale of the project is large and/or obstacles are presents that hinder private demand, public procurement can play an important role. The specification of technical requirement is a key element of the mechanism. In the context of the phases of the innovation process, this happens before commercial (large scale) activities begin.

The research and innovation life cycle transforming an idea into a final good or service is usually divided into four phases (see, among others, European Commission, 2006): phase 1 consists in the exploration of solutions and feasibility studies; phase 2 covers the R&D activities up to the creation of prototypes; in phase 3, R&D is performed to obtain the first pre-series batch of pre-commercial volumes of pre-products/services in order to perform field test for validation; in phase 4, the production and commercialisation of large scale volumes of the product eventually take place. The R&D risk level is typically decreasing through the four phases; conventionally (see, for instances, European Commission, 2006), it is assumed to take the value "4" at the beginning of the first phase, reaching "0" once phase four is completed.

The assessment of functional specifications takes place between industrial research and commercialisation, allowing the results of the former to be shaped into the design of new products, including the creation of a prototype, thus reaching a lower risk level, compatible with commercialisation. These intermediate phases are usually characterised by a lack of private financing, since this usually comes in when a prototype exists. Before that, technical risk is too high and a business case is lacking. The innovative process might therefore be interrupted, especially in cases in which it is costly to steer solutions towards the development of prototypes and the creation of first test products. The incapacity of translating top scientific performances into innovative products, the so called European paradox, represents a widespread problem of the European economies.

The risk of committing to buy a yet-to-be-tested new product or service can be too high also for a public procurer. This is even truer after the dissolution of state monopolies that have historically played the role of first-buyers in partnerships with private firms. An instrument tailored to the specific technological phase is PCP.

Pre- commercial public procurement is a kind of procurement of R&D services by which the public procurer shares the risks and the effort to pull R&D activities until the production of first-test products. It has thus been defined the "missing link" in the EU innovation cycle (European Commission, 2006). Like public procurement of innovation, in general (Edquist and Zabala-Iturriagagoitia, 2012a), one can distinguish between direct PCP, when the aim is to better meet the public procurers' needs, and catalytic PCP, when it is aimed at stimulating private demand for innovative goods or services.

Since it does not entail the procurement of existing products, it has been considered a supply-side instrument, rather than a demand-side one (Edquist and Zabala-Iturriagagoitia, 2012b). It is, however, a procurement of services, and therefore considered a demand-side policy by the majority of the literature.

The separation from the commercial phase is appropriate when technological and commercial risks are high. Since information improves and uncertainty declines along the innovation cycle, separating the initial activities from the rest of the procurement process reduces the risk, in particular allowing the public procurer to test the innovative products before ordering them. The separation from the commercial phase may, however, reduce the incentives for potential suppliers (see below).

According to the EU law, an essential feature of PCP is the sharing of risks and benefits at market conditions between the public procurer and the supplier of R&D services. This provides for the exemption from the general prohibition of State aid under article 87 (1) of the EC Treaty, if the procedure guarantees competition and transparency.[7]

Thus, the main characteristics of PCP are: a) the separation between the R&D phase and the phase of the production of commercial products; b) the sharing of risks and benefits at market conditions; c) the competitive development in phases (see, for instance, Ramboll, 2008): like the US SBIR and the UK SBRI programmes, PCP is a model of competitive funnelling. It is a single procedure, with specific contracts for each phase (phase one, exploration of solutions; phase two, construction of prototypes; and phase three, production of first test series) of the innovation process and two points of intermediate evaluation. At the end of phase one and of phase two, the best projects are selected and go on to the next step. It is thus a phased process with multiple suppliers.

The separation from the commercial phase distinguishes PCP from general public procurement of innovation: while in the latter case the public agency acts as a lead customer by procuring the innovative solutions, the former is a procurement of R&D services needed for a technologically demanding solution that does not exist yet. PCP allows evaluating alternative solutions, comparing prototypes and validating new designs in real field tests, before engaging in tenders for large scale deployment.

The separation between the procurement of R&D services and the procurement of innovative goods thus allows procurers to de-risk large deployment contracts. Moreover, the re-opening of competition in the commercial phase ensures the best value for money.

These two effects are at the advantage of the public procurer, in that they limit the risk being shifted from the seller to the buyer. By the same token, however, leaving a significant part of the risk on the supply-side, they can discourage participation and thus the effective working of competition. The issue recalls the arguments on the connections

[7] Moreover, art. XV GPA WTO exempts public procurement of R&D services from national treatment and non-discrimination obligations, given their pre-commercial nature.

between innovation, market power and technological life cycle, tackled in the previous sections.

Moreover, especially in the case of catalytic procurement, the separation from the commercial phase might leave a gap between the characteristics of the good obtained in the R&D, PCP phase and the quality/price ratio threshold required by the market for mass production. This is a case of innovation deadlock: suppliers have reached the technological ability to produce innovative goods, but demand is lacking or not sufficiently articulated, so that the innovative solutions do not receive the investment necessary for commercialisation. Also, obtaining funds is particularly difficult at this stage, as it is in the prototyping phase, since public support is no longer available, being the product beyond the research phase, and private support is not yet available, the product being still in the pre-commercial phase. A typical example is the above mentioned case of energy saving technologies.

In these situations, the announcement that a critical mass of buyers intends to use the innovative solutions can trigger-in mass production. The critical mass could be reached by bundling private and public procurers. A policy instrument specifically designed to address this problem is *forward commercial procurement*, an instrument developed in the UK. The process is articulated in three phases: 1) definition and publication of the functional requirements that are common to all buyers (functions, features, price); this starts markets consultations that clarify the innovation level the suppliers can reach and the critical mass of demand required to foster the necessary investment; 2) an invitation to present solutions; 3) if these meet the requirements, large-scale production can start.

Competition and the presence of more than one firm should guarantee supply, prevent monopoly, and ensure better value for money and more creativity, thanks to competition. These are advantages for the public procurer and society as a whole.

However, competition among suppliers can reduce the incentives to participate to the procedure. The general interconnections between competition and innovation have been exposed above. In the particular case of PCP, analysing these relations should consider that the number of firms participating in the procedure will typically be small. This suggests that interdependence among rival firms' decisions should be recognized and, therefore, the results of the game theoretical approach literature should be applied. According to these, one needs both technical uncertainty and uncorrelated R&D activities of each firm in order to have several firms simultaneously trying to innovate. Otherwise, there can be at most one innovator (these results were derived by Dasgupta and Stiglitz, 1980).

Under this respect, thus, the structure of PCP is compatible with the presence of multiple firms, since the procedure presupposes a relevant degree of technical uncertainty and is aimed at testing alternative solutions.

However, there are several obstacles that can hinder the participation of a plurality of competing firms. First, the number of producers in the relevant sectors might be small. Second, the funds initially available for each participant might be lower than in projects without multiple suppliers (in the procurer's perspective, instead, multiple suppliers can mean higher initial costs, that will be recovered with the lower price obtainable under competitive conditions). Then, a disincentive may derive from the possibility that business secrets be disclosed to rivals. Finally, because of the separation from the commercial phase, the winners of the pre-commercial phase do not necessarily obtain the contract for large scale deployment.

This might imply that the commercial tender is won by a non-innovating firm, substantially acting like an imitator. As argued above, the possibility of imitation reduces the incentive to innovate. Moreover, along the innovation cycle, two different situations have been distinguished: the initial phase, in which the innovator obtains monopoly profits being the unique seller of a product, and the phase in which a dominant design has emerged, in which the presence of economies of scale typically determines the dominance of a large firm. Profits obtained in the first phase might not be a sufficient incentive to innovate.

Thus, in PCP, the possibility that a (large) firm, substantially acting as an imitator, win the commercial phase, can discourage participation by innovating firms. This might be particularly true for SMEs that might foresee the weaker position vis-à-vis large firms in the commercial tender. There are, however, other aspects of the PCP procedure that might favour the participation of SMEs (European Commission, 2006). PCP covers the innovation cycle until the testing of new products to ensure that they comply with the functional requirements requested by procurers. Along the procedure, SMEs can become ready for large-scale production. In the perspective by Malerba *et al*. (2007), they have time to develop the product to meet the market quality threshold level, so that PCP can be used to break the lock-in deriving from the presence of sophisticated buyers. Moreover, PCP allows to gradually increase the financial requirements to perform the task, so that SMEs can grow together with the project.

The obstacles to the presence of a multiplicity of suppliers must be tackled with *ad hoc* measures, since the competitive development is a crucial feature of PCP: each supplier should typically maintain their IPRs, so that even those who do not pass to the successive phases can exploit the results of their R&D investment; the business plan should be reconsidered at the end of each phase, to ensure that all potential benefits are reaped; the degree of risk sharing should be differentiated among the different phases, with the procurer endorsing most of the costs in the initial phase.

This brings back to the role of supply and demand in bearing the risk connected to innovation. The two polar cases identified in the literature are the supply push and the demand pull. The former is the typical one, with the supplier bearing the costs and obtaining the benefits from innovating. The latter is technology procurement, where the buyer takes the risk, by procuring the innovative good or service.

With respect to this, PCP is a peculiar solution, which can explain the debate found in the literature relative to its configuration either as a supply-side or a demand-side instrument. The separation from the commercial phase allows the procurer to take only (part of) the risks connected to R&D services. Also, competition among suppliers gives the opportunity of evaluating different solutions and to obtain, in the commercial phase, lower prices for the good. The counterpart of this is a large portion of risk being left to the supplier.

To counterbalance this, producers need to obtain a larger share of the benefits of the innovation process. This economic reason, besides the legal restrictions on State aid, explains the need for a shared risks-shared benefits approach, centred on the agreements on the assignment of IPRs. This element is an important step in the innovation cycle: recall that, in one of the most famous examples of private technology procurement, the cooperation between Toyota and Nippon Steel, an agreement on the exploitation of research results preceded the beginning of large scale production.

PCP does not involve an exclusive use of research results by the public procurer; instead, these are typically shared with suppliers and other shareholders (for instance, another public procurer). This feature is directly linked to the fact that research results do not consist in a commercial product.

Benefit-sharing should be an incentive to suppliers to also share risks with the procurer, balancing the former's financial interest with the latter's interest not to bear the whole financial and technological risk. Under this respect, the benefits to the supplier stemming from the future commercialisation of the product are a relevant element. When the needs of the public procurer are in advance of those of the market, benefit sharing can favour the success of the future commercial phase and shorten the time to market of the new product. In such instances, the public sector can induce the formation of a lead market. Other benefits for the supplier are the opportunity to develop the product according to the feedbacks from potential clients and the possibility of cooperating with the public sector after the project.

IPRs are a key benefit of R&D projects and, therefore, of risk benefit sharing. Moreover, they are strictly connected to the presence of multiple suppliers and to the other key factors of PCP; that is, the bundling of demand,[8] the involvement of SMEs, the motivations and capacities of the public procurer, the technical dialogue between the public procurer and potential suppliers[9] and the financing strategy.[10]

All these factors are strictly interrelated. The choice of the IPRs strategy is a good perspective to analyse them.

7. The IPRs strategy

The problem of the assignment of IPRs can be identified with respect to its two extreme solutions: a) assigning IPRs to the supplier involves the risk of a vendor lock-in situation for the procurer, who has paid the good/service development costs; b) assigning the IPRs to the procurer reduces the incentives to innovate and to share risks, not allowing the supplier to exploit the innovation in the markets; the issue is clearly connected to the

[8] Bundling of demand reduces risks and costs for the single procurer; allows sharing knowledge; can favour the creation of a lead market, if the critical mass level is reached. It however involves coordination costs.

[9] The lack of technical dialogue has been considered among the reasons of the failure of the first version of SBRI in the UK.

[10] Government could support the creation of a venture capital fund dedicated to PCP, especially to support the participation of SMEs.

distinction between direct and catalytic procurement, which can, on turn, be connected to the different nature, public or private, of the goods or services procured: in the former case, one cannot foresee a commercialisation independently of public demand.

IPRs sharing can ensure to meet both the public procurer's and the supplier's fundamentals needs. The procurer should be able to freely apply the innovation, directly using it or licensing it to other producers to guarantee competition; the supplier should be able to commercially exploit it with other customers.

In PCP, IPRs are attributed either to the procurer or to the supplier in a non-exclusive way. In the first case, the public procurer does not keep exclusive IPRs, but allows the supplier to commercialise products, thus obtaining risk sharing, through a price reduction or participation in the costs of managing IPRs. In the second case, as in the US SBIR, the procurer keeps the right to freely use the innovation or to license it to third parties (or to require the supplier to license it to third parties at market conditions).

The degree of sharing should depend on the contribution that each party has given to the development of the innovation and on the ability to exploit IPRs. In general, the more innovative the solution and the larger the investment required, or the highest the probability of commercial exploitation and future improvements, the more IPRs should be left with the market. Instead, the higher the risk of vendor lock-in and uncertainty, the more IPRs should be left with the public procurer.

There are two main instruments for sharing IPRs: licences and royalties. The management of IPRs has repercussions on the competitive nature of PCP.

First, the application to the tender is probably a work protected by copyright itself. It is thus important for the procurer to be allowed to copy and use it to carry out the procedure. For instance, in the Austrian Asfinag, R&D services were totally financed by the administration, in exchange for the right to publish the results. As for the UK, in the ETI project, all information could be published, unless protected by a patent; in the DECC project, the procurer was allowed to publish information, together with data and results.

As for the IPRs that result from the project (foreground IPRs), the strategy depends upon the procurer's objective, that is, whether it wants to directly use them or control their protection and exploitation. The most used approaches in PCP are the following:

1) Non-exclusive licences; this is the most common approach. The procurer has a royalty-free, non-exclusive license; the supplier can use IPRs or license them to third parties.

2) Exclusive licences: only the public procurer can use the IPRs; it is not the right instrument if the administration intends to share the IPRs with the market.

3) Open licenses with royalty payment: the public procurer can use the IPRs for new projects and sub-license them, but they remain with the supplier and the public procurer pays royalties for each use. An example is the Dutch Civil Engineering Programme, a general agreement for the use of open licences in civil engineering works for the public sector in the Netherlands. The administration can maintain, repair, modify and demolish the works; it can apply innovations to new works subject to the payment of royalties; and stipulate contracts with other suppliers. Suppliers have the IPRs and can recoup the investment costs by using them in new works with the public administration or other

procurers and obtaining royalty payments. A particular case is the open source software licence, which grants the licensee a wide liberty of use; the public procurer can choose it when aiming at giving open access to the IPRs, in the meantime keeping the paternity of the solution for the supplier or for itself.

Of course, the participation to the tender is less attractive if fewer rights are granted to the supplier. From the public procurer's point of view, the right to use the innovation, to let other parties use it and to obtain a return for letting other use it are granted both by entitling the public procurer with the IPRs and by leaving them with the supplier, but granting the public procurer a licence.

The procurer's intent to limit the use of the innovation by third parties is obtained by assigning the IPRs to the public procurer or by assigning it to the supplier, but granting the public procurer with an exclusive licence. The public procurers have the right to patent the innovation only if the IPRs are assigned to them.

Some practical solutions can illustrate these arguments. The ETI is a public-private partnership among the UK government and eleven companies in the energy sector. The aim is to meet a grand societal challenge. Economic benefits are assigned based on individual contributions, valued at market prices. In particular, the public procurer finances the research services and IPRs are assigned to ETI in a non-exclusive way. Another example is that of the NHS (National Health Service)-NIC (National Innovation Centre), using PCP to directly address a need of the public administration. According to the desired participation level, one can have contracts with the IPRs being assigned to the NHS or contracts in which they are assigned to the suppliers. In the bioenergy DECC project, suppliers have the forward IPRs and must identify and protect patentable knowledge within a given time (three years); the procurer is granted a royalty-free, non-exclusive licence. First-test series belong to the suppliers.

In the Italian Arca project, IPRs are assigned to the supplier. The procurer can use the results for internal use, but must wait five months before implementing the commercial tender to allow the suppliers to protect their rights. In the case of vendor lock-in, the administration can ask the supplier to licence third parties at "equitable and fair" market conditions. The public procurer receives a financial compensation in the form of a 1% participation to the revenues obtained in the future by the supplier and licensee companies. Again in Italy, in the case of Regione Piemonte, IPRs are assigned in an exclusive way to the party that has autonomously developed the innovation, while property is common for those jointly developed. Transfers to third parties at market conditions must be agreed upon by both parties. In both projects the supplier must take care of the registration of patents. If the supplier does not fulfil the obligation, the public procurer can freely obtain the ownership.

Finally, one should consider that, in order to implement the innovative solution, in some cases it might be necessary to use IPRs developed independently of the PCP procedure, the so called background IPRs. Of course, they should be licensed to the public procurer, who can ask the applicants to reveal any background IPRs they know to be necessary to implement the solution. Should they belong to third parties, the need to obtain a licence should be taken into account when awarding the contract.

8. Conclusions

The initiative of innovation usually rests with the producer, who anticipates monopoly profits for being the unique seller of the new good. There are, however, situations in which uncertainty is so high that welfare increasing innovation activities are not undertaken in the lack of the assurance of future demand at a level high enough to recover R&D and production costs. In such cases, innovation procurement can shift the risk onto the buyers, through the specification of technical requirements and the commitment to buy the new product. However, also the demand side mechanism will not operate, if incentives to take the initiative are lacking or the critical level of demand is not reached.

In these situations, there is scope for government intervention. But the risk of committing to buy a yet-to-be-tested new product could be too high also for the public procurer. PCP, the procurement of R&D services by which the risks and the costs of R&D activities until the production of first-test products are shared between the public procurers and the suppliers, can be a solution. The separation from the commercial phase allows the procurer to test the innovative product before ordering it in commercial volumes.

The instrument appears appropriate, if one considers that the assessment of functional requirements takes place between basic research and commercialisation, in a phase characterised by a lack of private financing. It can, thus, potentially avoid the interruption of the innovation process, a cause of the so-called European paradox, that is, the inability of translating scientific and technological leadership into the commercialisation of new products.

The separation between pre-commercial and commercial procurement thus allows overcoming the risk of large deployment contracts. Moreover, it also allows re-opening competition in the commercial phase, ensuring lower prices.

This element, as well as the presence of multiple suppliers in the pre-commercial phase, can discourage participation (even if the structure of PCP is in principle compatible with the presence of multiple firms, since the procedure presupposes a relevant degree of technical uncertainty and is aimed at testing alternative solutions). This is even truer because of the possibility that a (large) firm, substantially acting as an imitator, eventually win the commercial tender.

To counterbalance all this, suppliers must obtain a larger share of the benefits than in usual procurement. This explains why PCP is a shared risks – shared benefits approach, besides the legal restrictions on State aid.

The key instrument of benefit-sharing is the management of IPRs. Their sharing can allow, on the one hand, the procurer to freely use the innovation and guarantee competition and, on the other hand, the supplier to commercially exploit it with other customers. The degree of sharing should depend on the contributions that the parties have given and on the ability of exploiting the IPRs. Some practical solutions have been illustrated.

The separation from the commercial phase marks the strength, but also the weakness of PCP. Especially in the case of catalytic procurement, a gap might remain between the characteristics of the prototype and the market requirements; private demand might remain unarticulated; private funding is still not available, being the product in the pre-commercial phase.

A remedy to this could be joining PCP with a policy instrument that bundles private and public demand; an example is forward commercial procurement. In other cases, subsidising buyers could be a more effective instrument than procurement, allowing risk to be shifted from suppliers to buyers, especially if PCP cannot guarantee an effective working of competition.

References

Antonelli, C. and A. Gehringer, 2015, “Knowledge externalities and demand pull: the European evidence”, *Economic Systems*, 39 (4), 608-631.

Arrow, K., 1962, “Economic welfare and the allocation of resources for inventions”, in: R.R. Nelson (ed.), *The rate and direction of inventive activity*. Princeton, NJ: Princeton University Press.

Baldwin, W.L. and G.L. Childs, 1969, “The fast second and rivalry in research and development”, *Southern Economic Journal*, 36, 18-24.

Bresnahan, T. and S. Greenstein, 2001, “The economic contribution of information technology: towards comparative and user studies”, *Journal of Evolutionary Economics*, 11 (1), 95–118.

Dasgupta P. and J. Stiglitz, 1980, “Industrial Structure and the Nature of Innovative Activity”, *Economic Journal* 90, 266-293.

De Bonis, V. and L. Spataro, 2005, “Taxing capital income as Pigouvian correction: the role of discounting future”, *Macroeconomic Dynamics*, 9 (4), 469-477.

De Bonis, V. and L. Spataro, 2010, “Social discounting, migration and optimal taxation of savings”, *Oxford Economic Papers*, 62 (3), 603-623.

Dosi, G., 1982, “Technological Paradigms and Technological Trajectories: A Suggested Interpretation of the Determinants and Direction of Technical Change”, *Research Policy* 11, 147-162.

Economic Policy Committee, 2002, *Report on Research and Development*, European Council, Brussels.

Edler, J. and Georghiou, L., 2007, “Public procurement and innovation – Resurrecting the demand side”, *Research Policy*, 36, 949-963.

Edquist, C. and L. Hommen, 1998, “Government Technology procurement and innovation theory”, *Innovation Systems and European Integration*, European Commission.

Edquist, C. and J.M. Zabala-Iturriagagoitia, 2012a, “Public Procurement for Innovation as mission-oriented innovation policy”, *Research Policy*, 41, 1757-1769.

Edquist, C. and J.M. Zabala-Iturriagagoitia, 2012b, *Why Pre-commercial procurement is not Innovation Procurement*, Paper n. 2012/11, Circle, Lund University.

European Commission, 2006, *Pre-commercial procurement of Innovation. A missing link in the European Innovation Cycle*, Brussels.

Faucher, P. and K. Fitzgibbons. 1993. “Public demand and the management of technological risk in large-scale projects”, *Science and public Policy*, 20 (3), 173-185.

Franke, N. and S.K. Shah, 2003, “How communities support innovative activities: an exploration of assistance and sharing among end-users”, *Research Policy*, 32, 157–178.

García-Quevedo, J., G. Pellegrino and M. Savona, 2014, *Reviving demand-pull perspectives: the effect of demand uncertainty and stagnancy on R&D strategy*, Document de treball de l’IEB 2014/11, Barcelona.

Geroski, P. A, 1990, “Procurement policy as a tool of industrial policy”, *International Review of Applied Economics*, 4 (2), 182-198.

Godin, B. and J.P. Lane, 2013, *“Pushes and pulls”: the (hi)story of the demand pull model of innovation*, Project on the intellectual history of innovation, Working paper no. 13.

Granstrand, O., 1984, *Technology procurement as a special form of buyer-seller interaction in industrial markets*, CIM report no. 84/06, Göteborg: Chalmers University of Technology, Department of Industrial Management.

Griliches, Z. and J. Schmookler, 1963, “Inventing and maximizing”, *American Economic Review*, 53, 725-29.

Harhoff, D., J. Henkel and E. von Hippel, 2003, “Profiting from voluntary information spillovers: how users benefit by freely revealing their innovations”, *Research Policy*, 32 (10), 1753–1769.

Hellman, J.-L., 1993, *Supplier-customer interaction in product development: A case study of Nippon Steel’s cooperation with Toyota*, Kunitachi, Tokyo: Hitotsubashi University, Institute of Business Research.

Jaffe, A.B., R.G. Newell and R. N. Stavins, 2004, *A tale of two market failures. Technology and environmental policy*, RFF DP 04-38, Washington.

Kamien, M.I. and N.L. Schwartz, 1982, *Market Structure and Innovation*, Cambridge University Press, Cambridge.

Kanz, J. W., 1993, “Technology, globalization and defence: Military electronics strategies in a changing world”, *International Journal of Technology Management*, 8 (1/2), 59-76.

Kuhn, T.S., 1962, *The Structure of Scientific Revolutions*, Chicago: University of Chicago Press.

Leibenstein, H., 1966, “Allocative efficiency vs. X-efficiency”, *American Economic Review*, 56, 392-415.

Lundvall, B.-Å, 1985, *Product innovation and user-producer interaction*, Industrial development research series no. 31, Aalborg: Aalborg University Press.

Lundvall, B.-Å., 1988, "Innovation as an interactive process: from user–producer interaction to the national system of innovation", in: Dosi, G., C. Freeman, R. Nelson, G. Silverberg, and L. Soete, (eds.), *Technical Change and Economic Theory*, Pinter, London, 349–369.

Lundvall, B.-Å. (ed), 1992, *National systems of innovation: Towards a theory of innovation and interactive learning*, London: Pinter Publishers.

Lundvall, B.-Å. and S. Borràs, 1997, "The globalising learning economy: implications for innovation policy", *Report based on contributions from seven projects under the TSER programme DG XII*, Commission of the European Union.

Malerba, F., 2002, "Sectoral systems of innovation and production", *Research Policy*, 31 (2), 247-264.

Malerba, F., 2007, "Innovation and the dynamics and evolution of industries: Progress and challenges", *International Journal of Industrial Organization*, 25, 675–699.

Malerba, F., R. Nelson, L. Orsenigo and S. Winter, 2007, "Demand, innovation, and the dynamics of market structure: The role of experimental users and diverse preferences", *Journal of Evolutionary Economics*, 17 (4), 371–399.

Mansfield, E., 1968, *Industrial Research and Technological Innovation: An Econometric Analysis*, W. W. Norton, New York.

Meyers, S. and D.G. Marquis, 1969, *Successful Industrial Innovations*, National Science Foundations, Washington.

Mowery, D. and N. Rosenberg, 1979, "The influence of market demand upon innovation: a critical review of some recent empirical studies", *Research Policy*, 8 (2), 102-153.

D.C. Mueller and J.E. Tilton, 1969, "R&D Cost as a Barrier to Entry", *Canadian Journal of Economics*, 2 (November), 570-579.

Nelson, R. (ed), 1993, *National systems of innovation: A comparative study*, Oxford: Oxford University Press.

Nilson, H., 1994, *Technology procurement for market transformation - a customer tool for sustainable design and manufacturing*, Stockholm: NUTEK.

OECD, 2014, "Intelligent Demand: Policy Rationale, Design and Potential Benefits", OECD Science, Technology and Industry Policy Papers, No. 13, OECD Publishing. http://dx.doi.org/10.1787/5jz8p4rk3944-en

Porter, M. E., 1990, *The competitive advantage of nations*, London: MacMillan.

Ramboll Management Consulting (2008), "Opportunities for Public Technology Procurement in the ICT-related Sectors in Europe", *Final Report fo the* DG Information and Society, CE.

Rothwell, R. and W. Zegveld, 1982, *Industrial innovation and public policy*, London:

Frances Pinter.

Rothwell, R., 1994, "Issues in user-producer relations in the innovation process: The role of government", *International Journal of Technology Management*, 9 (5/6/7), 629 - 649.

Schmookler, J., 1966, *Invention and Economic Growth*, Harvard University Press, Cambridge, MA.

Spataro, L. and V. De Bonis, 2008, "Accounting for the "disconnectedness" of the economy in OLG models: a case for taxing capital income", *Economic Modelling*, 25, 2008, 411-421.

Sutton, J., 1991, *Sunk Costs and Market Structure*, MIT Press, Cambridge MA.

Sutton, J., 1998, *Technology and Market Structure: Theory and History*, MIT Press, Cambridge, MA.

Schumpeter, J.A., 1975, *Capitalism, Socialism and Democracy*, New York: Harper.

Smith, K., 2000, "Innovation as a systemic phenomenon: rethinking the role of policy", *Enterprise & Innovation Management Studies*, 1 (1), 73-102.

Usher, D., 1964, "The welfare economics of invention", *Economica*, 31, 279-287.

Utterback, J.M., and F. F. Suarez, 1993, "Innovation, competition and industry structure", *Research Policy*, 22, 1 - 21.

Uyarra, E. and K. Flanagan, 2009, *Understanding the innovation impact of public procurement*, Manchester Business School Working Paper No. 574.

Von Hippel, E., 1986, "Lead users: a source of novel product concepts", *Management Science*, 32 (7), 791–805.

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