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# A time to nourish? Evaluating the impact of public procurement on technological generality through patent data

Emilio Raiteri\*

College of Management of Technology, École polytechnique fédérale de Lausanne (EPFL), Switzerland

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## ABSTRACT

Innovative public procurement is increasingly considered as a form of public support for private innovation activities by both innovation scholars and policymakers. Economic historians have suggested an even more fundamental role of public procurement in setting the pace of technological change, reporting how defense-related procurement has had a major impact on the emergence and diffusion of many general purpose technologies developed in the United States in the 20th century. In this paper, I suggest that procurement might represent one of the most important elements in creating the right soil to ‘cultivate’ a technology that may have the potential to reach high levels of pervasiveness. To test this hypothesis, I make use of patent data and patent citations. I design a quasi-experiment to compare the changes in the level of generality level over time, between a group of treated and a group of control patents. A patent is assigned to the treatment group if it receives a citation from a patent related to public procurement. Results suggest a positive and significant impact of innovative public procurement on the generality of a patent.

## 1. Introduction

Scholars have long acknowledged the important role played by market demand in shaping technological change and setting the pace of innovation (Schmookler, 1962; Kaldor, 1966). Although the difficulties involved in clearly differentiating between supply-side and demand-side induced innovations (Mowery and Rosenberg, 1979; Dosi, 1982) has hampered the study of this relation, the demand-pull hypothesis has never been abandoned and has recently regained momentum. In this context, the debate on the influence of public demand on technological change has been attracting attention. In particular, both economists and policy makers are increasingly considering innovative public procurement as an effective form of public support for private innovation activities, highlighting the need for demand-oriented technology policy (Edquist and Hommen, 2000b; Edler and Georghiou, 2007).

Even though policymakers’ acknowledgment of public procurement as a *de facto* technology policy is recent, economic historians have for long been suggesting an even more fundamental role for public procurement in affecting the speed of technological change. Several works that study the technological evolution in the United States (U.S.), stress that the government demand has been a crucial factor for the development of the most influential technologies of the 20th century (Mowery and Rosenberg, 1982; Levin, 1982; Langlois and Steinmueller, 1999). In addition, the theoretical literature on general purpose

technologies (GPTs), and in particular the seminal work by Bresnahan and Trajtenberg (1995) (hereafter BT), suggest that public procurement may considerably affect the arrival of a new GPT.

Despite the contributions of economic historians, no empirical work has so far provided evidence of the tight link between public demand and technological generality. This paper tries to fill this gap. Conceiving the arrival of a GPT ‘as a process unfolding in time rather than a single homogeneous shock’ (Cantner and Vannuccini, 2012, p.16), I suggest that procurement might represent one of the most important elements for creating fertile ground to ‘cultivate’ a technology that may (or may not) have the potential to reach high levels of pervasiveness. To formalize this hypothesis, I make use of patent data and, especially, of patent citations. I design a quasi-experiment that allows me to compare the change in the generality level (measured by the generality index) over time between a group of treated and control patents. Public procurement is the treatment variable and a patent is considered to belong to the treatment group if it received a citation from a patent induced by a public procurement contract. To build the relevant variables for the quasi-experiment, I create an original dataset exploiting data from four different sources: (i) the NBER patent data project; (ii) the Federal Procurement Data System (FPDS); (iii) the USPTO patent full-text and image database; and (iv) the Compustat North America Database.

The results retrieved through the conditional difference-in-differences estimator (CDiD) suggest a positive and significant impact of

\* Correspondence to: EPFL CDM ITPP IIP, ODY 2 19, Station 5, CH-1015 Lausanne, Switzerland.  
E-mail address: [emilio.raiteri@epfl.ch](mailto:emilio.raiteri@epfl.ch).

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innovative public procurement on the generality of a patent.

The rest of the paper is organized as follows. Section 2 presents the literature strands that provide the motivation and rationale for this work. Section 3 introduces the formal hypothesis to be tested and Section 4 describes the data and methodology used in the empirical analysis. Section 5 presents the results and robustness checks. Section 6 concludes.

## 2. Theoretical framework

### 2.1. Innovative public procurement as a technology policy

The idea that demand might be a major source of technological change dates back to the seminal contribution of Schmookler (1962) and Kaldor (1966). Despite some slowdown in the study of this relationship during the 1980s owing to disruptive critiques from Mowery and Rosenberg (1979) and Dosi (1982), the demand-side approach has slowly regained attention (see among others: Von Hippel, 1988; Malerba et al., 2007; Rogers, 1995; Fontana and Guerzoni, 2008; Guerzoni, 2010). Also, with the resurrection of the demand side, the debate on the role of public demand in fostering innovation has been revitalized.

Although the impact of government demand on firms' behavior appears to be plausible just because of its size,<sup>1</sup> attention has recently focused on its technological and innovative composition and to what is usually described as 'innovative public procurement'.<sup>2</sup>

Innovative public procurement is generally considered to occur when 'a public agency places an order for a product or a system that does not exist at the time but which could probably be developed within a reasonable period' (Edquist and Hommen, 2000b). This form of purchasing is usually opposed to 'regular public procurement', which occurs when a public agency buys ready-made simple products, such as pens and paper, where no R&D is involved (Edquist and Hommen, 2000b). However, some recent works (Uyarra and Flanagan, 2010; Rolfstam, 2012) highlight the potential limitations of this simple definition and stress that constraining the scope of innovative procurement to what happens after a formal order from a public agency is placed is missing the potential indirect effects of procurement on firm behavior. In line with Guerzoni and Raiteri (2015), in this paper, I adopt a somewhat broader definition that considers all the 'purchasing activities carried out by public agencies that may lead to, or promote, innovation of some kind' (Rolfstam, 2012) to be innovative public procurement. This definition includes what is usually referred to as pre-commercial public procurement, an R&D service contract that may involve exploratory research up to prototyping, as long as it produces a tangible innovative output.<sup>3</sup>

Leaving aside the debate over a narrower or broader definition, over the last few years, innovative public procurement has been considered increasingly as a form of public support for private innovation activities, and hence a 'de facto' technology policy (Cozzi and Impullitti, 2010).<sup>4</sup> Several theoretical works (Geroski, 1990; Dalpé, 1994; Edquist and Hommen, 2000a; Edler and Georghiou, 2007) emphasize the potential positive effects of innovative procurement on firms' innovative behavior through multiple and interacting channels. First, public procurement is thought to provide a minimal market size that allows firms to compensate costs and reduce the risks involved in doing R&D for

products or services for which private demand is highly unpredictable. Second, public agencies may act as lead users in certain industries such as defense or aerospace, providing producers with precious information about market needs and requirements, and enabling firms to uncover already existent demand that is unmet by currently available products or services. Third, procurement can also promote standards setting and the diffusion of specific technologies.

On this ground, numerous scholars have called for the need of 'de jure' procurement-oriented innovation policies. At the supranational level, the European Commission (EU, 2010) and the OECD (OECD, 2013), recently started listening to this call and now recognize innovative public procurement among other more consolidated technology policies, such as R&D subsidies and tax credits.

Alongside the theoretical and political attention that public procurement is attracting, there is a growing body of literature providing quantitative empirical evidence on the positive impact of public procurement on firms' innovative behavior and abundant qualitative evidence from case studies (Edquist and Hommen, 2000a; Rolfstam, 2009; Uyarra and Flanagan, 2010; Flanagan et al., 2011; Brammer and Walker, 2011). An early work in this area by Lichtenberg (1988) tested the effect of federal procurement on contractors' private R&D expenditures. The result of this study suggests that public procurement not only has a positive effect on the propensity of firms to engage in R&D but also that the demand-pull effect is stronger for public procurement than for private contracts. A more recent paper by Aschhoff and Sofka (2009) compares the impact of various technology policies (R&D subsidies, innovative public procurement, regulation, university research) on firms' innovative output. They find robust evidence of a positive impact of public procurement, particularly for small firms. Guerzoni and Raiteri (2015) is the first paper to provide evidence on the contextual impact of three different technology policies, innovative public procurement, R&D subsidies, and tax credits, on firms' innovative behavior measured as innovative input (total innovation expenditure). Their results suggest that innovative public procurement is very effective for raising private investment in R&D, especially when combined with other complementary technology policies.

### 2.2. Public procurement in the economic-historical analysis of technological change

As discussed above, policymakers and innovation scholars increasingly consider public procurement as an effective policy tool to foster innovation. However, recent works in this strand of literature discuss neither the types of innovations that public procurement induces nor their technological impact. This gap is somewhat surprising when we consider the numerous historical and economic analyses that investigated the contribution of defense-related procurement in shaping the patterns of technological change during the 20th century, especially in the U.S. Early works by Levin (1982), Mowery and Rosenberg (1982), and Katz and Phillips (1982) stress that the sheer size of procurement for components and systems for purposes of national defense and spatial exploration resulted in fundamental technological advances in the semiconductor, computer, and aviation industries.<sup>5</sup> Levin (1982) highlights that the presence of government demand greatly reduced the risk of investment in semiconductor technologies, such as the silicon transistor and the integrated circuit, in the early years of their development. Other studies (Mowery and Rosenberg, 1989; Langlois and Steinmueller, 1999; Mowery, 2011, 2012) confirm that large procurement contracts drove private R&D efforts in the semiconductor sector and also that some of the most important inventions in the industry,

<sup>1</sup> According to OECD (2013) member countries spend on average 13% of their GDP on public procurement.

<sup>2</sup> Expressions like 'public technology procurement' and 'public procurement of innovation' are used to refer to very similar phenomena. For further discussion see Rolfstam (2012).

<sup>3</sup> In the context of the present paper, the filing of a patent document by the contractor will represent the tangible innovative output of a procurement contract.

<sup>4</sup> For a review of the state of the art of this debate on innovative public procurement, including definitions and taxonomies, see Uyarra (2013).

<sup>5</sup> These studies are collected in a volume edited by Richard Nelson in 1982 (Nelson, 1982), in which different scholars analyze how public policies affected technical progress in seven key American industries: Semiconductors, Commercial Aircraft, Computers, Agriculture, Pharmaceuticals, Motor Vehicles, Residential Construction.

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