Demand-side vs. supply-side technology policies: Hidden treatment and new empirical evidence on the policy mix

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ABSTRACT

This paper provides new empirical evidence about the impact of various technological policies upon firms' innovative behaviour. We take into consideration the role of policies for innovative activities and we focus on their interaction. While supply-side policies such as R&D subsidies and tax credits have been both extensively discussed in the literature and empirically investigated, the analysis of innovative public procurement is a growing trend in the literature, which still lacks robust empirical evidence. In this paper, we replicate the existing results on supply-side policies, surmise fresh empirical evidence on the outcome of innovative public procurement, and address the issue of possible interaction among the various tools. When controlling for the interaction with other policies, supply-side subsidies cease to be as effective as reported in previous studies and innovative public procurement seems to be more effective than other tools. The preliminary evidence suggests that technology policies exert the highest impact when different policies interact.

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1. Introduction

R&D subsidies are a form of innovation policy that has been extensively analyzed in the literature. One of the most debated issues has been whether R&D subsidies displace private efforts or, on the contrary, favour them due to some form of complementary relationships. The more recent literature seems to converge towards a substantial rejection of the presence of a crowding-out effect in R&D subsidies. Since the seminal paper by Almus and Czarnitzki (2003), a widespread empirical method to approach the issue has been the use of a quasi-experimental setting in which the outcome variable is the innovative performance and the treatment is whether firms receive subsidies or not. In order to control for the selection bias, subsidized firms are compared with a control group that has been previously made comparable through the implementation of non-parametric matching techniques. Most of these studies point in the direction of substantial complementarity of R&D subsidies and private R&D investment. However, this specific empirical method in use deserves further analysis. In quasi-experimental settings, the researcher runs the risk of omitting

non-observable variables which can nevertheless influence the results. When these variables are randomly distributed among the subsidized firms and the control group, they do not bias the results. However, when the omitted variables change with the level of the subsidies, they can be a possible source of a confounding effect. The literature is very well aware of this problem and in the next section we mention various papers that try to cover the majority of possible sources of confounding factors. A second possible confounding factor, which has not been discussed at all in the literature, consists of the presence of potential hidden treatments. In the case of a specific technology policy, a hidden treatment might be represented by a confounding variable that is not a firm's characteristic, but an additional strategic option that can be implemented by the policy maker to obtain the same results. If this event is not taken into account, it is impossible to conclude that the observed innovative outcome is due to the use of R&D subsidies or, by contrast, to the implementation of other non-observed technology policies or the interaction of a policy mix.

More specifically this paper considers R&D tax credits and innovative public procurement as possible hidden treatments. While R&D tax credits have been extensively analyzed (Eisner et al., 1984; Mansfield, 1986; Hall, 1993; Hall and Van Reenen, 2000), there is a growing trend in the literature on technology policy about the role of innovative public procurement as a possible complement or alternative policy to supply-side policies

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(Edler and Georghiou, 2007). In the case of R&D subsidies and tax credits scholars have mostly focused on the impact upon the innovative input; conversely, the literature on innovative public procurement has focused on the effect of innovative public procurement upon both innovative input and innovative output such as innovative turnover. Despite various theoretical accounts, the empirical evidence is still very fragmented. In this paper, we surmise that R&D subsidies, R&D tax credits, and innovative public procurement are tools of the technology policy mix that can contextually affect a firm's innovative performance. For this reason, in order to evaluate the effect of either policy a researcher should implement a method able to disentangle the various effects.

In this paper we aim to test the contextual impact of R&D subsidies, R&D tax credits, and innovative public procurement upon a firm's private R&D investment. Hence, we make three points. First, by taking into account innovative public procurement and R&D tax credits, we control the past results on R&D subsidies for a possible hidden treatment such as alternative technology policies. Second, we provide empirical evidence on the effectiveness of innovative public procurement. Finally, we discuss the interaction of the various policies and call for further research on the policy mix rather than on policy in isolation.

In the next section we discuss the state of the art. In Section 3.2 we present the data and methodology. The empirical results and conclusion follow.

2. Theoretical framework

2.1. Supply-side technology policy: R&D subsidies and tax credits

The impact of public R&D subsidies upon innovation outcome has been broadly discussed in the literature, yet there is still puzzling evidence about the nature of the interaction of R&D subsidies with private investment. The central question is whether public support displaces private efforts, simply adds to them, or even favours their increase. The argument concerning whether substitutability, additionality or complementarity exists between R&D subsidies and private R&D investments has long been debated in the literature. David et al. (2000) survey the empirical literature and find mixed evidence for various levels of aggregation of the unit of analysis. On the one hand, some studies at the firm level suggest that public R&D subsidies crowd out private R&D investment (Shrieves, 1978; Carmichael, 1981; Higgins and Link, 1981), while others indicate the existence of a possible reinforcing mechanism between the two of them (Holemans and Sleuwaegen, 1988; Link, 1982; Antonelli, 1989). Capron (1992) and Capron and De La Potterie (1997) show that the effect might depend on various covariates that are idiosyncratic to the specific subsidies programmes such as country and sector of eligibility, to the firm and market size and to the intensity of the subsidies. Garcia-Quevedo (2004) discusses the studies reviewed in these surveys and counts 37 articles presenting some evidence of complementarity, and 24 showing a net effect of substitutability, while the remaining 15 do not produce statistically significant results. Moreover, he empirically rejects the hypothesis that the ambiguity in the literature can be due to differences in the methodological tools. Additionally David et al. (2000) discuss the methodological issues and hold the difficulty of dealing with the problem of endogeneity in such a context responsible for this ambiguous empirical support.

> This [mutual interdependence of public and private R&D expenditures] may present an issue for econometric analysis, either because of simultaneity and selection bias in the funding process, or because there are omitted latent variables that are correlated with both the public and private R&D investment decisions (David et al., 2000, p. 509).

Similarly, Busom (2000) suggests the possible endogeneity of R&D subsidies and tries to deal with the issue of selection bias with a structural approach whereby she first estimates the probability of a firm taking part in a public R&D subsidies programme and only thereafter does she estimate the private R&D efforts to test for the presence of the crowding-out effect. Almus and Czarnitzki (2003) address the issue of selection bias as well: the challenge is to make use of a statistical technique that allows for a counter-factual analysis comparing the innovative behaviour of firms that receive R&D subsidies with the hypothetical situation in which the same firms did not receive them. As it is not possible to observe the same firm in both states of the world, the first-best solution would be to run an experiment on a group of subsidized firms vs. a control group of not-subsidized firms and test whether there is a significant difference in the mean of a particular proxy for innovative behaviour. This procedure requires the two groups to be perfectly randomized, *i.e.* the innovative behaviour of a firm does not correlate with the probability of the firm to be in a specific group. However, when a real randomized experiment is not at hand and the researcher is forced to use non-experimental data, the existence of a selection bias precisely undermines this requirement. In such a case, the solution suggested by Almus and Czarnitzki (2003) consists of dealing with the data as in a quasi-experimental setting, in which, although initially the control group cannot be used as a base line because of the lack of randomization, it could be made comparable with the treated group by manipulating it with various techniques. Almus and Czarnitzki (2003) choose to implement propensity score matching to assign each subsidized firm to a control firm exhibiting the greatest similarity in terms of various characteristics. Almus and Czarnitzki (2003) conclude by showing a reinforcing effect between public R&D subsidies and private R&D efforts.

Their result has been corroborated by several empirical studies that control for the selection bias in a quasi-experimental setting *á la* Almus and Czarnitzki. Among others, González and Pazó (2008) indicate in a sample of Spanish manufacturing firms both the absence of the crowding-out effect and, under certain circumstances, the presence of complementarity. Using the same dataset, González et al. (2005) suggest that the lack of R&D subsidies can even restrain firms from investing in R&D at all. Czarnitzki and Licht (2006) show the additionality of R&D subsidies for Western- and Eastern Germany. Czarnitzki et al. (2004) conclude that R&D tax credits increase the overall R&D engagement for a sample of Canadian firms. Goerg and Strobl (2007) find that the absence of additionality depends on the size of the R&D grants and on the country of origin: evidence relating to Irish firms suggests that additionality in R&D subsidies holds for small grants, while large grants might crowd out private investment. These results hold only for Irish firms and not for foreign ones. Czarnitzki et al. (2007) show for a sample of Finnish and German firms that R&D subsidies affect more innovative output measures such as the number of patents rather than R&D expenditure. Aerts and Schmidt (2008) reject the hypotheses of the crowding-out effect in a comparisons between firms in Germany and the Flanders.

All in all, although the evidence is not yet conclusive, it seems that when controlling for the selection bias in quasi-experimental settings, the presence of a crowding-out effect has to be rejected and, under certain conditions, there is empirical support for the claim that R&D policies positively impact upon private investments.[1] However, a quasi-experimental framework is not immune to possible flaws. The first shortcoming is the presence of *extraneous variables*, that is, unobserved firm characteristics that

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[1] Many other studies can be cited which can corroborate these hypotheses in a non quasi-experimental setting as well, such as Hussinger (2008) and Blanes and Busom (2004), which still control in various ways for selection bias.