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# Research subsidies, industry–university cooperation and innovation

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ABSTRACT

We evaluate the impact of the EC's Seventh Framework Programme, a large-scale research subsidy programme, on the innovation activities of subsidized firms, with a particular regard to industry–university partnerships. Using matching and difference-in-difference estimation, we find a positive effect on a range of innovation indicators. The number of project participants in general and university participants in particular positively affect performance, suggesting knowledge spillovers between project members. Research centres, on the other hand, do not exert positive externalities. We also find that the benefits of collaborating with universities are amplified by their academic quality.

## 1. Introduction

Public subsidies to R&D have been steadily rising over the past decades. This evolution occurred in tandem with mounting evidence that research leads to substantial social benefits and that therefore private R&D investment by companies is likely to fall short of the R&D level corresponding to the social optimum (Nelson, 1959; Arrow, 1962; Klette et al., 2000). The EC's Seventh Framework Programme (FP7) ran from 2007–2013 and was, with a total budget of over 50 billion €, one of the largest publicly funded research subsidy programmes in the world. One of the goals of the EC framework programmes was to strengthen research collaboration between member states and between universities and firms (Veugelers and Cassiman, 2005). The largest FP7 sub-programme with a budget of over 32 billion €, 'COOPERATION', subsidized research joint ventures between universities, research and technology organizations and private companies with the specific goal of fostering transnational cooperation in R&D. Almost 8000 individual research projects were subsidized, each of them involving partners from at least three different countries.

The goal of this paper is to evaluate if and to which extent FP7 was successful in fostering innovation by promoting research cooperation. Our data include 41% of funding that was awarded to private companies under the 'COOPERATION' sub-programme, as well as 71% of funded projects. The data are thus well-suited for a comprehensive ex-post evaluation of the programme's overall impact. In particular, we focus on the following research questions:

Our first goal is to provide a general evaluation of FP7's impact on innovation indicators of the involved firms and thus answer the question of whether FP7 succeeded in making recipient firms more innovative (the impact of earlier EC programmes on firms' innovation is evaluated in Benfratello and Sembenelli (2002), Bayona-Sáez and García-Marco (2010) and Barajas et al. (2012)). We also estimate heterogeneous effects on outcomes by defining the intensity of treatment as either the number of project participants or as the amount of EC funding received. While evaluating traditional innovation indicators, such as patent counts and citation measures, we distinguish whether innovation induced by research subsidies is incremental or radical in nature (Beck et al., 2016). In this vein, we evaluate the impact of FP7 funding on a set of newly-developed measures of technological novelty (Verhoeven et al., 2016).

Second, we follow a recent string of literature that has focused on the innovation impact of industry–university collaborations (Scandura, 2016; Maietta, 2015). Our data include research collaborations involving universities in the narrow sense as well as collaborations involving publicly-funded research institutions, and permit us to differentiate between the two. Thus, in addition to evaluating the impact of industry–university partnerships, we also evaluate the impact of research collaborations with public research and technology organizations. In this context, the academic quality of universities has long been recognized as a determinant of the success of research collaboration (Mansfield, 1995), but empirical evidence remains scarce (Baba et al., 2009; Maietta, 2015). By linking the universities involved in the research projects in our data to a university ranking, we provide new evidence on the issue.

We find that the overall impact of FP7 participation on innovativeness is limited, as there is no significant effect on the various innovation indicators. However, we find evidence that the treatment effects are quite heterogeneous. The number of project participants strongly increases all innovation indicators, suggesting the existence of substantial knowledge spillovers between contributors. Firm-level

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funding, another measure of project size, has similar effects.

Differentiating further between the types of project participants, we find that cooperation with universities exerts a positive effect on citation measures, while the impact on novelty indicators appears to be due to the overall number of participants. Cooperation with research centres, on the other hand, has a negative impact on average citations and does not significantly affect other innovation indicators. The quality of academic institutions also seems to play a role: the better a universities' ranking, the greater the benefits of cooperating with it.

The remainder of the paper is organized as follows: Section 2 reviews the relevant literature while Section 3 describes the dataset, the matching procedure as well as the empirical model. Section 4 presents the findings and Section 5 concludes.

## 2. Literature

### 2.1. Economic justification of research subsidies

What is the economic rationale for providing public support to private enterprises' research activities? If firms employ resources to do research until their marginal revenue equals their marginal cost, an efficient allocation should result. Thus, public subsidies would only be justified in the case of market failure. One of the first studies to argue that the social value of R&D is higher than the private value is Nelson (1959). Since research projects often yield unexpected results, the knowledge generated may be of little value to the sponsoring firm. Even if the findings are of value, the firm may struggle to prevent others from economically exploiting the generated knowledge. In addition, factors such as the time lag from research to a marketable product and the uncertainty associated with it could further discourage firms. These considerations lead Nelson to argue in favour of public support for basic research.

In a similar vein, Arrow (1962) argues that the three classical reasons for non-optimal resource allocation in a competitive market ('indivisibilities, inappropriability, and uncertainty') are likely to apply in the case of invention. Like Nelson, Arrow reaches the conclusion that only large and diversified corporations will be able to bear the risks associated with invention and that this allocation will not be a social optimum. From this, he also makes a case for public support of research.

These classical 'market failure'-type arguments for research subsidies are extended and new approaches to the economics of science with a focus on institutions and norms are discussed by Dasgupta and David (1994). Among many other things, they discuss issues of knowledge transfer and intellectual property in industry–university cooperations. They conclude that the current institutions and norms, while conducive to the growth of scientific knowledge, are not optimal in terms of securing the economic rents of invention.

Martin and Scott (2000) argue that while underinvestment in innovation and R&D market failures are common, their causes are highly industry specific and that this needs to be taken into account by policy makers seeking to remedy these problems. They sketch out a set of potential remedies designed to improve innovation performance under different and industry specific innovation modes.

### 2.2. Empirical evaluation of research subsidies and research collaboration

With a regard to our research questions, we first provide a review of the empirical literature on the effects of research subsidies and then review the most relevant empirical contributions on research collaboration.

Evaluating the impact of an earlier Framework Programme on Spanish firms, Barajas et al. (2012) find that public subsidies lead to an increased accumulation of intangible capital, which – in turn – positively affects labour productivity. In a similar vein, Benfratello and Sembenelli (2002) contrast the impact of one of the EC's earlier research subsidy programmes (EUREKA, running from 1985 to 1996) with that of the early Framework Programmes (FP3 and 4, running from 1992 to 1996). They find that firms participating in EUREKA show significantly improved labour productivity and price-cost margins and find no impact of the Framework Programmes on firm performance. The EUREKA programme is also evaluated in Bayona-Sáez and García-Marco (2010), who find that participating firms experience an increase in their return on assets.

Clausen (2009) uses a sample of Norwegian firms to investigate whether public subsidies and private R&D spending are complements or substitutes. He finds that subsidies induce private spending when a project is 'far from the market' (i.e. research), but substitute private spending in projects that are 'close to the market' (i.e. development). Similarly, Almus and Czarnitzki (2003) find that public subsidies in Eastern Germany do not crowd-out, but increase private R&D spending.

Colombo et al. (2011) use a sample of Italian technology-based firms to investigate the role of allocation mechanisms on the effectiveness of research subsidies. Distinguishing between automatic and competitive allocation of funding, they find that only the latter allocation mechanism leads to positive innovation effects.

A number of case studies and studies focusing on spillover effects of R&D support are reviewed in Klette et al. (2000). Most of these earlier contributions do not account for selection effects. In a more recent survey of 52 microstudies (Dimos and Pugh, 2016), all reviewed studies account for selection, either through matching, selection models, instrumental variables or control functions. This meta-analysis rejects the hypothesis that public subsidies fully crowd-out private research efforts, but finds little evidence for additionality effects.

As far as the literature on research collaborations is concerned, two pioneering studies on subsidized research joint ventures are Sakakibara (2001) and Branstetter and Sakakibara (2002) who evaluate publicly-funded research consortia in Japan. In both cases, increases in R&D spending and in patenting activity are found. Hottenrott and Lopes-Bento (2014) evaluate subsidized research collaborations in Belgium. They find that subsidies trigger R&D spending, thus rejecting the crowding-out hypothesis. Effects are particularly strong for small firms and international collaborations. They also find that subsidies lead firms to develop marketable product innovations.

The effects of publicly subsidized research joint ventures are also evaluated by Czarnitzki et al. (2007). They find that Finnish subsidy recipients significantly increase their R&D spending and their patenting, while the same effects are insignificant in a sample of German companies. The efficacy of Finnish R&D subsidies is confirmed by Einiö (2014), who exploits a population-density rule in the allocation of subsidies to identify the effect on innovation. He finds that subsidized firms on average increase R&D investment, sales and employment and, after a 3-year lag, experience productivity gains. Bronzini and Piselli (2016) also implement a regression discontinuity approach by comparing barely-granted with barely-rejected subsidy applications in Italy. They find that grant-receiving firms apply for more patents than non-receivers and that this effect is particularly pronounced for smaller firms.

While there is a stream of literature on the origins of radical innovations (Ahuja and Morris Lampert, 2001; Schoenmakers and Duysters, 2010), the impact of research subsidies on whether innovation is incremental or radical in nature is not well studied. An exception is the study by Beck et al. (2016), evaluating public research subsidies in Switzerland. They find that while privately funded R&D increases both types of innovation, subsidized R&D leads only to radical innovation. Further, they find no evidence for benefits of R&D collaboration.

### 2.3. Industry–university relationships in research

There is a sizeable and rapidly growing literature on the innovation impact of research cooperation between firms and academic institutions. From the point of view of economic incentives, collaboration with a research institution or university is less problematic for a firm than cooperation with a potential product market rival, because information can be more easily shared (Veugelers and Cassiman, 2005).