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# Impact of flexibility in public R & D funding: How real options could avoid the crowding-out effect

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ABSTRACT

This paper explores new mechanisms to ensure grants are additional to private research and development investment with no displacing or crowding-out effect. Our results indicate that by studying the flexibility embedded in these type of projects, using the real options framework, it is possible to reduce the size of grants given by financing bodies while remaining equally attractive to companies. This result is reached due to the higher flexibility provided in potential new grant schemes. In addition to the obvious consequence of less expensive public R & D funding, there are other side benefits to this new scheme, such as avoiding the crowding-out effect while also allowing more honest and sincere research and development investment by companies because they are sharing the risk with the funding body. This paper presents a case study - an R & D project carried out in the Concentrated Solar Power sector - in which we propose and calculate the effect of providing the grant 2 years earlier with a sensitivity analysis performed over the discount rate, volatility and first commercial revenue. This paper may encourage funding bodies to consider implementing alternative grant schemes valuing the flexibility embedded in R & D projects.

## 1. Introduction

Private research and development (R & D) investment in renewable energy technologies is often associated with market failure from the economic perspective [1]. This designation is employed to describe a situation in which there are no conditions to reach an efficient allocation of resources [2]. Thus, companies that invest in this type of project do not realise the full potential benefits that said projects could generate. Specifically, these projects positively impact society as society benefits from a less polluted environment, for instance. In fact, society demands greater investment by private companies in renewable energy R & D projects that would naturally be carried out by companies under perfect market conditions.

One of the main reasons justifying the use of public funding for private R & D investments is precisely to overcome this market inefficiency in order to reach the socially optimal level of development [2]. In this way, public funding can help companies to receive some of the potential benefits that are generated by their R & D projects, as well as incentivising R & D projects that, due to their high cost and risk, would not be undertaken by companies despite being socially valuable projects [3].

When public funding for private R & D investment is considered, specifically by means of public subsidies, one of the questions that has attracted the attention of researchers regards the effect of these public subsidies on private R & D investment [4–6]. In particular, the specialised literature has distinguished two types of effect: the crowding-in effect, which implies that public subsidies to R & D projects tend to stimulate private R & D investment and therefore have an additive effect; and the crowding-out effect, which, on the contrary, implies that public subsidies to R & D investments tend to reduce private investment with the result that public funding would negatively displace private R & D investment. As shown by Zúñiga et al. [7], the empirical evidence of this effect is inconclusive: they found differences that may be due to factors such as the countries and industries considered, or the empirical approach conducted. In their wide literature review, these authors highlight that most studies have not considered the amount of the subsidy granted to the firm in their empirical assessments. Various factors, however, support the existence of a level of inflection in the subsidy amount that reduces private R & D investment (for instance, the rising of specialised workforce costs [8,9]; the reduction of inflection in the efficiency of these subsidies for larger projects [4,10–12]; or that these projects stop having the desired level of efficiency in relation to the social benefits that justify the existence of these subsidies).

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This paper aims to fill the gap in the existing literature by establishing a reference for policy makers and funding bodies to determine the maximum amount of public subsidies to be given to private R & D investment in order to accelerate companies' R & D activity while reducing the crowding-out effect on private investment. In order to do so, this paper applies the Real Option Analysis (ROA) to the case of an R & D project in solar thermal power carried out by a consortium of European companies.

The traditional technique of Net Present Value (NPV) presents several important limitations to value R & D projects, such as the use of a static risk-adjusted discount rate, the underestimation of the impact of economic uncertainty [13], and the failure to consider the value of the flexibility. In this respect, the ROA allows us to overcome these limitations, particularly when the uncertainty conditions that characterise the current context are considered [14] because the ROA values the flexibility which implies that managers can readjust their R & D projects in the face of the potential impact of both external and internal factors [13,15].

Thus, this paper contributes to the specialised literature by proposing an assessment system based on ROA that justifies the reduction of the amount of public subsidies for private R & D investment by showing that companies could prefer a lower public subsidy for their R & D investment, but that the public subsidy allows them greater flexibility by permitting options such as abandoning or deferring the R & D project. Traditionally, public subsidies to R & D programmes, such as the European Commission's Horizon2020 programme [16], restrict the flexibility of companies when deciding whether to continue their project. We did not confirm the anticipated results in this study; the decision to abandon a project, if this were the case, would imply the partial repayment of the public subsidy – if the funding body considers the project has not reached a minimum level - which, in turn, would reduce the probability of being granted future subsidies as a consequence of the reputation loss of the company towards the funding body. Likewise, since the probability of a crowding-out effect can be expected to increase with the subsidy size [6], other things being equal, the proposal of this paper also contributes to reducing the probability of said effect because it justifies the reduction of the public subsidy to private R & D investment. Hence in restructuring classical grant schemes by giving firms options, these companies could decide to undertake projects a few years earlier and accept lower levels of grant funding. Thus, a more flexible scheme could reduce the crowding-out effect, deferring the inflection point where grants are less efficient for attracting private investors.

The remainder of this paper is structured as follows: Section 2 presents the literature review by considering firstly, the main factors that can impact the relationship between public subsidies to R & D and private R & D investment, and, secondly, the specific influence of the subsidy size on the R & D activity of private companies. Section 3 describes a methodology known as stage-gate that companies use as an R & D framework, a reference to common R & D incentives in Spain and Europe, and the model framework employed in this paper. Section 4 presents the empirical analysis including project description, parameter estimation and scenario analysis. Section 5 addresses the discussion of results obtained in the study, and Section 6 presents the study's conclusions.

## 2. Rationale for R & D grants: motivation, limitations and effect on companies

This section describes the main goals sought by Governments and Public Bodies when subsidising private R & D investment., Furthermore, a set of limitations to this process is described.

### 2.1. Reasons to subsidise R & D investments

There are several justifications for the subsidisation of R & D investment, first and foremost being the uncertainty surrounding the technical and economic success of an R & D project and its potential benefits [17]. In fact, government R & D expenditures are funded through public agencies because it may generate social benefits beyond the direct provision of government services. A further objective is pursued with this spending: generating social benefits in the form of knowledge and "training" spillovers [4]. Second, a company will never be able to appropriate all returns of a successful R & D project because the developed knowledge can quickly and easily diffuse into the public domain [18]. These are positive externalities to society that are not remunerated to firms. Third, firms take the risk that the knowledge created in their R & D programme will be available to other companies (free riders), taking advantage of the progress of R & D programmes from competitors [18]. Fourth, external funding for R & D projects is relatively scarce. Managers are reluctant to reveal all the features of company projects to external parties, including investors, due to the strategic nature of R & D activities and to avoid disclosing critical information to competitors [19]. Investors are discouraged from supporting R & D projects because they face problems of information asymmetry, such as adverse selection and moral hazard [20]. R & D investments are more risky and their assessment is less reliable for external parties [21]. In subsidising R & D projects, both firms and investors are compensated for several reasons: the uncertainty of the project, the spillover benefits R & D expenditures provide to society, and the increased risk and reduced cost of capital. Therefore, because subsidies are a necessary tool for the development of knowledge in society, this paper contributes to optimising how they are awarded.

### 2.2. Limiting factors

The main factors regarding the equilibrium between public Research & Development (R & D) subsidies and private R & D investment are reviewed below. Probably the most important issue, one which also deeply affects this work, is the effect of the size of the grant given to firms and its effects on firms' R & D activity.

#### 2.2.1. The equilibrium between public R & D subsidies and private R & D investment

The results of studies on the relationship between public R & D subsidies and private R & D investment are highly heterogeneous due to, among other reasons, the differences between each analysed industrial sector, the country to which the firms belong, and the methodology employed [7]. In the specialised literature, it is nevertheless possible to distinguish some factors that have been frequently considered, such as the size of the firm, the economic context, the type of incentive, and the recurrence in the public funding. As it is most likely the most important issue, the size of the grant will be discussed separately in following subsections.

#### 2.2.2. Size of the firm

As regards the size of the firm, Busom [22] found in a sample of Spanish companies that smaller firms are more likely to apply for and be granted a subsidy. This is probably aligned with the public agency's goals, which may be to incentivise R & D investment in small and medium enterprises (SMEs). In the same sense, in another study on Spanish firms, González and Pazó [23] concluded that subsidies have a greater effect on inducing new R & D activities in smaller firms. Meanwhile, Ali-Yrkkö [5] concluded that receiving a positive decision to obtain public R & D funds increases privately financed R & D and that this effect is also bigger in large firms than in small firms, although the results of Löof and Heshmati [24] show that there are additive effects of public R & D financing on private research expenditures only for small firms. Duguet [25] considered a sample of French firms and found that the probability of being awarded a subsidy increases with the debt ratio and the importance of privately funded R & D, as well as with the size of firms. Görg and Strobl [26] conducted their study on