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TAX INCENTIVES AND DIRECT SUPPORT FOR R&D: WHAT DO FIRMS USE AND WHY?

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Abstract

We contribute to empirical work on public support to private R&D by jointly estimating the access by firms to R&D tax incentives and to grants and loans. We focus on the potential correlation between two sources of underinvestment in R&D and firms? access to these policy instruments. Using firm-level data we find that firms facing financial constraints and newly created firms are less likely to use R&D tax credits and more likely to apply for and obtain direct public funding. Regarding appropriability, our estimates show that large firms using legal methods to protect their intellectual property are more likely to apply for and obtain direct support, while SMEs are more likely to use tax incentives. These

results suggest that direct funding and tax credits do not have the same ability to address the two types of failure associated to R&D, and that these tools may be complements rather than substitutes.

Jelcodes:H25,M21

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JEL classifications: H25, L60, 038, O31

1. Introduction

Tax incentives and direct funding are two instruments used in many countries to stimulate private R&D activity. Both belong to a portfolio of tools that includes intellectual property rights (IPRs), public funding of basic research and public provision of venture capital. While IPRs and direct public funding of private R&D have a long tradition in many countries, tax incentives have spread gradually, although with some exceptions. Figure 1 shows OECD estimates of the relative weight of each instrument as a share of GDP in 2009 by country. Canada, The Netherlands and Japan rely mostly on tax incentives, while direct funding is still preferred in Sweden, Finland or Germany. Other countries use both instruments: France, Denmark, Spain, the United Kingdom and the United States fall in this category.

[Insert Figure 1 here]

The main rationale for using any of these tools rests on the notion that market failures affect private R&D level: on one hand, appropriability difficulties caused by knowledge spillovers, and on the other external funding constraints derived from asymmetric information. Which particular form public support should take to correct for these sources of market failure is, however, a matter of debate. Do R&D tax credits and direct grants address in practice both sources of market failures? Are there any conditions where one is to be preferred to the other? Is there an "optimal mix" of both instruments? While there is substantial empirical research estimating the effects of each instrument separately on private R&D decisions and outcomes, to the best of our knowledge the explicit comparative analysis embedded in the questions we raise remains virtually unexplored.[1]

This paper aims at providing evidence with respect to the first question by analyzing the allocation of R&D tax credits and direct funding when both are

[1] For evidence on tax credits, see Bloom, Griffith and Van Reenen (2002) and Lokshin and Mohnen (2011). For evidence on direct grants or subsidized loans, see Gelabert, Fosfuri and Tribó (2009) or Czarnitzki, Ebersberger and Fier (2007). The concern about the adequate policy mix is expressed in OECD's documents about innovation policy (see OECD 2010, chapter 4) and in the testimony by the OECD for the US Senate Committee on Finance, OECD(2011b).

available. We assume that if the two standard factors causing market failures in R&D, limited appropriability and financial constraints, affect firms' R&D choices, they are likely to be perceived as hurdles for their potential innovation plans. Then, if the government aims at providing support to firms only when they are affected by these hurdles or barriers to innovation, we should observe a correlation between the presence of these barriers and the likelihood that a firm will claim an R&D tax credit or have direct support. This step may provide insights for interpreting results that are obtained in existing impact evaluation studies, which have focused so far on testing whether public support leads to additional private R&D investment. [2]

To illustrate this point, assume that from an impact estimation exercise with firm-level data we obtain that supported firms on average barely increase their private R&D investment, and that the share of sales of new products, a standard indicator of innovation outcomes, is not significantly different from a control group of non-supported firms. Should the conclusion be that the policy is not effective? Possibly not if the firm does introduce an innovation that is quickly imitated, and applied for and obtained support precisely in anticipation of imitation.

We use firm-level data from two non-overlapping waves of the Spanish edition of the Community Innovation Survey (CIS), 2003-2005 and 2006-2008, to study this question. We find that firms that face financial constraints, as well as newly created firms, are less likely to use R&D tax credits. Instead, they are more likely to apply for and obtain direct public funding. Regarding appropriability, large firms that use legal methods to protect their intellectual property are more likely to apply for and obtain direct funding, while SMEs are more likely to use tax incentives. Estimates are robust to changes in the definition of dependent variables and for most subsamples of firms.

These results suggest that direct funding and tax credits do not have the same ability to address the two types of failure associated to private R&D. From the firms' perspective, they are not perfect substitutes: firms that are financially

[2] The need to link R&D subsidy impact analysis with subsidy allocation was pointed in the survey by Klette, Moen and Griliches (2000).

constrained but have good innovation projects are more likely to prefer and use direct support to be able to carry them out, because they have to obtain profits before being able to claim tax credits.[3] On the other hand, firms that face small or limited appropriability difficulties but are not financially constrained may find tax incentives more appealing than direct support, because the cost of applying for direct funding may be high compared to the chances of obtaining it. Provided that crowding out effects can be ruled out, some combination of both instruments could be preferable from a social point of view to relying on only one when both sources of underinvestment in R&D are at play.

The paper is organized as follows: in the next section we review the literature most closely related to our research questions. In section 3 we lay out some hypotheses regarding the use of R&D tax credits and direct support. In section 4 we describe the data, variables and empirical model that will be used. In section 5 we show and discuss estimation results. Finally section 6 contains concluding remarks.

2. Previous evidence

There is a wide consensus, grounded on empirical evidence both at the firm and the aggregate level, that often innovation is affected by limited appropriability, for an innovating firm, of the total benefits generated by its innovation. There is a slightly weaker consensus about the existence of a financing gap for innovation, although empirical evidence supports this hypothesis at least for SMEs.[4] Although the case for policy action seems well established, policy instruments designed to address these market failures may have drawbacks. Direct public funding through subsidies or grants reduces the private costs of investing in R&D, but places high information requirements for the public agency awarding them. Tax credits and

[3] This depends though on the specific design of R&D tax incentives. While in Spain and France firms that invest in R&D can obtain a deduction from the their tax liability, which therefore has to be positive (at some point, given carryforward provisions), in the Netherlands the R&D deduction is applied to wages paid to staff employed to conduct R&D, and is thus independent of the tax position of the firm.

[4] See Hall and Lerner (2010) for a survey on the funding gap for investment in innovation. They conclude that even in the absence of knowledge externalities small and new firms experience high costs of capital, while for large firms the evidence is mixed.

allowances may appear to be a neutral, simple and non-interfering tool, but the specific design is important, as they may be easily claimed for projects that yield high private returns and would have been carried out anyway. Empirical evidence evaluating the impact of both tools becomes therefore very valuable for policy design and improvement.

Over the last two decades, a significant volume of empirical research to assess the impact of either direct support or of R&D tax credits on the level of private R&D investment has been produced. The main concern of most of this research has been testing for full crowding out effects, which would imply a waste of public resources. In addition, the impact on a firm's outcomes such as patents, productivity or sales of new products has also been analyzed.

With only a few exceptions (Haegeland and Moen, 2007, Berubé and Mohnen, 2009 and Marra, 2008), however, the effects of each tool have been independently studied.[5] Ignoring that both mechanisms are in place in some countries may lead to overestimating these effects.

Most work on R&D tax incentives is based on standard investment models, where tax incentives are part of the user cost of capital. The purpose of this modelling approach is to explain R&D investment as a function of its price, and provides a framework for testing crowding out effects. It is not designed to ask which types of firms are more likely to use tax incentives, and whether indicators of appropriability and financial constraints play any part.

Some researchers have used matching methods to obtain a control group for treated firms and then estimate the impact of tax credits on some outcomes. This method requires controlling for the non-random nature of program participation in order to be able to compare the outcomes of treated and untreated firms. Corchuelo and Martínez Ros (2008), and Czarnitzki et al (2011) provide two

[5] Haegeland and Moen (2007) find that the additionality of tax credits is higher than the additionality of grants awarded through the Research Council and Innovation Norway, which would be consistent with the latter selecting projects with large externalities but low private return. Berubé and Mohnen (2009), use a sample of Canadian firms that benefited from tax credits, a subset of which received subsidies, and find that those receiving subsidies introduced more new products and made more world-first product innovations. These authors estimate program participation equations that do not include indicators of financing constraints or of spillovers. Marra (2008) estimates an R&D investment equation and finds that both instruments increase private investment.

examples of this approach.[6] In both cases the authors include an indicator of financial capacity to explain the likelihood of using R&D tax credits, finding a positive relationship, which suggests that this instrument may not be able to address well one of the sources of underinvestment.

Research on the impact of direct funding (grants and loans) is extensive. The main point of interest for our purpose is that regardless of the modelling approach, some program participation equation is also estimated to control for selection. Generally, firm size, industry dummies, and other firm characteristics are typically included in the equation, but no link to indicators of sources of market failures is fully and explicitly made.[7]

Possibly the work closest to ours in linking impact evaluation to indicators of market failures is Gelabert, Fosfuri and Tribó (2009), who focus on direct support and ask whether the degree of appropriability affects the impact of support on private R&D. Using an instrumental variable approach, they find that as the level of appropriability increases, the elasticity of privately financed R&D expenditures with respect to public support decreases. In performing a robustness analysis, they estimate a program participation equation that includes indicators of appropriability and of financial constraints. Their appropriability indicator turns out not to be significant; the financial constraints indicator is significant but with a negative sign, contrary to expected. These results would seem to suggest that the public agency does not target firms according to criteria closely linked to market failures.

Our work, therefore, adds to existing research by explicitly seeking to test whether there is a correlation between the two potential sources of underinvestment in R&D and actual use of direct support and tax incentives, and whether this correlation is similar for both instruments. The different nature of both tools in some potentially relevant dimensions, and the different degree of public

[6] See Cappelen et al (2008) for work with Norwegian data, and Duguet (2010) with French firms.

[7] Hussinger (2008) uses a credit rating index, and finds that firms with better rating are more likely to obtain direct public funding in Germany. Czarnitzki et al (2007) use an indicator of appropriability, but do not include indicators of funding constraints.

involvement associated to each, set the stage for anticipating heterogeneous effects both across tools and across firms.

3. The allocation and use of direct and indirect R&D support: some hypotheses.

The specific questions we address are: Who applies for each type of R&D support, and who is selected? Do appropriability and financing constraints play a role in either side's decisions, in both types of support? As in most existing research in this area, we take an empirical, reduced form approach to answer these questions, given the information provided by the available data.

Only very recently structural models of firm and agency behavior to explain and evaluate direct support have been developed. In Takalo and Tanayama (2010), firms face constraints to finance their R&D projects, some of which are high quality and others are low quality. The role of the public agency is to screen projects and provide a subsidy. The model predicts that firms with high quality projects will always apply for funding, firms with low quality projects will apply with some probability, and that subsidies will increase private effort through two effects: first, by reducing the amount of market based capital needed, they reduce R&D cost, and second, the subsidy becomes a signal of quality for private external funds, which again then reduces their cost.[8] For our purposes the relevance of this work is that financial constraints and project quality are drivers of firms' application and agency's granting decisions. Takalo, Tanayama and Toivanen (2011) develop a model of firm application and agency granting decisions, with fixed application costs. They estimate a set of equations, an agency decision rule among them, and although they find that technical challenge and risk affect these decisions, financial constraints or spillover indicators are not explicitly included in their empirical model.

On the other hand, in the corporate taxation literature, Keuschnigg and Ribi (2010) discuss how business taxation may affect financially constrained

[8]. The certification or halo effect was pointed out by Lerner (1999).

innovative firms, and predict that R&D tax credits will not only encourage innovation but also relax finance constraints and help innovative firms to exploit investment opportunities to a larger extent. From this work it would seem that both types of support might be equivalent in addressing financing constraints.

However, some differences in the design and timing of direct funding and tax incentives may have an impact on who benefits from each as well as on innovation decisions and outcomes. Direct public funding is obtained only if the firm presents an application to the public agency and the public agency decides favourably after screening the proposals. The requirements explicitly and publicly set by the public agency are usually related to the innovative content of the proposal, the technical ability of the firm to carry it out, and the potential market.[9] The agency may have additional preferences for some industries or type of innovation project: it may consider, for instance the expected spillovers generated, or the extent of financing constraints faced by the firm, but these are not always made explicit in national-level programs. Funded projects will reflect both firm and agency preferences. The firm runs the project once funding has been approved.

Tax credits, on the other hand, do not require the approval of a specific project by a government agency. A firm may claim a tax credit on any expense that qualifies as a research and development expenditure according to the tax code. The only requirement usually is for the firm to follow proper accounting rules for this type of expenses. Claiming the credit is relatively easy if the firm fulfills these conditions. To be able to benefit from a tax credit, however, the firm must have positive taxable income.[10]. A firm will obviously tend to choose R&D projects that yield a high private profitability, and a lower R&D price may simply induce

[9] There may be important differences across countries in the specific design of direct support. In the United States, the description of SBIR program (see http://www.sbir.gov) states that R&D risk and fixed costs are key motivations for the program, which targets SMEs. Public agencies involved with the program set R&D topics in solicitations. In Finland, the public agency Tekes values the degree of novelty and research intensity of projects but does not appear to set specific topics (http://www.tekes.fi). The Spanish case is similar to the Finish. See Huergo and Trenado (2010) for a detailed description of the Spanish case.

[10] In some countries the design of R&D tax incentives may allow firms to get a direct refund of their tax credit if the firm has no tax liability, so this requirement would not apply (see France, for young innovating firms, or Canada, for all firms domestically owned).

more investment in projects that do not involve appropriability difficulties. Even if the lower R&D price induces the firm to pursue projects that involve some spillovers, there is no guarantee that the size of the tax credit will be related to the equivalent optimal subsidy.

A potentially important difference between both tools is that, in the case of tax credits, the firm must be able to privately fund the project in advance, and expect to have taxable income during the same period or within a reasonable time horizon in order to be able to claim the credit. New and small firms may thus be at a disadvantage to benefit from this instrument, as well as those whose potential projects are affected by important appropriability difficulties, because in this case taxable income may be low precisely for this reason.[11]

We therefore think that tax credits and direct support will not have the same ability to deal with both sources of market failures, and that this should show up in the use by firms of each instrument. If indicators of financing constraints and of appropriability difficulties are available, this conjecture could be tested.

As a result of this discussion, we would expect to find the following patterns in the data: i) a negative correlation between financing constraints and the likelihood of claiming tax credits, particularly for young firms; ii) a positive correlation between financing constraints and the likelihood of applying for and obtaining direct support; iii) a positive correlation between appropriability difficulties and direct support; iv) the correlation between appropriability difficulties and use of tax credits will be undetermined.

To test these predictions, we will use a discrete choice model as explained below. Obviously other factors that may affect a firm's decision to apply for or use public support for R&D at the same time. These include all those shaping the incentives to innovate and/ or perform R&D. Competitive pressure (Aghion et al., 2005 and 2009; Artés, 2009), vertical integration, sunk entry costs (Mañez-Castillejo et al., 2009) and market size may also affect the profitability of engaging in product or process innovations. Some of these factors may be partially taken into account in

[11] Recent evidence suggests that constrained firms are less likely to start innovative projects. See Hajivassiliou and Savignac (2008).

our empirical analysis. We now turn to the description of the most relevant features of our data.

4. Data, Variables and Empirical Method

4.1 The Data

The empirical analysis is based on data from the PITEC, a firm-level panel data set developed by the Spanish Statistical Office (INE) that corresponds to the Community Innovation Survey, which in Spain is conducted yearly.[12] It collects information related to innovation activities by firms with more than 10 employees in all manufacturing and service industries. Answering the survey is mandatory in Spain, and the response rate is high (about 90%). The sample is split in two groups by firm size because for firms with less than 200 employees the sample is biased towards innovators. [13]

We use data from the surveys conducted from 2005 to 2008, and focus on manufacturing firms. It is important to note that some questions refer to a three year period (2003-2005; 2004-2006; and so on) and others to the survey year. Examples of the first type of information are geographical market of the firm, introduction of new products and/or processes, information sources, cooperation to innovate, barriers to innovation, use of public support to innovate and use of intellectual property. Examples of the second type are the number of employees,

[12] PITEC is the abreviation for "Panel de Innovación Tecnológica en las Empresas". A description of the survey can be found at the following link (in Spanish): http://www.ine.es/jaxi/menu.do?type=pcaxis&path=%2Ft14%2Fp061&file=inebase&L=0. The Community Innovation Survey has been widely used for innovation and policy evaluation studies. Mairesse and Mohnen (2010) discuss some characteristics and shortcomings of the data.

[13] All firms that have received any form of public support for R&D or those that have reported R&D expenses in the current or past years are surveyed every year. The remaining surveyed firms come from a random sample stratified by size and sector among non-R&D performing firms. In the case of large firms, the sample represents the population, but for SMEs, innovators are overrepresented.: about 50% of firms in the PITEC sample invest in R&D against 24% in another frequently used data base of Spanish manufacturing firms, the Encuesta Sobre Estrategias Empresariales.

sales volume, exports, innovation expenditures by category (in-house R&D and others), and sources of funding for in-house R&D.

Table 1 describes some features of the sample. The table shows that for large firms both data sources are very similar in terms of the share of firms that invest in R&D or use R&D support. Table 1 also shows that the use of tax credits is more widespread than direct support, particularly in the sample of SMEs, and that overall large firms benefit proportionally more from both tools. [14]

[Insert Table 1 here]

A distinctive characteristic of this survey is the availability of qualitative information on barriers to innovation as perceived by the firm, as well as on the importance of several sources of information for the firm's innovation process. These questions can provide indicators of potential sources of underinvestment in R&D. In particular, firms are asked to rank a series of potential barriers to innovate according to the degree of importance they have for the firm. The barriers are, among others, financing constraints, both internal and external, and demand uncertainty, which be associated to market failure in the financial market for R&D projects. In addition, the item "market dominated by established enterprises" points to one feature of market structure that may affect potentially a firm's decisions (Cabral and Polak, 2007).

Lack of internal and external finance, together with uncertain demand, are the barriers most often perceived as important. SMEs are more sensitive to these than large firms, as well as to access to information on markets or technology. The simple correlation among the first three barriers is high (about 0.7), while it decreases across the remaining barriers. We have checked whether firms change their perceptions of barriers between the 2005 and 2008 surveys, and find that about half of the firms keep the same perception. Almost all that change their

[14] According to Spanish official tax information, 3150 firms filing for the corporate tax claimed tax credits in 2008. The total number of firms that declare using tax incentives in 2008 in PITEC is 1742 (this includes the manufacturing and service sectors); our sample covers thus about 55% of all claimants.

answer do so only moderately (they may change from level of importance "high" to level "medium", but very few change from level "high" to "not relevant".

Quite surprisingly, the survey does not include any direct question related to the firm's concern for imitation by rivals, which would provide an indicator of expected appropriability difficulties.[15] The current version of the Spanish CIS, however, asks about the actual use by the firm of legal protection mechanisms. We assume that use of these mechanisms signals that firms believe that threat of imitation is important.

4.2. Variables

Our dependent variables are obtained from PITEC 2008, where variables refer either to the period 2006-2008 or to year 2008. In order to be able to deal at least partially with potential endogeneity, we use most explanatory variables from PITEC 2005, where variables refer to the period 2003-2005 or to 2005. We describe next the definition of each variable, indicating in brackets the name assigned to the variable in the tables showing estimation results. Descriptive statistics are provided in Appendix B.

We have two discrete dependent variables: a binary indicator for having claimed tax deductions for R&D and binary indicator for obtaining direct support. For *Tax Incentives,* we define a binary variable which equals 1 if the firm declares having claimed tax credits any year within the period 2006-2008.[16] We believe that since tax credits are subject to carry-forward provisions, using a three year period instead of a single year may provide a more accurate description of firm behavior. In addition, questions about direct support also refer to this three year period. We

[15] Two surveys conducted in the US, the Yale survey (Levin et al 1987) and the Carnegie Mellon Survey (Cohen, Nelson and Walsh, 2000), did ask the firms about the perceived effectiveness of some appropriation mechanisms, and some early editions of the CIS survey contained similar questions. These data have been used for example by Cockburn and Griliches (1988) to study the stock market's valuation of R&D and patents, and more recently by Dushnitsky and Lenox (2005), and Ceccagnoli (2009).

[16] The basic features of R&D tax credits in Spain are explained in Appendix A.

later test for the sensitivity of results to changes in the definition of these dependent variables.

Direct support. We define a binary variable which equals 1 if the firm has applied for and obtained direct funding from the Central Administration in the period 2006-2008. Although firms may obtain direct support from local, central or European administrations, we consider that since R&D tax incentives are a policy decided by the Central government, they should be compared to direct support policy from the same government level.[17] Note that the survey does not provide information about whether a firm applied for but did not obtain direct support. The observed outcome will therefore capture not only the firm's decision but also the public agency's preferences. Finally, the awarded funds may spread over more than one year, so using a three year period may again be appropriate.

Financing constraints. As described above, firms report the degree of importance of lack of access to internal and to external financing as a barrier to innovation. Because of the observed high correlation between both barriers, we define a single binary variable which equals 1 if the firm considers that either of them has high importance as a barrier in the period 2003-2005. [Financially constrained]

Regarding the set of questions on barriers, several previous studies that have used CIS data obtain counterintuitive results with respect to the correlation between barriers and innovative activities. In a study by the OCDE (2009), reporting the results of a multi-country firm-level estimation of a variant of the Crepon-Duguet-Mairesse model of R&D and productivity, the estimates show a positive association between most barriers and the probability of engaging in innovation activities for most countries.[18] A possible explanation that has been offered for this unexpected finding is that innovative firms are more aware of the difficulties associated to innovating than non-innovating firms. This interpretation suggests that self-assessment of barriers may be endogenous to innovative behavior,

[17] Regional governments that also may provide direct support for innovation and do not use tax incentives. Eligibility criteria for support may differ between government levels and across regional agencies (Blanes and Busom (2004)), so aggregation would not be appropriate. Overall, the volume of regional government support is small.

[18] The same type of firm-level data source and methodology were used for each country and the data were fundamentally of a cross-section nature.

particularly because in these studies barriers and innovative behavior refer to the same time period, and innovative firms may become more aware of constraints than non-innovative firms. An additional problem is that there may be individual-specific heterogeneity in subjective evaluations of constraints: some respondents may tend to be optimistic, while others pessimistic. We address these concerns by i) using lagged indicators of barriers and ii) including an additional control variable that aims at capturing the firm's overall perception of difficulties, which is computed as follows: we add the rankings given by the firm to all barriers, and rescale so that it takes values in a 0 to 1 scale [Awareness of constraints]. Larger values indicate that a firm perceives a high overall level of barriers.[19] We expect that this lagged variable will capture the subjective effect, so the importance of individual barriers may be isolated from the firm's overall individual-specific perception.

Although some other biases may remain in subjective responses to this type of question, there is some evidence that subjective and objective indicators of financing constraints are positively correlated (Hajivassiliou and Savignac, 2008).[20]

Appropriability. It is very difficult to obtain a measure of the degree of ex-ante appropriability of R&D investments in order to test whether it deters innovation. We know appropriability matters because we observe that firms use the patent system or other ways to avoid quick imitation. In much existing empirical work, the standard indicator of appropriability has been the use of legal protection mechanisms. We also take this approach and define a binary variable which takes the value of 1 if the firm has used any of the legal protection mechanisms (copyrights, trademarks, design or patent) in the period 2003-2005 [Appropriability]. Although this variable might capture past innovation

[19] We later check for the robustness of estimates to alternative ways to control for these potential biases.

[20]) Hajivassiliou and Savignac use a French firm-level data set that includes direct, subjective direct indicators of financing constraints similar to ours and objective but indirect indicators such as leverage ratio, cash flow or the profit margin. They find that they are highly correlated. When accounting for the possible simultaneity between contemporaneous financing constraints and the probability of engaging in innovation activities, they find that financing constraints have a negative effect, as expected.

experience, we will include as well past in-house R&D [Did-in-house R&D], so that we expect that the use of protection methods in the past captures the concern the firm has for potential imitation of its innovations. In our sample, we observe that around 35% of firms declare having used legal protection mechanisms in 2003-2005.

The survey also provides information, although only for innovators, on the importance that the firm gives to information from competitors as a source of ideas for innovation in the period 2003-2005 to construct a second indicator of spillovers. Although usually meant to capture incoming spillovers (Cassiman and Veugelers, 2002), which are thought to be complementary to own R&D, this indicator may also capture the extent of rivalry in the firm's industry. Firm A would follow the developments of firm B in the same industry, so as to benefit from them, but also would know that firm B is likely to follow the same strategy, which would translate into a concern for imitation.[21] We would therefore expect firms in this situation to be more likely to apply for and use public support.

Dominant Firm. To capture the possible disincentive effect that the existence of an established dominant firm may have on other firms (Cabral and Polak, 2007), we define a binary variable which equals 1 if the firm considers that this is a barrier of high importance. [Dominant Firm]

New firm. Because young or newly created firms may not have much taxable income, and at the same time, may face financing constraints because they lack reputation, we expect them to be less likely to use tax incentives when intending to generate and introduce innovations, and more likely to apply for direct funding. We define a binary variable to represent a new firm in 2003-2005. [New firm]

Other barriers are also included in the empirical specification, although they are not the main focus of this research: lack of skilled labor, and lack of information. They are introduced as binary variables, where the value is equal to 1 if the firm considers that a particular barrier is of high importance [Lack of personnel, Lack of information].

[21] Czarnitzki et al (2007) also used this information from CIS to construct an industry-level index of appropriability.

The information in the data set allows us to include several control variables. Each firm was asked whether it took into account existing tax incentives when planning its potential R&D investment. We believe that the answer may capture the managers' view on the strategic importance of R&D for their firm. Lacking other indicators of managerial characteristics that might be relevant for innovation decisions, we include this binary indicator as a control variable (Take into account tax incentives).[22]

Incentives to innovate may be affected by the firm's position relative to the technological frontier, as shown in Aghion et al, 2009. We will consequently include a measure of technological distance of the firm relative to the mean of its sector of activity. Manufacturing is classified into 30 subsectors, and for each we compute the average labor productivity as sales per employee. We then divide each firm's labor productivity in 2005 by the average of its sector [log of Relative productivity].

We include several additional variables to control for other sources of heterogeneity across firms. The following are binary: Past R&D activity [Did-in-house R&D], belonging to a group [Group membership], being a private domestic firm [Private domestic firm], being an exporter [Exporter], location near a science or technological park [Located in technological park], regional location and industry dummies capturing technological intensity [high, medium high, medium low and low]. We finally include firm size, measured by the log of the number of employees [log of Number of employees]; human capital, measured by the proportion of employees with a higher education degree [Share of highly educated employees], and the age of the firm [Age]. The main descriptive statistics for all variables are shown in Appendix B.

[22] Note that taking into account tax credit incentives does not predetermine claiming them. Although most firms that do not take them into account do not claim tax credits, 56% of SMEs and 60% of large firms that do take them into account do not claim them. The Pearson correlation between the two variables is .28 for SMEs and .30 for large firms.

4.3 Econometric Model

Given that we observe whether a firm obtains or not direct support, and whether it uses or not tax incentives, we specify a discrete choice model with two binary dependent variables. We use a bivariate probit model because it allows for correlation between the random terms across alternatives and is less restrictive than a multinomial model. In addition, a bivariate probit model possibly captures more accurately the decision process by the firm. Tax filing periods may not be the same as grant application and granting periods; in addition, firms may not be able to anticipate their tax position when applying for direct funding. Hence we believe that a multinomial logit approach would not be appropriate in this case.

We will drop from the sample those firms that declare not having an interest in innovating as the main reason for not doing so, as we want to focus on the role of barriers for firms that do have a potential interest for innovating, thus distinguishing between behavior resulting from preferences from behavior resulting from perceived restrictions.

There will be four possible situations a firm can be in: no support (0,0), no grant but claims a tax credit (0,1), gets a grant but does not claim a tax credit (1,0) and both gets a grant and claims a tax credit (1,1), and therefore four sets of corresponding predicted joint probabilities, as well as four sets of marginal effects on these joint probabilities.

The model consists of a direct support equation (S), which can be viewed as a reduced form of the application and granting process, and a tax incentive equation (T): [23]

(1) $$S = 1 \text{ if } S^* = b_s X + e_s > c,$$

$$S = 0 \text{ otherwise}$$

(2) $$T = 1 \text{ if } T^* = b_t X + e_t > h$$

[23] Note that we do not have information on R&D direct support application: firms are not asked whether they applied for but did not obtain public grants or loans.

T = 0 otherwise

where e_s and e_t are jointly distributed as a bivariate normal, S and T are the observed binary variables for use of direct support and tax credits in the period 2006-2008, and X are lagged explanatory variables. Several types of marginal effects may be computed: the marginal effect computed at the mean value of explanatory variables, the marginal effect computed at a representative value of the explanatory variables, and the average marginal effect, which is the average of the marginal effect at each x. We will report the latter.

5. Estimation Results

5.1 Baseline estimation

We report in Tables 2 and 3 below the estimated average marginal effect of a change in explanatory variables on the joint probability of each of the four possible situations a firm may be in. We test for equality of coefficients for equations (1) and (2), and the null is rejected (chi-square tests not reported in the tables). As a specification test, we perform a test for normality of residuals, and do not reject the null.[24] Finally, we obtain a moderate, positive and significant correlation between the residuals of both equations, suggesting that on average unobserved variables affect the use of both instruments in the same direction (rho=.36 for large firms and rho=.30 for SMEs).

We first discuss the estimated average marginal effects we have obtained for the probability of using only tax credits and of using only direct support, because we expect the results of these two cases to offer a sharper picture of the differences, if any, between the two tools from the firms' perspective. We find that both for large firms and SMEs, being financially constrained reduces the probability of using only tax credits by about 4 percentage points, while it increases the probability of

[24] See Chiburis (2010).

obtaining direct support by about 2.5 percentage points. These results are consistent with the first two propositions formulated in section 3.

Regarding appropriability concerns, as captured by the use of legal protection mechanisms, we find that for large firms the average marginal effect on the probability of using only tax incentives is negative and significant, but it has in contrast a positive effect on the probability of using only direct support. Since we control for past R&D investment, we believe that this result suggests that firms whose R&D projects have more innovative content and are more concerned about imitation prefer direct support to tax incentives.[25] For SMEs we find a different pattern: those with appropriability concerns are more likely to use either tax incentives alone or both instruments. It is possible that SMEs' innovation projects are on average of an incremental nature and that the cost of applying for direct funding is high relative to the expected probability of obtaining it. Finally, we find that for both SMEs and large firms, being a new firm increases the probability of having only direct support, and reduces the probability of using only tax credits.

We find other interesting differences in the effects of other variables on these probabilities. Human capital increases the likelihood of using only direct support, but has no effect on the use of tax incentives. A firm's relative productivity has a positive effect on the probability of using tax incentives only, and on the probability of using both types of support. As expected, the variable that captures the overall level of barriers perceived by the firm has a positive effect on the use of any support, and a negative effect on the use of none. Finally, we find different patterns across industries. While industry type does not affect the use of tax incentives, large firms in high-tech industries and in medium-low technological intensity are more likely to use direct support. Among SMEs, firms in high-tech and medium high-tech industries are those more likely to use tax incentives.

We now look at the other two groups of firms: those that do not use any support, and those that use both tax credits and direct support. We find that having

[25] Although applying for direct support entails revealing project information to the public agency, the agency does not disclose this information to the general public. If the firm obtains direct support its R&D costs fall even if imitation by rivals is immediate, whereas it might be unable to use tax credits if innovation barely generates profits.

previous experience in R&D is the most important determinant of using both kinds of support, both for large firms and for SMEs. For large firms financial constraints do not seem to have a significant effect, while for SMEs they reduce the likelihood of using both tools, and increase the likelihood of using none.

We believe that the significance of past R&D in explaining the use of tax credits (alone or in combination with direct support), but not the use of direct support, points to a characteristic of R&D-related behavior that previous research has identified: persistence.[26] In our sample, 89% of large firms and 73% of SMEs that were investing in R&D in 2005 also invested in 2008.

Overall, our results suggest that direct support may be more effective to encourage firms that face financial constraints to invest, or invest more, in R&D, while tax incentives may encourage increasing R&D by firms that are not financially constrained and already invest in R&D. Direct support and tax incentives would therefore not be substitutes, as the latter would not be well suited to financially constrained firms. They may provide some compensation to firms affected by some appropriability difficulties, especially in the case of SMEs.

When we estimate the model including as a proxy for appropriability the importance of information from competitors, which involves using the subsample of innovating firms only, we find differences in the effects for large firms and for SMEs. In the case of large firms, those that give a high importance to this source of information are more likely to use tax incentives only. The sign of this effect is the opposite of the use of protection, suggesting that both variables capture different things.

[Insert Table 2 about here]

[Insert Table 3 about here]

[26] See Mañez-Castillejo, J. A., Rochina-Barrachina, M. E., Sanchis-Llopis, A. and Sanchis-Llopis, J. (2009). Sunk costs or increasing dynamic returns to R&D (through learning effects) might explain persistence.

5.2 Robustness analysis.

In this section we explore the robustness of previous results to (a) differences in the firms' innovativeness status, (b) changes in the definition of barriers to innovation, and (c) alternative definitions of the dependent variables.

We begin by re-estimating the baseline model for different subsamples of firms. We first estimate the model for the subset of firms that introduced products new to the market in 2005 or before, because this particular subset may be more sensitive to appropriability issues; second, we re-estimate for the subset of firms that were doing R&D in 2005, and finally we estimate the model for the subset of firms in high tech and medium tech manufacturing sectors.

Second, we change the way we calculate innovation constraints, partly because of our concern that remaining correlation among the set of barriers to innovation might affect standard errors. We calculate for each barrier the ratio between the firm's ranking for that barrier to the average value for all barriers, as perceived by the firm, so we get an indicator of the relative importance of each particular constraint for the firm.

Third, we change the definition of dependent variables, a firm's use of tax credits and of direct support. Instead of using variables referring to the 2006-8 period, we use binary dependent variables referring to year 2008 only. In addition, regarding direct support the question asked is not identical. In the baseline model, in the case of direct support, firms are asked whether they received any direct support for innovation activities, including loans and grants. We now use, for direct support, the firm's answer to the question of whether it received in 2008 public grants for in-house R&D. Similarly, for tax incentives the binary variable now will indicate whether the firm claimed tax credits in 2008.

Table 4 reports estimated average marginal effects for the two independent variables of interest, financial contraints and appropriability. [27] We find that the main estimates of interest remain quite stable, especially for SMEs. For SMEs, financial constraints are always negatively correlated to the use of tax incentives

[27] Detailed results are available on request.

only; the estimated coefficient is highest in absolute value for firms in the high and medium-high tech industries. They increase the likelihood of using direct support. For the subsample of large firms some results change. We find that for firms that were doing R&D in 2005, financial constraints do not seem to be associated to the likelihood of using direct support or tax incentives. Appropriability however is negatively correlated with the use of tax credits, and positively correlated with direct support.

[Insert Table 4 about here]

We now compare the results we obtain for using only direct support to those obtained by Gelabert et al. who use the same data source, keeping in mind that there are some differences with respect to the sample and empirical model. First, they use data for the years 2000 and 2002 to 2005, keep an unbalanced panel of firms that reported positive internal R&D expenditure at least one of these years in all sectors, including services, and do not perform separate estimations for large firms and SMEs. Second, they estimate a univariate probit model, because they do not take into account the use of tax incentives. Third, their dependent variable for direct support corresponds to our redefined variable in the robustness analysis. The definitions of appropriability and financing constraints are very close to ours.
While they find that firms with financial constraints reduces the likelihood of obtaining public support, we find that the opposite effect for SMEs. The implication would be that in their case direct support would not be addressing this source of market failure, whereas according to our results it would at least for SMEs, at the allocation stage. Gelabert et al. do not find appropriability to be related to the likelihood of using direct support, although it is significant in explaining the response of private R&D to public support. We find this result a little intriguing: if we interpret the use of protection mechanisms as indicator of high appropriability of returns, as the authors do, then public support should lead to higher private R&D, not less, because it lowers the cost of R&D projects whose benefits will accrue to the firm. We find instead that large firms that have used

protection mechanisms are more likely to obtain direct funding. We interpret that firms that face imitation seek both to use protection mechanisms and to obtain public support, because these mechanisms do not offer full protection. The public agency would be willing to grant support to projects that generate knowledge spillovers. To sum up, we think that by jointly estimating the use of direct support and of tax credits, and by discriminating by firm size, we are better able to characterize the use of both tools and the role of constraints.

6. Conclusions

Our analysis has addressed the use by firms of two tools of public support to private R&D activities, direct support and tax incentives, linking them to potential barriers to innovation, with a special focus on the role of financial constraints and appropriability indicators. Using data from a sample of two waves of the Spanish CIS survey, 2003-2005 and 2006-2008, we have estimated the determinants of the likelihood of using these tools jointly, in isolation or none, separately for SMEs and large firms.

Estimation results support the main hypothesis that tax incentives and direct funding are not substitutes from the firms' perspective. Financing constraints affect differently the likelihood of using each instrument. In particular, we find that the probability of using tax incentives falls when firms face financing constraints, while the likelihood of using direct funding increases. There are differences as well regarding the effect of appropriability, as measured by the use of legal forms of protection. The direction of this effect is not the same for large firms and for SMEs. While large firms that have used protection methods are less likely to use tax incentives and more likely to use direct support, SMEs that use legal protection mechanisms are more likely to use tax incentives.

These results do suggest that there is a link between the source of market failures related to R&D and the use by firms of these two tools of public support to R&D, an issue that has not been previously studied in the literature. The main implication of these results is that tax incentives may not be a good instrument to address private R&D underinvestment when financing constraints are the main

source of the problem, while direct support may be more appropriate. A second implication is that the ability of direct support to address appropriability issues may differ for SMEs and large firms. In that case tax credits for SMEs might be more effective.

One limitation of this work is that the available data does not allow us to take into account possible dynamic effects across and within instruments, as well as firm heterogeneity. For instance, firms that obtain subsidies in one period may qualify for tax credits in future periods. Another limitation is that we think that there is some ambiguity in the interpretation of the available indicator of appropriability obtained through the Community Innovation Survey. Some innovation project level information could be helpful in that regard, as well as adding some more direct questions. Finally, there are two issues that are not addressed in the CIS survey and yet empirical evidence shows they are important for private innovation decisions: one is the role of competition/ rivalry, and the second is managerial practices and abilities.[28]

As the design and administration of innovation surveys is spreading to the US and other non-European countries, reviewing the questions in light of the results of empirical work, might be not too costly and have a significant pay-off.

[28] For an example of a survey on management practices that has been designed to quantify them and to test their association to productivity and other variables, see Bloom and Van Reenen (2007).

REFERENCES

Aghion, Philippe, Nicholas Bloom, Richard Blundell, Rachel Griffith, and Peter Howitt (2005) "Competition and innovation: an inverted-U relationship", *Quarterly Journal of Economics*, 701-728.

Aghion, Philippe, Richard Blundell, Rachel Griffith, Peter Howitt, and Susanne Prantl (2009) "The effects of entry on incumbent innovation and productivity", *The Review of Economics and Statistics*, 91(1), 20-32.

Artés, Joaquin (2009) "Long run versus short run decisions: R&D and market structure in Spanish firms", *Research Policy*, 38, 120-232.

Berube, Charles and Pierre Mohnen (2009) "Are firms that received R&D subsidies more innovative?", *Canadian Journal of Economics*, 42(1), 206-225.

Bloom, Nicholas, Rachel Griffith, John Van Reenen (2002) "Do R&D credits work? Evidence from an international panel of countries 1979-1997", *Journal of Public Economics*, 85, 1-31.

Bloom, Nicholas and John Van Reenen (2007) "Measuring and explaining management practices across firms and countries", Quarterly Journal of Economics 122(4), 1341-1408.

Bloom, Nicholas, Mark Schankerman and John Van Reenen (2007) "Identifying Technology Spillovers and Product Market Rivalry", NBER WP 13060.

Cabral, Luis and Ben Polak (2007) "Does Microsoft Stifle Innovation? Dominant Firms, imitation and R&D Incentives", NYU Working Paper EC -07-06.

Cappelen, Adne, Arvud Raknerud and Maruba Rybalka (2008) "The effects of R&D tax credits on patenting and innovations", Discussion Papers 565, Statistics Norway.

Cassiman, Bruno and Reinhilde Veugelers (2002) "R&D Cooperation and Spillovers: Some Empirical Evidence from Belgium," American Economic Review, vol. 92(4), pages 1169-1184

Chiburis, Richard (2010) "Score tests of normality in Bivariate Probit Models: Comment", U. Texas at Austin, mimeo.

Corchuelo, Beatriz. and Ester Martínez-Ros (2008) "Application of R&D fiscal incentives in Spanish manufacturing firms", *Hacienda Pública Española*, IEF, Vol 187(4).

Czarnitzki, Dirk., Bernd Ebersberger and Andreas Fier (2007) "The relationship between R&D collaboration, subsidies and R&D performance: Empirical evidence from Finland and Germany", *Journal of Applied Econometrics* 22:1347-1366.

Czarnitzki, Dirk, Peter Hanel and Julio Miguel Rosa (2011) "Evaluating the impact of R&D tax credits on innovation: A microeconometric study on Canadian firms", *Research Policy* 40: 217-229.

Dushnitsky, Gary and Michael J. Lenox (2005) "When do firms undertake R&D by investing in new ventures?", Strategic Management Journal 26: 947-965.

Gelabert, Liliana, Andrea Fosfuri y Joan A. Tribó (2009) "Does the effect of public support depend on the degree of appropriability?", *The Journal of Industrial Economics* Vol LVII (4), pp. 736-767.

Haegeland, Tor and Jarle Moen (2007) "The relationship between the Norwegian R&D tax credit scheme and other innovation policy instruments", Reports 2007/45, Statsitics Norway.

Hajivassiliou, Vassilis and Frédérique Savignac (2008) "Financing Constraints and a Firm's Decision and Ability to Innovate: Establishing Direct and Reverse Effects", Banque de France WP 202.

Hall, Bronwyn and Josh Lerner (2009) "The Financing of R&D and Innovation", chapter 14 in B. Hall and N. Rosenberg (ed) Handbook of the Economics of Innovation, North Holland.

Huergo, Elena and Maite Trenado (2010) "The Application for and the Awarding of Low-Interest Credits to Finance R&D Projects," *Review of Industrial Organization*, Springer, vol. 37(3), pages 237-259

Hussinger, Katrin (2008) "R&D and subsidies at the firm level: An application of parametric and semiparametric two-step selection models", *Journal of Applied Econometrics* 23:729-747.

Keuschnigg, Christian & Ribi, Evelyn (2010) "Profit Taxation, Innovation and the Financing of Heterogeneous Firms" University of St. Gallen Department of

Economics working paper series 2010 2010-01, Department of Economics, University of St. Gallen.and CEPR Discussion Papers 7626, C.E.P.R.

Klette, Tor J., Jarle Moen and Zvi Griliches (2000). "Do subsidies to commercial R&D reduce market failures? Microeconometric evaluation studies", Research Policy 29, 471-495.

Lerner, Josh (1999) "The Government as Venture Capitalist: The Long-Run Impact of the SBIR Program", Journal of business 72(3), pp. 285-318.

Lokshin, B. and Pierre Mohnen (2011) "How effective are level-based R&D tax credits? Evidence from the Netherlands", *Applied Economics*, forthcoming (also as UNU-MERIT Working Paper 2010-040,

Mairesse, Jacques and Pierre Mohnen (2010) "Using Innovation Surveys for Econometric Analysis", NBER WP No. 15857.

Mañez-Castillejo, Juan A., Maria E. Rochina-Barrachina, Amparo Sanchis-Llopis, and Juan Sanchis-Llopis (2009) "The role of sunk costs in the decision to invest in R&D", *Journal of Industrial Economics*, 57(4).

Marra, Maria A. (2008) "Efecto de los incentivos fiscales y subvenciones públicas a la inversión en I+D+i de las empresas manufactureras españolas", *Hacienda Pública Española/Revista de Economía Pública* 184, 35-66.

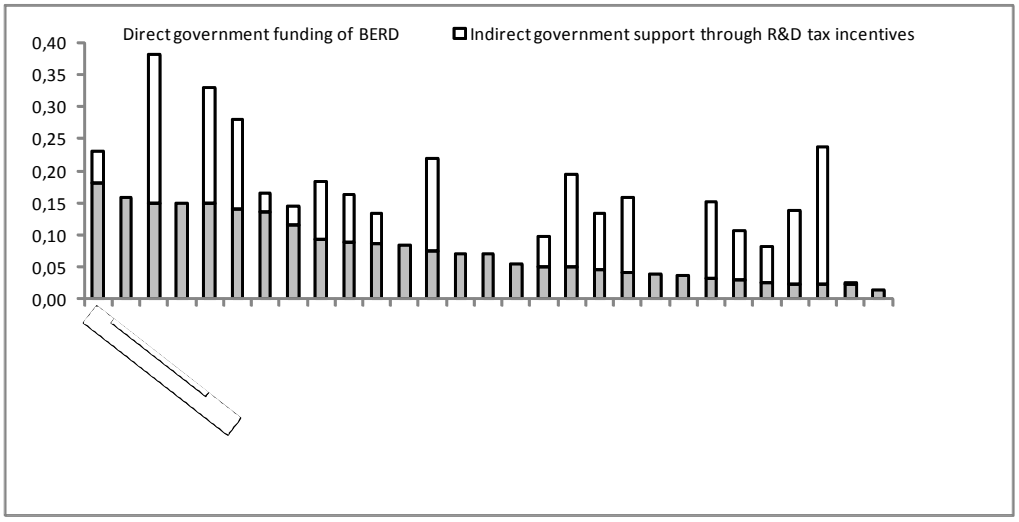
OCDE (2011a) "OECD Science, Technology and Industry Scoreboard 2011", OECD © 2011

OECD (2011b) Testimony by the OECD, US Senate Committee on Finance, September 2011.

Takalo, Tuomas, Tanja Tanayama and Otto Toivanen (2011) "Estimating the benefits of targeted R&D subsidies", forthcoming in *Review of Economics and Statistics.*

Takalo, Tuomas and Tania Tanayama (2010) "Adverse selection and financing of innovation: is there a need for R&D subsidies?", *Journal of Technology Transfer* 35, 16-41.

FIGURE 1. DIRECT FUNDING AND TAX INCENTIVES FOR BUSINESS R&D 2009
(IN % OF GDP)



Notes:

Direct funding includes grants, credits and public procurement. Indirect funding refers to all tax incentives related to R&D: tax credits and allowances, social security contributions, reductions in R&D labor taxes. Sub-national tax incentives are not included. Israel, Italy and Slovak Republic provide R&D tax incentives but cost estimates are not available. For detailed information check the source.

Source: OCDE (2011a), OECD Science, Technology and Industry Scoreboard 2011

TABLE 1. FIRMS, INNOVATION AND PUBLIC SUPPORT TO PRIVATE R&D

MANUFACTURING FIRMS	PITEC 2006-2008	
	SMALL	LARGE
Total number of firms in the sample in 2008	4503	1074
% firms invest in innovation in 2008 (a) (includes R&D and other innovation related expenditures)	64.5	79.6
% firms invest in R&D in 2008 (in-house and/or external contracting))	57.8	72.5
% firms introduced new products/services in 2006-2008	57.9	74.4
% firms introduced new products, services or new processes in 2008	75.8	84.3
% firms that received direct support from the Central Administration in 2008 (a)	8.3	19.2
% firms obtained tax incentives in 2008 (b)	21.5	34.6
% firms used both types of support in 2008 (b)	4.1	10.6
% firms benefiting from tax incentives that also received direct support in 2008 (b)	19.2	30.6
% firms having direct support that also claimed tax incentives in 2008 (b)	49.5	55.3
% firms received direct support from the Central Administration in 2006-2008 (loans and grants)	15.7	34.1
% firms obtained tax incentives in 2006-2008	26.8	44.5
% firms used both types of support in 2006-2008	8.5	23.6
% firms benefiting from tax incentives that received direct support	31.7	53.1
% firms benefiting from direct support that also claimed tax incentives in 2006-2008	54.2	69.4

Notes:

Definitions: Innovate = firms that introduce at least one product, or process or service innovation in the period 2006-2008; Invests in Innovation = has positive investment during 2008 in any of the following categories: in-house R&D, external R&D, acquisition of equipment or software, acquisition of external knowledge, training, design and market introduction of innovations. For PITEC, the total number of observations may vary for some of the annual variables: in 2008, the number of SMEs is 3912 and the number of large firms is 933.

Source: Authors' calculations

TABLE 2. LARGE FIRMS. BIVARIATE PROBIT REGRESSION

AVERAGE MARGINAL EFFECT ON THE PROBABILITY OF…

Panel A	*Only using tax incentives*			*Only having direct support*		
Variable	Av.Marg Eff	s.e.	p-value	Av.Marg Eff	s.e.	p-value
Awareness of constraints	.093	.043	0.033	-.013	.018	0.473
Financially constrained	-.048	.018	0.010	.023	.011	0.031
Lack of personnel	-.064	.028	0.020	.017	.015	0.254
Lack of information	.059	.033	0.072	-.019	.009	0.046
Dominant firm	-.029	.022	0.200	.005	.009	0.482
Demand risk	.031	.025	0.215	-.018	.007	0.007
Appropriability_a	-.044	.015	0.003	.033	.009	0.000
Log of Relative productivity	.031	.013	0.015	-.016	.005	0.887
Share of highly educated employees	-.000	.001	0.360	.001	.000	0.011
Take into account tax incentives	.156	.016	0.000	-.028	.005	0.000
Group membership	-.013	.018	0.472	.011	.008	0.124
Private domestic firm	-.007	.018	0.713	.022	.009	0.015
Exporter	.032	.021	0.140	-.001	.008	0.942
Did in-house R&D	.046	.025	0.067	.001	.007	0.937
Log of number of employees	-.036	.011	0.002	.024	.003	0.000
New firm	-.082	.037	0.028	.074	.019	0.000
Age (x10)	-.009	.003	0.005	.004	.001	0.001
Located in technological park	-.059	.037	0.114	.050	.024	0.042
N observations		176			90	

Panel B	*Not having any public support*			*Having both types of support*		
Variable	Av Marg Eff	se	p-value	Av Marg Eff	se	p-value
Awareness of constraints	-.134	.048	0.005	.053	.028	0.090
Financially constrained	.017	.020	0.395	.008	.012	0.521
Lack of personnel	.066	.035	0.059	-.019	.018	0.297
Lack of information	.033	.033	0.321	-.007	.018	0.690
Dominant firm	.031	.023	0.171	-.009	.012	0.437
Demand risk	.014	.026	0.560	-.027	.011	0.014
Appropriability_a	-.031	.017	0.076	.041	.012	0.001
Log of Relative productivity	-.059	.013	0.000	.028	.007	0.000
Share of highly educated employees	-.001	.001	0.048	.001	.000	0.002
Take into account tax incentives	-.192	.015	0.000	.063	.013	0.000
Group membership	-.022	.020	0.282	.022	.012	0.075
Private domestic firm	-.086	.018	0.000	.070	.014	0.000
Exporter	-.066	.022	0.003	.035	.015	0.019
Did in-house R&D	-.319	.015	0.000	.272	.025	0.000
Log of number of employees	-.023	.012	0.054	.034	.004	0.000
New firm	-.089	.129	0.486	.096	.102	0.342
Age (x10)	.000	.003	0.914	.004	.002	0.043
Located in technological park	-.056	.053	0.289	.065	.038	0.087
N observations		332			210	

Notes: Total number of observations: 808; Wald chi2(48)=332.09; Log Pseudolikelihood= -850.69; rho= 0.36 with s.e. 0.06. Regional and industry binary variables have been included but results are not reported.

TABLE 3. SMEs. BIVARIATE PROBIT REGRESSION

AVERAGE MARGINAL EFFECT ON THE PROBABILITY OF…

Panel A	*Only using tax incentives*			*Only having direct support*		
Variable	Av.Marg Eff	s.e.	p-value	Av.Marg Eff	s.e.	p-value
Awareness of constraints	.002	.020	0.906	.030	.016	0.062
Financially constrained	-.044	.006	0.000	.025	.007	0.000
Lack of personnel	.009	.010	0.348	-.0111	.007	0.114
Lack of information	-.014	.009	0.113	.007	.008	0.349
Dominant firm	.007	.008	0.741	-.005	.006	0.359
Demand risk	.015	.008	0.073	-.012	.006	0.048
Appropriability_a	.031	.007	0.000	.001	.005	0.890
Log of Relative productivity	.036	.004	0.000	-.010	.003	0.001
Share of highly educated employees	-.000	.000	0.944	.000	.000	0.000
Take into account tax incentives	.118	.008	0.000	-.021	.004	0.000
Group membership	.003	.008	0.637	.008	.006	0.209
Private domestic firm	.039	.013	0.003	-.003	.009	0.891
Exporter	.038	.008	0.000	-.002	.006	0.704
Did in-house R&D	.067	.010	0.000	.009	.007	0.171
Log of number of employees	.006	.004	0.121	.024	.003	0.000
New firm	-.063	.016	0.000	.094	.023	0.000
Age (x10)	.000	.001	0.873	.003	.001	0.041
Located in technological park	.014	.020	0.485	.0338	.017	0.045
Num. observations		744			262	

Panel B	*Not having any public support*			*Having both types of support*		
Variable	Av Marg Eff	se	p-value	Av Marg Eff	se	p-value
Awareness of constraints	-.074	.025	0.004	.043	.014	0.002
Financially constrained	.030	.009	0.002	-.011	.005	0.015
Lack of personnel	.009	.012	0.468	-.007	.006	0.261
Lack of information	.011	.013	0.401	-.003	.007	0.590
Dominant firm	.008	.010	0.453	-.005	.005	0.355
Demand risk	-.001	.011	0.945	-.003	.006	0.595
Appropriability_a	-.060	.008	0.000	.030	.005	0.000
Log of Relative productivity	-.043	.005	0.000	.018	.003	0.000
Share of highly educated employees	-.004	.000	0.000	.002	.000	0.000
Take into account tax incentives	-.201	.007	0.000	.103	.0068	0.000
Group membership	-.027	.010	0.009	.001	.0058	0.009
Private domestic firm	-.085	.017	0.000	.044	.011	0.000
Exporter	-.072	.010	0.000	.035	.006	0.000
Did in-house R&D	-.201	.011	0.000	.124	.010	0.000
Log of number of employees	-.069	.005	0.000	.038	.003	0.000
New firm	-.070	.028	0.013	.039	.017	0.022
Age (x10)	-.007	.002	0.002	.004	.001	0.001
Located in technological park	-.127	.028	0.000	.080	.020	0.000
N observations		2172			339	

Notes: Total number of observations=3517; Wald chi2(48)=912.67; Log Pseudolikelihood=-3156.4; rho=0.30 with s.e.=0.03. Regional and industry binary variables have been included but results are not reported.

TABLE 4. ROBUSTNESS ANALYSIS

AVERAGE MARGINAL EFFECTS OF FINANCING CONSTRAINTS AND APPROPRIABILITY, BY SUPPORT STATUS

Panel A: SMEs	*Financially constrained*				*Appropriability*			
	00	*01*	*10*	*11*	*00*	*01*	*10*	*11*
Baseline								
Whole sample	.03	-.04	.03	-.01	-.06	.03		.03
Subsample of firms that introduced products new to the market in 2003-2005		-.07	.03					
Subsample of firms that did R&D in 2005	.04	-.05	.02		-.07	.03		.03
Subsample of firms in high and medium-high tech industries	.06	-.07	.02		-.07			.03
Subsample of innovative firms	.03	-.05	.03	-.01	-.06	.03		.03
Change in computation of barriers		-.05	.03		-.06	.04		.03
Change of dependent variables								
Whole sample	.02	-.03	.05		-.07	.04		.02
Subsample of firms that did R&D in 2005		-.04	.01		-.07	.04		.02
Subsample of firms that introduced products new to the market in 2003-2005		-.05						
Subsample of firms in high and medium-high tech industries	.06	-.05			-.08	.04		.03
Subsample of innovative firms	.03	-.05	.03	-.01	-.06	.03		.03

Panel B: Large Firms	Financially constrained				Appropriability			
	00	01	10	11	00	01	10	11
Baseline								
Whole sample		-.05	.02		-.03	-.04	.03	.04
Subsample of firms that did R&D in 2005					-.05	-.08	.05	.08
Subsample of innovative firms		-.05	.02		-.03	-.05	.04	
Change in computation of barriers		-.09	.06		-.04	-.06	.05	.06
Change of dependent variables								
Whole sample		-.05	.03				.02	.02
Subsample of firms that did R&D in 2005			.05				.04	.04

Notes: 00=no direct support and no tax credit; 01=tax credit only; 10= direct support only; 11= both types of support. Only significant estimates are reported. For large firms estimations for some subsamples could not be performed because the number of observations falling in some of the categories was too small (less than 45 firms).

APPENDIX A: Main features of R&D tax incentives in Spain.

R&D Tax incentives have been in place in Spain since 1995. In 2001 some techonological innovation expenditures were included as eligible for the credit. The definitions of R&D eligible expenses follow the OECD Frascati Manual guidelines. The credit rates are 25% of the average expenditures in the preceding two periods, and 42% of the difference between current R&D expenditure and this average. In addition, 17% of the labor cost of employees assigned to exclusively R&D tasks can be deducted. For innovation expenditures other than R&D the credit rate is 8%. There is a cap on the maximum credit applicable a given year, which is 50% of the corporate tax liability. Excess can be carried forward up to 15 years.

APPENDIX B: Sample Descriptive Statistics

	SMEs			Large Firms		
Variable Description	**N**	**mean**	**sd**	**N**	**mean**	**sd**
Awareness of constraints	3685	.507	.224	835	.424	.232
Financially constrained	3685	.389	.487	835	.241	.428
Lack of personnel	3685	.133	.340	835	.069	.254
Lack of information	3685	.135	.342	835	.082	.275
Dominant firm	3685	.206	.405	835	.158	.365
Demand risk	3685	.206	.404	835	.134	.340
Appropriability_a	3685	.355	.478	835	.388	.487
Appropriability_b	3439	.137	.344	736	.138	.346
Log of Relative productivity*	3685	-.331	.822	835	-.041	.706
Share of highly educated employees*	3685	18.65	18.48	835	13.42	14.44
Take into account tax incentives	3912	.411	.492	933	.533	.499
Group membership*	3685	.237	.425	835	.748	.434
Private domestic firm*	3685	.927	.258	835	.665	.471
Exporter*	3685	.711	.452	835	.843	.363
Did in-house R&D*	3685	.768	.421	835	.717	.450
Log of number of employees*	3685	3.606	.956	835	6.00	.717
New firm*	3685	.023	.150	835	.009	.077
Age*	3735	22.94	17.85	904	32.95	22.75
Located in technological park	3912	.020	.143	933	.027	.164
Firm located in Madrid	3912	.077	.267	933	.173	.378
Firm located in Catalonia	3912	.296	.456	933	.302	.459
Firm located in Andalusia	3912	.052	.222	933	.039	.195
Firm in high tech sector	3912	.097	.296	933	.117	.322
Firm in med-high sector	3912	.340	.473	933	.305	.460
Firm in med-low sector	3912	.261	.439	933	.270	.444

Notes: All variables marked * refer to year 2005; otherwise they refer to the period 2003-2005.

The share of highly educated employees refers to 2006, the first year this variable becomes available.