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Public support to business R&D and the economic crisis: Spanish evidence

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PUBLIC SUPPORT TO BUSINESS R&D AND THE ECONOMIC CRISIS: SPANISH EVIDENCE

Abstract:
The objective of the present study is to compare the effect of public support of business R&D on technological inputs and outputs before and during the recent economic crisis. To do so, we use information provided by the Centre for the Development for Industrial Technology (CDTI), which is the main public agency in Spain that grants financial aid of its own to companies for the execution of R&D projects. Specifically, we consider firms supported through CDTI programmes for periods the 2002-2005 and 2010-2012. Impact assessment is conducted using "matching" techniques. Our preliminary results suggest that, during the crisis, public support continued to have positive effects on the resources devoted to R&D activities, and also increased the technological outputs obtained from these resources.

Keywords: Impact assessment, Economic crisis, Public aid, Business R&D.

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1. Introduction

While today it is unquestionable that there is a direct relationship between innovation and economic growth, the consideration of technological advance as an economic factor is relatively recent. Endogenous growth theory (Romer, 1990) places technological capital as an engine of growth in the long term, subject to the decisions of agents. To the extent that technology is no longer considered an exogenous factor, we admit that the business cycle can also affect R&D investment. A relevant question is whether this impact will be positive or negative.

From a theoretical point of view, during recessions, the allocation of firms' resources would tend to be more efficient, concentrated on activities that generate higher returns in terms of long-term productivity. Therefore, if a company increases R&D expenditures to strengthen its competitiveness, the effect on its productivity should be positive. However, the empirical literature finds discrepancies with respect to this argument. Aghion et al. (2012) explain these discrepancies from the existence of financial restrictions on companies. In times of recession, R&D investment behaves counter-cyclically in those firms that have enough resources to fund it, while the opposite happens if companies have difficulties accessing external financing.

Other authors confirm these results (Bovha-Padilla et al., 2009; López-García et al., 2013), although there are also analyses which demonstrate the relevance of other variables to qualify the relation between financial constraints and business R&D investments during the economic cycle. This is the case of Beneito et al. (2015), who find that the pro-cyclical effect of financial constraints is lower if the company is family-owned, or if it belongs to a business group because of the greater availability of internal resources to finance R&D activities. In fact, in times of recession, R&D investment behaves counter-cyclically in these firms.

From this perspective, the role of public funding could be decisive as long as it mitigates the negative effect of financial constraints during the crisis. The key question is whether this support is really having such an effect or, on the contrary, public aid is less effective in adverse economic conditions.

Notice that firms' financial constraints are also important for agencies that award aid, as the main justification for public intervention is the presence of R&D-related market failures, which are associated with: (i) the incomplete appropriability of technological results due to knowledge spillovers and the existing gap between private and public return, and (ii) the cost of capital when the innovation financer and the investor are not the same agents. In this sense, both the conditions and the effects of public support can be affected by the business cycle.

The objective of the present study is to compare the effect of public support of business R&D before and during the recent economic crisis. To do so, we use information provided by the Centre for the Development for Industrial Technology (CDTI). This organism is the main public agency in Spain that grants financial aid of its own to companies for the execution of R&D projects.

In a previous paper, Huergo and Moreno (2017) obtain evidence of a positive impact of low-interest credits granted by the CDTI to business R&D projects during the period 2002-2005. These effects took place in both the decision to perform R&D activities and the R&D intensity of supported firms (input additionality, in the terminology of Cunningham et al., 2012). In line with previous empirical evidence (David et al., 2000; García-Quevedo, 2004; Zúñiga-Vicente et al., 2014; Becker, 2015), the hypothesis of full crowding-out of private R&D was rejected.

During the crisis, the CDTI continued granting public aid in the form of low-interest credits, and our purpose is to study whether the impact of this type of public aid has changed. With this objective, we combine the information of firms supported through CDTI programmes for the periods 2002-2005 (years of expansion) and 2010-2012 (years of recession), with the information provided by the Spanish Institute of Statistics (INE) about non-supported firms from the Spanish Technological Innovation Survey (the Spanish version of the CIS). Impact assessment is conducted using "matching" techniques. Our preliminary results suggest that, during the crisis, public support continued to have a positive effect on the resources devoted to R&D activities, and also increased the technological outputs obtained from these resources (output additionality).

The rest of the paper is organised as follows. Section 2 summarises the main characteristics of CDTI programmes before and during the crisis. Section 3 describes the empirical model and the data. In Section 4, we present the results and, finally, Section 5 concludes.

2. CDTI Projects

The type of project analysed in this study consists of R&D business projects funded by CDTI in two periods: 2002-2005 (years of expansion) and 2010-2012 (years of recession). In both periods, CDTI programmes were targeted to the creation or significant improvement of a production process, product or service. Through these programmes, financial support is primarily provided in the form of loans, granted at an interest below market rate and with a reimbursable period of 10 years, regardless of the firm activity sector and size.[1] The projects could be developed by one single firm or in collaboration with other organisations and may have a non-reimbursable part (a grant).

In general, CDTI annually finances about 1,000 projects in which more than 850 companies are involved, 60% of which are SMEs. Funding is offered throughout the year so that companies can submit a funding application linked to a project proposal at any time. The average eligible budget of a project financed by CDTI is approximately 600,000 € and its duration may vary from 12 to 36 months.

Eligible costs include salaries (researchers, technicians and other supporting staff); costs of instruments and equipment; contractual research costs; technical knowledge and patents bought or licensed from outside sources at market prices; additional overheads incurred directly as a result of the research project; and other operating expenses, including costs for materials, supplies and similar products, which result directly from the research project.

In order to assess the impact of these programmes, their objectives should be taken into account. These objectives are aligned with the overall mission and goals of the CDTI:

- Increasing private innovation expenditure in Spain. The purpose is to encourage firms to engage in R&D. CDTI requires beneficiaries to contribute with their own resources to the

[1] In most years, the interest rate was equal to zero. Only in 2012 was a positive but favorable (below market) rate applied, based on the 12 month Euribor rate.

total project budget so that the company guarantees the co-financing and an adequate capacity of project execution.

- Promoting growth and business competitiveness. With CDTI's funding, companies should be able to improve the competitiveness of their products and services.
- Achieving high-quality and innovative R&D projects. CDTI carries out a technical and thorough evaluation of the projects which apply for aid, to guarantee the innovative component and the high quality of the research activities, as well as the use of new leading technologies.
- Commercial approach and market-oriented projects. The main aid instrument (loan) is best suited for these projects, as it enables companies to notably speed up their work and enter target markets.

The results of R&D activities may facilitate international technological cooperation and exports and investments abroad. Cooperation between companies, research organisations and other economic agents in the field of R&D and innovation is also to be encouraged.

Although these objectives have remained constant in recent decades, funding conditions partially changed between the periods 2002-2005 and 2010-2012. In particular, the maximum percentage of the approved project costs covered by the loan increased from 60% in the first period up to 85% in the second. Furthermore, as of 2008, CDTI funding does not cover the purchase of physical assets (equipment, machinery, etc.). In addition, during the first period, the non-reimbursable part of the loan was provided only to collaborative projects, while in the second period it was available for every project, with different subsidy intensity (from 5% to 30% of the total aid) depending on the type of project (individual, international or with research organisations), the size of the beneficiary (SME or large company) and the source of the funds (Structural or CDTI Funds).

Changes in funding conditions in the period 2010-2012 also came with new requirements on guarantees. Specifically, firms carrying out around 20% of the supported projects during those years were asked for real guarantees. These differences in the features of CDTI programmes between periods will be taken into account when interpreting the results in Section 4.

3. Empirical model and data

Following the literature on impact assessment of public aid, the implicit question to answer is what the behaviour of a funded firm would have been if it had not received the public support. Notice that each firm can only be observed either in the status of being supported or not. Therefore, to measure the effect of public aid on innovative performance, we have to take into account that the participation within the funding programme probably depends on the same firm characteristics that determine its innovative performance.

To solve these problems of selection and endogeneity, econometric literature has developed several methodologies (Heckman, 1979; Cerulli, 2010; Cerulli and Potì, 2012). In this paper, we employ an econometric matching procedure which is one of the most preferred methods. This procedure does not require any functional form or a distributional assumption on the errors of the equations for technological inputs and outputs. However, we need to assume that the conditional independence assumption holds, that is, all firm characteristics that explain selection into a public funding program are observed.

Following this procedure, to obtain the propensity scores that allow us to build the counterfactual, for each period a probit model is estimated. Specifically, our first equation is devoted to the participation of firm $i\,(i=1\cdots N)$ in the CDTI funding programme during year t $(t=1\cdots T)$ and is given by:

$$y_{it}=\begin{cases}1 \text{ if } y_{it}^{*}=x_{it}\beta+u_{it}>0 & u_i \approx iid\ N(0,\sigma_u^2)\\ 0 \text{ otherwise}\end{cases} \qquad [1]$$

where y_{it}^{*} is a latent dependent variable, x_{it} is the set of explanatory variables, β is the vector of coefficients and u_{it} is the error term. Firm i will participate if y_{it}^{*} is positive.

To define the matched samples, we choose the caliper matching algorithm with replacing, in which participants are matched with the non-participants that are closest in terms of the propensity score subject to the constraint that the maximum distance between the treated and non-treated firms can be no greater than 0.005.[2]

[2] The procedure is performed in Stata 13 using the psmatch2 routine implemented by Leuven and Sianesi (2003).

In a second step, to quantify the stimulus effect of public support, we estimate different equations for each of our measures of technological inputs and outputs in the two matched samples. In every case, we adapt the econometric specification to the continuous or binary character of the dependent variable.

3.1. Data and variables

The database used for the analysis is provided by the CDTI. The CDTI database includes information about Spanish firms' participation in its financing programs. The specific features of CDTI programmes during the two periods considered in this paper (2002-2005 and 2010-2012) have been explained in the previous section.

The information from the CDTI has been complemented with two different control samples of firms not receiving aid. These records were provided by the Spanish Institute of Statistics (INE) on the basis of the annual responses to the Spanish Innovation Survey.[3] After merging the databases, the sample for period 2002-2004 includes 13,498 observations and 1,764 awarded projects, while in the case of period 2010-2012, the sample includes 29,921 observations and 920 awarded projects.

One constraint for our analysis is that we cannot merge the information of both periods, as the empirical analysis for the second period has been undertaken at secure places in the INE. In addition, the set of variables provided by the INE about non-supported firms differs between the two periods analysed in the paper, as each of the control samples has been available at different moments and under distinct confidentiality conditions. The list and definitions of all variables used in the study are shown in Table 1.

Insert Table 1

In Table 2, the means of main variables for participants and non-participants, distinguishing between both periods, are shown.

[3] The data from the INE are anonymised for quantitative variables, so firms from the control sample cannot be identified.

Insert Table 2

Specifically, we use information about four technological inputs and three technological outputs. As for the inputs, we consider the intensity of internal R&D expenditures, innovation expenditures, R&D personnel and fixed capital investment. In all cases, the variables are defined as ratios over total employment.

As can be seen in Table 2, and regardless of the period considered, the means of these variables are greater in firms supported by CDTI programmes than in firms without public aid, although in the case of fixed capital intensity, the difference of means is not statistically significant. Comparing both periods, internal R&D and innovation intensities have decreased in the second period not only for non-supported firms but also for firms financed by the CDTI. However, it is interesting to highlight that, during the crisis, the percentage of non-supported firms which perform R&D activities sharply decreased, but the percentage of firms supported by the CDTI slightly increased. A similar pattern is found in the case of R&D personnel intensity.

Regarding technological outputs, we have information about the generation of process and product innovations and the application for patents. Again, the sample mean of these variables is higher for participants in CDTI programmes than for non-participants. In addition, during the crisis, a smaller percentage of (supported and non-supported) firms applied for patents. However, and as in the case of technological inputs, for firms supported by the CDTI, the chance of obtaining process and product innovations increased.

The selection of explanatory variables in equation [1] is based on previous empirical literature (Czarnitzki and Licht, 2006; García and Monhen, 2010; Czarnitzki and Lopes-Bento, 2014; Huergo and Moreno, 2017) and is also determined by the availability of information in our databases. Unfortunately, as we have explained before, although we have several common variables, we cannot use exactly the same set of information for both periods. The set of common variables includes being a *continuous R&D performer*, *export intensity*, receiving *foreign capital* investment, *labour productivity*, activity sector (*agriculture*, *manufacturing*, *services* or *construction*) and being a *small or medium-sized enterprise* (*SME*).

Most previous papers consider measures of the firm's technological profile as explanatory variables of its participation in public aid programmes. In general, it is expected that the probability of applying for public funding increases when the propensity to perform R&D projects is higher. Therefore, as an indicator of being a continuous R&D performer, we use a dummy variable that takes the value 1 if the firm carries out R&D activities on a constant basis.

Another aspect that should be taken into account is the firm's international competitive position, which we are going to approach by the exporting activity. As Czarnitzki and Licht (2006) point out, operating in international markets might reflect the ability of exporters to transform innovations into successful products. In addition, as they are more experienced in dealing with bureaucracy compared to non-exporters, they might also be facing lower application costs (Takalo et al., 2013). In our samples, the presence of continuous R&D performers and exporters is higher among supported firms. Moreover, this presence was bigger during the crisis than it was before the crisis.

Labour productivity is another indirect measure of a firm´s competitive position. Table 2 shows that this variable is smaller for supported firms before the crisis. However, there are not differences between funded and non-funded firms during the crisis. Comparing both periods, labour productivity of participants increases in the second sample.

The presence of foreign capital among shareholders is used as an indicator of the ease of access to external capital markets. There are no significant differences between funded and non-funded firms before the crisis. However, the percentage of supported firms with more than 50% of foreign capital sharply decreased during the crisis and is smaller for participants in CDTI programmes.

We also consider the firm's size in our specifications. The expected effect of this variable on participation in public programmes is ambiguous. The benefits from public aid for SMEs might be higher because they are more affected by innovation-related market failures. However, large firms typically have more resources with which to undertake R&D projects and apply for financial support. The statistics in Table 2 show that firms funded by the CDTI are smaller than non-supported companies in terms of employment. The crisis reduced the mean size of both supported and non-supported firms. However, the percentage of SMEs (firms with fewer than 250 employees and with sales of less than €40m) with CDTI support was slightly larger/smaller before/during the crisis.

The statistics in Table 2 also show that the percentage of supported firms operating in the manufacturing sector is larger than the percentage of non-supported firms. The opposite happens for firms operating in the services sector. Although the result is similar in both periods, the percentage of supported firms in the services and construction sectors slightly increased during the crisis.

Besides these common variables, we have information about business group membership, the presence of public capital, being a start-up and having technological agreements only for the period 2002-2005. Although *belonging to a group* and the presence of *public capital* can be indicators of the ease of access to external capital markets, they possibly also imply a better knowledge of the public aid system. The expected effect of being a *start-up* is not clear. Although older firms are more likely to use public aid, young firms tend to be more financially constrained and, consequently, they might apply for and receive public aid more regularly. Finally, firms that adopt *technological cooperation* as strategy invest more in R&D when these practices are complementary (Cassiman and Veugelers, 2002), and in this case, we would expect a higher probability of applying for public aid. Notice that, with the exception of public capital, the means of these variables are higher among supported firms during this period.

On the other hand, we have data about the existence of financial constraints that hinder a firm's innovation and about the relevant objective of its innovation only for the period 2010-2012. Firms with liquidity constraints are expected to have more difficulties undertaking R&D projects and might apply for public aid more frequently. However, note that CDTI programmes consist mainly of loans that firms must reimburse under favourable conditions. In this sense, applicants should have an acceptable solvency situation in order to reduce the default ratio. The existence of financial constraints can reduce the chance of being funded by the public agency. In our sample, the percentage of firms which face financial constraints for innovation between 2010 and 2012 is larger among supported firms. Similarly, the percentage of firms which declare that job creation (or job maintenance) is a relevant objective of its innovation activity is also larger for this group of firms.

Finally, time dummy variables are included in all estimates to allow for business cycle effects and changes in the CDTI budget. In fact, direct funding provided by the CDTI between 2010 and 2012 decreased around 50%.

As we have mentioned before, once we have defined matched samples for both periods, in a second step we estimate different equations for each of our measures of technological inputs and outputs to quantify the stimulus effect of public support. In these estimates, besides the dummy variable denoting participation in CDTI programmes, we include the same explanatory variables as in equation [1], with two remarkable exceptions: Firstly, only for the period 2010-2012, we take into account the type of R&D activity undertaken by the firm: applied research, basic research or technological development.[4] Secondly, internal R&D intensity is also added as an explanatory variable in technological output equations. This allows us to discuss the existence of direct and indirect effects of public funding on technological performance.

4. Results

In this section, we analyse the results of estimating the impact of participation in CDTI programmes before and during the recent economic crisis on some performance measures of Spanish firms. As we have explained in the previous section, we compare the impact of CDTI programmes for two different periods: 2002-2005, which are years of expansion, and 2010-2012, which fully correspond to the economic crisis in Spain.

Among the different techniques to deal with the typical selection problem in this kind of analysis, we use a matching procedure. For each period, we construct a sample of firms that do not participate in CDTI programmes but have characteristics similar to participants prior to participation. This allows us to create the counterfactual of what would have happened with performance measures of a participant had it not participated.

Therefore, firstly, we present the estimates of the equation for the probability of participation in CDTI programmes. In a second stage, we analyse the impact of this participation on some measures of technological inputs and outputs in matched samples.

[4] This information is not available for the period 2002-2005.

4.1. The probability of participation in CDTI programmes

To compute the predicted probability of participating in CDTI programmes (propensity score) before and during the crisis, we estimate a probit model for every period. As we have explained before, the type of information provided by the INE about non-supported firms differs between the two periods analysed in the paper. As a consequence, we have also considered different specifications for probit models of CDTI programmes, although we have used the maximum set of available common variables. As can be seen in Table 3, most explanatory variables are statistically significant and marginal effects of common variables have the same sign in both estimates.

Insert Table 3

Regardless of the period, continuous R&D performers --firms that carry out R&D activities on a constant basis-- achieve a higher probability of participating in CDTI programmes than other firms. Applicants showing previous R&D experience seem to prepare more solid proposals because of their knowledge capital and are expected to have a lower probability of project failure. This result is in accordance with Czarnitzki & Hussinger (2004), Huergo et al. (2016) and Huergo and Moreno (2017), who also obtain that firms with a higher technological profile present a bigger probability of participation in public aid programmes. The impact of this variable is quite similar before and during the crisis.

With respect to the other common explanatory variables, being an exporter increases the probability of participating in these public programmes. This might explain why the innovative activity of firms with international experience suffered less from the recessive effect of the crisis. The presence of foreign capital has a negative effect on the probability of obtaining CDTI funding in both periods. This result, in accordance with Huergo & Moreno (2017), suggests that the CDTI is less prone to finance firms that belong to foreign groups than to domestic firms, probably because the latter tend to apply for public aid more frequently. More productive firms in terms of labour productivity are also more likely to be considered in CDTI programmes. More productive firms are more capable of assimilating new knowledge, whether it is developed internally or externally, and the probability of success increases. Again, the explanatory power of the last two variables is bigger before the crisis.

Interestingly, firms´ size had different effects before and during the crisis. Although SMEs are usually more influenced by innovation-related market failures and their benefits from public aid might consequently be higher, large firms usually have more resources with which to undertake R&D projects and apply for the aid. SMEs were more likely to participate in CDTI programmes before the crisis. However, and in accordance with Huergo et al. (2016), the probability of participating during the recession was smaller for SMEs. This result suggests that applying for CDTI loans has some costs (time and searching for information) that might be bigger during a crisis, so larger firms will have a higher probability of participation. Moreover, this result is consistent with the evolution of the number of innovative SMEs in Spain. Between 2009 and 2012, this figure diminished around 20%, whereas the decrease was 6% for big companies (INE, 2009-2012). The effect of expanded requirements on real guarantees by the CDTI during this period should also be considered. These guarantees are more difficult for small firms to provide.

In the same line, Venturini et al. (2017) find that the percentage of subsidised firms in Spain and France during the period 2007-2009 was higher among large companies. As an explanation for this result, they point to the complex administrative procedures to access R&D grants, which only firms with larger resources can easily handle. Despite this evidence, in the case of firms supported by the CDTI, SMEs do not seem to have been punished by these administrative barriers during the first period, probably because CDTI procedures were more adapted to SMEs' needs.

As for the rest of the variables, before the crisis, being a start-up positively increased the probability of participating in the soft loan programme. Although older firms are more likely to know and use public aid programmes, younger firms are usually more financially constrained, having more incentives to apply for and receive them. In addition, having technological agreements in general increases the probability of obtaining CDTI funding. Group membership also positively affects the chance of participation in CDTI programmes. Unfortunately, we do not have information about these variables for CDTI programmes during the economic recession.

In addition, during the crisis, it seems that the CDTI supported firms which use innovative activity to create or maintain jobs. This fact can be associated with the big job losses suffered by the Spanish economy during this long financial crisis. Surprisingly, being hindered by financial constraints to innovate does not seem to affect the probability of participating in the CDTI programme. This evidence is coherent with the features of CDTI aid, which consists mainly of loans that firms must reimburse under favourable conditions. In order to reduce the default ratio, applicants should have an acceptable solvency situation. Unfortunately, we cannot compare the effects of these variables on participation in the CDTI programmes before the crisis.

Regarding the sectorial dimension, it seems that CDTI programmes are more adapted to manufacturing sectors, although, after the crisis, this variable lost its significance, reflecting the adverse conditions faced by this activity branch. Firms operating in services reduced the probability of participation in both periods. On the other hand, construction, one of the sectors most punished by the crisis, also seems to have lost its favourable position.

As for time dummies, marginal effects show a positive trend in the first period and a negative path during the crisis. This result can be explained by the increased budget restrictions in CDTI public funding during the second period as a result of the crisis.

The estimates in Table 3 allow us to compute the propensity score needed to define matched samples. As we have already mentioned, we use the caliper matching algorithm with replacing, in which participants are matched with the non-participants that are closest in terms of the propensity score subject to a maximum threshold distance. Before the matching, in the sample there are 1,764 and 920 observations that correspond to supported firms in the periods 2002-2005 and 2010-2012, respectively. The treated group consists of 1,587 and 920 supported firms in each period, and they are matched respectively with 1,509 and 858 non-participants in CDTI programmes, which form the control group.

In order to assess the matching quality, we check whether the distribution of covariates is balanced in the treated and control groups (Table 4). Notice that, after matching, all variables have the same mean in both groups.

Insert Table 4

In addition, to check whether the distribution of covariates is balanced in the treated and control groups, Table 5 reports that, for all covariates, the mean and median absolute biases are also reduced. Regardless of the period, the Pseudo-R2 after matching is close to zero, which suggests that after matching, the covariates do not explain the probability of participation well. Overall, it seems that the matching procedure has been able to balance the treated and non-treated groups, creating a homogenous group with common characteristics before participation.

Insert Table 5

4.2. Impact of public support on technological inputs and outputs

Table 6 shows the results of the estimates of the equations for the determinants of technological inputs in the two matched samples that we have obtained for the two analysed periods. To deal with potential endogeneity problems, most explanatory variables are introduced in all equations with one lag.

We consider four different technological inputs: internal R&D intensity (columns (1) to (4)), innovation intensity (columns (5) and (6)), R&D personnel intensity (columns (7) and (8)) and fixed capital intensity (columns (9) and (10)). In the case of internal R&D intensity, we present the results of a Generalized Tobit model where participation and intensity equations are jointly estimated by maximum likelihood. Notice that the correlation term rho between the two equations is non-significant in both periods (previous to and during the crisis), suggesting that it is not necessary to estimate a selection model for the observed intensity. However, we prefer to present these selection models in order to distinguish the impact of CDTI programmes on both, the probability of undertaking technological activities and their intensity. We also estimate a Generalized Tobit model for total innovation expenditures (which include internal and external R&D), although in this case, we only present the results for the intensity equation.

As can be seen in the first row of Table 6, participation in CDTI programmes positively affected all our measures of technological inputs both before and during the crisis. As we explained before, the effect of the financial crisis on the impact of public aid on technological input is ambiguous. Subsidies or loans might be more effective in crisis years because firms face more financial constraints, so public aid is needed more to undertake R&D activities than in expansion years. However, a smaller impact is expected during recessions if firms use public funds to reduce private investments that they would have made in non-crisis years (Hu and Hussinger, 2014).

With respect to the decision to engage in internal R&D activities, the estimations in columns (1) and (3) of Table 6 show that being awarded a CDTI loan increases the probability of conducting R&D activities with one's own resources. Participation in CDTI programmes before the crisis increased the probability of self-financing internal R&D activities 17.4 percentage points. The impact was smaller during the economic crisis but still quite relevant: 9.7 percentage points.

As for the intensity of R&D inputs, once the firm has decided to invest in R&D, public aid also stimulates the intensity of R&D investment (columns (2) and (4) of Table 6). CDTI public aid remained useful to help firms to undertake R&D activities during the crisis. In addition, the impact on internal R&D intensity was quite similar to the one before the crisis.

When we consider innovation intensity, previous results are confirmed. The impact of participating in CDTI programmes is positive and there are not remarkable differences in marginal effects between the two periods. Therefore, the results provide evidence against the hypothesis that R&D loans (subsidies) fully crowd out private funds for research. However, given that we have no information about the quantity of the loan (or grant), we cannot test the additionality hypothesis. These results are in accordance with Huergo and Moreno (2017), García and Monhen (2010) and Czarnitzki & Lopes-Bento (2014), although in the last two papers, R&D intensity is defined as the ratio of R&D expenditures over sales.

Table 6 (cont.) also shows the estimates of the equations for the determinants of R&D personnel intensity and fixed capital intensity. Given that both variables are expressed in logarithms, the coefficients reported are elasticities or semi-elasticities. Participation in CDTI programmes increased the ratio of R&D personnel intensity by more than 4% both before and during the crisis, which points out the relevance of public financing in maintaining R&D human capital.

CDTI public aid also stimulates the intensity of fixed capital investment. However, in this case the impact was bigger, almost double, before the crisis. This result is consistent with a normative change in CDTI programmes in 2008. As of this year, CDTI funding does not cover the purchase of physical assets. However, the impact of public aid was still quite relevant during the crisis, 34.4%. In a period with a strong decrease of fixed capital investment in most Spanish firms, this result again confirms the importance of public support.

Table 6 also shows that, during the crisis, being an exporter not only increased the probability of carrying out R&D activities but also positively affected R&D intensity. Specifically, firms operating in international markets are 7.2 percentage points more likely to self-finance internal R&D activities, stressing the complementarity between internationalisation and R&D investment strategies. However, before the crisis, being an exporter did not seem to affect R&D activities. Nevertheless, in that period, exporting status was highly correlated with the status of continuous R&D performer, and this last variable increases the propensity to undertake internal R&D about 58 percentage points.

Unexpectedly, regardless of the period, the probability of undertaking R&D activities is not affected by firms´ size. However, once the firm has decided to invest in R&D, SMEs present bigger R&D intensities than large firms. The impact on R&D intensity was higher during the crisis. This result is consistent with the evolution of innovative firms in the last period: the survival ratio among innovative SMEs as consequence of the crisis was lower than for the rest; it seems that small and medium-sized survivors were those with higher R&D intensities.

The estimates in Table 6 also allow us to analyse how the type of R&D activity is related to R&D intensity in the period 2010-2012. Most firms are focused on applied research and technological development. These kinds of activities are less risky than basic research and allow firms to better face the crisis. Nevertheless, and as expected, firms which spend on basic research activities show the highest R&D intensities. Unfortunately, we cannot compare this result for the period before the crisis because these variables are absent in our database for the years 2002-2005.

As for the rest of the explanatory variables in Table 6 (cont.), regardless of the period, continuous R&D performers present higher R&D personnel and fixed capital intensities. The presence of foreign capital had a negative effect on R&D personnel intensity, bigger during the crisis. This result suggests that in the case of subsidiaries, the main R&D department may be located at the parent company, and this trend might be even higher during the crisis. In addition, SMEs showed larger R&D personnel intensities. However, fixed capital investment was smaller for SMEs, especially during the crisis.

In the period 2002-2005, being a start-up and having technological agreements increased both technological inputs. In addition, in the period 2010-2012, firms focused on applied research activities and especially technological development presented a higher fixed capital investment per employee. R&D personnel intensity was positively affected by R&D activities regardless of the type, although the biggest coefficient corresponds to technological development.

Table 7 shows the results of the estimates for three alternative measures of innovation outputs: process innovation, product innovation and patent application. Given the binary character of our innovation outputs, the specifications are estimated as probit models. As in Table 6, to deal with potential endogeneity, most explanatory variables are included lagged one period. In these estimates, we consider internal R&D intensity an explanatory variable, assuming that the more the firms spend on R&D activities, the higher their probability of obtaining technological outputs will be. Notice that, under this assumption, public support can also affect innovation outputs indirectly by increasing R&D intensity (see Table 6).

As can be seen in Table 7, being supported by the CDTI clearly increased the probability of applying for patents: 6.7 and 3.4 percentage points before and during the crisis, respectively. However, the effect on process and product innovations differed according to the period considered. Participation in CDTI programmes during the crisis increased the probability of achieving product innovations 4.5 percentage points. However, being supported by CDTI aid did not directly affect the probability of obtaining process innovations in this period. The opposite result is found when we consider the period 2002-2005. Participation in the CDTI programmes increased the probability of achieving process innovations 4.8 percentage points, but did not directly affect the chance of obtaining product innovations. As the purchase of physical assets is usually more relevant for process innovations, this result could be partially explained by the normative change in CDTI funding conditions during the crisis. Given that CDTI funding did not cover the purchase of physical assets as of 2008, firms would have focused more on obtaining product innovations.

However, with the only exception of process innovations in the second period, internal R&D intensity had a positive impact on the generation of all technological outputs. In this sense, there is an additional indirect effect of the CDTI support on technological results by stimulating internal R&D intensity.

Regarding other control variables, being an exporter increased the probability of obtaining every technological output, again with the exception of process innovations in the period 2010-2012. But foreign capital investment did not seem to have any effect. With respect to size, and regardless of the period considered, large firms showed higher propensities to achieve innovation results.

5. Conclusions

Nowadays, most governments recognise the relevance of new knowledge as a basic determinant for the growth of countries. In fact, the most important consequence of the well-known Lisbon Treaty (European Council, 2000) was an increase in public budgets to support R&D projects by several European countries during the first years of the 2000s. However, this tendency was interrupted because of the economic crisis and the increase in public budget deficits. As a consequence, many governments introduced austerity measures in the form of spending cuts.

In this context, impact assessment of public support for business R&D has become crucial, as public aid for R&D must compete in public budgets with other public spending items, and the final distribution is largely conditioned by a desire of governments to meet the demands of citizens. However, most databases used in the estimation of the impact of public support correspond to a specific moment of the business cycle. This fact prevents the comparison of the effects between periods of expansion and recession.

The objective of our study is to contribute to this analysis by comparing the effect of public support of business R&D on technological performance before and during the recent economic crisis. To do so, we use information provided by the CDTI, the main Spanish public agency that grants financial support to firms for the execution of R&D projects. Specifically, we consider firms supported through CDTI programmes for the periods 2002-2005 and 2010-2012.

To deal with selectivity and endogeneity problems that are usually present in this type of analysis, impact assessment is conducted using "matching" techniques. In a first stage, we estimate a probit model for the determinants of participation in CDTI programmes. The results of this estimation allow us to compute the propensity score needed to define the matched samples of non-participants for the two periods considered. Then, in a second stage, we use matched samples to analyse how this participation affects different technological inputs and outputs.

The results of the first stage suggest that, regardless of the period, being a continuous performer, export intensity and labour productivity increase the probability of participating in CDTI programmes, while the opposite effect is found for the presence of foreign capital. Interestingly, SMEs were more prone to participate before the crisis and less likely to participate during the recession. This is in line with the evolution of the number of innovative SMEs in Spain during the crisis, which decreased at a much higher percentage than innovative large companies. Another reason might be related to the increase in real guarantees required by the CDTI during the second period. Providing these guarantees is more challenging for SMEs and consequently they must deal with an additional restriction.

As for the impact of participation on technological inputs, being awarded a CDTI loan increased the probability of self-financing R&D 17.4 percentage points before the crisis, while the impact diminished to 9.7 percentage points during the period 2010-2012. Regardless of the period, the effect of having public support was also positive on the intensities of internal R&D expenditures, total innovation expenditures, R&D personnel and fixed capital investment. It is worth noting that estimated marginal effects for CDTI participation were quite similar between the periods 2002-2005 and 2010-2012, with the exception of the intensity in fixed capital investment. In this case, the effect was quite smaller during the crisis, which is consistent with the normative change in CDTI funding, which does not cover the purchase of physical assets as of 2008. However, the impact of CDTI support remained quite relevant during the crisis, which confirms the importance of public support in a period with a strong decrease in fixed capital investment in most Spanish firms.

Regarding technological outputs, being supported by public programmes clearly increased the probability of applying for patents before and during the crisis. However, the effect on process and product innovations differed according to the period considered.

Participation in CDTI programmes increased the probability of achieving process innovations only before the crisis, while it enhanced the chance of obtaining product innovations only during the period 2010-2012. These results are again consistent with the normative change in CDTI funding concerning the purchase of physical assets, which is more relevant for process innovations. As a consequence, since 2008, supported firms seem to have focused more on obtaining product innovations.

Our study has some limitations. First, confidentiality rules of the Spanish Institute of Statistics prevent us from merging the information of the two periods considered for the analysis. Given that the features of CDTI programmes also changed between the periods 2002-2005 and 2010-2012, we cannot perfectly identify the relation between the effect of public support and the economic cycle. Second, our data restrictions also affect the information about the amount of loans awarded to each firm, so we can test only full crowding out of public funding. These limitations suggest a starting point for future lines of research.

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Table 1: Definition of variables

Belonging to a group	Dummy variable which takes the value 1 if the firm belongs to a group.
CDTI participant	Dummy variable which takes the value 1 if the firm participates in a project awarded by the CDTI in the current year.
Continuous R&D performer	Dummy variable which takes the value 1 if the firms carries out R&D activities on a constant basis.
Export intensity	Ratio of exports over sales in the current year.
Exporter	Dummy variable which takes the value 1 if the company exports during the period.
Financial constraints	Dummy variable which takes the value 1 if the firm declared that innovation is hindered by financial constraints in the last three years.
Fixed capital investment intensity	Ratio of net fixed capital investment per employee in the current year.
Foreign capital	Dummy variable which takes the value 1 if the firm is partly owned by a foreign firm during the period (more than 50% of foreign capital).
Innovation intensity	Ratio of innovation expenditure over total employment in the current year.
Innovation performer	Dummy variable which takes the value 1 if the firm has positive innovation expenditure during the year.
Internal R&D intensity	Ratio of internal R&D expenditure over total employment in the current year.
Internal R&D performer	Dummy variable which takes the value 1 if the firm has positive expenditure on internal R&D during the year.
Labour productivity	Ratio of sales over total employment in the current year.
Objective employment	Dummy variable which takes the value 1 if the firm declared that job creation or job maintenance were relevant objectives of innovation activity in the last three years.
Patent application	Dummy variable which takes the value 1 if the firm applied for patents during the last three years.
Process innovation	Dummy variable which takes the value 1 if the firm obtained a process innovation during the last three years.
Product innovation	Dummy variable which takes the value 1 if the firm obtained a product innovation during the last three years.
Public firm	Dummy variable which takes the value 1 when the firm is partly publicly owned (more than 50% of public capital during the period).

R&D performer		Dummy variable which takes the value 1 if the firm has positive expenditure on R&D during the year.
R&D personnel intensity		Ratio of R&D employment over total employment in the current year.
Sector of activity	Agriculture	Dummy variable which takes the value 1 if the company works in agriculture activities.
	Construction	Dummy variable which takes the value 1 if the company works in construction activity.
	Manufacturing	Dummy variable which takes the value 1 if the company belongs to manufacturing sectors.
	Services	Dummy variable which takes the value 1 if the company belongs to services sectors.
SME		Dummy variable which takes the value 1 if the company has fewer than 250 employees and sales are lower than € 40m in the current year.
Start-up		Dummy variable which takes the value 1 if the firm was created during the last three years.
Technological cooperation		Dummy variable which takes the value 1 if the company established technological cooperation agreements with other partners during the last three years.
Type of R&D activity	Applied	Dummy variable which takes the value 1 if the firm has positive expenditure on applied research activities in the current year.
	Basic	Dummy variable which takes the value 1 if the firm has positive expenditure on basic research activities in the current year.
	Development	Dummy variable which takes the value 1 if the firm has positive expenditure on technological development in the current year.

Table 2: Means of main variables

Period:	2002-2005			2010-2012		
	Non-supported firms	Supported firms	Difference of means test*	Non-supported firms	Supported firms	Difference of means test*
Technological inputs:						
Internal R&D intensity	5,826.52	12,843.98	0.000	4,325.67	10,231.92	0.000
Internal R&D performer (%)	54.75	87.93	0.000	40.43	89.67	0.000
Innovation intensity	7,156.86	15,187.20	0.000	6,311.42	13,736.86	0.000
Innovation performer (%)	58.16	90.08	0.000	50.38	94.67	0.000
Fixed capital investment intensity	20,132.28	20,766.09	0.875	9,247.10	11,125.09	0.216
R&D personnel intensity (%)	12.74	20.39	0.000	9.78	21.68	0.008
Technological outputs:						
Patent application (%)	15.31	28.40	0.000	8.42	23.15	0.000
Process innovation (%)	42.38	57.54	0.000	44.98	68.04	0.000
Product innovation (%)	46.56	67.40	0.000	42.38	75.65	0.000
Other firm characteristics:						
Continuous R&D performer (%)	45.84	68.37	0.000	32.63	79.24	0.000
Exporter (%)	52.43	71.37	0.000	51.80	76.63	0.000
Export intensity (%)	15.70	26.29	0.000	18.62	31.48	0.000
Foreign capital (%)	11.59	11.34	0.757	12.01	8.48	0.001
Labour productivity	288.97	239.58	0.007	260.52	262.94	0.870
Sector of activity						
Agriculture (%)	0.17	0.45	0.020	1.29	2.07	0.043
Construction (%)	0.47	0.85	0.038	3.99	2.07	0.003
Manufacturing (%)	51.00	76.08	0.000	51.68	70.00	0.000
Services (%)	46.89	21.66	0.000	43.04	25.87	0.000
SME (%)	66.18	69.10	0.015	73.08	69.02	0.006
Belonging to a group (%)	38.96	46.71	0.000			
Public firm (%)	2.14	0.79	0.000			
Start-up (%)	2.54	5.95	0.000			
Technological cooperation (%)	31.54	49.43	0.000			
Financial constraints (%)				43.92	47.61	0.026
Objective employment (%)				18.04	36.85	0.000
Type of R&D activity						
Basic research (%)				4.99	10.65	0.000
Applied research (%)				26.30	57.50	0.000
Development (%)				30.10	73.26	0.000
Number of observations	*11,734*	*1,764*		*29,001*	*920*	

Notes: All monetary variables are expressed in real terms (K€). Dummy variables in %. *P-value of a two-sample difference of means test. This is a t- test for continuous variables and a two-sample z-test of proportions in case of dummy variables.

Table 3: Participation within CDTI projects
(Probability of being awarded)

Period:	**2002-2005**		**2010-2012**	
	(1)		**(2)**	
Continuous R&D performer	0.055***	(0.006)	0.047***	(0.002)
Export intensity	0.069***	(0.010)	0.011***	(0.000)
Foreign capital	-0.029***	(0.008)	-0.011***	(0.001)
Labour productivity	0.020*	(0.012)	0.007**	(0.002)
SME	0.026***	(0.006)	-0.005**	(0.002)
Sector of activity:				
Construction	0.091*	(0.057)	-0.012**	(0.003)
Manufacturing	0.040*	(0.021)	-0.007	(0.005)
Services	-0.053**	(0.021)	-0.016**	(0.005)
Time dummies:				
2003	0.003	(0.008)		
2004	0.033***	(0.009)		
2005	0.025***	(0.008)		
2011			-0.005**	(0.001)
2012			-0.017***	(0.001)
Belonging to a group	0.031***	(0.006)		
Public firm	-0.033	(0.021)		
Start-up	0.169***	(0.024)		
Technological cooperation	0.043***	(0.006)		
Financial Constraints			0.000	(0.000)
Objective employment			0.006***	(0.002)
Log of likelihood function	-4,785.8		-3,561.4	
Number of observations (censored)	13,486 (1,587)		29,921 (920)	

Notes: Marginal effects (*dy/dx*) are computed at sample means. For dummy variables, the marginal effect corresponds to change from 0 to 1. Estimated standard errors are in parentheses. Coefficients significant at 1%***, 5%**, 10%*. The estimate includes the constant. Time dummy excluded for the year 2002 in column (1) and for the year 2010 in column (2).

Table 4: Balancing tests: Difference of means

	Mean				t-test	
	Treated	**Control**	**% bias**	**Reduction**	**t-value**	**p-value**
Panel A: 2002-2005						
Continuous R&D performer	0.684	0.709	-5.2	88.9	-1.61	0.107
Export intensity	0.263	0.252	4.0	89.5	1.11	0.265
Foreign capital	0.113	0.112	0.4	59.5	0.11	0.915
Labour productivity	0.194	0.200	-2.8	60.5	-0.83	0.406
SME	0.690	0.699	-1.8	69.7	-0.55	0.583
Sector of activity:						
Construction	0.009	0.010	-2.1	55.6	-0.52	0.600
Manufacturing	0.762	0.765	-0.5	99.1	-0.16	0.874
Services	0.215	0.211	0.9	98.4	0.29	0.773
Time dummies:						
2003	0.209	0.206	0.7	66.3	0.21	0.835
2004	0.290	0.284	1.3	84.3	0.37	0.709
2005	0.308	0.305	0.7	57.3	0.22	0.826
Belonging to a group	0.468	0.457	2.2	86.2	0.64	0.521
Public firm	0.008	0.005	2.4	78.8	1.05	0.296
Start-up	0.057	0.051	3.1	81.3	0.82	0.413
Technological cooperation	0.495	0.491	0.8	97.8	0.24	0.813
Number of observations	1,587	1,509				
Panel B: 2010-2012						
Continuous R&D performer	0.792	0.795	-0.5	99.5	-0.12	0.908
Export intensity	0.315	0.323	-2.8	93.3	-0.57	0.572
Foreign capital	0.085	0.087	-0.7	93.8	-0.18	0.868
Labour productivity	0.210	0.199	5.1	68.2	1.10	0.270
SME	0.690	0.715	-5.5	39.0	-1.17	0.241
Sector of activity:						
Construction	0.021	0.026	-3.2	71.9	-0.77	0.441
Manufacturing	0.700	0.693	1.4	96.5	0.30	0.761
Services	0.259	0.260	-0.2	99.4	-0.05	0.958
Time dummies:						
2011	0.360	0.355	0.9	84.3	0.19	0.864
2012	0.165	0.154	2.6	93.2	0.64	0.525
Financial Constraints	0.476	0.485	-1.7	76.4	-0.37	0.709
Objective employment	0.368	0.349	4.5	89.6	0.87	0.382
Number of observations	920	858				

Note: The econometric model used for the matching procedure is based on the estimates of Table 3.

Table 5: Overall measures of covariate balancing

	Mean abs. std. bias	% mean bias reduction	Median abs. std. bias	% median bias reduction	Pseudo R^2	LR-test* Chi^2	LR-test* p>Chi^2
Panel A: 2002-2005							
Before matching	20.4		11.2		0.084	872.14	0.000
After matching	1.9	90.7%	1.8	83.9%	0.002	10.18	0.809
Panel B: 2010-2012							
Before matching	30.5		26.4		0.133	1095.39	0.000
After matching	2.4	92.1%	2.2	91.7%	0.002	5.19	0.951

Note: *Likelihood-ratio test of the joint insignificance of all regressors.

Table 6: Technological inputs

	Internal R&D performer				Internal R&D intensity (in logs.)				Innovation intensity (in logs.)			
Period:	**2002-2005 (1)**		**2010-2012 (2)**		**2002-2005 (3)**		**2010-2012 (4)**		**2002-2005 (5)**		**2010-2012 (6)**	
CDTI participant$_{t-1}$	0.174***	(0.017)	0.097***	(0.018)	0.376***	(0.063)	0.361***	(0.068)	0.423***	(0.068)	0.393***	(0.072)
Continuous R&D performer$_{t-1}$	0.584***	(0.028)	0.295***	(0.042)	0.180	(0.123)	0.606***	(0.119)	0.258*	(0.135)	0.688***	(0.117)
Exporter$_{t-1}$	0.019	(0.022)	0.072**	(0.025)	0.095	(0.085)	0.147*	(0.088)	0.061	(0.091)	0.192**	(0.092)
Foreign capital$_{t-1}$	0.000	(0.026)	-0.025	(0.035)	-0.164*	(0.096)	0.000	(0.119)	-0.097	(0.101)	0.000	(0.119)
SME$_{t-1}$	-0.009	(0.019)	-0.004	(0.020)	0.793***	(0.074)	1.091***	(0.074)	0.757***	(0.080)	0.875***	(0.077)
Sector of activity:												
Construction	0.080	(0.064)	-0.266	(0.220)	-0.406	(0.538)	-0.261	(0.310)	-0.676	(0.546)	-0.532	(0.327)
Manufacturing	0.077	(0.076)	-0.125**	(0.060)	-0.022	(0.252)	-0.047	(0.228)	-0.261	(0.234)	-0.118	(0.241)
Services	0.047	(0.055)	-0.233	(0.145)	0.639**	(0.261)	0.622**	(0.237)	0.520**	(0.246)	0.445*	(0.248)
Public firm	0.095**	(0.041)			-0.061	(0.363)			0.020	(0.032)		
Start-up$_{t-1}$	0.121***	(0.015)			0.959***	(0.135)			0.059**	(0.028)		
Technological cooperation$_{t-1}$	0.067***	(0.018)			0.174***	(0.063)			0.042**	(0.020)		
Type of R&D activity:												
Applied$_{t-1}$			0.120***	(0.023)			0.147*	(0.077)			0.186**	(0.080)
Basic$_{t-1}$			0.021	(0.032)			0.397***	(0.105)			0.396***	(0.112)
Development$_{t-1}$			0.187***	(0.029)			0.183**	(0.089)			0.340***	(0.091)
Selection term, rho					-0.109	(0.085)	0.111	(0.178)	-0.320**	(0.124)	-0.055	(0.139)
Number of observations	2,014		1,451		1,582		1,193		1,655		1,263	

Notes: Marginal effects (*dy/dx*) are computed at sample means. For dummy variables, the marginal effect corresponds to change from 0 to 1. Estimated standard errors are in parentheses. Coefficients significant at 1%***, 5%**, 10%*. All regressions include the constant and time dummies.

Table 6 (cont.): Technological inputs

Period:	R&D personnel intensity				Fixed capital investment intensity			
	2002-2005 (7)		2010-2012 (8)		2002-2005 (9)		2010-2012 (10)	
CDTI participant$_{t-1}$	0.042***	(0.009)	0.049***	(0.012)	0.620*	(0.137)	0.344*	(0.180)
Continuous R&D performer$_{t-1}$	0.123***	(0.011)	0.104***	(0.018)	1.070***	(0.177)	1.224***	(0.304)
Exporter$_{t-1}$	-0.007	(0.011)	-0.004	(0.016)	0.432**	(0.172)	0.967***	(0.245)
Foreign capital$_{t-1}$	-0.038**	(0.014)	-0.056***	(0.015)	-0.012	(0.024)	0.448	(0.302)
SME$_{t-1}$	0.103***	(0.010)	0.163***	(0.011)	-0.530***	(0.161)	-1.050***	(0.194)
Sector of activity:								
Construction	0.058	(0.058)	-0.082	(0.055)	-2.146**	(0.896)	-1.243	(0.856)
Manufacturing	0.001	(0.038)	-0.098**	(0.045)	-0.782	(0.591)	-0.311	(0.674)
Services	0.148***	(0.039)	0.051	(0.047)	-1.738**	(0.601)	-0.558	(0.683)
Public firm	0.088	0,054)			0.293	(0.830)		
Start-up$_{t-1}$	0.262***	(0.020)			0.988***	(0.315)		
Technological cooperation$_{t-1}$	0.023**	(0.009)			0.423***	(0.146)		
Type of R&D activity:								
Applied$_{t-1}$			0.043**	(0.014)			0.363*	(0.207)
Basic$_{t-1}$			0.045**	(0.023)			-0.078	(0.294)
Development$_{t-1}$			0.057***	(0.016)			0.726**	(0.243)
R^2	0.277		0.261		0.083		0.109	
Number of observations	2,014		1,451		2,014		1,451	

Notes: Estimated standard errors are in parentheses. Coefficients significant at 1%***, 5%**, 10%*. All regressions include the constant and time dummies.

Table 7: Technological outputs

	Process innovation				Product innovation				Patent application			
Period:	**2002-2005 (1)**		**2010-2012 (2)**		**2002-2005 (3)**		**2010-2012 (4)**		**2002-2005 (5)**		**2010-2012 (6)**	
CDTI participant$_{t-1}$	0.048**	(0.023)	0.026	(0.027)	0.023	(0.022)	0.045*	(0.026)	0.067***	(0.020)	0.034*	(0.020)
Exporter$_{t-1}$	0.063**	(0.028)	0.000	(0.033)	0.131***	(0.027)	0.093***	(0.033)	0.081***	(0.023)	0.064**	(0.023)
Foreign capital$_{t-1}$	0.025	(0.037)	0.080	(0.048)	0.040	(0.035)	0.017	(0.047)	0.019	(0.032)	0.048	(0.038)
Internal R&D intensity$_{t-1}$	0.016***	(0.004)	0.002	(0.006)	0.041***	(0.003)	0.036***	(0.006)	0.026***	(0.004)	0.031***	(0.006)
SME$_{t-1}$	-0.092***	(0.026)	-0.185**	(0.029)	-0.028	(0.025)	-0.085**	(0.029)	-0.127***	(0.025)	-0.085***	(0.026)
Sector of activity:												
Construction	-0.028	(0.151)	-0.062	(0.125)	0.219**	(0.070	0.007	(0.115)	0.048	(0.144)	-0.001	(0.100)
Manufacturing	0.067	(0.099)	-0.071	(0.090)	0.236**	(0.104)	0.179**	(0.091)	0.023	(0.088)	0.069	(0.071)
Services	-0.074	(0.101)	-0.135	(0.096)	0.161*	(0.080)	0.087	(0.084)	0.000	(0.092)	0.025	(0.083)
Public firm	-0.019	(0.141)			-0.007	(0.134)			-0.134	(0.088)		
Start-up$_{t-1}$	0.015	(0.051)			0.055	(0.047)			0.099**	(0.050)		
Technological cooperation$_{t-1}$	0.167***	(0.023)			0.102***	(0.023)			0.025	(0.020)		
Type of R&D activity:												
Applied$_{t-1}$			0.135***	(0.033)			0.083**	(0.032)			0.043*	(0.023)
Basic$_{t-1}$			0.001	(0.046)			-0.063	(0.046)			0.059*	(0.035)
Development$_{t-1}$			0.170***	(0.038)			0.121***	(0.038)			0.033	(0.025)
Log of likelihood function	-1253.3		-908.9		-1110.6		-809.4		-1085.8		-661.6	
Pseudo R^2	0.084		0.070		0.124		0.127		0.067		0.092	
Number of observations	2,014		1,451		2,014		1,451		2,014		1,451	

Notes: Marginal effects (*dy/dx*) are computed at sample means. For dummy variables, the marginal effect corresponds to change from 0 to 1. Estimated standard errors are in parentheses. Coefficients significant at 1%***, 5%**, 10%*. All regressions include the constant and time dummies.