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

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CDTI activity

- CDTI (Minister of Economy, Industry and Competitiveness), in charge of **fostering R&D&I of Spanish companies**.
- CDTI provides funding for R&D&I business projects.
- Projects may be carried out by one single undertaking or in collaboration with other companies.
- Annually, CDTI finances about **1.000 business R&D projects** (above 850 companies), 60% of which are SMEs.
- The minimum budget of a project must be 175.000 €. The average eligible budget of a project financed by CDTI is approximately **625.000 €**.
- The duration of the projects may vary from 12 to 36 months.

Ex –post evaluation at the CDTI

- Monitoring
- Impact evaluation  Research in cooperation with academic experts

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1. Motivation

- **R&D investments usually change with the business cycle:**
 - Counter-cyclically: 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
 - Pro-cyclically in firms with financial constraints. In recessions, R&D investment behaves pro-cyclically in firms that have difficulties accessing external financing (Aghion et al., 2012; Bovha-Padilla et al., 2009; López-García et al., 2013)
 - 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 (Beneito et al., 2015)

- **Effect of public support to business R&D**
 - Scarce evidence how economic cycle can affect the impact of public support
 - Hu & Hussinger (2014), Venturini et al. (2017): R&D subsidies during the crisis
 - Could mitigate the negative effect of financial constraints during the crisis.
 - But, public aid might also be less effective in adverse economic conditions.

2. Objectives

- To compare the effect of public support to business R&D before and during the recent economic crisis for Spanish firms.
- This will allow us to answer:
 - Are the determinants of the firm's participation in public R&D programmes different along the business cycle?
 - How does this participation affect firms' technological capabilities (inputs and outputs) along the business cycle?

3. Results

- The **determinants of the firm's participation** in public R&D programmes are quite **similar** along the business cycle.
- **Positive effect** of being awarded a CDTI loan on all technological **inputs**. Marginal effects for CDTI participation were quite similar before and during the crisis (with the exception of the probability of self-financing R&D and the intensity in fixed capital investment).
- 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.

3. CDTI Projects

- **R&D business projects funded by CDTI in two periods:**
 - 2002-2005 (years of expansion)
 - 2010-2012 (years of recession)

- **Common features:**
 - Targeted to the creation or significant improvement of a production process, product or service.
 - Financial support: **low-interest loans** with a reimbursable period of 10 years.
 - Developed by one single firm or in collaboration with other organizations and may have a non-reimbursable part (a grant).
 - Duration may vary from 12 to 36 months.
 - **Eligible costs** include salaries; 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.

3. CDTI Projects

➤ Changes between periods:

- The maximum percentage of coverage increased from 60% in the first period up to 85% in the second.
- As of 2008, CDTI funding only covered the amortization of physical assets (equipment, machinery, etc.) related to the project and NOT their total purchase price.
- During the first period, the non-reimbursable part of the loan was only provided 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 organizations), the size of the beneficiary (SME or large company) and the source of the funds (Structural or CDTI Funds).
- New requirements on guarantees: firms carrying out around 20% of supported projects were asked for real guarantees in the period 2010-2012.

4. The empirical model and the data

- ❑ **What the behavior of a funded firm would have been if it had not received the public support?**
 - Each firm can only be observed either in the status of being supported or not.
 - The participation within the funding programme probably depends on the same firm characteristics that determine its innovative performance.

- ❑ **Our methodology: Matching procedure**
 - We create the **counterfactual group**: a control sample of firms with characteristics similar to those of funded firms (treated group).
 - For each treated firm, we search for a firm in the counterfactual group that had the same probability of receiving the treatment but did not actually get it.
 - Following Gerfin and Lechner (2002): these nearest neighbors are selected based on **propensity scores** of receiving a certain treatment.

4. The empirical model and the data

Matching procedure:

- **Step 1: The participation of firm i in CDTI programme during year t**

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

- Probit model: The dependent variable is a latent variable. x_i :
 - Technological characteristics: R&D intensity, patent application, technological cooperation, industries dummies...
 - Others characteristics: exporter, foreign capital, belonging to a group, size, public firm...
 - Propensity score to define the matched samples: caliper matching algorithm with replacing (maximum distance of 0.005 between propensity score of the treated and non-treated firm)
- **Step 2: Effect of CDTI participation on technological inputs and outputs in matched samples (treated and control firms).**
 - Econometric specification adapted to the continuous or binary character of the dependent variable

4. The empirical model and the data

Databases: CDTI and Spanish CIS: 2002-2005 and 2010-2012

- ✓ CDTI database of low-interest credits: 1,764 and 920 projects
- ✓ Spanish CIS: two samples of innovative firms from the Spanish Survey of Innovation in Companies provide by Spanish Institute of Statistics (INE). Information about technological characteristics.
- ✓ After merging: 13,498 and 29,921 observations for each period.
- ✓ We cannot merge the information of both periods: empirical analysis undertaken at secure places in INE

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
<i>Sector of activity</i>						
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 constrains (%)				43.92	47.61	0.026
Objective employment (%)				18.04	36.85	0.000
<i>Number of observations</i>	<i>11,734</i>	<i>1,764</i>		<i>29,001</i>	<i>920</i>	

Step 1:

Table 3: Participation in CDTI programmes

Period:	2002-2005 (1)		2010-2012 (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)
Labor productivity	0.020 [*]	(0.012)	0.007 ^{**}	(0.002)
SME	0.026 ^{***}	(0.006)	-0.005 ^{**}	(0.002)
<i>Sector of activity:</i>				
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)
<i>Time dummies:</i>				
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 Constrains			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. 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).



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Table 4: Balancing tests: Difference of means

	Mean		% bias	Reduction	t-test	
	Treated	Control			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
Labor 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
<i>Sector of activity:</i>						
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
<i>Time dummies:</i>						
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				



Table 4: Balancing tests: Difference of means

	Mean		% bias	Reductio n	t-test	
	Treat d	Contro l			t-value	p- value
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
Labor 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
<i>Sector of activity:</i>						
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
<i>Time dummies:</i>						
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 Constrains	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				

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	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.

Step 2:

Table 6: Technological inputs

Period:	Internal R&D performer				Internal R&D intensity (in logs.)				Innovation intensity (in logs.)				
	2002-2005		2010-2012		2002-2005		2010-2012		2002-2005		2010-2012		
	(1)	(2)	(3)	(4)	(5)	(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)	
Cont. 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)	
<i>Sector of activity:</i>													
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)			
Tech. cooperation _{t-1}	0.067***	(0.018)			0.174**	(0.063)			0.042**	(0.020)			
<i>Type of R&D activity:</i>													
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)
No observations	2,014		1,451		1,582		1,193		1,655		1,263		

Step 2:

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)
Cont. 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)
<i>Sector of activity:</i>								
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)		
Tech. cooperation _{t-1}	0.023 ^{**}	(0.009)			0.423 ^{***}	(0.146)		
<i>Type of R&D activity:</i>								
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	

Step 2:

Table 7: Technological outputs

Period:	Process innovation				Product innovation				Patent application			
	2002–2005		2010–2012		2002–2005		2010–2012		2002–2005		2010–2012	
	(1)	(2)	(3)	(4)	(5)	(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)				
<i>Sector of activity:</i>												
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)							
Tech. cooperation _{t-1}	0.167*** (0.023)		0.102*** (0.023)		0.025 (0.020)							
<i>Type of R&D activity:</i>												
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						

5. Conclusions

➤ First stage: Participation in CDTI programmes

- Regardless of the period, being a continuous performer, export intensity and labor productivity increased the probability of participation. The opposite effect is found for the presence of foreign capital.
- SMEs were more prone to participate before the crisis and less likely to participate during the recession.

➤ Second stage: Impact on technological inputs

- Higher impact on the probability of self-financing R&D and on the intensity of fixed capital intensity before the crisis (although also positive during the crisis).
- Positive (and quite similar between periods) effect on the intensities of internal R&D expenditures, total innovation expenditures and R&D personnel.

5. Conclusions

➤ Second stage: Impact on technological outputs

- Positive effect on the probability of applying for patents before and during the crisis.
- Participation increased the probability of achieving process innovations only before the crisis (normative changes in CDTI funding, which does not cover the purchase of physical assets as of 2008)
- Participation enhanced the chance of obtaining product innovations only during period 2010-2012 (since year 2008 supported firms seem to have focused more in obtaining product innovations).
- Indirect positive effect through technological inputs.

5. Conclusions

➤ Some Limitations

- 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.
- Our data restrictions also affect the information about the amount of loans awarded to each firm, so we can only test full crowding out of public funding. These limitations suggest a starting point for future lines of research.

➤ Some Opportunities

- Research conclusions reinforce the role of the CDTI during economic crisis.
- Collaboration between public agencies and external experts enable us to conduct complex research applied to practical requirements.
- Valuable lessons learned from the research for future collaborations.

Thank for your attention!



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