Papeles de Trabajo

AN IMPACT EVALUATION OF THE EU FUNDS ON RESEARCH AND DEVELOPMENT IN SPANISH COMPANIES IN 2007-2011(*)

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ABSTRACT

Research and development (R&D) have been playing a very important role in business growth during the last decades. The aim of this paper is to assess the impact of the European Funds on R&D in Spanish companies during the period 2007-2011 taking into account that other factors but the EU Funds could have affected their results. Using data of companies, the impact of the EU grants is assessed on key outcome variables making use of three quasi-experimental models: a Difference in Difference approach based on panel data, the Propensity Score Matching technique, and a combination of the two. The research yields positive effects on the majority of the outcome variables studied. As an example, sales and internal company's investment are statistically larger for those businesses taking part in the EU support than for those not receiving the funds. This paper contributes to show evidence of the effects of the EU cohesion policy on R&D by means of impact evaluation tools.

Keywords: Technology policy, impact evaluation, R&D support, EU Funds, ERDF.

JEL: O31, H32, L52.

1. INTRODUCTION[1]

Scientific research, development and innovation are key factors for economic growth and competitiveness of any country. They are undoubtedly the basis of their long-term sustained progress and a way of increasing welfare (Toh and Choo, 2002). The importance of research and development (R&D) in economic growth is considered by authors such as Griliches (1986) or Fagerberg (1988). The generation of modern and advanced technologies is a major factor for achieving a competitive position (Freeman, 1987; Porter, 1990). Within this framework, R&D policy turns into a key instrument for public policy makers to improve their country's production system and strengthen the economic growth looking for the desired social welfare. Indeed sustainable growth is also increasingly related to the capacity of regional economies to innovate and transform.

During the last two decades Spain has experienced a significant economic growth over the European average, partly due to the support of the European Funds. The Europe 2020 strategy (and the formers) has put much greater effort into creating the eco-systems that encourage innovation, research and development and entrepreneurship.

This positive trend has generated a cohesion process of the Spanish economy on the most advanced countries of the European Union, which can be reflected in a process of convergence in terms of economic welfare. The promotion of innovation for 2007-2013 (around €86.4 billion) was nearly 25% of the total allocation and has been strengthened in the new 2014-2020 programming period, where this percentage is almost a third of the total funding.

The innovation on a country's production system is particularly important to ensure business competitiveness. Over the last decade, and especially since the beginning of the crisis in 2008, much has been discussed about the need to change the production model for Spain, reinforcing a science and technology-centered economy rather than construction-based, in order to generate products with high technological value.

For this reason, in recent years, and not only in Spain, the importance of the R&D policies, at regional, national and European level, has repeatedly been highlighted, trying to strengthen the basic research and innovation as key elements to jointly contribute to the generation of knowledge and setting a favorable environment for businesses to be fully incorporated into the culture of technological innovation and increase their competitiveness.

These European and national policies also focus on stimulating and boosting the private investment of the company.

R&D and innovation funded by the private sector are known to suffer from market failure, making the investment levels stand below the desired. Governments of industrialized countries try to correct for such market failure by subsidizing R&D and innovation. Czarnitzi and Lopes Bento (2011) explicitly distinguish the effects of R&D investment between national and European funds using a multiple treatment effects analysis, and yield that both sources of grants, as well as the combination of the two, lead to higher innovation input in the economy when compared to a situation where these policies would be absent.

Profitability and business growth have been successively addressed in the scientific literature with the aim of identifying determinants and also the key to the business survival. By creating knowledge companies can experience sales growth, profitability and job creation, expecting a positive relationship between investment in R&D and the company's growth.

Many variables have been identified as business growth promoters. However, in recent decades, the role of innovation in business development and investment in R&D seem to be key factors to assure business growth. Given its importance, a large number of studies have examined to what extent R&D can affect business growth.

[1] We thank the programming and evaluation team of the Directorate General of the EU Funds (Spanish Ministry of Finance) led by Jorge García, in particular María Gorriti for her perseverance on making result evaluation possible. We are also grateful for David Azcárate's support on making up the ERDF beneficiary database. Finally, thank you to the National Statistics Institute for matching the beneficiary database to an extremely valuable panel database with companies' information to complete the input data needed for our research on impact evaluation.

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The literature shows contradictory findings when assessing the relation between investment in innovation and business growth depending on the industry, the country or even the period (Brynjolfsson and Yang, 1996) Some authors find positive results of the R&D investment in business growth (Woolridge, 1988) whereas other papers do not yield the same outcomes (Jaruzelski *et* al., 2005)

From a theoretical point of view, the causes for business growth can be explained according to two main approaches: deterministic and stochastic (Oliveira and Fortunato, 2006). The deterministic approach assumes that differences in the company's growth rate depend on the industry, as indicated by Hannan and Freeman (1977), and also on the specific characteristics of the company, studied by Baum and Locke (2004).

In contrast to the deterministic approach, the stochastic theory supports the idea of independence between growth rates and company size. This theory holds that in the absence of *ex ante* differences in certain characteristics of the company such as profits or the size or market power, the company's growth rate is defined randomly and independently of its current size and the past growth.

In this framework, Klette and Griliches (2002) present a theoretical model considering the variable "R&D investment" as the key factor to assure business growth (Del Monte and Papagni, 2003). This is indeed the main assumption for this research paper and will be developed in the following sections.

In the context of the literature on innovation policies this paper provides an empirical contribution to the impact assessment of EU funds[2]. The aim of our work is to evaluate the impact that the EU grants on R&D have had on Spanish companies over the period 2007-2011. For this purpose we will study whether those companies that received aid from EU Funds have performed better than those not receiving such support, taking into account that other factors apart from the EU Funds could have affected their business results.

To assess whether the design of this EU policy has been effective is necessary to evaluate the returns on aided companies on innovation from different perspectives, trying to answer the following questions:

— Has the level of sales increased in those companies that have performed R&D funded by the European Funds compared to those that did not perform any activity?

— By performing R&D, is there a higher level of own investment in research for those companies financed by structural funds?

— How much has the staff been enlarged, and especially the personnel belonging to the research department of the company, to carry out R&D co-financed activities?

To answer these questions three quasi-experimental models have been carried out. First of all, a Difference in Difference (DiD) approach with panel data have been fixed. Then a Propensity Score Matching (PSM) method is set to match beneficiary and non-beneficiary companies, and finally a combination of the two is fit. To estimate the impact of the EU Funds in business growth, two files have been used. On the one hand, an administration file of the Ministry of Finance and Public Administration, and on the other hand, the Technological Innovation Panel (PITEC), which is created from the innovation survey of companies conducted by the Spanish National Statistics Institute.

The structure of the paper is as follows. This introduction summarizes the general features of the research. The second section introduces the data base and the variables of interest. Section three presents the evaluation designs and the econometrics used to assess the impact of the EU support. The results of the estimations are found in Section 4 and finally the paper ends with a brief list of conclusions and possible future extensions.

2. DATA BASE AND VARIABLES OF INTEREST

Good quality data are one of the most important aspects for conducting an impact evaluation. Indeed, before choosing the optimal econometric method to correct selection bias, providing a good data set is essential to answer the impact evaluation questions in a reliable way.

[2] The analysis of the EU support effects needs clarification of the causality. What product is causing what? Within the "EU support" this paper is including several activities funded by the ERDF under its programming structure but not only one type of product or service, what leads to understand the effects on, for instance, business sales, as the effect of the mean product.

The available information to assess causality between a program and an outcome variable is usually the one referred to the program beneficiaries, where some non-administrative variables can be missing. Moreover, there is not information on the non-beneficiaries, which are needed to apply the impact evaluation techniques.

In this paper, apart from the beneficiaries file of the ERDF containing information on the supported companies, extra information has been matched from the PITEC, made up from the companies innovation survey and conducted by the Spanish National Statistics Institute.

The ERDF has been funding since 1988 (in Spain) many activities related to R&D, IT, energy, transportation, etc. For the 2007-2013 programming period, we need to identify within the Spanish ERDF Operational Program (OP) structure where the R&D activities considered in this paper are so that the product of the impact evaluation analysis is clearly defined.

There were 4 pluri-regional and 19 regional OPs for the period 2007-2013 in Spain (17 autonomous communities and the two autonomous cities of Ceuta and Melilla) The OPs were structured into priority axis (PA) and themes.

On the one hand, regarding the 4 pluri-regional OPs, the participation of the *PO de Economía del Conocimiento* was minor whereas the *PO FEDER por y para el beneficio de las empresas (FONDO TECNOLÓGICO),* in all regions of Spain, with one priority axis, is the main program to study companies support for the 2007-2013 period. On the other hand, the regional OPs have priority axis to support companies within the 4 types of regions (convergence, phasing-in, phasing-out and competitiveness[3]). These axes are structured the same way in all regions except for competitiveness.

For the convergence, phasing-out and phasing-in regions, there are two priority axis (1 and 2) divided into themes which are all included in our research except "06" and "08". The reason to exclude these two themes is to avoid including certain activities recorded within "06" and "08" that do not match with our understanding of R&D. For the competitiveness region there is only 1 axis (number 1)

Table 2.1

COMPANIES SUPPORTED BY R&D PROJECTS

Year		PA0101	PA0102	PA0103	PA0202	FONDO TEC-NOLÓGICO
2007	aid	0	0	0	1,711,763	10,218,646
	expenditure	0	0	0	3,423,525	17,136,175
	beneficiaries	.	.	.	37	691
2008	aid	14,362,864	0	6,372,712	19,756,498	11,148,259
	expenditure	17,953,580	0	7,965,890	39,512,994	18,533,643
	beneficiaries	204	.	120	421	405
2009	aid	68,589,442	37,140,645	91,402,456	71,897,939	167,081,692
	expenditure	85,736,805	46,425,807	113,449,316	143,795,850	248,522,810
	beneficiaries	4,543	1,017	2,913	7,538	1,955
2010	aid	85,240,910	19,704,837	99,852,102	109,187,263	177,727,721
	expenditure	106,551,138	24,631,046	124,003,718	218,374,484	269,123,904
	beneficiaries	9,485	1,492	4,802	3,043	3,617
2011	aid	50,349,020	13,153,688	79,841,271	123,917,053	249,127,521
	expenditure	62,936,275	16,442,110	98,418,678	247,834,079	343,464,355
	beneficiaries	2,051	860	4,056	2,348	3,235

Source: own elaboration based on data from the beneficiaries files.

Generally speaking, as it can be seen from Table 2.1, almost 55,000 companies were supported by the ERDF OPs during the 2007-2011 period. Companies started to make use of the EU Funds from 2009 onwards and that is mainly due to the N+2 rule of the previous period.

[3] Convergence regions: 18,752 million euros-80% co-financing. Phasing-in: 3,856 and 80%. Phasing-out: 1.419 and 80%. Competitiveness: 3,126 and 50%.

The expenditure increased over the period for those projects funded mainly by the *FONDO TECNOLOGICO* and the axis 2 of the OPs (PA0202). These differences with respect to the other PAs might be explained by the variability of type of regions included in each PA. It was easier for higher income regions to maintain their investment in R&D when the economic crisis initiated.

According to the "*Informe de Seguimiento Estrategico 2012 del MENR*"[4], in December 2011 the real spending was below the 50% planned for 2013. Nearly 10,000 R&D projects had been co financed and the number of new businesses had grown by 2,482.

Despite the extraordinary information presented in this file little information on the variables of interest can be found, that is, the impact variables needed to study the effectiveness of the public interventions. Moreover, the fact of not having a control group leads to the need for another source of information.

The second file used in this paper is the Technological Innovation Panel (PITEC). This database is a panel containing information on innovation activities of Spanish companies based on data provided by the Technological Innovation Survey conducted by the Spanish National Statistics Institute. The PITEC offers more than 460 variables for around 12,000 companies since 2005 allowing the study of the evolution and impact of innovation in the business sector and identifying the different strategies adopted in terms of innovation by companies. Being a fixed panel (though not completely), there is an annual observation for every company, making the data more reliable. The panel of companies is selected from national surveys conducted by the National Institute of Statistics in the field of innovation: "Survey on Technological Innovation in Companies" and "Statistics on R&D", which provides information on the structure of the innovation process (R&D/other innovative activities) and show the relationship between the process and the technology strategy of the companies, the factors that influence (or hinder) their ability to innovate and the economic performance for companies.

Indeed it provides the basic framework for further specific studies on concrete aspects of the innovation process (for instance, the use of cutting edge technology in manufacturing, technological payments and income, patent studies, etc.)

To obtain the final impact data base, a matching of these two files is performed. This cross-checking is done by the identification of the company (NIF) that exists in the two data sets, allowing a precise link of the two files. Table 2.2 shows the result of this matching.

Table 2.2

MATCHING BETWEEN BENEFICIARIES (ADMINISTRATIVE DATA-ERDF) AND PITEC (SURVEY DATA-INE)

Group		2006[5]	2007	2008	2009	2010	2011
Treatment	Both files	794	789	773	764	757	730
Initial control	Only PITEC	11240	10805	10409	10032	9623	9247
Final control	Only PITEC and false control removed	5460	5460	5463	5473	5481	5493

Source: own elaboration based on data from both the beneficiaries files and the PITEC.

This matching provides a database with information of companies both in the control and treatment group, making it possible to estimate the policy impact. Row 2 shows the companies in the treatment group, those having a common NIF in both files, while row 3 shows the control group, i. e. companies that initially where only in PITEC. Finally, a data cleaning has been necessary to avoid wrongly including companies within the control group when they were actually already doing some investment in R&D. This situation occurs because the ERDF file has only information about companies funded by them. However, companies investing in technological and innovation projects funded by other non-ERDF bodies, such as national or regional institutions, are not documented in this file.

Therefore, in a situation where the company is initially and wrongly classified into the control group when in fact it does not belong there because it is supported already by other institutions, some action

[4] http://ec.europa.eu/regional_policy/sources/how/policy/doc/strategic_report/2012/es_strat_report_2012.pdf.

[5] For applying an impact evaluation a baseline containing information on the "before-policy" scenario is required. That is why 2006-year's is displayed in Table 2.2.

must be taken to avoid any sort of distortion in the results. Fortunately, the PITEC provides information regarding whether a company has received EU Funds or other type of support on R&D investment.

All those companies in the control group in Table 2.2 that have received other financial support were removed. The units left in the control group after performing this cleaning are shown in the last row of Table 2.2 (named “Only PITEC and false control removed").

The main variables used in the study, both the outcome and explanatory variables, are described in the following sub-sections.

2.1. Impact indicators

The main interest of this paper is to quantify the business success due to the EU support on R&D. This success is measured through several impact variables. Ardishvili *et* al. (1998) provide an in-depth analysis by revising the literature that covers the most used indicators to assess business growth, such as the market value, the number of employees, sales, production value or the added value. However, there is a broad consensus in pointing sales as one of the most appropriate indicators for this purpose, mainly due to be widely used by managers in running their businesses and also because it explains other variables, such as the number of employees, profits or market share (Barkham *et* al., 1996). Taking this into account, in this paper we have considered the following outcome variables where the impact of EU funding on R&D will be measured.

2.1.1. *Sales*

It includes the amounts invoiced by the company during the reference year for their provision of goods and services. Taxes are included except for the VAT paid by the customer and they are recorded on a net basis by deducting the sales returns and sales volume discounts. Neither cash discounts nor discounts for prompt payment are deducted. The turnover does not include the sale of fixed assets or the production subsidies received and the amount of turnover is calculated as the sum of net sales of goods and provision of services.

The importance of this outcome variable when funding R&D activities on companies has been studied by Garcia-Manjon and Romero-Merino (2010), Mansfield (1962) or Coad and Rao (2008) among others. They show a positive relationship between R&D investment and company sales.

2.1.2. *Employees*

This variable is calculated as the number of people working for the company, included those outside the company who belong to it and are paid by it. It includes both paid and unpaid staff. A good summary of the published works up to date can be found on Ortega-Argiles *et al*. (2010) The works of Bogiacino and Vivarelli (2012); Greenan and Guellec (2000) prove positive effects on the labour market when investing in R&D whereas Antonocci and Pianta (2002) find that the technological change affects employment negatively.

2.1.3. *Employees in R&D*

The number of employees in R&D activities include all staff directly employed in R&D, regardless of their level of responsibility, as well as those agents providing services directly to the R&D department (managers, administrators and clerical staff) Persons performing indirect services such as security personnel and maintenance are excluded.

Staff data can be measured in two different ways, on the one hand in terms of the number of workers and, on the other hand, by number of full-time equivalent hours worked. The number of workers refers to the total number of individuals completely or partially employed in R&D, allowing match this information to other data series, such as education or employment characteristics or population census. On the other hand, the data relating to workers are the most appropriate measure for collecting additional information on the characteristics of individual (age, gender, citizenship, etc.).

In addition, it is strongly recommended to measure in terms of full-time equivalent for one year because the time devoted to R&D by the workers is usually a partial or secondary activity. The full-time equivalent staff on R&D are those individuals working at least 90% of their working time on R&D activities. A partial-time equivalent on R&D dedicate between 10% and 90% of their working time to R&D activities and the rest to other activities.

For this paper the outcome variable to assess impact has been "full time equivalent".

2.1.4. *Internal spending on R&D*

The expenditure on R&D contains all the R&D activities carried out within the research department (internal expenditure). All the expenditures incurred outside the department but supporting internal R&D tasks (purchase of supplies for R&D, for example) are also included as internal expenditures on R&D. The data relating to internal R&D should be collected from the information on the internal costs of doing R&D. However, it is also desirable to collect data on external R&D expenses, as supplementary information. Internal expenses include both current expenditures and capital. Deductible VAT invoiced by suppliers has been agreed to be excluded.

Several papers have studied the effect of the R&D support on the company's internal spending. David *et al*. (2000) and Klette *et* al. (2000) show a comprehensive study of the main findings without a clear conclusion, since one out of three reports seem to evidence that public R&D acts as a substitute for the private R&D. More recently Lach (2002) using panel data finds a positive impact of public subsidies on R&D with major effects on the SMEs. Similar findings can be found in Almus and Czarnitzki (2003). For Spain, the paper of Gonzalez and Pazo (2008) supports the same result.

2.2. Explanatory variables

In order to have the whole description of the impact of EU Funds on R&D on business growth, the regional environment and other characteristics of the company can explain this business result when making an investment in R&D activities. One of the most relevant variables that will be used in the PSM estimation is the type of region according to the EU policy classification.

In this paper we have considered the following explanatory variables:

- The type of region: dummy variable, which equals 1 if the company is allocated to a particular Autonomous Community[6] (17 possibilities) and zero otherwise.
- Size (size): size of company measured by the number of employees.
- New company (newcomp): takes value 1 if the company has been established that year, 0 otherwise.
- Age (age): number of years that the company has been active.
- Matrix (matrix): takes the value 1 if the company is the parent of a corporate group. 0 otherwise.
- Subsidiary (subsidiary): takes the value 1 if the company is a subsidiary of a business group. 0 otherwise.
- Activity: the following sectors have been considered: mining and quarrying (extrac), food (alimenta), textiles (textile), chemicals and pharmaceuticals (quimifama), rubber (cauchomin), metal (metal), electrical (electr), transport (transpo), furniture production (mueble), sun and water energy production (solagua), construction (constru), trade (comercio), storage (almac), hotel (hotel), consulting activities (consul), financial (finan) on R&D (imasd) and other activities (otrasacti).

Given these explanatory variables, the following table shows the position and dispersion statistics for the most relevant characteristics splitting by the two groups: the treatment and the control group.

[6] Spanish regional classification for NUTS2.

Table 2.3
DESCRIPTIVE STATISTICS BY GROUP (CONTROL AND TREATMENT)-MEAN VALUES FOR THE PERIOD 2005-2011

Variable	Control group		Treatment group	
	Mean	Standard deviation	Mean	Standard deviation
Log(sales)	15,976	2,033	15,551	2,044
Log(int r&d)	11,497	1,379	12,648	1,707
Log(staff)	1,287	0,9388	2,244	1,298
Log(staff in r&d)	0,451	0,736	1,264	1,372
size	371,950	1.482,336	283,955	1.415,923
extrac	.00586	.07632	0,0000	0,0000
alimenta	.04029	.19666	.12767	.33375
textil	.05139	.22079	.03208	.17624
quifarma	.04560	.20862	.06517	.24685
cauchomin	.04643	.21043	.03977	.19544
metal	.04964	.21721	.07503	.26346
electr	.06890	.25329	.15240	.35944
transpo	.01813	.13345	.0163	.12693
mueble	.03497	.18371	.01888	.13612
solagua	.00460	.06769	0,000	0,000
constru	.04711	.21188	.02506	.15634
comercio	.09413	.2920	.03342	.1797
almac	.03030	.17141	0,0000	0,0000
hotel	.03190	.17574	.00384	.06188
consul	.05343	.22490	.13469	.34142
finan	.03674	.18812	.03676	.18819
imasd	.00320	.05655	.10377	.30499
otrasacti	.33213	.47098	.13018	.33653
newcomp	.00337	.05797	.01487	.12105
matrix	.05178	.22159	.09592	.29450
subsidiary	.24651	.43098	.15574	.36264

Source: own elaboration based on data from both the beneficiaries files and the PITEC.

The above Table presents information on the control (columns 2 and 3) and treatment group (columns 4 and 5). The first four rows contain information about the result or impact variables and give a first insight of the possible differences between the two groups.

3. EVALUATION METHODOLOGY

The aim of an impact evaluation is to answer the following question: what is the impact or the causal effect of a program "D" on an outcome of interest "Y"?

This question can be expressed by the following formula:

$$\alpha = Y_{it}^{T} - Y_{it}^{C} \quad (1)$$

where Y_{it}^{T} is the outcome variable for the ERDF-supported-firm "i" (sales, internal R&D investment, etc.) in year "t" and Y_{it}^{C} is the same variable had the firm not been a program beneficiary.

By calculating the difference in sales, for instance, between receiving support or not receiving it (in the impossible situation where both actions could occur at the same time), the impact of the action of providing support could be known. Since Y_{it}^{C} cannot be observed, an estimation for this value will be needed: this is the well-known procedure of the counterfactual estimation. The proper analysis of impact evaluation requires a counterfactual of what the outcomes would have been in the absence of the intervention.

Although it does not exist a perfect clone for a company, by using statistical tools to generate two identical groups of firms, the researcher could get to have two comparable groups so that difference in outcome variables could be explained by the participation in a program and not to differences in the groups.

In practice, a key target of an impact evaluation is to identify a group of participants in the program (treatment group) and a group of non-participants (control group) which are statistically identical in the absence of the program.

Being both groups statistically equal with the only difference of participation, any difference found in the outcome variables can be assigned to the program. This difference, calculated as $E\left[Y_{it}^{T}-Y_{it}^{C}\right]$, allows compare the outcome variables for those ERDF beneficiary companies to those not being treated. The average treatment effect (ATT) is defined as:

$$\alpha = E\left[Y_{it}^{T}-Y_{it}^{C}\right] = E\left[Y_{it}^{T}\mid D=1\right] - E\left[Y_{it}^{T}\mid D=0\right] \qquad (2)$$

Expression (2) estimates the treatment impact –use of the EU Funds– as the difference between the mean outcome variable for those participating companies, $E\left[Y_{it}^{T}\mid D=1\right]$, minus the mean outcome variable for those companies had they not received the financial support on R&D, $E\left[Y_{it}^{T}\mid D=0\right]$, which cannot be known for those beneficiary companies. However, adding up and substracting $E\left[Y_{it}^{C}\mid D=0\right]$, expression (2) can be written as follows:

$$\begin{aligned}\alpha &= E\left[Y_{it}^{T}\mid D=1\right] - E\left[Y_{it}^{T}\mid D=0\right] + E\left[Y_{it}^{C}\mid D=0\right] - E\left[Y_{it}^{C}\mid D=0\right] = \\ &= \underbrace{E\left[Y_{it}^{T}\mid D=1\right] - E\left[Y_{it}^{C}\mid D=0\right]}_{observed\_values} + \underbrace{E\left[Y_{it}^{C}\mid D=0\right] - E\left[Y_{it}^{T}\mid D=0\right]}_{hypothesis=0}\end{aligned} \qquad (3)$$

The observed values of (3) represent the mean participation effect using two expressions that are known in the available data. However, the hypothesis in (3), $E\left[Y_{it}^{T}\mid D=0\right] - E\left[Y_{it}^{C}\mid D=0\right]$, known as the selection bias, represent the different in the outcome variables for the two types of companies (treated and non treated) in the absence of the program and that could affect the program impact.

The estimation of α will require the estimation of $E\left[Y_{it}^{T}\mid D=1\right] - E\left[Y_{it}^{C}\mid D=0\right]$. If the selection bias is cero (the hypothesis term in (3) =0), the impact estimation of the program will be unbiased. However, the fact of a company participating or not in a program depends on various characteristics, both observables and unobservables such as the company size, activity and so on, that will affect the outcome variable (e.g. sales) and also the participation on ERDF support. The easy calculation of substracting the mean outcome variable for the non-participants from the mean outcome variable for the participants will capture the program impact, other factors affecting the outcome variable and also the program participation. The effect of these other factors explaining the outcome variable and the participation are the ones to be removed using proper econometric techniques.

3.1. The Difference in Difference approach

Since selection bias can be due to observables and unobservables variables the first step is avoiding it by identifying known characteristics, X, explaining individuals behaviour in the absence of the program. In this context the counterfactual can be estimated using the non-participant group.

However, it seems difficult to have all the relevant characteristics of a company available. As mentioned by Blundell and Costa Dias (2002), there are unobserved characteristics that cannot be measured and violate the assumption of selection in non-observables. This question is closely related to the bias connected to the self-selection of companies in the process of applying for assistance for conducting R&D investment (Busom, 2000). Not every company applies for such assistance, and the companies that do, decide to apply for a grant assuming that the use of this aid will have an effect on the expected profitability compared to the alternative (not apply).

In order to solve the bias problems due to unobserved variables we use a panel data that allow us to identify the effect of the program correctly by properly treating the variation of companies over time. The impact design used in this work is the method of "difference in differences" (DiD). The model to be estimated has the following specification:

$$Y_{it} = \eta_i + \alpha D_{it} + \beta_1 X_{it} + \beta_2 \lambda_t + u_{it} \qquad (4)$$

Where Y_{it} is the outcome variable of interest of the company "i" in the period "t", where the impact of the policy wants to be measured, X_{it} is the vector of observed firm characteristics, D_{it} is a dummy on participation in ERDF, λ_t are dichotomous variables for different moments in time which controls the temporary effects affecting globally the investment opportunities for companies. η_i is a specific characteristic of the company "i" while u_{it} is the error term that is distributed with zero mean and finite variance.

Under the assumption of X_{it} and u_{it} not being correlated, the parameter of interest α identifies the impact of the EU support on R&D activities. The fixed effects model is a direct extension of the DiD estimator when only two groups and two periods exist.

3.2. The Propensity Score Matching Technique

When the program participants have not been randomly chosen and there exists selection bias, both groups are not comparable on the outcome variables. Removing or adjusting this bias is possible by using quasi-experimental techniques such as Propensity Score Matching (PSM) of Rosembaun and Rubin (1983). There is a large literature on the application of the PSM for program evaluation. For instance, Heckman, Ichimura and Todd (1997) and Lechner (2002), Dehejia and Wahba (2002) apply the PSM methods to estimate the effects of training programs on labour participation and Jalan and Ravallion (2003) assess the impact of programs against poverty.

The propensity score is defined as the probability of treatment assignment conditional on observed baseline characteristics. The PSM is the algorithm that matches participants and non-participants on a program according to the propensity score (PS) conditional on certain observed baseline variables.

If the outcome variable is not related to participation, conditional on those observed variables, using the control group obtained by means of this procedure, one can get an unbiased estimation of the mean impact of the program. This technique is divided into two steps:

The first step consists of a discrete choice model that calculates the probability of a company being supported by the ERDF Fund, taking into account other explanatory variables for that firm. The specification of the model is:

$$D_i^* = \gamma_0 + \gamma_1 X_i + U_i \qquad (5)$$

$$D_i = \begin{cases} 1 \text{ si } D_i^* \geq 0 \\ 0 \text{ si } D_i^* < 0 \end{cases} \qquad (6)$$

Where D is observed (beneficiary company: 1, non-beneficiary: 0), and D^* is never observed, although both are linked since D is related to the unobserved value D^*. The variable D is a dummy variable taking values {0,1}, and the model has a limited dependent variable. The estimation of this model will be using a Logit o Probit approach, allowing probabilities estimation in the range [0, 1].

Using a Logit estimation the expression to define the probability of a company receives EU Funds support is:

$$p\left(D_i \middle| X_i\right) = \frac{\exp\left(\gamma_0 + \gamma_1 X_i\right)}{1 + \exp\left(\gamma_0 + \gamma_1 X_i\right)} \qquad (7)$$

Where D is the dependent variable taking values {0,1}, X is the vector of the observed explanatory variables, γ_0 is the constant and γ_1 the vector of parameters to estimate.

After estimating these probabilities of participation, two steps are required. First it is necessary to fit two tests: the balancing test and the common support checks. The second step is for calculating the effect (in terms of impact) of the policy. Some of the matching algorithms used in this paper are the nearest neighbor matching and kernel methods. For both the formula for impact calculation is (Heckman, Ichimura and Todd, 1997):

$$\hat{\alpha}_{PSM} = \frac{1}{N_T} \sum_{i \in T} \left[Y_i^T - \sum_{j \in C} w(i,j) Y_j^C \right] \qquad (8)$$

Where N_D is the number of participants in the control group, Y_i^T the outcome variable for the participants and Y_i^C for the control group.

w(i,j) is the weight for j-th non-participant to be compared to the i-th individual treated, and where Σ_j w(i,j) = 1.

3.3. The combination of DiD and PSM

The combination of the two techniques allows combine the advantages of both methods. On the one hand, the use of the DiD and PSM solves the selection bias in unobservables and observed variables respectively, and on the other hand, only those companies in the common support are used for the analysis.

The formula for the combination is:

$$\hat{\alpha}_{PSM} = \frac{1}{N_T} \sum_{i \in T} \left[\left(Y_{i1}^T - Y_{i0}^T\right) - \sum_{j \in C} w(i,j) \left(Y_{j1}^C - Y_{j0}^C\right) \right] \qquad (9)$$

Where the expression in brackets corresponds to the DiD design: $\left(Y_{i1}^T - Y_{i0}^T\right)$ is the difference of the outcome variable on the treated between the baseline (index 0) and the post-treatment moment (index 1), and $\left(Y_{i1}^C - Y_{i0}^C\right)$ is the same expression for the non-treated.

Using these specifications, the results obtained are presented below.

4. RESULTS

4.1. Results for the Difference in Difference approach

In order to estimate the effect of R&D investment in business growth the econometric models that assess the causality relationship adding up more variables but the participation are presented here. Starting form equation (4), two different estimations are performed:

— Regression 1: fixed effects model without explanatory variables. That is, equation (4)-none additional explanatory variable.

— Regression 2: Fixed effect including vector of explanatory variables.

The various results assessing the impact of R&D policy are shown in Tables 4.1 and 4.2. To determine whether the aid on R&D have an impact on the different outcome variables we must check the parameter associated to the variable "trata", associated with the α parameter of the equation (4).

The estimations are:

Table 4.1

SPECIFICATIONS 1 AND 2 FOR THE "LOG SALES" AND "LOG INTERNAL R&D" DEPENDENT VARIABLES

Variable	"log of sales"				"log of internal investing in R&D"			
	reg1		reg2		reg1		reg2	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
trata	0,146	0,000	0,129	0,068	0,103	0,013	0,090	0,050
year5	0,014	0,256	0,056	0,033	0,115	0,073	0,085	0,000
year6	0,087	0,000	0,149	0,127	0,141	0,098	0,070	0,001
year7	0,138	0,000	0,230	0,209	0,223	0,179	0,117	0,000
year8	0,096	0,000	0,218	0,197	0,278	0,232	0,135	0,000
year9	-0,096	0,000	0,036	0,014	0,246	0,199	0,067	0,003
year10	-0,142	0,000	0,016	-0,008	0,267	0,218	0,055	0,025
year11	-0,185	0,000			0,247	0,193		
tamano			0,000	0,000			0,000	0,001
extrac			0,692	-0,704				
alimenta			0,532	-0,005			0,016	0,986
textil			0,460	-0,103			0,771	0,396
quifarma			0,644	0,093			0,530	0,537
cauchomin			0,650	0,094			0,571	0,490
metal			0,792	0,272			0,892	0,273
electr			0,633	0,137			0,766	0,338
transpo			0,622	0,050			0,818	0,348
mueble			0,620	0,103			0,639	0,433
solagua			0,116	-0,368			-1,059	0,120
constru			0,864	0,353			0,653	0,447
comercio			0,536	0,053			1,110	0,171
almac			0,295	-0,344				
hostel			1,810	0,936				
consul			0,270	-0,229			0,754	0,327
finan			-0,258	-0,749				
imasd			0,028	-0,586			0,404	0,632
otrasacti			-0,370	-0,807			0,789	0,279
nuevacrea			-0,509	-0,612			-0,373	0,000
matriz			0,132	0,086			0,093	0,035
filial			0,085	0,049			0,074	0,061
edad			-0,024	-0,028			0,033	0,000
_cons	15,91786	0	15,967	15,513	11,682	11,650	10,315	0,000

Table 4.2

SPECIFICATIONS 1 AND 2 FOR THE "LOG STAFF" AND "LOG STAFF ON R&D" DEPENDENT VARIABLES

Variable	"log staff"				"log staff on R&D"			
	reg1		reg2		reg1		reg2	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
Trata	0,088	0,006	0,080	0,013	0,068	0,051	0,062	0,075
year5	0,000	0,979	-0,016	0,291	-0,009	0,600	-0,018	0,269
year6	0,022	0,159	-0,010	0,474	0,021	0,210	-0,009	0,554
year7	0,063	0,000	0,007	0,640	0,044	0,010	0,001	0,964
year8	0,082	0,000	0,011	0,480	0,078	0,000	0,017	0,300
year9	0,109	0,000	0,016	0,323	0,091	0,000	0,013	0,444
year10	0,120	0,000	0,010	0,571	0,082	0,000	-0,011	0,540
year11	0,127	0,000			0,107	0,000		
							0,000	0,608
Extra								
alimenta			0,294	0,644			-1,097	0,114
Textil			0,166	0,793			0,210	0,761
quifarma			0,158	0,793			-0,958	0,143
cauchomin			0,342	0,554			-0,822	0,192
Metal			0,585	0,304			-0,662	0,285
Electr			0,542	0,331			-0,572	0,347
Transpo			0,366	0,549			-0,423	0,524
Mueble			0,446	0,434			-0,387	0,533
Solagua			-0,221	0,642			-1,250	0,016
Constru			0,367	0,540			-0,591	0,365
comercio			0,505	0,373			-0,632	0,306
Almac								
Hostel								
Cónsul			0,707	0,188			-0,298	0,611
Finan								
Imasd			0,413	0,484			-0,419	0,514
otrasacti			0,497	0,329			-0,430	0,438
nuevacrea			-0,263	0,000			-0,184	0,001
matriz			0,012	0,700			0,007	0,831
Filial			0,029	0,295			0,010	0,732
Edad			0,018	0,000			0,016	0,000
_cons	1,532	0,000	0,738	0,152	0,663	0,000	0,894	0,111

As it can be seen from the above tables and generally speaking there is a clear and positive impact of EU support on the growth and success of the company. However some details must be provided when explaining these favorable results about the effectiveness of EU funds.

On the one hand, it seems that the EU funds have a clear impact on the economic variables of the company. Analyzing the first four columns of Table 4.1 one can see that the parameter associated to the impact given by the variable "trata" is significant in both specifications, with a p-value below 0.05. That is, the policy does have an impact. Once it has been observed that the parameter is statistically different from zero, the next question is to measure the impact size. Regarding the variable "Turnover" the fact of being a beneficiary of European aids increases the level of sales in 14 log points. Indeed, the effect that the economic cycle has had on the sales of companies is clearly visible from the model estimations.

The parameters associated with "year5" to "year11" can conclude that until 2008 the economy was in an expansive cycle, since *ceteris paribus*, companies increased their turnover. However, from the year 2009 onwards the crisis had a clear impact changing the trend with negative parameters associated with those three years, and also the intensity of the recession increased, from a value of -0.09 in 2009, to -0.14 in 2010 and -0.18 in 2011 (if taking the "reg1" option as the reference).

The last four columns of Table 4.1 show the effect on other economic variable: internal company investments. This is also significant for the case of reg1 and reg2, with a p-value statistically different from zero and with a value of 10 log points.

Table 4.2 provides the impact of European funds on the staff of the company. In both variables the effect of using funds is positive, because in many situations the p-value associated with the parameter is below 0.05 or close to it. And finally, companies receiving European funds increased their workforces in 8 log points, while the section of the R&D increases by 6 log points.

4.2. Results for the Propensity Score Matching Technique

At the first stage we calculate the probability of a company participating conditional on some observed variables in the baseline (2007) following (5) and (6). The obtained results using the logit estimation are presented in Table 4.3.

Table 4.3

LOGIT ESTIMATION-EQUATION (7).
DEPENDENT VARIABLE: "PARTICIPATION ON ERDF FUND FOR R&D"

Variable	Coefficient	Standard error	t-statistic	p-value
Tamaño	0.00005	0.00002	3.37	0.001
Andalucia	-0.63435	0.23657	-2.68	0.007
Castilla león	0.56995	0.14757	3.86	0.000
Cataluña	-0.07288	0.09567	-0.76	0.446
Galicia	1.43553	0.20298	7.07	0.000
Madrid	-0.14451	0.13219	-1.09	0.274
Navarra	1.53900	0.16334	9.42	0.000
La Rioja	1.57068	0.26312	5.97	0.000
Alimentac	0.02239	0.15289	0.15	0.884
Textil	-0.62853	0.17954	-3.5	0.000
quimifarma	-0.26870	0.17254	-1.56	0.119
cauchomin	-0.67159	0.18285	-3.67	0.000
Metal	-0.26877	0.16004	-1.68	0.093
Electr	-0.06849	0.14849	-0.46	0.645
transpo	-0.23123	0.23381	-0.99	0.323
mueble	-0.49885	0.19000	-2.63	0.009
constru	-0.59500	0.19609	-3.03	0.002

(*Keep.*)

(*Continuation*.)

Variable	Coefficient	Standard error	t-statistic	p-value
comercio	-0.77876	0.17364	-4.48	0.000
hostel	-0.74716	0.26831	-2.78	0.005
Cónsul	-0.15608	0.16146	-0.97	0.334
Imasd	1.56518	0.21143	7.4	0.000
otrasacti	-0.63587	0.13681	-4.65	0.000
nuevacrea	0.03531	0.39109	0.09	0.928
Matriz	0.06234	0.11510	0.54	0.588
Filial	-0.43108	0.08572	-5.03	0.000
reg converg	0.58879	0.17320	3.4	0.001
reg pahout	0.59409	0.19019	3.12	0.002
reg pahein	0.97257	0.09561	10.17	0.000
constante	-1.35736	0.12505	-10.85	0.000

As it can be seen from the above Table, there are many statistically significant variables that explain the participation of the companies in the ERDF support during the period.

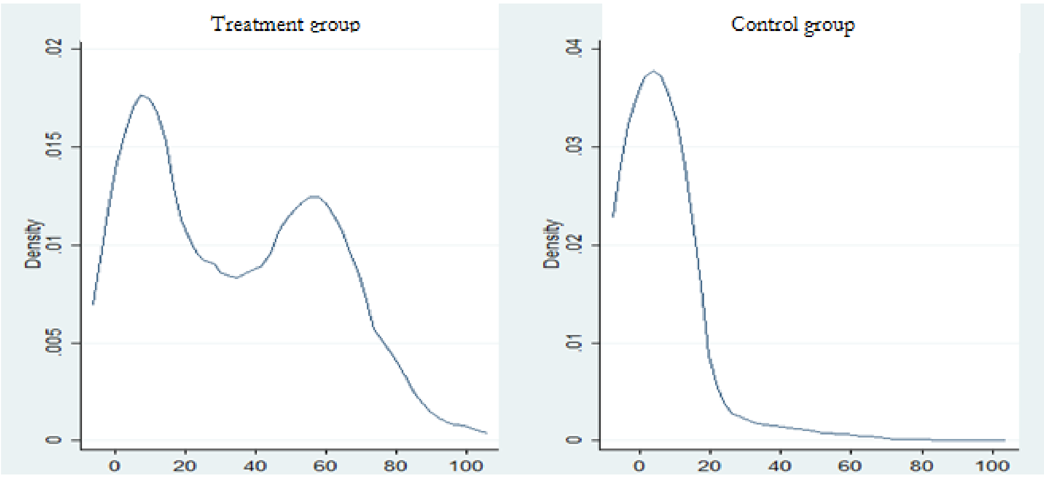
The company size and the new creation positively affect participation. Looking at the activity, those companies in R&D industry (imasd) are more likely to participate than other companies working on the textile, rubber, furniture or construction sector.

Looking at the type of region, and taking the convergence regions as the reference (50% co-financed), the other regions (80% co-financed) seem to need these Funds for R&D purposes more than de ones in the convergence area.

The common support yields in the range [0,006 – 0,987], almost de possible maximum [0,1].

Figure 4.1

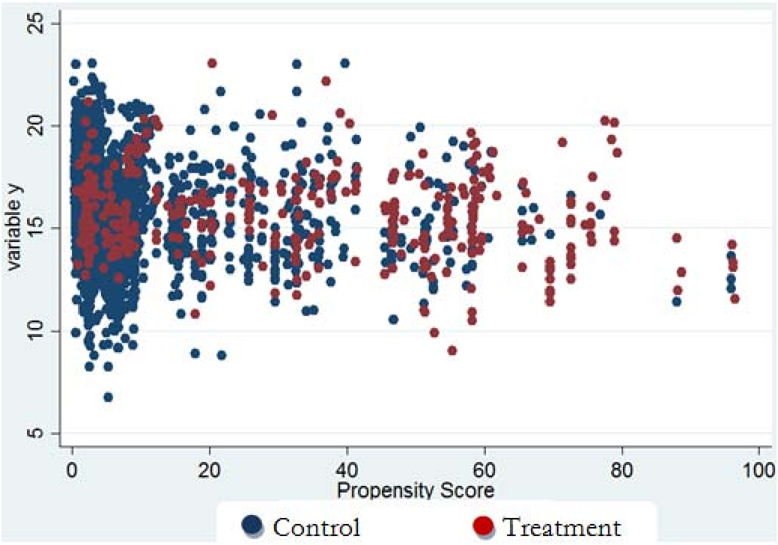
KERNEL ESTIMATION FOR THE PS OF PARTICIPATION ON ERDF FUND (HORIZONTAL AXIS)



Once the balancing test has been successfully fit the impact can be calculated for all the outcome variables.

To estimate the impact of the program, in the second stage, only three variables are included: the probability of participation calculated in the previous stage, a dummy variable for the treatment or control group and the outcome variable. As an example, the Figure 4.2 shows the scatter plot if the outcome variable was “log sales”

Figure 4.2
SCATTER PLOT FOR PSM FOR "LOG SALES".



Using equation (8), the impact of the ERDF support on the four outcome variables is estimated using the two approaches presented above: the nearest neighbourhood and the kernel estimation. The results are presented in Table 4.4.

Table 4.4
IMPACT OF THE PROGRAM USING PSM. DIFFERENT OUTCOME VARIABLES ON 2011

Method	Variable (2011)			
	Sales	Internal investment	Staff	R&D staff
nearest neighbourhood	0.265 (1.254)	3.239 (6.113)	0.799 (7.920)	0.621 (8.417)
kernel	0.253 (1.616)	3.906 (9.345)	0.889 (9.831)	0.651 (9.691)

Generally speaking participating in the ERDF grants has a positive impact on the outcome variables, since the t-value is above 1.96 for all variables except sales. Comparing the values for the two methods, they are pretty similar, proving consistency in the estimations. Moreover, participating in the EU Funds on R&D affects positively the internal investment in R&D had the company not received the grant, and also enlarging the internal staff.

4.3. Results of the combination of DiD and PSM

Finally, the impact of the EU support on R&D on the four outcome variables will be conducted combining the two methods from equation (9). In Table 4.5 the estimations are shown:

Table 4.5
IMPACT ESTIMATION USING BOTH METHODS

Method	Variable in dif (2011-2007)			
	Sales	Internal investment	Staff	R&D staff
nearest neighbourhood	0.303 (2.868)	1.523 (2.287)	0.539 (4.571)	0.414 (-5.371)
kernel	0.327 (4.851)	1.169 (2.109)	0.474 (3.732)	0.345 (-5.746)

As in Table 4.4, Table 4.5 shows the impact at the top of the cell whereas the t-statistic is presented underneath in parenthesis. Unlike the estimation using the variable levels, the evolution of the outcome variables between 2007 and 2011, calculated as the difference, shows that all values are statistically significant, even sales.

Looking at the figures, the participation in R&D support increases sales between the two years in 30 log-points compared to not using this fund. Internal R&D spending is performed due to the company's participation and also for the recruitment levels.

5. CONCLUSIONS AND FUTURE RESEARCH

The aim of this paper has been to assess the impact of the European grants on R&D in Spanish companies during the period 2007-2011 on their business results. Using data of companies, the impact of the EU Funds has been assessed on key result variables making use of three quasi-experimental models: Difference in Difference, Propensity Score Matching and a combination of both. For the DiD approach a panel data model estimates the effect of the investment in R&D on various outcome variables.

There is a relevant positive effect on increasing the turnover and the internal investment for the company. It also has positive effects on the workforce, both the company and the research department, although the impact is not as clear as that obtained for the monetary variables.

Similar results yield the PSM approach, where significant positive impacts are observed on internal R&D spending and staff. Finally the combination of the two models (PSM and DiD) confirms the previous findings providing a clear positive impact on the four outcome variables considered within the research.

Despite the great interest of this work in proving the positive effect of the EU support on R&D for companies, further analysis should be provided in future works. Special care should be taken controlling by company size, activity and particularly by the definition of innovation since it can be on production, products, processes or even patents.

And finally the dynamics of the explanatory variables should also be evaluated to the extent that an autoregressive panel data model would consider the changes along the period of the main independent variables to help explain the causality towards the outcome variables such as company's sales. For that purpose the estimation could follow the GMM of Arellano and Bond (1991)

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