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EVALUATING THE IMPACT OF PUBLIC SUBSIDIES ON A FIRM'S PERFORMANCE: A QUASI-EXPERIMENTAL APPROACH

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CENTRE DE RECERCA EN FEDERALISME FISCAL I ECONOMIA REGIONAL

EVALUATING THE IMPACT OF PUBLIC SUBSIDIES ON A FIRM'S PERFORMANCE: A QUASI-EXPERIMENTAL APPROACH[a,b]

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ABSTRACT: Many regional governments in developed countries design programs to improve the competitiveness of local firms. In this paper, we evaluate the effectiveness of public programs whose aim is to enhance the performance of firms located in Catalonia (Spain). We compare the performance of publicly subsidised companies (treated) with that of similar, but unsubsidised companies (non-treated). We use the Propensity Score Matching (PSM) methodology to construct a control group which, with respect to its observable characteristics, is as similar as possible to the treated group, and that allows us to identify firms which retain the same propensity to receive public subsidies. Once a valid comparison group has been established, we compare the respective performance of each firm. As a result, we find that recipient firms, on average, change their business practices, improve their performance, and increase their value added as a direct result of public subsidy programs.

Keywords: Public policy, evaluation studies, firm performance, Propensity Score Matching.
JEL Codes: H25, H32, L25, L53

Resumen: Muchos gobiernos regionales en los países desarrollados diseñan programas para mejorar la competitividad de las empresas locales. En este papel, evaluamos la efectividad de programas públicos cuyo objetivo es reforzar la actuación de las empresas localizada en Cataluña (España). Se compara la actuación de empresas subvencionadas (tratadas) con empresas similares, pero no subvencionadas (no tratadas). Se utiliza el Propensity Score Matching (PSM) para construir un grupo de control que, con respecto a las principales características, es muy similar al grupo tratado, lo que permite identificar empresas que presentan la misma propensión a recibir subvenciones. Una vez se ha establecido un grupo de comparación válido, se comparan los resultados de cada empresa. Como resultado se encuentra que, en promedio, las empresas tratadas cambian sus prácticas comerciales, mejoran su actuación, y aumentan su valor añadido como resultado directo de los programas públicos.

Palabras clave: Políticas públicas, evaluación, resultados empresariales, Propensity Score Matching.
Clasificación JEL: H25, H32, L25, L53.

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1. Introduction

In recent years, there has been an increase in the number of studies analysing the impact of economic policy measures whose aim is to boost industrial competitiveness. This increase has occurred within the context of burgeoning freedom of trading conditions, a context which has tended to generate stronger international competition, together with a need to both maintain balanced public accounts as well as ensure maximum effectiveness in the implementation of public policy measures.

Studies of the impact of public subsidy programs conducted at the national level[1] include Arvanitis et al. (2002), who analyse the effectiveness of advanced programs of technology diffusion in Switzerland, Lerner (1999) and Wallsten (2000), who examine the impact of the Small Business Innovation (SBIR) program in the US, and Roper et al. (2004) who, using an ex-ante qualitative exercise, study the private and social benefits of R+D projects for the UK. With regard to Spain, studies include Corchuelo (2006), González et al. (2005), Acosta and Modrego (2001), Heijs (1999 and 2001) and Busom (2000) who, interestingly, reports that public financing induces increased efforts in R+D by private firms.

While varying widely in their geographic scope, all of the aforementioned studies have in common their use of parametric techniques for performing policy evaluations.[2]

Recently, however, a non-parametric technique, Propensity Score Matching (PSM, hereafter), has gained increased popularity in the performance of evaluation exercises. Using PSM to undertake studies at the national level, Almus and Czarniztki (2003) look at the impact of public subsidies on a firm's R+D intensity in Germany, Duguet (2003) analyses the consequences of public subsidies for the private financing of R+D activities in France, and Herrera and Heijs (2003) evaluate the importance of public subsidies for R+D in Spain. With Czarniztki and Fier (2002) and Aerts and Czarniztki (2004) who analyse the impact of R+D policies in the Flemish region in Belgium, and Gabrielle et al. (2006) who study the Trento region in Italy representing notable exceptions, the PSM technique has, however, scarcely been utilised in studies at the regional level. Yet it is precisely the regional level, for countries such as Spain, the most appropriate for studying the impact of public polices.

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[1] In general, evaluation exercises conducted at the regional level are less frequent. See for instance, Lenihan (2004) who studies the impact of public subsidies on the Shannon region in Ireland or Meeusen and Janssens (2001) who analyse the impact of subsidies on the Flemish region of Belgium.

[2] For instance, Arvanitis et al. (2002), Corchuelo (2006) and Busom (2000) use a probit estimation, Lerner (1999) an OLS estimation, while Wallsten (2000) uses a simultaneous equation approach to deal with possible problems of endogeneity of public subsidies.

The decentralization process initiated in Spain during the 1980s has allowed regional governments to adopt their own industrial promotion measures and so tackle the peculiarities of the regional industrial structure more effectively. In this paper we focus on the region of Catalonia, whose industrial structure is characterised by the presence of a majority of Small and Medium Enterprises (SMEs, hereafter), and a high degree of productive diversification. Catalan industry represents around 25% of Spain's total industry and, as such, its competitive position as well as the impact of public policy actions to promote it, is of particular interest.

Over the last two decades, Catalan regional industrial policy has undergone a radical evolution in orientation; with interventions forming part of various plans aimed at overcoming some of the region's structural weaknesses and reinforcing the innovative capacity of Catalan firms (see Callejón and García-Quevedo, 2000). Beginning with the adoption of such measures as support for specific sectors (the so-called "picking winners approach"), it has evolved towards a policy which seeks to enhance the economic environment in which all firms operate and, thus, promote R&D activities as the source of competitiveness (see Costa and García-Quevedo, 2000).[3]

The public subsidies which we evaluate in this paper form part of the Catalan industrial policy that is incorporated within the European Commission's *Regional Program for Technology Transfer Strategy 2000*.[4] Public subsidies in Catalonia are managed by a Catalan Public Agency (CIDEM, hereafter)[5] whose job is to promote the competitiveness of Catalan industry. The total value of subsidies evaluated in this paper is around €8.6 million, which represents approximately 66% of CIDEM's total budget and around 0.03% of the Catalan industrial Gross Value Added (see section 3 for more details).

The aim of this paper is to evaluate the impact of the public subsidies conceded by CIDEM in 2000. We estimate the impact of these subsidies on the growth rate of the recipient firms' Value Added (2000-2002) in two steps. First, we use PSM to evaluate the impact of public subsidies by comparing outcomes associated with firms which receive public support and those which do not. Here, PSM is a highly appropriate methodology as it enables us to both control the

[3] The new Catalan government, which took office in November 2003, has recently implemented a new plan called *Catalonia's Research and Innovation Plan 2005-2008*.

[4] Some of the subsidies analysed were designed by the Spanish central government to promote local industries through high-priority lines for SME such as the *SME's Consolidation and Competitiveness Plan 2001-2006*, drawn up by the Spanish Ministry of Industry. In this case, however, the Central government transfers funds to regional governments, which are guaranteed independence in procedures, resolutions and liquidations in the application of the program.

[5] From the Catalan acronym for *Centre d'Innovació i Desenvolupament Empresarial* (http://www.cidem.com).

distribution of public subsidies as well as reduce some of the main methodological problems associated with policy evaluation.

Second, and also using the propensity scores, we match each recipient firm with the one that it most closely resembles in the control group. Thus, we obtain a dataset of firms which allows us to assess, through regression techniques, the impact of public programs on the competitive position of Catalan firms.

The rest of the paper is organized as follows. Section 2 summarises the main methodological issues involved in the discussion. Section 3 describes the database used. Section 4 presents the main results obtained. Finally, section 5 concludes.

2. Methodological issues

The best method for evaluating public programs is "true" or natural experiments based on random assignments, as they offer the strongest foundations for analysing the relationships of causation (see Lalonde, 1986). In experimental designs of this type, units are assigned at random to "treatment and control groups". On average, the units in each group are equivalent with respect to all their shared characteristics. Thanks to this equivalence, the influence of external factors that could contribute to the observed results of units can therefore be eliminated. Hence, any differences in the observed results between the two groups can be attributed exclusively to the implementation of the public program.

Nevertheless, the adoption of an experimental plan based on random assignments for the evaluation of public programs designed for firms, such as those analysed in this paper, is generally not practical for a variety of reasons. First, public agencies are unable to refuse the concession of subsidies to eligible companies.[6] Second, often treated and non-treated firms differ in characteristics that affect the results of the program (i.e. selection bias).[7]

[6] In other words, a natural experiment cannot be designed in this framework because the concession of subsidies for eligible firms cannot be refused on the grounds of conducting an evaluative experiment.

[7] Consider a situation in which there exists a type of manager who is more likely to adopt measures which will improve the firm's results. It is probable that such a manager will seek public subsidies more actively than a manager who is satisfied with the current situation of her company. Thus, the improvements observed can be more closely attributed to management differences between firms than to the services provided by public programs.

The evaluation of public programs therefore requires an alternative method, a quasi-experimental approach which allows us to compare the results between two groups of companies: those which receive public subsidy (treated firms), and those that do not (non-treated firms), with the understanding, however, that not all the subsidies are randomly assigned. In other words, we construct a control group that has ex-ante the same probability of receiving a public subsidy in such a way that both treated and non-treated firms can be considered *as if* they have been randomly assigned.

If we consider receiving public subsidy as being the treatment effect, we can define the primary effect that we wish to capture as the expected treatment effect for the treated population, or ATT:

$$ATT = E(Y_1 - Y_0 | D = 1) = E(Y_1 | D = 1) - E(Y_0 | D = 1) \tag{1}$$

where, Y_1 is the outcome for firms which receive public subsidy and Y_0 is the outcome for recipient firms not exposed to the treatment, that is, firms who do not receive public subsidy. Finally, $D_i \in \{0,1\}$ is an indicator of participation ($D=1$ for the treated firms, $D=0$ for the non-treated firms).

As we mention above, receiving a public subsidy cannot be considered a completely random event and, therefore, $E(Y_0 | D = 1)$ is not observable and must be estimated given that is the counterfactual outcome that participants on average would experience if they do not to participate in the program.[8] To support this, matching econometric estimators, based on the seminal contribution of Lalonde (1986),[9] are shown to produce valid estimates of program impacts.

Using matching estimators we are then able to build a counterfactual sample of firms (the control group) by pairing each recipient firm with a non-treated firm.[10] As Rubin (1977) points out, a necessary assumption here is conditional independence between non-treated firms'

[8] Many evaluation techniques are based on regression equations which do not consider the counterfactual state of the results' variables (for instance, sales or revenues), or in other words, which do not compare the levels of these variables in the absence of public subsidies with those in the presence of such subsidies.

[9] Many studies examine the strengths and limitations of matching methods using non-experimental data, see for instance Dehejia and Wahba (1999, 2002) and Smith and Todd (2004).

[10] See section 3 for more details on the construction of both groups of firms, and on data requirements.

outcomes and program participation, conditional on observables (X).[11] The control group, therefore, is constituted by non-participant firms whose distribution of observed characteristics is as similar as possible to that of the treated firms. This requires:

$$0 < \Pr(D = 1 | X = x) < 1 \qquad \text{for} \quad x \in \tilde{X} \tag{2}$$

and guarantees that all treated firms have a counterpart in the control group.

An implementation problem arises when the vector X is highly dimensional, as it is in our case (see Section 3). Rosembaum and Rubin (1983) proposed the use of the probability (a scalar function) of receiving treatment conditional on covariates. This probability is the propensity score, $p(X)$. The matching method would estimate the ATT as:

$$ATT = E\{E(Y_1 | D = 1, p(X)) - E(Y_0 | D = 0, p(X) | D = 1)\} \tag{3}$$

Eq. (3) is derived from Eq. (1) with the requirement of an adequate balancing of pre-treatment variables. If this balancing hypothesis is fulfilled, observations with the same propensity scores must have the same distribution of observable characteristics which are independent of their treatment status. In other words, the establishment of a random exposure to the treatment and control groups.

Given that the propensity score is defined as the conditional probability of receiving a treatment given the pre-treatment characteristics, we estimate a probit model with the covariates estimation

$$\Pr\{D = 1 | X\} = \Phi\{h(X)\} \tag{4}$$

where Φ is the logistic function, and $h(X)$ is an initial specification which includes all the covariates as linear terms (see Greene, 2003 for more details).

As we clarify in Section 3, thirteen covariates are included in the initial specification. These can be broadly grouped in variables associated with the firms' characteristics, market-related variables, and classic productive factors.

[11] See for more details Rubin (1974 and 1977) or Angrist et al. (1996).

Once we calculate the propensity scores, we can use several matching estimators. We construct the match for each treated firm as a weighted average over the outcomes of non-participants, where the weights depend on the distances between estimated propensity scores. The more similar the firms are in terms of these propensities, the higher the weight. Here, we employ four matching alternatives: the Nearest Neighbour estimator (NNM), the Radius estimator, the Stratification estimator and the Kernel estimator (see Becker and Ichino, 2002 for technical details).[12] With the two groups of firms, "treated" and "non-treated", constructed using this methodology, we are now able to perform the first evaluation exercise defined in Eq. (1), which is to estimate the average treatment of the treated firms.

In a second evaluation exercise, we use the estimated propensity scores to construct various control groups (a robustness check)[13] which when combined with the treatment group allow us to estimate, through a regression model (see appendix 1), the impact of public subsidies conceded by CIDEM, measuring the difference in the evolution of certain results' variables (for instance value added, sales, or productivity) and controlling for other potentially influential factors.

3. Data

The main information source used in this paper is the *Sistema Anual de Balances Ibéricos* (SABI, hereafter). This database is a fully representative sample of firms in Spain and Portugal and contains accounting information at the firm level. It holds information on 838 076 Spanish firms, 182 004 of which are Catalan.[14]

The SABI database enables us to analyse the behaviour of a very wide sample of firms, as it contains information both on the variables which appear on a standard balance sheet, such as those referring to the firms' results, including revenue from activity and value added, as well as on the various measures of these results (from exploitation, from financial activities, from

[12] Briefly, the various matching estimators differ in their definition of closeness between a treated firm and its most similar non-treated firm in terms of the estimated propensity score.

[13] The various groups are constructed with different numbers of observations, that is, matching each treated firm with the one, two, and five most similar (with respect to the propensity score) firms from the control group.

[14] The availability of data from the SABI database increases with the size of the firm. For small firms the SABI includes less than 5%, although they represent 31.4% of the overall employment in that category. However, the SABI covers 31% of firms with more than nine workers, and more than half of the larger firms (55.3%). The importance of these figures shows that the sample of firms recorded in the SABI can be considered sufficiently representative of the population of Spanish (and Catalan) firms.

ordinary activities and/or from extraordinary activities). Information can also be derived from the ratio analysis: profitability (economic and financial), financial expenses, manoeuvre margin, treasury ratios and balance ratio, ratios of solvency, indebtedness, and liquidity (both general and immediate).

As we have the firms' postal codes, we can organize the information at a territorial level, and as such locate firms with increased precision. As the activity of each firm is classified according to the NACE-Rev.1 classification,[15] we can also disaggregate by sector. Finally, we can accurately define company size by examining information concerning the number of employees.

For our study, we collected data from the SABI database for the variables which we are interested in from two points in time: first from 2000, the year in which the subsidy was granted, and second from 2002, in order to determine if, over time, a significant impact from public subsidies on the main aggregates of firms had been felt.[16]

All the information required to construct the treatment group was obtained directly from CIDEM, while all the information needed for those firms that did not apply for a public subsidy, and thus were not recorded by CIDEM, was located in SABI. The total number of applications received by CIDEM in the year 2000 was 1 844, of which 821 were accepted.[17] We were able to locate 601 of the successful applicants in the SABI database, but we were not able to obtain the relevant information for all of them. Therefore, our study is conducted using 421 firms which received a public subsidy and for which there is complete information in the SABI database. This gives us a covering ratio (treated firms with all the relevant information with respect to the total number of treated firms) of 51.3%.

Our treatment group, then, is comprised of 421 firms which received a public subsidy from CIDEM. These companies are distributed by sector, by type of subsidy, as well as by location. In the sectoral dimension, the NACE-Rev.1 classification is used (two digits) and includes 60 economic activities.

As mentioned earlier, we use matching techniques for constructing a valid comparison or control group. We also choose those firms that have the same propensity to receive public

[15] Classification of Economic Activities in the European Community.

[16] The year 2002 is the last year for which we have most information for a high proportion of firms recorded in the SABI.

[17] We only have information for firms that finally received a public subsidy and not for the rest, i.e. those firms which unsuccessfully applied for a subsidy.

subsidies, given a series of characteristics of the firms, from the SABI database. Clearly, the first step in selecting firms that might have been considered for the control group involves eliminating all those companies that received a subsidy and all those companies that operate in economic sectors not represented by any firm in the CIDEM records (sectors in which firms did not apply for a subsidy). Therefore, we had the records of 66 763 firms from SABI, with the eventual group from which we could select (using matching techniques) the control numbering 32 011, after a process of elimination for those firms not eligible because data availability issues.

Finally, we selected the control group by using the estimated propensity score and as well as matching techniques. We estimate the scores using a probit estimation which included the covariates outlined in the section below.

3.1 Variables for determining the propensity to receive public subsidies

The variables used to estimate the propensity scores were selected on the basis of related empirical evidence and the information available in the SABI database. Previous studies have identified certain variables that can determine the propensity to obtain a public subsidy. Structural variables such as size, economic sector or location seem to be important here. Other studies have also identified as relevant information about the competitive position of the firm, its effort and orientation in innovation, management strategy, and the degree of internationalisation of the firm. Finally, studies based on multivariate models (see Bonnet, 2002) have considered, in addition to structural variables, aspects such as innovative behaviour, the characteristics of the market and the difficulties involved in obtaining financing for innovation.

Thus, the three groups of relevant variables that appear when analysing factors which influence propensity to receive a public subsidy are a firm's characteristics, market-related variables, and classic productive factors. Table A.1 in Appendix 2 presents the descriptive statistics from the variables used.

From the first group of variables, size (**L**), proxied by the number of workers, is one of the most commonly used, although the findings on the effect of this variable are unclear. Despite the presence of a number of public subsidies designed exclusively for SMEs, the hypothesis that public subsidy dispensation favours firms of smaller size is not confirmed in all the studies consulted (Heijs, 1999 and 2001; Arvanitis et al., 2002; and Almus and Czarnitzki, 2003). Some studies report positive discrimination in favour of SMEs, while others point out that bigger firms are more frequently the beneficiaries of public subsidies.

Another important variable here would appear to be the <u>economic sector</u> in which the firm operates. Previous studies suggest that public programs mainly benefit companies in highly dynamic sectors, but in studies of Spain, however, the empirical evidence is not conclusive. On the one hand, some analyses identify sectoral differences (Heijs, 1999, 2001; Busom, 2000), by reporting a low level of participation in public programs on the part of firms operating in traditional sectors (or sectors with low propensity for innovation), and a high level of participation among high technology firms and firms based in the R&D sectors. On the other hand, other studies report evidence of an absence of such sectoral differences (see Fernández et al., 1996). We include in the PSM estimation two dummy variables to control for the economic sector in which the firm operates: high technology manufacturing (**Dht**), and high technology services (**Sht**).

A third salient variable is a firm's <u>age</u> (**Years**), which is calculated as the number of years the firm has been operating in the market. We can therefore interpret this variable as an indicator of a firm's experience and the ability to obtain external resources (Busom, 2000; and Almus and Czarnitzki, 2003). Although it would seem that the explanatory power of this variable is generally poor, in Busom (2000) it is shown to be statistically significant and useful for explaining the propensity of firms to participate in public programs.[18]

<u>Location</u> (**Loc**) is another variable commonly taken into account in the literature. The results, however, do not seem to show a significant influence on the propensity to receive a public subsidy. In developed countries, where there are unquestionably more instruments to support private initiative, public instruments operate in one of two ways: either to support advanced regions (efficiency argument) or to support lagging regions (equity argument) where there is a greater need for public intervention. In case of Catalonia, these arguments can be translated into a dummy variable that distinguishes between firms located in the municipality of Barcelona (a central and comparatively territory) and the rest of the Catalan region.

Another frequently used variable which we adopt here is a firm's <u>property structure</u>. The hypothesis is that firms with a greater share of foreign capital are less likely to apply for (and hence obtain) local subsidies while firms with a higher percentage of shares in public sector hands appear to have a greater propensity to apply for a public subsidy, and in the case of Spain,

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[18] We also include a quadratic term for the effect of a firm's age on its propensity to receive a subsidy ($years^2$) in order to capture any possible non-linearities in the relationship.

these hypotheses appear to have been confirmed.(see Busom; 2000). Moreover, Almus and Czarnitzki (2003) show that firms belonging to an entrepreneurship group have a greater propensity to apply for subsidies than "independent" firms. We use an indicator of independence (**Inin**) directly provided by SABI, which takes the value 1 if any shareholder has more than 25% of the total number of shares.

Although the literature considers it important for determining the innovative behaviour of firms, few studies have quantified and analysed the role of management in a firm's propensity to request or receive a subsidy.[19] In this study, we use a diversification variable to (partially) proxy the management strategy, given that diversified firms (firms with a more ample range of products) might be more interested in public subsidies than specialised firms, as it can be argued that the purpose of a subsidy is more likely to coincide with the activity of a diversified company than with that of one more specialised. Here, we use the number of subsidiaries as an indicator of the degree of diversification of a firm (**Nsub**).

A final important variable in this group is credit constraints which appear to be an important determinant of a firm's propensity to apply for a public subsidy. First, because the firm may be more likely to seek financing in the public sector if it encounters difficulties in the private sector, and second, because some subsidies are specifically addressed to firms for which credit constraints act as a barrier to certain activities, among these innovation. We proxy credit constraints with the firm's solvency ratio (**Solv**).

The second group of variables, the market-related variables, which might affect the propensity of a firm to receive a public subsidy, serve to control for the competitive atmosphere in which firms operate, although many studies do not include this type of variable because of the difficulties involved in obtaining relevant data. Here, we analyse two aspects of the competitive atmosphere; firstly the degree to which the firm has opened up internationally as a proxy for the level of competitiveness, and secondly the investment capacity of the firm.

In common with other studies (Heijs, 1999 and 2001; and Busom, 2000), we consider a firm's exports to be its measure of competitiveness. Firms with a high propensity to export appear to be more likely to participate in public programs since such activities as R&D are of strategic importance to a firm's ability to compete and remain in the market. Additionally, the government might be more likely to support these firms given their potential to transfer innovation to the rest of the economy. Unfortunately, as we do not have data on the value or

[19] One of the main reasons for not including this variable is the difficulty involved in reflecting the notion of management in a single variable.

volume of exports and/or imports, we make use of two dummy variables; one which indicates whether the firm exports (**Exp**) and another which indicates whether the firm imports (**Imp**).[20]

The second variable of this group which we consider is a firm's investment capacity, directly related to its development process and to the evolution in its main markets.[21] It is important to control for this variable when analysing the propensity to obtain a public subsidy since firms with a greater investment capacity are more likely to invest more heavily in R&D and therefore do not retain any evident need for a public subsidy. To capture this effect, we use the capital requirements variable (**Creq**) taken from the SABI database.

Finally, it is worth noting that many of the studies mentioned up to this point report that the firms which participate most in public programs tend to be the most innovative. In this study, however, given the limitations of our database, we have been unable to include any variables related to firms' innovation. Nonetheless, it seems clear that the classic productive factors play a role in the determination of the competitive capacity of firms, and consequently in their results. For this reason, we have included a firm's capital (**K**) and intermediate inputs (**M**) in the estimation of its propensity to obtain a public subsidy. In addition, we use the labour factor, a factor already incorporated in the first group of variables.

4. Main results

With the dataset outlined above, we first estimate a probit model to obtain the propensity scores (section 4.1) for each firm. Second, using these scores and various matching techniques to obtain the control group, we calculate the average benefits to the treated firms (ATT) by examining the effects of public subsidies on a firm's results (section 4.2). Third, and for various control group sizes, we use a regression technique to evaluate the impact of the different public programs aimed at promoting the performance of Catalan firms (section 4.3).

4.1 Determinants for receiving public subsidies

The results of the probit estimation used to calculate the propensity scores (PS) are presented in Table 1 for three different specifications (denoted by SP1, SP2 and SP3, respectively), enabling

[20] This lack of data concerning the value or volume of exports/imports prevents us from constructing, for instance, an import activity variable, which might also capture the pressure of foreign competition in the domestic market.

[21] Firms usually invest heavily in modernization and innovation during these processes.

us to check their robustness. Of the variables considered in the previous section, some do not appear in Table 1 as their presence violates the requirements imposed by the calculation of the PS (Loc, Nsub, Solv and Creq).[22]

Briefly, the variables that determine the propensity to be awarded public subsidies from CIDEM are stable across the three different specifications shown. The variables which prove significant in all specifications are those variables related to a firm's characteristics. First, the variables that accounts for high technology sectors: manufacturing (Dht) and services (Sht) variables are highly significant, indicating that firms operating in these sectors have a greater propensity to receive subsidies. Second, export activity (Exp) is also significant, which indicates that firms facing external competition are more likely to be subsidised in order to transfer their technology to international markets, or simply to maintain their competitiveness both domestically and internationally. Finally, the number of years that a firm has been operating (proxy for organizational capacity and experience) is also statistically significant. In this case, we also include the square of the number of years' term so as to capture the effects of the learning curve; our results show an inverted U relationship, indicating that the propensity to receive a subsidy increases with the age of the firm up to a certain point and then subsequently decreases.

[22] Not all the specifications satisfy the requirements to construct the PS. In Table 1, therefore, we only present the variables that satisfy these so-called balancing conditions. For the technical details of this method, see Becker and Ichino (2002).

Table 1. Propensity to receive a public subsidy

	SP1		SP2		SP3	
Constant	-6.4531	***	-5.7685	***	-6.4821	***
	(-20.36)		(-26.27)		(-20.16)	
Years	0.0452	***	0.0484	***	0.0448	***
	(3.26)		(3.49)		(3.21)	
Years^2	-0.0006	***	-0.0006	***	-0.0006	***
	(-2.82)		(-2.91)		(2.78)	
VA	0.2718	***			0.2762	**
	(3.77)				(2.48)	
L	-0.1237		0.0561		-0.1485	*
	(-1.51)		(1.02)		(1.75)	
K					-0.0192	
					(-0.23)	
M			0.0863	**	0.0343	
			(2.48)		(0.80)	
Inin	0.5138	**	0.5643	**	0.5189	**
	(2.11)		(2.32)		(2.13)	
Imp	0.2527		0.2341		0.2354	
	(1.52)		(1.40)		(1.41)	
Exp	0.3281	**	0.3361	**	0.3196	**
	(2.03)		(2.08)		(1.98)	
Dht	0.6715	***	0.6973	***	0.6645	***
	(4.98)		(5.18)		(4.92)	
Sht	0.8624	***	0.9312	***	0.8974	***
	(2.99)		(3.22)		(3.09)	
Log-Likelihood	-2189.6		-2167.5		-2162.8	
Pseudo R^2	0.025		0.024		0.026	

Notes: t-statistics in parentheses. *, ** and *** indicate statistical significance at the 90, 95 and 99 percent levels, respectively. Data are for the year 2000. The number of observations was 32,431. The dependent variable is 1 if the company receives a public subsidy and 0 otherwise. Estimation carried out with a probit model. Inin is 0 if the company has one or more shareholders with more than 25% of the shares. Imp is 0 if the company does not import. Exp is 0 if the company does not export. Dht is 0 if the company is not part of a high technology manufacturing sector. Sht is 0 if the company is not part of a high technology services sector.

From Table 1 we can conclude that sectoral differences are highly significant in determining the propensity of a firm to receive a public subsidy. This indicates that public subsidies in general (without specifying program type or origin) are mainly directed towards high technology sectors. This result confirms previous empirical findings for both Spain (Heijs, 1999 and 2001; Busom, 2000), as well as other countries (Arvantis et al., 2002; Almus and Czarnitzki, 2003; Czarnitzki and Fier 2002), which indicate that certain sectors, most prominently high tech, participate more actively in public programs than others.

We can also see that while structural variables, such as a firm's size and independence indicator, influence its propensity to obtain a public subsidy, location and difficulties encountered in financing managerial activities (credit constraints) do not appear to have an impact. For this reason, we do not include the latter variables in the determination of the propensity scores.

In the case of market-related variables, a firm's investment capacity seems to have no impact on the propensity score, while in the case of the classic productive factors, their relevance is found to be small and not very significant. For instance, capital (K) only entered in SP3, and is not significant, while intermediate inputs (M) is only significant in SP2.

Size, proxied by the number of employees, is not significant in the first two specifications, but in the third we find it to have a negative and significant influence on the propensity. It seems, then, that SMEs do receive public subsidies with a greater frequency than big firms. This finding contradicts usual reports for this variable both in the Spanish case (Fernández et al., 1996; Heijs, 1999 and 2001; Zubiaurre, 2002) as well as in the cases of other countries (Almus and Czarnitzki, 2003; Czarnitzki and Fier, 2002). In fact, a classic result from the literature is that a 10% increase in the size of a company typically implies a 0.7% increase in the probability of participating in public programs. We cannot consider, however, the results we present here for size in SP3 as being robust given the poor performance of this variable when changing specification.

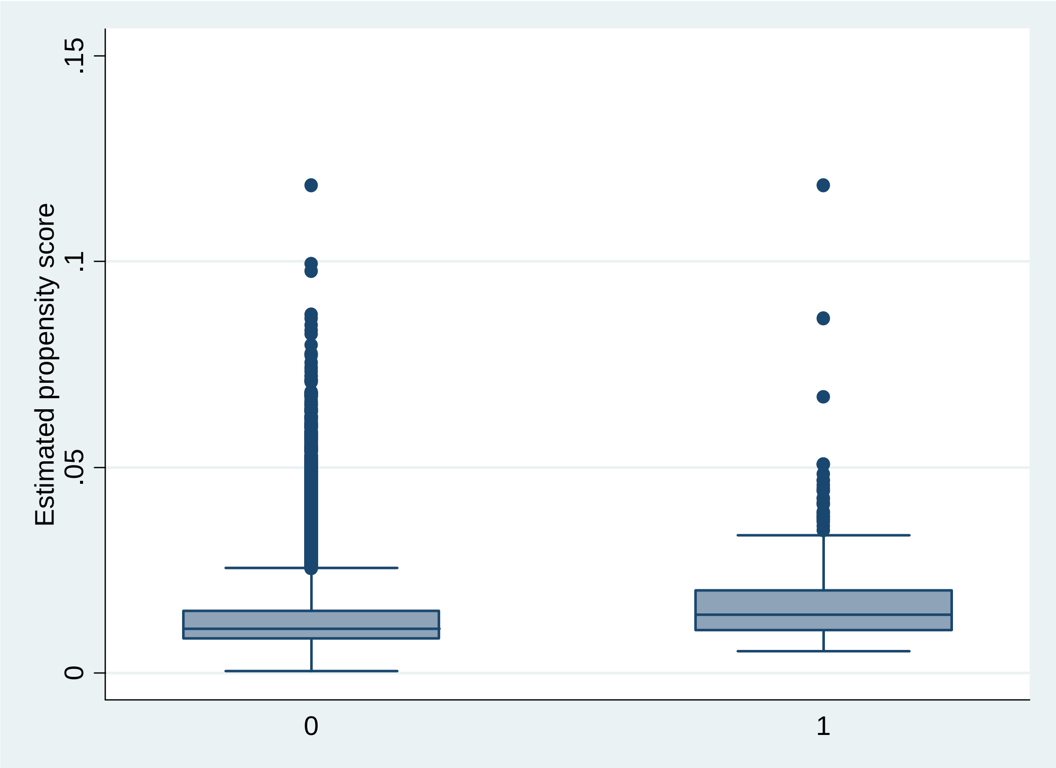
4.2 The effects of public subsidies on a firm's performance: a first approximation

After analysing and controlling for observable differences between groups of firms, we then estimate the average effect of public subsidies on the value added growth rate of the treated firms. Our results for the third specification (SP3 in Table 1) presented in the previous section are summarized in Table 2.[23]

In order to estimate the average effect of the treatment, we use an area of common support, which enables us to eliminate those firms that present poor matching (see Figure 1). The sample of firms varies according to the proposed estimator, as companies can never be identical, and so the size of the control group is non homogeneous. Moreover, as the requirements that have to be met when calculating the different estimators vary, the number of firms in the treatment group also varies. Thus, the number of firms receiving a subsidy is 417 (or 416 in the case of the Radius estimator), with the control group oscillating between 414 in the lowest case (Nearest Neighbour estimators) and 30 603 in the highest case (Stratification and Kernel estimators).

[23] The estimators for SP1 and SP2 are presented in Tables A.2 and A.3 in Appendix 1.

Figure 1. Box-Plot of treatment and control distributions of predicted propensity scores (using specification 3 in Table 1)



Source: Own elaboration.

The average effect of the public subsidies granted by the Catalan government is, in most of the cases, significantly different from zero. In the period 2000-2002, the treated firms recorded a value added growth that was, on average, between 3.5 and 5.6% higher than that of non-treated firms. Table 2 shows that the parameters obtained by means of nearest neighbour estimators, NNM(1) and NNM(2), are not statistically significant, but remain significant in all the other cases.

Significant estimations show that treated firms present value added growth rates that are 3.5% higher in the case of the Kernel estimator, 4.4% higher in the radius estimator, and 5.6% higher in the stratification estimator than non-treated firms. It seems, therefore, that the inclusion of more companies increases the statistical significance of the estimators (bearing in mind, of course, that the requirements for the construction of the control group differ according to the estimator used).

Table 2. Average effect of subsidies on firm's performance for SP3

	ATT	t-statistic A	B	Firms T	C
NNM (1)	0.017	0.7	0.606	417	414
NNM (2)	0.011	0.436	0.439	417	414
Radius	0.044	2.307	2.246	416	10 316
Stratification	0.056	-	3.091	417	30 603
Kernel	0.035	-	2.034	417	30 603

A – t-statistic (analytic)
B – t-statistic (bootstrapping)
T – Treated firms
C - Control firms
(1) Nearest neighbour with random selection
(2) Nearest neighbour with identical weights
Source: Own elaboration.

These results appear robust, as the estimators obtained for the other specifications considered in Table 1 to obtain the PS (SP1 and SP2 in Tables A.2 and A.3 in Appendix 2) confirm. Effectively, nearest neighbour matching parameters are not statistically significant, but with other estimators the parameters present a variation ranging from 3.5% in the Kernel estimator and 5.7% in the stratification estimator for SP1 and 2.5% and 4.4% for SP2. Moreover, we always find the radius estimator to lie somewhere between the two extremes (the kernel and stratification estimators).

In short, Table 2 shows that the subsidies granted by CIDEM have a positive effect on the value added growth rate of firms which receive them. It is clear that the organisational, managerial and other internal changes necessary to ensure the successful implementation of the projects for which they receive the subsidy makes companies more dynamic and competitive, and that this is manifested in a growth differential when compared with those firms that did not receive subsidies.

4.3 The impact of public subsidies on value added growth

In this section, we conduct a second evaluation of the public programs available to Catalan firms. Our ATT results show that, on average, firms that receive subsidies are more dynamic. However, the matching technique we adopt does not discriminate by sector or by any other variable as it simply uses the estimated PS. In this section, we perform a new matching exercise.

First, we separate firms by sector and, then, to construct the control group, we matched up the most similar firms within each sector according to the PS. We perform this matching on three levels:

i) 1:1 matching: we match a firm receiving a subsidy with the most similar firm from the same sector according to the PS.
ii) 1:2 matching: for each treated firm we identify the two most similar firms in the same sector.
iii) 1:5 matching: we identify five control firms for each treated unit, although always selecting from the same sector of activity.

We identify these three different control groups in order to determine the threshold of similarity between treated and non-treated units. The hypothesis we formulate is that if there is no average treatment effect differential between the treated unit and its most equal control group (that is, with a 1:1 matching), then both groups are so equal that non-treated firms will be seen to carry out projects similar to those of treated firms but financed by non-public sources in order to maintain their competitiveness. This holds, however, only in the case of a significant average effect differential with the larger control groups, and determines the real effect of the subsidies. Should there be no average effect differentials of public subsidies between the treated group and the largest of the control groups (1:5), then we are left with the indication that public programs to promote a firms' competitiveness are ineffective. We use this approach for checking the robustness of the results, and estimate using regression techniques for the production function presented in Appendix 1, as well as the different control variables presented in section 3.

Table 3. Impact of public subsidies on value added growth

	Control group					
	(1:1)		**(1:2)**		**(1:5)**	
Constant	1.16	***	1.3362	***	1.4319	***
	(11.89)		(16.62)		(25.03)	
ΔL	0.5407	***	0.5560	***	0.5205	***
	(16.37)		(20.86)		(28.11)	
ΔK	0.3334	***	0.2943	***	0.3227	***
	(10.47)		(11.76)		(17.86)	
L_{t-1}	0.2889	***	0.3221	***	0.3471	***
	(11.03)		(14.61)		(22.04)	
VA_{t-1}	-0.3003	***	-0.3446	***	-0.3683	***
	(-12.24)		(-16.9)		(-25.28)	
Inin	-0.0367		-0.0015		0.0131	
	(-0.37)		(-0.12)		(0.14)	
Nsub	0.017		0.0239	*	0.0328	***
	(1.30)		(1.99)		(3.29)	
Loc	0.0304		0.0359		0.0861	***
	(0.65)		(0.86)		(2.72)	
Exp	0.0138		0.0263		0.1584	***
	(0.22)		(0.43)		(3.21)	
Dht	0.0433		0.0303		0.0096	
	(1.11)		(0.94)		(0.42)	
Sht	-0.0195		-0.0458		-0.0458	
	(-0.24)		(-0.68)		(-0.96)	
T	0.1025	***	0.1325	***	0.1011	***
	(2.70)		(4.10)		(3.79)	
N	826		1239		2478	
F	56.13		92.77		184.71	
Adjusted R^2	0.424		0.449		0.449	

Note: t-statistic in parentheses. *, * * and *** indicate statistical significance at the 90, 95 and 99 percent levels, respectively. The dependent variable is value added growth between 2000 and 2002. Estimates carried out by means of ordinary least squares. Inin is 0 if the companies have one or more shareholders with more than 25% of the shares. Loc is 0 if the company is located outside the municipality of Barcelona. Exp is 0 if the company does not export. Dht is 0 if the company is not part of a high technology manufacturing sector. Sht is 0 if the company is not part of a high technology services sector. T is a dummy variable that takes the value 0 if the firm did not receive a subsidy.
Source: Own elaboration.

As Table 3 shows, we observe that the change in the number of employees (ΔL), the change in the capital stock (ΔK), along with the value added (VA_{t-1}) and the number of employees (L_{t-1}) for the base year are highly significant. The variables that capture the variation in the quantities of the productive factors (K and L) are positively related with the firms' value added growth rate. In addition, as we successively use control groups containing more firms, the estimated parameters remain constant as the number of observations increases.

Our results show that both firms with a higher number of employees in the initial period and firms with smaller value added in the initial period grow rapidly. This result points to the idea that once firms have reached a certain level of value added, it is more difficult to find mechanisms which allow high growth rate to be maintained. In other words, firms with low value added have a greater margin in which to increase this factor at higher rates than firms that have already achieved a high level of value added. We should stress that the definition of value added that we use here refers to the increase in the value of a firm's products, calculated as the deduction of intermediate costs from the production value.

When using all three control group sizes, we obtain a significant effect for the variable that accounts for a firm receiving a public subsidy or not. This result is highly robust to the three sets of estimations presented. When we consider a narrow control group, in which each firm is matched to its most similar control, public subsidies are significant with an elasticity of around 10%. When we expand the control group to consider more than one match per firm, 1:2 and 1:5 respectively, we find that public subsidies are statistically significant and they have a positive and significant impact on the determination of differential growth in value added for recipient firms in the period under analysis. The results also indicate that the optimal threshold for controlling the average effects of public subsidies is that of the 1:2 matching and that the regression in this case gives the best results in terms of precision.

The results presented in Table 3 show that, in general, both the variables which define a firm's characteristics as well as its market-related variables are not significant when explaining value added growth for the 1:1 and 1:2 control groups.[24] Only when the control group is increased to a 1:5 relationship do these variables appear significant. Specifically, these variables are the number of subsidiaries (Nsub), defined as a measure of differentiation, which indicates that diversified firms grow faster, location (Loc) which signifies that firms in the municipality of Barcelona also grow faster and, finally, the exports variable (Exp) which indicates that exporting firms also show higher growth rates for value added. Finally, it is worth noting that the dummy variables controlling for high technology manufacturing and services sectors are not significant, indicating that there is no differential growth rates for these two groups of firms.

Public subsidies, therefore, can be seen to have a positive and significant impact on the value added growth of the firms which received them.

Given that the objective of subsidies is the promotion of quality, R&D activities, managerial information services and the strengthening of managerial cooperation between firms as a mechanism for the enhancement of their competitiveness and, hence, market positioning and

[24] The only exception is the number of subsidies in the regression with the 1:2 control group, which is significant at a 10% level of confidence and shows a positive sign.

results, we can verify that the firms which receive a subsidy become more dynamic. This is something which becomes apparent when their growth differential is compared with firms which did not receive a subsidy.

5. Conclusions

In this paper, we carry out an evaluation exercise to analyse the impact of public subsidies whose aim is to improve the performance of Catalan firms. An important element for such an evaluation exercise is that it fulfils the requirements necessary for a counterfactual design based on the construction of a control group which allows for the accurate measurement of the effects of such subsidies.

As such, the Propensity Score Matching methodology is used to build up a control group comprised of firms which do not receive a subsidy, but which can be considered as the closest matches to their treated, or recipient, counterparts. This method allows us to evaluate the impact of public subsidies through the Average Treatment of the Treated.

The propensity scores obtained here indicate that variables such as age, sector (especially high-tech), property structure, and export activity of firms positively affect a firm’s propensity to receive a public subsidy, and that the results seem to be robust to different specifications. Using the propensity scores in an initial attempt to estimate the effects of public subsidies, we find that, on average, the firms which received a subsidy in the year 2000 recorded a higher growth rate of value added during the period 2000 - 2002.

Furthermore, in a second step, we estimate a production function at the firm level for the treatment and control groups (the latter we create with the estimated propensity scores), and find that the public subsidies managed by CIDEM have a positive impact on the growth rate of the value added for recipient firms. This positive and significant impact, bearing in mind the construction of the control groups, suggests that the results are robust and that, indeed, public subsidies promote growth differentials between treated and non-treated firms.

These conclusions must be framed within a comprehensive evaluation of the subsidies conceded by CIDEM for the promotion of local firms. Although the rigorous approach which we present here yields credible estimates of program impacts, in the absence of random experiments, causality can always be called into question, particularly given potential selection bias. While the construction of the control group and the specification of the model that we use in this evaluation helps to minimize potential bias, future efforts need to address this problem more exhaustively. The explicit modelling of the selection process using longitudinal data awaits further attempts by those interested in measuring the impact of public subsidy programs.

Appendix 1

Our aim is to estimate the variation in the firms' results, focusing our attention on the effect of public subsidies. We use a modified Cobb-Douglas production function, where production (*Q*) is a function of labour (*L*), capital (*K*) and materials (*M*), as well as of the specific effects for each firm (*F*) and industry (*I*):

$$Q_i = f(L_i, K_i, M_i, F_i, I_i)\,, \tag{A.1}$$

subtracting materials (M) from each side of the equation yields:

$$V_i = Q_i - M_i = f(L_i, K_i, F_i, I_i)\,, \tag{A.2}$$

where V_i is the value added of firm *i*.

Since we are interested in estimating the contribution of public subsidies from CIDEM to a change in firms' value added, we adopt a growth accounting framework. By first taking the differences in the production function in (A.2) we obtain the following relationship:

$$\Delta_t \log V_i = \Delta_t \log L_i + \Delta_t \log K_i + F_i + I_i\,, \tag{A.3}$$

where value added is expressed as the change between two years: 2000 and 2002. The specific effects for company and sector are also assumed to be fixed in the growth equation and, therefore, they are not represented in terms of a variable of change.

To control for specific effects at firm level, we include the logarithm of the total number of workers and the logarithm of the value added, both for the base year. The first variable controls for the initial firm size, while the second controls for the initial levels of competitiveness and positioning in the market. Formally, the estimated equation appears thus:

$$\Delta_t \log V_i = \Delta_t \log L_i + \Delta_t \log K_i + \log VE_i + \log E_i + I_i + e_i\,, \tag{A.4}$$

where $\Delta_t \log V_i$ is the change in the logarithm of value added, $\Delta_t \log L_i$ is the change in the logarithm of the number of workers, $\Delta_t \log K_i$ is the change in the logarithm of capital, $\log VE_i$ is the logarithm of the value added in the initial year, $\log E_i$ is the logarithm of the number of workers in the initial year, I_i is set of dummy variables to control for certain characteristics of the participating firms, and, finally, e_i is an error term.

To conclude, we introduce the variables related to public subsidies (denominated as *T*) to estimate their effects on the growth rate of value added for recipient firms compared with non-recipient firms:

$$\Delta_t \log V_i = \Delta_t \log L_i + \Delta_t \log K_i + \log VE_i + \log E_i + I_i + T_i + e_i \,. \tag{A.5}$$

T denotes dummy variables that take the value 1 if the firm received a subsidy (treated) and 0 if not.

Appendix 2

Table A.1 Summary statistics

	Treated				Non treated			
	Mean	**Std. Dev.**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Max**
L	25.6	36.7	1	465	29.6	169.8	1	15 003
K	3 759.2	6 252.2	72.4	57 809.1	6 499.8	10 8470.3	3.3	11 400 000
M	2 353.5	4 209.7	0	43 262.7	3 317.8	45 873.1	0	5 024 350
Dht	0.2	0.4	0	1	0.1	0.3	0	1
Sht	0.0	0.2	0	1	0.0	0.1	0	1
Years	19.0	10.9	5	71	16.3	10.2	5	107
Loc	0.2	0.4	0	1	0.1	0.4	0	1
Inin	0.0	0.2	0	1	0.0	0.1	0	1
Nsub	0.4	1.6	0	17	0.3	2.3	0	226
Solv	30.3	22.8	-130.6	90	28.9	32.1	-948.8	100
Exp	0.1	0.3	0	1	0.1	0.2	0	1
Imp	0.1	0.3	0	1	0.1	0.3	0	1
Creq	44.8	127.8	-93.4	952	45.9	134.8	-99.9	996
N	421				32011			

Source: Own elaboration.

Table A.2. Average effect of subsidies on firm's performance for SP1

		t-statistic		Firms	
	ATT	A	B	T	C
NNM (1)	0.011	0.446	0.434	421	420
NNM (2)	0.002	0.070	0.081	421	420
Radius	0.045	2.388	2.297	420	11 089
Stratification	0.057	-	2.527	421	31 309
Kernel	0.035	-	1.946	421	31 309

A – t-statistic (analytic)

B – t-statistic (bootstrapping)

T – Treated firms

C - Control firms

(1) Nearest neighbour with random selection

(2) Nearest neighbour with identical weights

Source: Own elaboration.

Table A.3. Average effect of subsidies on firm's performance for SP2

		t-statistic		Firms	
	ATT	A	B	T	C
NNM (1)	-0.007	-0.257	-0.274	417	417
NNM (2)	-0.005	-0.196	-0.230	417	417
Radius	0.034	1.695	1.907	415	11 237
Stratification	0.044	2.346	2.137	417	30 704
Kernel	0.025	-	1.344	417	30 704

A – t-statistic (analytic)

B – t-statistic (bootstrapping)

T – Treated firms

C - Control firms

(1) Nearest neighbour with random selection

(2) Nearest neighbour with identical weights

Source: Own elaboration.

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