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SMEs PERFORMANCE AND PUBLIC SUPPORT FOR INTERNATIONAL RJVs

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Abstract

The objective of the present study is to analyse the impact of public support for international RJVs on SMEs performance considering two dimensions: technological and economic results**.** The investigation is also intended to examine the time pattern of this effect. For that purpose, we use a panel data set containing information about Spanish participants in research joint ventures supported by the SME-specific measures of the sixth Framework Programme. Empirical evidence corroborates a direct and positive impact on technological assets of participants. On the part of the economic indicators, EBITDA per employee and real sales are positively influenced by the improvement of technological background. The same results are found for productivity. All those effects are effective in the medium term, confirming that SMEs use to be involved in market-oriented R&D projects.

Keywords: research joint ventures, SMEs, impact assessment

J.E.L. Classification: H81, L2, O3

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1. Introduction

In general, empirical literature on R&D cooperation concludes that big companies have a greater probability to cooperate, due to their higher technological capability and the considerable scope of their R&D projects (Bayona et al., 2001; López, 2008). Nevertheless, current trends indicate that cooperation is taking a relevant roll within corporative strategies of innovative firms, regardless of their size. The increasing dynamism of SMEs in intensive industries, such as biotechnology and ICT, cooperating with other companies and with research institutions, illustrates this fact. Although the percentage of firms cooperating on innovation activities is much higher considering large firms, the available data (OCDE, 2009) show a relevant activity of SMEs in some countries such as Finland (28% of all SMEs cooperate), Austria (18%) or France (24%, considering only manufacturing SMEs).

Public policies aiming to encourage cooperation between SMEs and research centers have been implemented by the R&D Framework Programme of the European Union (FP) since its third edition, being strongly reinforced in the fifth and the sixth ones. SMEs can be supported by the classical actions, such as Integrated Projects or Specific Targeted Research Projects, but also through the specific measures for small companies. These measures follow two schemes. The Cooperative research scheme supports European SMEs with a specific research objective or need but without (or limited) technological capacity. Thus, a great part of the technological development will be done by the R&D performers involved in consortia. SMEs own all intellectual property rights resulting from the project but R&D performers may benefit from preferential use of the outcomes. The Collective Research scheme is similar, but specifically oriented to SMEs associations. Both schemes follow a bottom-up approach and there is neither thematic nor technological priority set up by the European Commission. Under the sixth FP, the evaluation criteria stress the business interest of the project and not only its technological novelty.

According to qualitative analysis carried out under the auspices of the European Commission, a high percentage of supported SMEs reach their own goals (European Commission, 2010). Nevertheless, this approach is not able to quantify at what extend this aid improve firms performance. The objective of the present study is to analyze whether public support for research joint ventures (RJVs) have a positive impact on SMEs performance considering two dimensions: technological and economic results. With this approach, we study a set of key performance indicators. Our investigation is also intended to examine the time pattern of these effects, in case they exist.

The empirical research is divided in two phases. First, through the estimation of a knowledge production function, we measure the impact of the SMEs participation in R&D consortia supported within the FP on technological results, proxied by intangible fixed assets. Second, we analyze whether the participation has also a significant impact on three economic performance indicators: real sales, EBITDA and labour productivity.

For this purpose we integrate two data sets. The first one, owned by the Center for the Development for Industrial Technology (CDTI, the public organism in charge of monitoring the participation of Spanish firms within the FP), contains much relevant information about the SME-specific measures of the sixth FP (rejected and supported projects) and the participants. The second one is the SABI database, which consists of company accounts for over 1,000,000 Spanish firms. The resulting database could be considered an original and powerful instrument to measure the impact of the FP on economic performance for a period large enough to capture the medium and long-term effect of the FP R&D projects.

Overall, we compile a homogeneous sample that consists of an unbalanced panel of 41,800 observations, 10,450 companies, and 1,526 proposals. Available data allow us to consider variables related to the characteristics of consortia (leadership, geographical origin of partners, technological area) and the economic performance of SMEs.

Our results corroborate a direct and positive impact of SME-specific measures on technological assets of participants. Labour productivity, real sales and EBITDA are also positive influenced by the improvement of technological background. All these effects are effective in the medium term, confirming that SMEs use to be involved in market-oriented R&D projects. From the aforementioned results and complementary evidence obtained in this paper, some conclusions will be drawn regarding the interest of policy makers.

The rest of the paper is organized as follows. Section 2 summarizes previous evidence about the impact of cooperative agreements by SMEs. Section 3 describes the empirical model and the data. In Section 4, we present the results and, finally, section 5 concludes.

2. SMEs and technological agreements

Empirical papers based on the resources-based theory and the absorptive capacity approach corroborate that internal technological competences facilitate the access to resources generated outside the firm (Cohen and Levinthal, 1990). In particular, external knowledge could be internalized by innovative firms throughout technological alliances. As empirical evidence shows, the probability of a firm to be involved is this type of alliances is positively related to its own R&D competences. Although this affirmation is generally confirmed by researchers, there is no clear consensus about how to measure internal capacity. As we will see, this discussion determines our understanding of the core topic of the present paper: the participation of SMEs in subsidized RJVs.

Frequently, R&D capacity has been related to firm size, assuming that it is necessary a critical mass of resources to generate and maintain R&D assets. In this regard, empirical evidence confirms that big companies have a higher probability of participating in RJVs (Bayona et al., 2001; Cassiman and Veugelers, 2002; Miotti and Sachwald, 2003; Negassi, 2004; López, 2008).

In line with these evidences, statistics show that SMEs tend to collaborate less than large firms (OCDE, 2009). This fact can be explained by disadvantages related to the setting up of communication channels with R&D organisations (Rothwell and Dodgson, 1991) and by the high risk associated to the partner selection. Therefore, outsourcing could be a suitable alternative for many SMEs (Narula, 2004), although the lack of financial resources negatively affects the probability of gathering external knowledge, wherever its origin is (Bougrain and Haudeville, 2002).

However, other authors stress that, in spite of (or because) their smaller size, cooperation is a core strategy for innovative SMEs aiming to acquire external resources and, doing so, to compete with big companies (Audretsch and Vivarelli, 1996; Rothwell and Dodgson, 1991). Collaboration could be so important that a "*firm's competitiveness may in fact be determined more by its external network than its size*" (Narula, 2004). Therefore, the effect of size on collaboration should be qualified by the positive influence of other factors, such as the existence of an own R&D unit (Kleinknecht and van Reijnen, 1992); the relative importance of R&D personnel (Belderbos et al., 2004); the previous experience in collaboration (Hernán et al., 2003) or the number of registered patents (Colombo et al., 2009). Taking a step forward, Barge-Gil (2010) considers not only the frequency of collaboration, but also the type of firms for which cooperation is more relevant. Using a sample of firms with internal R&D activities, he concludes that companies outside high-tech sectors and smaller firms with greater needs of external knowledge have a higher probability to be cooperate-based innovators. Thus, the decision to cooperate seems to be influenced by a combination of internal capacity and external needs.

Absorptive capacity has also been considered a key factor to explain the access to international networks. Costs associated to geographical distance could decrease if the cognitive distance between partners is lower. For a sample of high-tech small firms, De Jong and Freel (2010) demonstrate that increasing R&D expenditure is associated with geographically distance collaboration. This research is focused on a specific type of SMEs, characterized by a higher technological capacity. A more extensive analysis of international technological alliances reflects that European SMEs are more focused on intra-EU and intra-country networks than big companies (Belderbos et al., 2004). In this line, Barge-Gil (2010) corroborates that being involved in international partnerships is negatively correlated to the frequency of collaborations. These results reflect that, despite the improvements in communication and information technologies, costs associated with geographical distance still matter, especially for SMEs with a medium or low technological level.

The complex nature of collaboration is present also in the impact assessment literature. Although the theory states clearly that collaboration improves firms' innovativeness, empirical research faces many obstacles to measure the effect of R&D partnerships on firms' performance, mainly because of the lack of suitable and homogeneous indicators.

Following the resource-based theory, cooperative and in-house R&D activities are considered complementary strategies aiming to increase technological capacities of firms. In order to measure this effect, many authors build objective performance indicators related to technological capabilities (mainly from patents databases) and conclude that R&D partnerships have the predicted positive effect on internal capacity (Mowery et al., 1998; Branstetter and Sakakibara, 2002; Scott, 2003). Other papers find a positive relationship between cooperation with universities and research centers and innovation output measured by the volume of sales due to new products (Lööf and Heshmati, 2002; Faems et al., 2005; Lööf and Broströn, 2008) or the number the publications (Schwartz et al., 2012).

Empirical evidence also seems to corroborate that, taking into account different types of partners and different cooperation objectives, the more market-oriented the project is, the higher the probability of finding positive economic effects (Benfratello and Sembenelli, 2002; Cincera et al., 2003; Belderbos et al., 2004; Bayona-Sáez and García-Marco, 2010).

For the specific case of SMEs, Bougrain and Haudeville (2002) do not find a significant effect of cooperation in innovation success (measuring success as not having incidences in the development of supported projects). Other authors explore new perspectives aiming to measure the theoretically positive effect of cooperation on SMEs. Nieto and Santamaría (2010) draw a comparison with big companies and conclude that technological partnerships could improve the innovativeness of SMEs compared to that of large firms. They also find a significant pushing effect of collaboration on non-innovative SMEs, which decide to start to innovate with partners. Kaiser and Kuhn (2012) support this favorable result for SMEs: although for the whole sample of participants in the Danish

Innovation Consortia program, the membership increases the number of patent applications, there are no statistically significant effects for large firms.

Literature shows a growing interest in analysing the collective of new technology-based firms (NTBFs), since they are a clear example of SMEs with great R&D internal capacity and with high constrains of resources. Colombo et al. (2009) find a positive relationship between the number of partnerships and NBTFs performance (measured by total factor productivity). They remark that this effect increases when industrial partners are located in countries which are in the forefront of knowledge generation.

In general, the literature confirms the existence of a positive relationship between R&D cooperation and innovative results, but the effect on economic performance is not so evident. This conclusion is also valid for the case of cooperative projects carried out under the FP scheme. However, in this case innovative or economic results can be affected not only by the spillovers of the cooperation among European firms but also by the impact of public financing on their private expenditures.

There are few papers which integrate both literatures (technological cooperation and impact assessment of public aid) while considering R&D collaboration and R&D public support as alternative instruments to increase technological results. Czarnitzki et al. (2007) is an exception. They interpret RJVs and subsidies as heterogeneous treatments for a sample of German and Finnish firms. Using matching techniques, they find that the combination of both treatments has a positive impact on the firm's R&D expenditures or the number of patents. And what is more relevant, when cooperation and public support are separately analysed, subsidies for individual research do neither exhibit a significant impact on R&D nor on patenting of German firms.

In spite of Czarnitzki et al. (2007), most papers that study the impact of FP projects on technological outputs or economic inputs consider the participation in this kind of agreements as an integrated treatment (Luukkonen, 1998; Benfratello and Sembenelli, 2002; Polt et al., 2008; Dekker and Kleinknecht; 2008; Arnold *et al.*, 2008; Aguiar and Gagnepain, 2011). Again, whereas the effect on innovativeness is demonstrated, no clear evidence is obtained about economic performance. Barajas et al. (2011) go a step forward and corroborate that the impact of cooperation within the FP on firms' productivity is produced through the indirect channel of intangible assets.

For the specific case of SMEs, empirical evidence reinforces the existence of a positive technological effect. Thus, Arnold et al. (2008) remark that, in live sciences or energy, the most relevant impact of the FP is related to the increasing technological capabilities of SMEs. Dekker and Kleinknecht (2008) find a positive influence on R&D intensity for companies with fewer than 100 employees. In line with these results, the European Commission (2010) carried out a descriptive analysis of SMEs specific measures and states that, whereas 30% of participants obtained new IPR, the commercial exploitation of results is the least effective factor. On the contrary, the survey undertaken by the EC confirms that SMEs have improved the degree of R&D formalization and their own R&D capabilities, incorporating new scientific and technological knowledge and reinforcing their network abilities.

In line with previous literature, in next sections we analyze the effect of R&D consortia supported within the FP on SMEs, considering both technological and economic outputs and using a methodology that allows for capturing its direct effect as well as the indirect one. A major difference with respect to the works mentioned above is that our dataset is rich enough to measure medium term effects on relevant and objective performance indicators, such as intangible assets, real sales, EBITDA and productivity.

3. Empirical model and data

As we have explained previously, we want to quantify the impact of SME-specific measures financed by the sixth FP on SMEs performance. Specifically, in a first step we analyse how the participation of an SME in an FP project affects its generation of new knowledge. This new knowledge is approached by intangible fixed assets reported in firms' accounting, which include, among others, capitalized R&D expenditure, intellectual property and software.

Corrado et al. (2005) distinguish three main categories of intangibles: (1) computerized information; (2) innovative property and (3) economic competencies. The last one, which refers to brand equity, human capital training and organizational management, is beyond the scope of this work due to the lack of data. According to Van Ark et al. (2009), investments of Spanish firms in computerized information and innovative property represent more than 65% of total intangible private investment.

We suppose that our data on intangible assets constitute an indirect measure of innovation output, given that expenditures generated in the cooperative project related to R&D, software and patenting will be capitalized once the firm recognize that these outlays will generate future benefits. Formally, the equation in our model in year *t* is:

$$k_{it} = p_{it-s}\gamma + x_{it}^{'}\beta_1 + e_{it}, \quad 2 \leq s \leq 4, \qquad [1]$$

where $i = 1, \cdots, N$ index firms, k_i stands for a firm's intangible fixed assets, p_i denotes the SMEs participation within the FP, and x_i is a vector of other control variables.

After this, in a second step we use alternative measures of economic success g_i as dependent variables: EBITDA, real sales and labour productivity. The equation takes the form:

$$g_{it} = p_{it-s}\delta + z_{it}^{'}\beta_2 + u_{it}, \quad 2 \le s \le 4, \qquad [2]$$

where z_i stands for other additional controls in the equation. This set of controls also includes intangible assets. Therefore, if we find that intangibles are affected by participation within the FP, and that these intangibles increase the firm's performance, the economic impact of the cooperative project will also be supported by the evidence.

Given that R&D projects supported by the SME-specific measures of the FP are generally medium-term projects[1]and that target recipients are European SMEs with a specific research objective or need but without (or limited) technological capacity, we believe that it is reasonable to analyze their impact once the project has formally finished. For this reason, we will experiment alternatively by including our indicator of the SMEs participation in equations [1] and [2] referred to projects awarded 2, 3 or 4 years ago. This allows us to study the lag required to obtain a positive impact of the FP participation on technological capabilities, EBITDA, real sales and labor productivity.

Following the literature on impact assessment of R&D policies[2], in this analysis we take into account that the participation in this specific type of supported cooperative projects implies a selection process that in our case includes both the self-selection by participants to join the consortia and the selection of projects by the European Commission to award the public aid. To face this double-selection problem, instead of the dummy for observed participation, in empirical specifications of [1] and [2] we include the prediction

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[1] The average duration of a project is around 24 months.
[2] See, for example, Busom (2000), Lach (2002), González et al. (2005) or Czarnitzki et al. (2007).

of the probability of participating that we obtain from an auxiliary estimation of two equations for the probability of applying for a cooperative project (involving at least one Spanish SME) and the probability of awarding by the European Commission.[3] Assuming than the error terms of both equations can be correlated (with correlation coefficient equal to rho), we estimate these two equations as a Probit model with sample selection by maximum likelihood.

The database used for the analysis is provided by the CDTI, which is the public organisation in charge of monitoring the participation of Spanish firms within the FP. The CDTI database includes information about all the applications for the SME-specific measures financed by the sixth FP (2002-2006).[4] Granted and rejected proposals in which at least one Spanish firm participated within are considered for the present work.

This information from the CDTI database has been complemented with the SABI database that contains the company accounts of more than 1,000,000 Spanish firms between 1998 and 2009. The merger has been possible because Spanish SMEs are identified through their company tax codes in both databases.

From the SABI database, we have selected a control sample that takes into account the availability of data about the relevant variables for each firm. Given that Spanish firm size is smaller than the European average (European Commission, 2003), we have designed the sample selection considering a firm to be SME when its number of workers do not exceeds 200, although the threshold in international statistics is usually set at 250. Firms employing between 10 and 200 employees are selected by a random sampling scheme for each NACE class (two-digit) level, and represent around 4% of the Spanish

[3] With this method we also take care of the endogeneity of k_i in equation [2]. Barajas et al. (2011) apply the same methodology in a similar framework.

[4] Specifically, Cooperative Research projects and Collective Research Projects are considered.

Central Companies Directory (CCD), which comprises all Spanish companies and their local units. This makes our control sample representative of the Spanish economy.[5] The sample used in the empirical analysis of participation refers to the period 2003 to 2009[6] given that we use the forward values of output measures to capture long-term relationships.

Since our objective is to analyze the impact of collaboration within the SME-specific measures of the FP on performance variables, our unity of analysis is the firm. In this sense, although some firms have applied in more than one proposal every year, we only consider one project per firm and year. We have given priority to those supported projects with bigger subsidies. We have also excluded observations of the extreme values of employment and sales growth rates. Specifically, we have eliminated values in the extreme percentiles (1 and 99%). In addition, we dropped negative values for productivity, tangibles and intangible fixed assets. Overall, the final sample consists of an unbalanced panel of 41,800 observations; 10,450 companies; and 1,526 applications.

The CDTI database allows us for analyzing specifically those aspects determining the firm's decision to engage in a cooperative project, those factors related to agency selection[7], and the impact of participation on the firm's output. Table 1 presents the descriptives of the main variables in our model, distinguishing between applicants and awarded firms.

Award recipients seem to have more profits than non-participants. On the contrary, the labour productivity of participants is lower, although the difference is small. As expected, the presence of awarded firms is greater among activities corresponding to a high

[5] Coverage of the data is basically restricted to firms that have at least 10 employees (annual average), but we have also included 615 micro-companies (0.5% of the CCD, chosen again by means of a random sampling scheme), given that 330 applications for SME-specific measures belong to this category.
[6] Although the sixth FP was formally launched in 2002, during that year there is no application registered.
[7] Proposals are evaluated by independent experts according to some common criteria. However, such information is absent from our database.

and medium-tech manufacturing sector or a high-tech service sector. Notice, however, that the average of intangible fixed assets, that will be our indirect measure of the firms' technological capabilities, is lower for awarded firms both in terms of volume and when defined relative to size. This is coherent with the evidence provided by the European Commission (2010) that suggests that the SMEs participating in the SME specific measures have less formalised R&D activities compared to the SME participants in the other FP measures.

Table 1: Descriptive statistics of main variables

	Total sample	**Applicants**	**Award recipients**
Age (years)	15.8	17.5	17.1
Construction (%)	3.6	4.1	4.0
EBITDA (€)(*)	616,605	674,568	699,340
EBITDA per employee (€)	20,576	19,564	21,671
Exporter (%)	25.3	44.3	43.5
High and medium-tech manufacturing (%)	11.2	20.5	18.2
High-tech services (%)	4.5	7.3	6.3
Intangible fixed assets (€)	374,912	462,141	331,436
Intangible fixed assets per employee (€)	14,374	12,889	9,309
Labour productivity (€)	231,608	217,192	220,265
Leverage ratio (%)	66.4	65.5	65.7
Real Sales (€)	8,491,037	7,985,601	7,879,756
Size (nº of employees)	30.7	42.2	42.1
Tangible Fixed Assets (€)	1,807,126	2,084,991	2,069,954
Tangible Fixed Assets per employee (€)	75,433	61,453	75,371
Number of observations	41,800	1,526	253

(*) All monetary variables are expressed in real terms (€, 2006), see Appendix A.

In what follows we investigate econometrically the relationships between these variables and the SMEs participation in the sixth FP taking into account that the impact of these cooperative agreements is likely to occur in the medium to long term.

4. Results

In this section, we present the results of estimating the impact of SME-specific measures financed by the sixth FP on some SMEs performance measures. First, we estimate the determinants of the generation of new knowledge (equation [1]), approaching the innovation output by the ratio of intangible fixed asset over employment (in logarithms). Second, we estimate equation [2] using three alternative dependent variables - labour productivity, EBITDA and real sales- as measures of a firm's economic performance. In this second stage, to take into account the potential endogeneity of knowledge capital, the predicted value of intangible fixed assets per employee from the equation [1] is included as explanatory variable.

To control for the double-selection process in the participation within FP programs (participants self-selection and the selection by the European agency), instead of introducing the observed status of participation in the estimation of equation [1],) we use the predicted value of the probability of participating obtained from an auxiliary estimation. The results of this auxiliary estimation, made by means of a Heckman Probit procedure, are presented in Table 2.[8]

The first column exhibits the coefficients of the Probit model for the SMEs decision to apply for an FP project, while the second one corresponds to the determinants of the probability of being awarded the subsidy by the EC. The explanatory variables included in this estimate follow the selection made in previous empirical literature about the determinants of R&D cooperation for the Spanish economy.[9] In addition, specific characteristics of Cooperative and Collective Projects are considered. The results basically confirm the regularities obtained in existing research: previous experience in FP proposals not only increases the probability of applying in future FP editions but also the probability

[8] Find the exact definition of the variables in Appendix A and their descriptives in Table B1 of Appendix B.
[9] See, for example, Santamaría and Rialp (2007), Segarra-Blasco and Arauzo-Carod (2008), Marin and Siotis (2008) and Barajas y Huergo (2010).

of being supported. Exporters and firms with a higher ratio of intangible fixed assets per employee are also more likely to apply.

Table 2: Results of the Heckman Probit model for the probability of participation within SME-specific measures of FP

	Probability of applying (1)			Probability of being awarded (2)		
Prior experience in FP						
Prior experience in 5FP proposals	0.528	***	(0.051)			
Application in previous year	1.030	***	(0.072)			
Rejected proposal in previous year	0.726	***	(0.072)	0.481	*	(0.259)
Prior experience in 5FP granted projects				0.147		(0.134)
Granted project in previous year				0.452	**	(0.232)
Firm characteristics						
Exporter	0.168	***	(0.032)			
Indebtedness	0.040		(0.031)			
Intangible fixed assets per employee	0.048	***	(0.009)			
EBITDA	0.009		(0.007)			
Size dummies (no. of workers):						
From 10 to 49	0.118	***	(0.033)			
From 50 to 99	0.163	***	(0.047)			
From 100 to 200	0.108	*	(0.057)			
Age dummies (years):						
From 6 to 10	-0.138	***	(0.041)			
From 11 to 20	-0.190	***	(0.040)			
More than 20	-0.108	**	(0.043)			
High-tech services	0.276	***	(0.053)			
High and medium-tech manufacturing	0.161	***	(0.036)			
Construction	0.174	***	(0.063)			
Project characteristics						
Collective				0.904	***	(0.176)
Total budget (of consortium)				0.272	**	(0.139)
Leadership dummies:						
Spanish firm				0.076		(0.156)
Non-Spanish firm				0.407	***	(0.102)
Spanish Organism				0.286	**	(0.125)
Biohealth				0.461	***	(0.174)
ICT				0.060		(0.115)
Non-EU partners				-1.425	**	(0.543)
Central Europe partners				0.365	*	(0.207)
Selection term: Rho				0.139		(0.176)
Log of likelihood function	-5,675.17					
Number of observations	41,800					
Number of censored / uncensored obs.	40,274 / 1,526					

Notes: Standard errors in parentheses. Coefficients significant at: 1%***, 5%**, 10%*. All estimates include the constant. Estimate in column (1) includes temporal and regional dummies, and omits dummies for firms with fewer than 10 employees and firms less than 6 years old. In estimate of column (2), dummy is excluded for Non-Spanish organism.

Impact on technology capabilities

Table 3 shows the results of estimating equation [1] by OLS using a random effect model for panel data and assuming that all explanatory variables are strictly exogenous[10]. As already stated, our measure of new knowledge is the ratio of intangible fixed assets over employment. This measure can be interpreted as an indirect measure of technological output, given that the knowledge generated in R&D projects will usually be reflected by the volume of intangibles inside the firm.[11]

Table 3: Results of the random effects linear regression for the determinants of intangible fixed assets per employee

	Dependent variable: Intangible fixed assets per employee								
	FP Project awarded 2 years ago (s=2) (1)			FP Project awarded 3 years ago (s=3) (2)			FP Project awarded 4 years ago (s=4) (3)		
SME participant$_{t-s}$	0.104		(0.157)	0.542	**	(0.197)	0.807	***	(0.279)
Exporter	0.273	***	(0.030)	0.279	***	(0.030)	0.275	***	(0.032)
Size dummies (nº. of workers):									
From 10 to 49	0.118	***	(0.019)	0.124	***	(0.022)	0.143	***	(0.026)
From 50 to 99	0.155	***	(0.029)	0.190	***	(0.034)	0.194	***	(0.041)
From 100 to 200	0.168	***	(0.037)	0.144	***	(0.043)	0.188	***	(0.050)
Age dummies (years):									
From 6 to 10	-0.021		(0.020)	-0.048	**	(0.024)	-0.075	**	(0.031)
From 11 to 20	-0.102	***	(0.024)	-0.137	***	(0.028)	-0.125	***	(0.033)
More than 20	-0.139	***	(0.030)	-0.148	***	(0.034)	-0.138	***	(0.039)
High & medium-tech manufacturing	0.195	***	(0.037)	0.203	***	(0.038)	0.208	***	(0.038)
High-tech services	0.628	***	(0.064)	0.646	***	(0.065)	0.669	***	(0.069)
Construction	-0.068		(0.055)	-0.052		(0.056)	-0.049		(0.057)
Sigma of u	1.094			1.062			0.933		
Rho	0.739			0.713			0.591		
Number of observations	36,393			26,487			16,527		

Notes: Standard errors in parentheses. Coefficients significant at: 1%***, 5%**, 10%*. All regressions include the constant and temporal and regional dummies. Dummies excluded for firms with fewer than 10 workers and less than 5 years old.

[10] The OLS fixed effect estimator (or within estimator) can also be used. This method allows for unbiased estimates in presence of correlation between independent variables and unobservable firm-specific characteristics. However, we prefer to show the results obtained using a random effects model for two reasons: first, when we repeat the regressions using a fixed effects estimator,the parameters of interest keep their signs and significance; second, most of the variation in our data is in the cross-section dimension and the within estimator not only eliminates time-invariant firm-specific characteristics but also useful inter-firm variation (see Hu et al., 2005).

[11] Other measures of technological outputs as product and process innovations used in previous empirical evidence are not available in our database.

Following the suggestion of most empirical evidence (Benfratello and Sembenelli, 2002; Dekker and Kleinknecht, 2008), we assume that the expected economic results from cooperative FP projects will be generated in the medium-long term. As the European Commission (2010) points out, the nature of R&D activities supported under SME-specific measures of the sixth FP focuses on finding solutions to technical problems that SMEs identify, that mainly constitute applied research. Specifically, the most important objective for SMEs in this kind of projects is the development of a new or improved product. Moreover, Luukkonen (1998) confirms that small firms participating in the FP have shorter-term objectives than big companies. In this sense, we experiment by including alternatively our participation variable referred to projects awarded 2, 3 and 4 years ago.

As can be seen in Table 3, the predicted probability of participation positively affects our measure of technological output but it is necessary a delay to obtain a positive impact. Only three years after the project has been awarded, the coefficient for the SME participation is significant.[12] In this case, being an SME that cooperates within the FP increases the ratio of intangible fixed assets over employment almost 55%. As we expected, the impact is even higher if the project was awarded 4 years ago: the cooperation increases the ratio more than 80%. This result is in concordance with those presented by Dekker and Kleinknecht (2008).[13] In the same line, the post evaluation of the European Commission (2010) establishes that the participation of SMEs within the fifth and sixth FP increased their degree of R&D formalisation (yearly R&D budget, for example).

[12] Note that, although the average duration of a project is around 24 months, the phase of negotiation with the European Commission before the awarding could also take several months.

[13] Kaiser and Kuhn (2012) also investigate the time pattern in the impact of subsidized Danish RJVs on technological output measured by the number of patent applications. The obtain evidence of a positive effect that appears both instantaneously and with lags of up to three years.

As for the control variables[14], being an exporter positively affects the generation of new knowledge. Specifically, the ratio of intangible fixed assets per employee of the firms operating in foreign markets is almost 28% bigger than the ratio of non-exporters. The size dummies also present a positive effect, although their impact is nonlinear. Most empirical evidence for Spanish manufacturing also provides a positive relationship between firm size and the probability of obtaining product or process innovations.

However, we find a negative effect of the firm's age. This result is in accordance with the prediction of the theoretical model developed by Keppler (1996) that establishes that the number of innovations per firm at a given moment will be higher the younger the cohort is. For Spanish industry, Huergo and Jaumandreu (2004) support this result.

Firms belonging to high-tech manufacturing and services and medium-tech manufacturing have a higher potential of generating technological outputs. The level of intangible fixed assets per employee is almost 20% higher in manufacturing firms and 65% in services.

Impact on economic performance

To analyze the impact of R&D cooperation on economic performance of SMEs we used three alternative measures of economic success: labour productivity, EBITDA over employment and real sales. Estimations of equation [2] for these three variables are shown in Table 4. Again, estimations are carried out using random effects models for panel data. In this table, the SMEs participation refers to projects awarded 3 years ago which is the first period where a positive impact of the FP participation on technological output is

[14] The coefficients of the control variables don't differ among the columns.

achieved. We have also tried with this variable referred to projects awarded 2 and 4 years ago, but the results do not differ substantially[15].

The coefficients reported in Table 4 are elasticities or semi-elasticities, since the dependent variables are expressed in logarithms. As control variables we consider dummy variables referring to size, industry, year, firm age and location. In addition, we include a proxy of physical capital intensity measured throughout the variable "tangible fixed assets per employee".

Finally, to capture the effect of knowledge accumulation, we use the predicted value of "intangible fixed assets per employee" from equation [1] in order to control for potential endogeneity. When the dependent variable is labour productivity, the estimation allows for comparing our results with some previous empirical evidence which relates technological output to productivity. The EBITDA per employee can also capture improvements in the firm's efficiency or market share associated with the generation of new knowledge. When we introduce real sales as dependent variable, this equation can be interpreted as a kind of production function; therefore, in addition to the number of employees, as inputs we include the magnitude of tangible and intangible fixed assets (in logarithms) instead of their ratios over employment.[16]

These estimations permit to analyze whether R&D cooperation supported by the FP has not only a direct effect but also an indirect effect on SMEs economic success. Specifically, if we find that FP participation has a significant effect on our measures of economic success, a direct effect of cooperation on economic performance would be corroborated. In addition, if we find a positive relationship between the proxy of

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[15] These results are available from the authors upon request.

[16] In this case, the prediction of "intangible fixed assets" (in logs.) is obtained from an estimate where this variable is the dependent variable in equation [1]. The results when the SMEs participation refers to projects awarded 3 years ago are shown in Table B2 of Appendix B.

technological output and labour productivity, EBITDA per employee or real sales, this would suggest the existence of an indirect economic impact of R&D cooperation.

Table 4: Results of the random effects linear regression for the determinants of economic performance

	Dependent variable:					
	Labour productivity (1)		EBITDA per employee (2)		Sales (3)	
SME participant$_{t-3}$	-0.105	(0.088)	0.001	(0.429)	-0.138	(0.087)
Intangible fixed assets per employee$^{(p)}$	0.121 ***	(0.012)	0.252 ***	(0.026)		
Intangible fixed assets$^{(p)}$					0.111 ***	(0.006)
Tangible fixed assets per employee	0.172 ***	(0.008)	0.395 ***	(0.017)		
Tangible fixed assets					0.098 ***	(0.006)
Number of employees					0.621 ***	(0.014)
Exporter	0.493 ***	(0.023)	0.424 ***	(0.056)	0.624 ***	(0.024)
Size dummies (nº of workers):						
From 10 to 49	-0.036 **	(0.015)	0.318 ***	(0.049)	0.051 ***	(0.018)
From 50 to 99	-0.052 **	(0.023)	0.210 **	(0.073)	0.110 ***	(0.030)
From 100 to 200	-0.044	(0.028)	0.094	(0.091)	0.178 ***	(0.037)
Age dummies (years):						
From 6 to 10	0.026 *	(0.014)	0.130 **	(0.057)	0.039 ***	(0.014)
From 11 to 20	0.068 ***	(0.018)	0.123 **	(0.061)	0.114 ***	(0.017)
More than 20	0.123 ***	(0.023)	0.066	(0.071)	0.208 ***	(0.022)
High and medium-tech manufacturing	-0.002	(0.030)	0.126 *	(0.070)	0.011	(0.025)
High-tech services	-0.289 ***	(0.047)	0.092	(0.113)	-0.299 ***	(0.049)
Construction	0.246 ***	(0.073)	0.299 ***	(0.132)	0.266 ***	(0.077)
Sigma of u	0.872		1.811		0.877	
Rho	0.866		0.484		0.884	
Number of observations	26,204		26,407		26,204	

Notes: Standard errors in parentheses. Coefficients significant at: 1%***, 5%**, 10%*. All regressions include the constant and temporal and regional dummies. Dummies excluded for firms with fewer than 10 workers and firms less than 5 years old. $^{(p)}$: predicted value from equation [1].

As shown in Table 4, regardless the dependent variable the FP participation is not statistically significant. Therefore, it seems that technological cooperation within FP does not have a direct effect on performance. This result is in concordance with Dekker and Kleinknecht (2008) who obtain that the sales of innovative product per employee –as measure of innovative output- of French, German and Dutch firms are not enhanced by the participation in the FP. In a similar way, Benfratello and Sembenelli (2002) do not find significant differences in labour productivity of firms that have participated in the third and fourth FP, and the European Commission (2010) does not detect any impact of project participation on economic performance of the SME, suggesting that, although in many projects new technologies have been developed, these have not been translated yet into potential commercial products.[17]

However, our results show that the impact of intangible fixed assets per employee (or intangible fixed assets) on economic performance is clearly significant, reflecting a difference in favor of innovative firms. Specifically, if the ratio of intangible assets duplicates, it causes productivity to grow more than 12%. These results are in line with Hao et al. (2008), Van Ark et al. (2009) and Roth and Thum (2010). These works confirm for several countries that a relevant part of the labor productivity growth is explained by investments on intangibles.

The effect on EBITDA per employee is also positive, being its magnitude the double than for productivity. With respect to the real sales, the elasticity of sales to intangible fixed assets is 0.1%. As we have shown in the previous section, given that firms participating within the FP present higher technological outputs, this result supports an indirect effect of cooperation on these performance variables.

In addition, the coefficient for tangible fixed assets suggests that capital-intensive firms are also more productive, and present bigger earnings. As in previous empirical evidence, exporting firms are also more efficient than non-exporting firms. Firms operating in international markets also present a higher ETBIDA per employee. This last result is in

[17] Using a different methodology to control the selection bias, Aguiar and Gagnepain (2011) analyze the impact on productivity labor of the participation on the fifth European FP using the CORDIS and the AMADEUS data bases. They take into account the different instruments from the programme (Key Actions) and they obtain that the instantaneous impact of participation is quite heterogeneous across them but they are rarely significant.

line with Moreno and Rodríguez (2010), which find that Spanish manufacturing non-exporters have smaller margins than persistent exporters.

With respect to the size dummies, we find a negative non-linear relationship between firm size and productivity. However, larger firms present a greater ETBIDA per employee. The results also reflect a positive effect of firm's age on economic performance. Previous empirical evidence shows that firms entering in the industry experiment high growth rates of productivity. Huergo and Jaumandreu (2004) confirm this result but also show that the growth of surviving firms converge to the one of incumbents.

Finally, as expected, firms from high-tech and medium-tech manufacturing industries present larger levels of ETBIDA per employee. However, the earnings of firms from high-tech services do not differ from the other sectors. This result is even clearer when we analyse labour productivity and real sales: firms in high-tech services present smaller levels of both variables. However, the results obtained for firms operating in Construction are in accordance with the Spanish cycle behaviour during this period. The participation of this industry in the Spanish economy has strongly increased due to its high growth rate.

5. Conclusions

The objective of the present paper is to analyse the effect of public support for international RJVs on SMEs performance. For this purpose we use a data set that contains information about Spanish firms participating in consortia supported by the specific SMEs measures of the FP. This type of RJVs is characterized by the low technological capabilities of industrial partners, in such a way that research performers involved in consortia carry out the great part of R&D activity. Through this scheme, the European

Commission aims to incentive SMEs to find technological solutions that improve their competitiveness.

Empirical evidence shows that RJVs have a clear positive effect on technological capabilities of firms (Branstetter and Sakakibara, 2002; Scott, 2003), although there is no general accepted conclusion about the economic impact. Economic performance seems to be more influenced by the type of technological partner, the distance to the market of the cooperative project and the type of firm (Benfratello and Sembenelli, 2002; Cincera et al., 2003; Belderbos et al., 2004; Bayona-Sáez and García-Marco, 2010; Colombo et al., 2009).

For the specific case of SMEs, the literature remarks that cooperation could be a suitable strategy to access external knowledge when resources constrains are an obstacle to innovate (Audretsch and Vivarelli, 1996; Rothwell and Dodgson, 1991). In this line, Nieto and Santamaría (2010) find that technological partnerships could improve the innovativeness of SMEs compared to that of large firms.

In the present paper, we confirm the positive impact of R&D consortia supported within the FP on firms' performance. In particular, we find that: (1) being a SME involved in a supported RJV increases the ratio of intangible fixed assets over employment almost 55% and (2) the impact of intangible fixed assets on economic performance, measured alternatively by productivity, EBITDA per employee or total real sales, is clearly significant. Nevertheless, all effects are significant three years after the end of the project, confirming that SMEs participating in the FP have shorter-term objectives than big companies (Luukkonen, 1998).

These results are in line with previous empirical evidence on cooperation, although our methodology allows us to go a step forward and demonstrate that economic impact of

RJVs should be analysed as a consequence of increasing technological capabilities. This evidence could be relevant regarding future impact assessment activities of cooperation programmes, and specifically of the FP.

Considering that those small firms with limited or null technological capability are the target recipients of the SMEs specific measures, we can conclude that this programme has reached one of its main goals: results show that firms obtain significant gains in intangible assets. Under the sixth FP, the evaluation criteria established by the European Commission stress the business interest of the project. However, descriptive analyses (European Commission, 2010) show that firms do not exploit technological results as expected. Probably, SMEs need an additional support for the post-cooperation phase, in order to overcome commercialization barriers. Also, R&D performers should be involved in this phase, to guarantee that the final output of the project meets all the market needs.

However, empirical evidence obtained in this paper indicates that the effect of this kind of supported RJVs on performance indicators is similar for SMEs than for big companies, although the extent of R&D projects, and consequently the time period for their impact, tends to be shorter. Assuming that SMEs with low or almost null technological capabilities are involved in different kind of consortia, it seems appropriate to support these companies with specific measures.

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Appendix A: Definition of variables

Age	Difference between the current year and the constituent year reported by the firm
Application in previous year	At least one of the Spanish firms involved in the consortium applied to the FP the previous year.
Biohealth	Project is related to bio and health technologies.
EBITDA	Earnings Before Interest, Taxes, Depreciation and Amortization in real terms (deflated by the Price index) (in logs.)
Collective research project	Collective project
Construction	Company belongs to the construction activity
Exporter	Company exports during the period.
Firm size	Firm’s number of employees (<10, 10-49, 50-99, 100-199, >200)
Granted project in the previous year	At least one of the Spanish firms involved in the consortium participated in a granted project the previous year.
High-tech services	Company belongs to the high-tech services (NACE2 codes 64, 72, 73).
High and medium-tech manufacturing	Company belongs to any high or medium-tech manufacturing sectors (NACE2 codes 24, 29, 30, 31, 32, 33, 34, 35).
ICT	Project is related to information and communication technologies.
Intangible fixed assets per employee	Ratio between intangible fixed assets in real terms (deflated by the Price index) and total employment in the current year (in logs.)
Labour productivity	Real sales per employee (in logs.)
Leadership	The leader of the consortium is (Spanish firm, Non-Spanish firm, Spanish Organism).
Leverage ratio	Ratio of total debts to total liability
Participation of Non-EU partners	At least one Non-EU partner is involved in the consortium
Participation of Central Europe partners	At least one Central Europe partner is involved in the consortium
Price index	Price indexes for 25 branches (2006=1). Sources: EUROSTAT, INE and Spanish National Accounts.
Prior experience in 5FP proposals	The Spanish firm applied to the fifth FP.
Prior experience in 5FP granted projects	At least one of the Spanish firms involved in the consortium participated in a cooperative project financed during the fifth FP.
Real sales	Nominal sales deflated by the Price index (in logs)
Rejected proposal in the previous year	At least one of the Spanish firms involved in the consortium participated in a rejected project during the previous year.
Tangible fixed assets per employee	Ratio between tangible fixed assets in real terms (deflated by the Price index) and total employment in the current year (in logs.)
Total budget (of consortium)	Total budget of the project financed during the sixth FP.

Appendix B: Complementary estimates

Table B1: Features of the applications. Descriptive statistics

	Total applications	Granted applications
Collective research project (%)	8.7	22.1
Experience (%)		
Prior experience in 5FP proposals	19.9	24.5
Application in previous year	39.1	40.7
Prior experience in granted 5FP projects	16.2	20.2
Granted project in previous year	6.5	10.7
Rejected project in previous year	32.6	30.0
Leadership (%)		
Spanish firm	10.0	7.5
Non-Spanish firm	31.3	39.9
Spanish Organism	18.4	15.0
Participation of Non-EU partners (%)	10.5	8.8
Participation of Central Europe partners (%)	33.9	37.8
Proposals related to *biohealth* technologies %)	4.7	7.1
Proposals related to ICT (%)	14.9	14.6
Total budget (€)	1,553,436	1,768,011
Number of observations	1,526	253

Table B2: Results of the random effects linear regression for the determinants of intangible fixed assets

	Dependent variable: Intangible fixed assets		
SME participant$_{t-3}$	0.866	**	(0.380)
Exporter	0.990	***	(0.057)
Size dummies (nº. of workers):			
From 10 to 49	0.949	***	(0.041)
From 50 to 99	1.861	***	(0.068)
From 100 to 200	2.347	***	(0.085)
Age dummies (years):			
From 6 to 10	-0.012		(0.045)
From 11 to 20	-0.099	**	(0.051)
More than 20	-0.061		(0.063)
High and medium-tech manufacturing	0.508	***	(0.071)
High-tech services	1.234	***	(0.112)
Construction	-0.012		(0.113)
Sigma of u	1.969		
Rho	0.687		
Number of observations	26,574		

Notes: Standard errors in parentheses. Coefficients significant at: 1%***, 5%**, 10%*. All regressions include the constant and temporal and regional dummies. Dummies excluded for firms with fewer than 10 workers and firms less than 5 years old.