

DO R&D PROGRAMS OF DIFFERENT GOVERNMENT LEVELS OVERLAP IN THE EUROPEAN UNION?

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Abstract - Multiple levels of government currently design and implement research and innovation programs both in the US and in Europe. Empirical analysis of interdependencies among programs has not been fully explored, however. Our contribution is a first step in understanding potential complementarities across R&D programs. Using a sample of Spanish manufacturing firms, we study the determinants of firms' participation in national and in European level research programs and test for differences across programs. Our results suggest that firms' participation in European and national R&D programs is largely driven by different factors. We interpret these results as suggesting that, ex-post, there is no significant overlap of R&D policies between these two government levels, as intended ex-ante by policymakers in fulfillment of the principle of subsidiarity.

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KEYWORDS: R&D, Subsidies, CIS, innovation policy, subsidiarity

I. INTRODUCTION

Several levels of government are involved in the provision of public support for R&D conducted by firms, both in the United States and in Europe. A relevant policy question is whether programs implemented by different jurisdictions are complementary, in the sense that that they both lead to a globally efficient allocation of R&D and do not duplicate efforts. Efficient coordination requires that the nature and extent of externalities and other relevant market failures associated with research and innovation be taken into account. Within the European Union the "principle of subsidiarity" rules the distribution of competences between regional, national and supra-national jurisdictions. It allows the European Community to act only when action in an individual country is insufficient. In the case of R&D, supra-national policies are justified by the existence of economies of scale and cross-border spillovers. Surprisingly we have not found empirical evidence at the firm-level comparing R&D programs at different levels of government. Most previous work has focused on evaluating the effects of particular programs

(see, for example; Wallsten, 2000; Lach 2002; Hernan and Siotis 2003), but the relationships between programs or government agencies have been studied only indirectly.¹

Our contribution is a step towards assessing ex-post the extent of subsidiarity between European R&D and Spanish level policies. Our main hypothesis is that subsidiarity implies that the different government levels should have different selection criteria for awarding R&D subsidies to firms. We test this by estimating a bivariate probit model for program participation. Our results indicate that the determinants of firm participation in each program are different, suggesting that these programs do not systematically overlap ex-post, as intended ex-ante by policy makers.

II. R&D PROGRAMS AND DATA

During the period under study (1996-1998), firms could participate in programs implemented at the National level and/or at the European level. The Spanish Third National Plan of R&D (1996-1999) was in place at the time. This plan included various types of R&D programs, including: 1) Pre-competitive industrial research projects, developed jointly by firms and public research organizations or technological centers; 2) technological development projects of applied nature, and 3) technological innovation projects, intended to encourage the use of new technologies in the firm. In addition, firms could obtain subsidized loans in order to finance patent applications to international agencies, to formalize license contracts or expenditures related to exploiting abroad a newly developed technology. At the regional level, firms could take part in programs under the Second Catalan Research Plan (1997-2000).

At the supra-national level, firms could apply to the Fourth European Union Framework Program (1994-1998), and to other international programs managed by the Spanish Center for Technological and Industrial Development (CDTI), including Eureka, a European level program aimed at transforming technology into marketable products.² The main distinctive trait of European level R&D programs is that they

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¹ See, for example, the Advanced Technology Program report authored by Schahtel and Feldman (2000) and Blanes and Busom (2004).

² Firms could also participate in other cross-border programs such as Iberoeka, but as mentioned before we don't focus on these initiatives, as the number of cases in our sample is very small.

are explicitly designed to encourage inter-European cooperation. For a proposal to be eligible it had to involve firms and/or institutions from several member countries, and contribute European added value. These partnerships, even if subsidized, may entail significant access and management costs.³

This brief description of the program ex ante the objectives of the two jurisdictions are diverse. Assuming that there is a relationship between the type of proposals in terms of scale and external effects and firm characteristics, the subsidiarity principle should translate into different firm selection rules, whether explicit or implicit, by each government level. We would thus expect the determinants of program participation to vary across programs.

To test this hypothesis, we use data from the Spanish version of the Community Innovation Survey (CIS) in the period 1996-98. The CIS is a European-wide firm level survey that is conducted biannually in all European Union member countries. Among other questions, the survey asks firms whether they receive public funding for doing innovation, as well as the origin of funding, distinguishing between local, regional, national and supra-national sources. However, it does not provide information on the amount of public funding received by the firm.⁴

Our sample consists of 716 manufacturing firms that report positive innovation expenditures during the period 1996-1998, 30% (212) of which claim participation in national research programs while 8% (55) claim participation in international R&D programs, mostly the European Union Framework Program and Eureka.⁵

Table 1 shows the distribution of firms by source of funds. A high percentage of firms that take part in European programs (58%) also participate in national programs, but only 15% of firms that benefit from domestic public support participate in European level programs. These facts suggest that participation requirements or costs of European programs are higher. It is also possible that participation in national research programs may act as an informational signal to European agencies resulting in more success at the European level.

Tables 2 and 3 report variable description and descriptive statistics for three groups of firms: non participants, participants in National programs, and participants in European programs. Firm size appears to be correlated to participation status, but otherwise no clear pattern seems to

³ A detailed description of national and supra-national R&D programs can be found in <http://cordis.europa.eu/erawatch/> and in <http://www.eureka.be/about.do>.

⁴ Public funding refers to financial support in terms of grants and loans. The survey defines innovation as new or improved products or process new to the firm only, or new to the firm and to the firm's market. More information on the CIS survey can be found at www.cordis.lu, and at www.ine.es on the Spanish edition.

⁵ All the firms are located in the Spanish region of Catalonia. This region is one of the core industrial regions in Spain contributing 25 per cent of Spanish total industrial production. A number of firms (41) participate in regional level programs but almost all of them also participate in national level programs. The number of firms participating in other international programs is very small, so our description focuses basically on national and European level programs.

TABLE I
PARTICIPANTS IN NATIONAL AND/OR EUROPEAN LEVEL PROGRAMS

Program participation	Number of firms
Both programs	32
National programs only	180
European programs only	23
National programs	212
European programs	55
Do not participate in any program	481
Total number of firms in the sample	716

TABLE II
VARIABLE DESCRIPTION

Variable	Description
Size	Number of employees in 1996
Stable RD*	Does R&D regularly in 19998
RD wage	Log (R&D salaries/ nb.of R&D employees) in 1998
Researchers	Researchers /non RD employees in 1998
PatSp*	Applied for patents only in the Spanish Patent Office in 1996-98
PatInt	Applied for patents in Spain and some international Patent Office (EPO, USPTO) in 1996-98*
Foreign*	Multinational subsidiary
Export	Exports/sales in 1996
IndLT*	Low tech sector
IndCHF*	Chemical or pharmaceutical
IndMHT*	Medium-high tech sector
IndMLT*	Medium-low tech sector
IndHT*	High tech sector

* binary variable emerge.

III. EMPIRICAL MODEL

Program characteristics and observed participation rates suggest that European and national level R&D programs may have different goals and participation costs. To test this hypothesis we specify a model relating some firm characteristics to the likelihood of participation in each program.

Our sample consists of participants and non-participants in each program. The model can be specified as follows:⁶

$$P^*_E = Z_E b_E + v_E \quad (1)$$

$$P^*_N = Z_N b_N + v_N \quad (2)$$

⁶ In 1998 firms presented 1138 applications to CDTI, the agency responsible for allocating public funds to firms. 31% were rejected and 37% were approved. Remaining applications were postponed. As Wallsten (2000) points out, we can assume that the process of applying and being awarded is in equilibrium, so that firms know what the selection criteria are, and agencies know that firms know.

TABLE III
DESCRIPTIVE STATISTICS

Variable	Non-participants 481 firms		National participants 212 firms		European level Participants 55 firms	
	Mean	SD	Mean	SD	Mean	SDv
Size	195.5	341.9	326.7	995.3	531.5	1,793.8
Stable RD	0.78	0.41	0.90	0.30	0.93	0.26
RD wage	31995	15453.19	32491	13429	32568	12158.12
Researchers	0.03	0.06	0.05	0.10	0.05	0.07
PatSp	0.12	0.33	0.16	0.37	0.05	0.23
PatInt	0.28	0.45	0.49	0.50	0.38	0.49
Foreign	0.29	0.46	0.22	0.42	0.20	0.40
Export	0.27	0.27	0.33	0.26	0.41	0.25
IndLT	0.28	0.45	0.24	0.43	0.16	0.37
IndCHF	0.26	0.44	0.29	0.46	0.20	0.40
IndMHT	0.23	0.42	0.25	0.43	0.36	0.49
IndMLT	0.12	0.33	0.11	0.31	0.15	0.36
IndHT	0.09	0.28	0.11	0.32	0.13	0.34

where P^*_E and P^*_N are the unobserved propensity to be a participant in a European and a national level program, respectively, Z_E and Z_N are vectors of exogenous variables, and v_E and v_N are the error terms. A binary participation status indicator is observed in each case: $P_E=1$ if [$Z_E b_E + v_E > 0$] and $P_N=1$ if [$Z_N b_N + v_N > 0$]. As firms can engage simultaneously in both programs, we estimate a bivariate probit model. This model should be interpreted as a reduced form where b_E and b_N capture the total effect of a given characteristic in participation. This total effect is the combination of the effect on the likelihood of application and the effect on the agency's decision rule, conditional on applying.

The set of explanatory variables includes firm size, measured by the average number of employees, human capital, measured as the ratio of research to non research employees, foreign ownership, R&D stability, exporting intensity, researchers' salaries, and patent applications.⁷ To test for industry effects in the application and selection of firms we define five industry level binary variables: chemical/pharmaceutical industry (IndCHF), high tech industries (IndHT), medium-high tech (IndMHT), medium-low tech (IndMLT) and low tech (IndLT).⁸

⁷ Variable definition is shown in table 2.

⁸ Ideally we would like to distinguish between different types of high-tech industries (e.g. pharmaceuticals and IT). Our data only allows us to single out the chemical/pharmaceutical industry. In our definition high-tech industries include office and computing machinery, communications equipment, and precision instruments; medium-high-technology industries include machinery and equipment, electrical machinery and apparatus, motor vehicles and other transport equipment; medium-low-technology industries include petrochemicals, rubber, plastics, basic metals and fabricated metal products. Low-technology industries include food products and beverages, textiles, wood and wood-based products, pulp, paper, paper products, printing and publishing.

Our hypothesis is that that firm size, knowledge capital (captured by human capital and patent applications) and R&D experience are likely to be positively associated with an R&D project's technical and commercial feasibility, and hence with participation in R&D programs. However, to the extent that a variety of market failures may affect SMEs in particular, and that national level agencies intend to address them through their programs, the relationship between firm size and the probability of participation in national programs could be negative. However, a positive relationship between firm size and participation would be expected in the case of European programs, mostly because of partnership management costs.⁹ We also expect the national agency to have a preference for domestic relative to foreign owned firms. Whether the firm is export oriented or not would not in principle be a matter of concern for any public agency. Finally, we expect agencies to have a preference for firms in high-tech industries.

IV. RESULTS

Table 4 reports the estimated marginal effects of the bivariate probit model¹⁰. The single most important factor affecting participation in national R&D programs is the firm's research intensity, followed by having experience in applying for international patents. Overall, results suggest that the firm's knowledge capital is one of the main determinants of participation in national programs.

In contrast, we find that the key characteristic of participants in European programs is the extent to which the firm operates in foreign markets, as measured by export intensity. A possible interpretation for this result is that exporting allows firms to develop links with potential international R&D partners (e.g., customers or suppliers), making partnerships more likely even if the Spanish firm does not have high in-house research capabilities.¹¹ We believe that it is not very likely that export intensity is an eligibility requirement of European level agency, but rather that it affects the outcome through the firms' application decision. Finally, industry type and patenting experience do not seem to have any significant effect on participation in European level programs.

A significant, high and positive estimate of the correlation between the error terms is obtained as well, indicating the presence of common unobserved factors that affect both the probability to participate in both programs. When testing for equality of coefficients in both equations, the joint chi-square test clearly rejects equality. Single tests for each coefficient

⁹ Existing evidence on participating in European level programs suggests that firm size and previous participation experience increase the likelihood of participating, while industry-level characteristics are also significant, especially R&D intensity (see, for example, Hernán, Marín and Siotis, 2003).

¹⁰ We experiment with several different specifications, including sales as proxy for size, as well as interaction terms between size and industry indicators, but no major changes are found in the regressions. We also estimate two independent univariate probit models for every program, and find similar results. Table A in the Appendix reports the estimated marginal effects.

¹¹ Recall though that in our sample all firms are R&D performers.

leads to rejecting equality for having applied for international patents.¹²

Our results suggest that the two types of programs do not overlap, as in fact intended by national and European level policymakers. However, we are aware that the number of participants in EU programs in our sample is relatively small and that further analysis with more observations and for more time periods is needed. In addition, this analysis could be

V. CONCLUSIONS

In this article, we find evidence that European and national level R&D programs satisfy, ex post, the principle of subsidiarity across jurisdictions, as intended by policymakers. While participation of Spanish firms in national programs is mostly related to the firms' in-house research capacity, participation in European level programs is mostly related to the export orientation of the firm. These results suggest that participation of Spanish firms in European level programs is mostly related to their exposure to international markets because this enables them to form partnerships and apply for this source of research funds. Since different firm characteristics are associated to participation in each program, we may conclude that there is no evidence of ex-post program overlap or wasteful duplication of resources in this case. However, a similar analysis should be performed for other European member countries in order to assess subsidiarity in all countries.

TABLE IV
PARTICIPATION IN NATIONAL LEVEL AND EUROPEAN LEVEL R&D PROGRAMS ESTIMATED MARGINAL EFFECTS: BIVARIATE PROBIT MODEL

Variable	National Programs Equation (Y ₁)		European Programs Equation (Y ₂)	
	Pr(Y ₁ =1)	Pr(Y ₁ =1 Y ₂ =1)	Pr(Y ₂ =1)	Pr(Y ₂ =1 Y ₁ =1)
Size (in logs)	0.08*** (4.12)	0.06*** (2.53)	0.03*** (3.42)	0.04*** (2.75)
Stable RD	0.07 (1.44)	0.06 (0.86)	0.02 (1.15)	0.04 (0.38)
RD wage	0.00 (0.24)	0.00 (0.52)	0.00 (-0.69)	0.00 (-0.72)
Resear chers	0.92*** (3.37)	0.99*** (2.86)	0.14 (1.21)	0.12 (0.59)
PatSp	-0.08 (-1.64)	-0.04 (-0.44)	-0.05*** (-3.11)	-0.08*** (-2.56)
PatInt	0.21*** (4.50)	0.23*** (4.47)	0.01 (0.55)	-0.01 (-0.22)
Foreign	-0.18*** (-4.77)	-0.17*** (-2.69)	-0.06*** (-3.89)	-0.09*** (-2.94)
Export	0.11 (1.64)	0.04 (0.48)	0.09*** (2.92)	0.14*** (2.59)
IndLT	0.03 (0.44)	0.08 (1.01)	-0.04 (-1.64)	-0.07 (-1.70)
IndCHF	0.10 (1.45)	0.14 (1.79)	-0.02 (-0.84)	-0.05 (-1.11)
IndMHT	0.03 (0.43)	0.03 (0.32)	0.01 (0.28)	0.01 (0.21)
IndHT	0.08 (0.92)	0.09 (0.90)	0.00 (0.90)	0.00 (-0.03)
Log likelihood Function			-562.44	
Wald chi2(24)			100.69	
Rho (1,2)			0.33	
LR chi2 (1) of rho=0			12.66***	

Notes: z statistics in parentheses. *** denotes significance at the 1 % level; ** a 5 % level. Results obtained with the alternative specification as in Model 2 in Table 3 are very similar.

performed for other European member countries in order to assess subsidiarity in all EU member countries. Finally, we should note that from our results no inference can be made as to the additionality or complementarity effects of both programs on R&D outcomes; this requires more sophisticated data and analysis.¹³

¹² We have also estimated a multinomial logit model to tests for systematic differences between four mutually exclusive categories for program participation: participation only in national programs (N=180), participation only in EU programs (N=23), participation both in national and EU programs (N=32), and no participation in any program (N=481). Results corroborate the different nature of national and EU programs, but as the number of observations only in EU programs is small, we should take them with caution.

¹³ For example, Mohnen and L-H Roller (2005) propose to conduct supermodularity and submodularity tests. Due to the cross-sectional nature of our data we cannot conduct these tests.

APPENDIX

TABLE A. PARTICIPATION IN NATIONAL LEVEL AND EUROPEAN
LEVEL R&D PROGRAMS
ESTIMATED MARGINAL EFFECTS: UNIVARIATE PROBIT

Variable	National Programs Equation		European Programs	
	Model1	Model 2	Model 1	Model 2
Size (in logs)	0.08*** (4.14)	–	0.03*** (3.25)	–
Size (level)	–	0.0002*** (2062)	–	0.00 (1.58)
Size squared	–	0.00 (-1.20)	–	0.00 (-0.34)
Stable RD	0.07 (1.34)	0.10** (2.12)	0.02 (0.95)	0.04 (1.53)
RD wage	0.00 (0.27)	0.00 (0.71)	0.00 (-0.63)	0.00 (-0.21)
Researchers	0.94*** (3.40)	1.55*** (3.15)	0.15 (1.34)	0.18 (0.74)
Researchers squared	–	-1.31** (-2.19)	–	-0.19 (-0.49)
PatSp	-0.08(-1.51)	-0.07 (-1.30)	-0.05** (-2.11)	-0.05** (-1.94)
PatInt	0.21*** (4.57)	0.21*** (4.59)	0.01 (0.55)	0.01 (0.56)
Foreign	-0.18*** (-4.24)	-0.15*** (-3.35)	-0.06*** (-3.00)	-0.05** (-2.43)
Export	0.11 (1.61)	0.12 (1.74)	0.09*** (2.78)	0.09*** (2.78)
IndLT	0.03 (0.44)	0.04 (0.61)	-0.04 (-1.62)	-0.04(-1.42)
IndCHF	0.09 (1.46)	0.07 (1.07)	-0.02 (-0.89)	-0.03(-0.96)
IndMHT	0.03 (0.46)	0.01 (0.23)	0.01 (0.26)	0.00 (0.07)
IndHT	0.07 (0.91)	0.03 (0.32)	0.002 (0.04)	-0.01 (-0.21)
Log-likelihood	-395.41	-397.51	-173.35	-175.07
Observations	716	716	716	716
Y=1	180	180	55	55
% correctly predicted	66%	65%	67%	66%

Notes: z statistics in parentheses. *** denotes significance at the 1 % level; ** a 5 % level

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