

The Role of National and Regional Innovation Programmes In Stimulating International Cooperation in Innovation

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Abstract: Innovation programmes have direct and indirect effects on enterprise strategies. In this paper we argue that national and regional programmes, not necessarily designed to increase international links, indirectly leverage international collaborative innovation, by providing additional funding, experience in domestic collaboration, and learning about public funding application rules. Our empirical findings confirm a positive (but small) influence of domestic-level programmes on the probability that a firm develops innovation with foreign partners. Implications for policy are multiple, including the need to consider systemic measures of innovation when evaluating the impacts of innovation programmes on firm's behavior.

Keywords: R&D; international cooperation, innovation policy, evaluation.

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1 Introduction

Firms cooperate in innovation with international partners for a number of reasons. Sometimes companies need specific knowledge that is not available domestically. Other times firms seek to internalize widely dispersed scientific and technological spillovers through international collaboration. Yet it remains the case that the majority of innovative firms that might gain from international collaboration do not participate in such agreements (Abramovsky *et al.*, 2004). Lack of information on who the right partner could be, concerns about appropriability, and high coordination costs are among potential barriers that hinder firms' entry into these partnerships (Hladik, 1988; Hladik and Linden, 1989; Lundvall 1993; Hagedoorn, 1995). In addition, there are other alternative ways through which firms can access international scientific and technological capabilities. These include technology licensing, mergers and acquisitions, or the hiring of new internationally-experienced scientists and technologists.

Paralleling the debate on potential barriers to international collaborative innovation, a series of policy initiatives have explicitly promoted the initiation of cross-border research agreements between firms and between firms and science-based organizations. These initiatives have become a common tool of innovation policy, particularly (but not exclusively) in Europe (Georghiou, 1998; OECD, 2002; Wagner *et al.*, 2000; Prange, 2003). By correcting the market and systemic failures that typically arise with international partnerships, governments hope to increase private investments in innovation activities, while reducing regional disparities in science and technology. Indeed, several authors, including Mowery (1989) and Narula and Dunning (1998), suggest that these policy actions have contributed greatly to increases in cross-border R&D partnerships.

Other policy actions that are not explicitly geared to encourage international cooperation in innovation may, directly or indirectly, also be influential. Public promotion of programmes for collaborative innovation involving domestic partners or other public support for private innovation may have additional impacts on the organization and internationalization of innovation processes by firms. In this paper we adopt a holistic view of innovation policy and argue that it is plausible, if not likely, that innovation policy instruments at the national and regional levels have leverage effects on the internationalization of private innovation. Participation in national and regional innovation programmes may trigger a change in the way supported

firms do innovation with foreign partners, for example by releasing resources for additional R&D activities, by providing experience in and encouragement of new forms of cooperation, and by building up networks and other capabilities.

To test these propositions, we empirically investigate whether firms with public support from national and regional sources have a higher probability to enter into a cooperative research arrangements with foreign partners than do firms who do not receive such support. Using a sample of manufacturing firms from the Spanish version of the European Community Innovation Survey (CIS), our results confirm that participation in national and regional level innovation programmes has positive effects in terms of additional international cooperation generated. The probability to engage in international agreements is up to eight percentage points higher for publicly-supported firms when compared to a matched control group. This effect may be seen as modest. However, it is significant when it is considered in a context where observed cooperation with foreign partners among innovating firms is only 11%.

Our results have several policy implications. First, improved awareness of how public support for private innovation induces indirect behavioural changes in other innovation activities may aid in improving future policy development. Second, our integrated perspective on public policy and innovation may assist policy impact evaluators in measuring changes in non-technological aspects of innovation. Third, we find evidence that national and regional policy instruments are also having a role in the construction of a more networked and integrated European Research Area (ERA).

The paper is organized as follows. Next section gives an overview of the motives that induce the conduct of innovation in cooperation with foreign partners. Then we discuss possible reasons why national or sub-national public innovation programmes may foster international cooperation in innovation. Succeeding sections provide details about our method, data, main characteristics of innovation programmes under study, and empirical results. In the final section, we conclude the paper with some policy implications.

2 International cooperation in innovation: theory and evidence

International research and innovation collaboration has expanded markedly in last two decades. Several indicators confirm this trend. For instance, the share of internationally co-authored publications rose from 14.3% in 1986 to 31.3% in

1999 (OECD, 2002)³, while the share of patents involving at least two inventors from different countries increased from 2.1% in 1980 to 4.7% in 1995 (Guellec and van Pottelsberghe, 2001). Hagedoorn (2002), using data from inter-firm agreements, also demonstrates that international research partnering has gained importance over other forms of cross-national alliances such as international joint ventures. Narula and Hagedoorn (1999) find that international R&D partnerships have grown in importance relative to domestic R&D partnerships since the late 1970s. Beyond these global trends, important differences exist across countries, sectors and firms. Several factors are suggested in the literature to explain these differences. These factors can be grouped in five categories:

- domestic science, technology and innovation (STI) conditions;
- market imperfections and knowledge exchange;
- industry characteristics;
- perceived advantages of international cooperation; and
- firms characteristics.

We also suggest that policy effects are important. However, before we further develop this idea, we discuss how these five factors influence international R&D cooperation.

2.1 Domestic STI conditions

When necessary knowledge and skills are not available within the national innovation system, innovative firms need to expand their external knowledge sources beyond national boundaries. This frequently happens in small industrialized countries (Narula and Hagedoorn, 1999), and in countries with low technological intensity (Guellec and van Pottelsberghe, 2001). Size-related disadvantages include limitations of human resources, capital, and domestic demand (Walsh, 1988; Andersen and Lundvall, 1988). High technological specialization is another factor that forces domestic firms to seek complementary innovation inputs abroad. In addition, small-industrialized countries tend to be more dependent on foreign trade than larger countries, and therefore be more familiar and successful in establishing international links. As for less

³ Georghiou (1998) and Wagner *et al.* (2000) provide similar evidence.

technologically advanced regions, the main motivation for going abroad is lack of scientific and technological capabilities at home. Existing dysfunctions within national innovation systems, such as a lack of bridging organizations or knowledge asymmetries between types of firms, are other influences.⁴

2.2 Market imperfections and knowledge exchange

Necessary knowledge and skills can be acquired in the marketplace through international outsourcing, licensing, patents, know-how or trademarks (Archibugi and Michie, 1995). However, under certain conditions this exchange is difficult and costly. When knowledge is complex and highly specific, the existence of large information asymmetries between purchasers and sellers substantially increases transaction costs and reduces profit margins. Cooperation with international partners becomes then an effective mechanism for resolving bargaining problems and for managing a partner's opportunistic behaviour (Pisano, 1990). Similarly, when required knowledge has a high tacit component and is embedded in foreign companies or foreign innovation systems, close cooperation can be an effective mechanism to internalize key competencies (Hamel, 1991). Cooperation with international partners also help firms to appropriate the returns of their research investments when technological spillovers surpass national borders and when intellectual property rights regimes are imperfect mechanisms to protect proprietary knowledge.

2.3 Characteristics of industries

Literature suggests that international R&D partnerships are sector specific (Archibugi and Michie, 1995; Narula and Hagedoorn, 1999; Davenport and Miller, 2000; Hagedoorn, 2002; Hagedoorn and Van Kranenburg 2003). According to Hagedoorn and Narula (1996) international partnerships have become the preferred form of collaboration in industries characterized by rapid technological developments and high uncertainties. In these industries organizational flexibility and speed of information are vital to maintain profits. Soft forms of collaboration are, therefore, preferred over alliances and joint ventures. Archibugi and Michie (1995) suggest that this is particularly true for

⁴ The strength of intellectual property rights (IPR) systems in partners' home country has also been posed as a factor that may affect the mode of international research partnerships. Hagedoorn *et al.* (2005) find that with weak IPR regimes, firms prefer joint R&D ventures rather than cooperative R&D agreements.

industries in their infant states, where there is greater need for new knowledge and for sharing relevant information. In addition, Wagner *et al.* (2000) pinpoint that some high-tech activities require international sharing of data and specialized equipment. In the computer industry, Cloudt *et al.* (2006) observe a process of vertical disintegration of producers and a shift towards more flexible modes of inter-firm and cross-border R&D collaboration.

2.4 Perceived advantages of international cooperation

Often international cooperation in innovation is seen as a channel to speed the process of knowledge creation (Hamel, 1991). This is likely to be the case when existing knowledge is codified and protected through patents. Direct collaboration facilitates tacit knowledge exchanges while reducing timing needed to assimilate external knowledge. International agreements are also viewed as a source of scientific creativity. Wagner *et al.* (2002) recall that cultural diversity is a way to assure the varied flow of new knowledge that firms require to come up with new and breaking ideas. In a context where products have a short-life, accessing to heterogeneous sources of knowledge is particularly needed (Kodama 1992).

Access to new markets and distribution channels is also posed as critical when companies decide to cooperate with foreign partners (Hagedoorn, 1993; Sakai, 2002). Increased competition and shorter product life cycles add pressure to firms to commercialize their products in larger markets. Cooperating with foreign partners may be the only way to enter in some foreign markets. Mariti and Smiley (1983), for example, report that during the 1980s Japanese companies entered into European automotive markets through the establishment of cooperation agreements in R&D with local producers.

Collaboration is also seen as a mechanism to share cost and risks associated with R&D activities, while taking advantages of scale and scope economies of R&D production. This reason seems particularly strong for SME's due to their size limitation, and in high-tech industries, where individual firms may not be able to afford the scale of required R&D (Hagedoorn, 1993). In particular, it has been reported that high R&D costs is a major driving force behind global alliances in the pharmaceuticals sector (Sakai, 2002). It is also argued that international partnerships may help to negotiate standards and set the scene for future mergers and acquisitions (Hagedoorn, 1993).

2.5 Firms characteristics

Firm size is likely to affect a firm's entry in cooperation agreements. However the sign of the relationship between size and international cooperation remains an empirical question. On the one hand, large firms are better able to absorb fixed and operational costs linked to the set-up of international research partnerships. On the other hand, larger firms tend to devote effort and financial resources to strategic management, including partnership strategies. To the extent that large firms can more easily access international technology markets and have better international links, they will tend to use international cooperation more often. In addition, large firms may be more attractive as partners as they tend to have more technological capabilities, and have greater incentives to enter in a cooperation agreement because of their better position to capture the rents associated to partnerships (Sinha and Cusumano, 1991).

A counterargument is that small, highly innovative companies are more effective at taking advantage of external knowledge sources. Firm capacity to use external knowledge efficiently has been termed absorptive or learning capacity, and usually involves high levels of in-house R&D (Cohen and Levinthal, 1990; Griffith, Redding and Van Reenen, 2003). Small, innovative firms that have these capacities will identify valuable knowledge from abroad faster and easier, and will have less difficulty to integrate external knowledge with internally generated knowledge. As a result, motivation to search for international knowledge may be higher in small companies. On the other hand, larger corporations have their own research laboratories and innovation facilities, some of which may be in other countries. If this is the case, large firms may prefer doing R&D internally with other group members rather than engaging in cooperation agreements with companies located in foreign countries.

The international experience of firms is another factor likely to affect the propensity to participate in international agreements. Internationally oriented firms are likely to be better informed about new technologies developed abroad and suitable foreign partners than those oriented to domestic markets (Hagedoorn, 1993). Similarly, firms engaged in international markets are more likely to undertake higher levels of R&D, including more international R&D.

3 Direct/indirect effects of innovation policy on international cooperation

The effects of innovation programmes on international cooperation may be direct or indirect. Direct effects are found when international cooperative research is an explicit aim of innovation policy instruments. By making international partnerships a pre-condition for participation in specific programmes, governments hope to induce the development of joint cross-border research and innovation activities that otherwise might not occur. The European Union's successive European Framework Programmes provide significant examples of these policies.⁵ The aim of these programmes is to improve the effectiveness of national and international innovation systems, by increasing knowledge exchanges within and across countries (Narula, 2002; Balzat and Christensen, 2004; Borrás, 2003; Lundvall and Borrás, 1997). Policy makers also hope to reduce regional disparities in innovation, by encouraging firms in catch-up regions to cooperate in innovation with organizations from more technologically advanced areas.

In line with recent work by OECD (2006), we anticipate that government funding induces a variety of effects that go beyond traditional impacts such as increases in R&D expenditures or patenting. We believe that innovation programmes also produce behavioural changes.⁶ In particular, we suggest that firm participation in national or sub-national innovation programmes have indirect effects on international innovation collaboration as a result of several interconnected factors. We group these factors into the following categories:

- *Resource reallocation.* Firms usually assemble their research projects not in isolation but in the context of their overall innovation strategy. As a result, it is plausible that the availability of publicly-funded research awards releases at least some firm resources that can be targeted to additional or complementary innovation activities, including international partnering. Reallocating firm resources to international partnering is more likely to occur when, as mentioned in the previous section, the national innovation system has significant domestic scientific and technological shortages.

⁵ Other well-known examples of cooperative research programmes are the EU Intelligent Manufacturing Systems initiative, and national initiatives of small countries, such as the *Kplus programme* in Austria (OECD2006).

⁶ In the evaluation literature this effect is known as 'behavioral additionality'. See Buisseret *et al.* (1995) and Davenport *et al.* (1998).

- *Learning opportunities.* Firms that participate in national and regional publicly-supported research programmes presumably develop their capabilities and gain experience in collaborations. They accumulate experience about how to apply for and manage public funding. Contact with national and regional public funding administering agencies increases awareness about the availability of additional public funding for innovation at home and abroad. This learning process prepares firms to be interested in, and competitive, in applying for funding for international collaborations.
- *Adaptation mechanisms.* Although firms may use experience in national or sub-national programmes as a step-up to apply for international collaborative schemes, this is not necessarily the only route to develop innovation with foreign partners. Firms not wishing to follow the administrative and bureaucratic procedures involved in supra-national programmes will apply for national funding instead. Similarly, there may be a mismatch between program's requirements and firms' capacity to manage partnerships.⁷ Under this scenario, firms may then be prompted on their own to seek more flexible forms of international cooperation which are more adapted to their particular needs.

The empirical analysis of the effects of public policy on the creation of international research partnerships is not new, but remains scarce. Survey-based studies generally find that public support for private innovation helps to globalize firms' innovation processes. However, there is some variation across countries (OECD, 2006). Results are more ambiguous in econometric analyses that use firm-level data. For example, Kleinknecht and Reijnen (1992), based on a survey of Dutch firms, conclude that not all government initiatives enhance the probability to establish an international R&D partnership. Miotti and Sachwald (2003), using a sample of French firms, show that public funding has a significant positive effect on the probability to cooperate with US partners, but results do not hold when explaining cooperation with EU partners.

⁷ For example, several European collaborative innovation programmes require the involvement of many partners. Although many firms (particularly SMEs) may lack capacity and incentives to manage these large partnerships, their experience with smaller national and regional programmes may increase their willingness to forge international partnerships.

4 Methodological and empirical challenges

In previous sections we have developed two ideas. First, firms have several incentives to enter in international research partnerships, but market and coordination failures of such partnerships prevent initiation of projects involving partners from abroad. Second, there are several reasons to believe that domestic-level public programmes induce a behavioural change in the way firms organize their innovation process, and in particular in the way they search for international partners.

In order to empirically test these propositions, we treat seriously the likely sample bias involved in the selection of firms in public support programmes. The problem arises because of two issues,

- there may be several unobserved factors that affect public support and international partnerships at the same time (i.e., previous experience in receiving funding)
- firms that participate in public support programmes may already decide to cooperate in innovation with foreign partners (i.e., when international cooperation is a pre-condition for receiving public support).

If these factors are not properly taken into account when evaluating the impacts of public programmes, there may likely be a cause-effect dilemma with uncertainties in the direction of causation.⁸

One way to mitigate this selection bias problem is to find a set of project-specific variables that predict public support but are uncorrelated with the unobserved factors that affect firms' attitudes towards international cooperation.⁹ Another possibility is to use systemic and aggregated variables such as total available funds to do research. These variables are likely to affect selection rules in public research programmes, but not private decisions, as (in principle) they are unknown by companies. Several authors have indeed used this latest approach for evaluating technological impacts of public innovation programmes (see for example, Wallsten, 2000). Unfortunately, it is very difficult

⁸ See Heckman *et al.* (1998) and Blundell and Costa Dias (2000) for a methodological treatment of sample selection due to program participation.

⁹ For example, Arora and Gambardella (2005) use the scores that reviewers give to research proposals to predict the likelihood of being awarded with a National Science Foundation (NSF) grant. Then they estimate the number of publications of individual researchers in the five years after the grant, conditional on receiving an award. After doing this correction, they find that NSF effect increases the number of publications over 8%. Authors obtained similar results with non-parametric techniques.

to find strong instruments that are not truly associated with agents' innovative decisions (Jaffe, 2002). Another possibility is to compare the difference in average behaviour before and after participation in a public research program, between the group that receives public support and the group of firms that is used as a control. In the evaluation literature this approach is known as 'difference in differences'.¹⁰ To conduct such analysis a balanced panel of firms is needed.

A third possibility to deal with sample selection problems is to construct an artificial counterfactual group of firms as if a pure experiment was taking place. The idea of this method is to match a group of funded firms with a control group of firms that are as similar as possible with respect to key observed characteristics. Matching methods have been recently used in Europe to evaluate the effects of public support on input R&D measures (see for example, Almus and Czarnitzki 2003) and on patents (Czarnitzki *et al.* 2007; and Czarnitzki and Licht 2006). Busom and Fernández-Ribas (2008), using data from the Spanish version of the Community Innovation Survey, evaluate the impact of public funding on the multidisciplinary of research cooperation. Their findings suggest that matched firms with public funding are more likely to enter in public-private partnerships, than similar firms that do not receive public funding.

There are advantages and disadvantages to each of these methodological approaches.¹¹ The selection of one or other method depends to a great extent on the richness of information that is available for analysis:

- whether data contains instruments that can be used as exclusion restrictions in the impact equations of the programmes, and
- whether there is information on firms that are eligible to apply for public funding, but do not, and firms that apply but are rejected.

The advantage of using non-parametric techniques over more conventional methods is that no functional form is assumed between public support and impact variables, and no instruments are needed. When it is difficult to find

¹⁰ Lach (2002) has used this method to investigate the impacts of R&D subsidies in Israel, finding crowding-in effects over private expenditures in R&D. Branstetter and Sakakibara (2002) employ difference in differences to evaluate productivity gains of publicly-supported Japanese consortia and also find positive results.

¹¹ See Jaffe (2002) for a discussion.

strong and meaningful instruments that are related to public programmes but not to impact variables, quasi-experimental methods are more adequate.

5 Modelling the effects of public support on private innovation

5.1 Model specification

In developing our approach to modelling the effects of public support on private innovation, we recognize that the possible endogeneity of public support needs to be assessed. We chose to use propensity score matching methods to deal with these problems.¹² But first we delete from the analysis those firms that received public support from international sources (since international collaboration is often a precondition of such awards).¹³

To do the matching, we use an estimation routine proposed by Becker and Ichino (2002). The first step is to estimate the predicted probability (propensity score) that a sample firm receives public support from national/regional authorities, P_i . The specification of the model is the following,

$$P_i = \Pr(W_i, u_i) = \Pr(P_i=1 | W_i, u_i) = \Phi (b_W W_i) \quad (1)$$

where i indexes firm, P_i is an indicator of a firm's participation in a domestic research program (national, regional or local) and equals one if a sample firm is in a program and 0 otherwise. W_i is a set of firm-specific characteristics found to be significant in previous theoretical and empirical works. W_i includes the following variables:

- whether a firm is small, medium or large;
- whether a firm does R&D on a continuous basis;
- whether a firm uses patents to protect innovations;
- R&D intensity, measured by the ratio of current R&D researchers over non R&D personnel;
- whether a firm buys external technology;

¹² See Wooldridge (2004) and Dehejia and Wahba (2002) for the methodological aspects of this technique. We also experimented with a two-stage instrumental variable probit model using as instruments: publicly available funds to do research at the national level by industry type and a proxy for cost as a factor hampering innovation. However, the F-test for the validity of instruments did not confirm strong results.

¹³ There are 59 firms that receive public support from the EU, including those firms that receive public funding from the IV or the V Framework Programmes. These firms are excluded from the sample.

- export intensity, measured by the exports over sales, and
- industry type where a firm operates.

u_i is a set of unobservable characteristics and $\Phi (\cdot)$ denotes the standard normal distribution.¹⁴

Once the predicted probability of participation status is estimated, firms are distributed into subgroups of supported and non-supported firms. Then the model tests whether the means of each characteristic do not differ between supported and non-supported firms. Non-supported firms, for which it is not possible to find, at least, one supported firm with the same W_i characteristics, are dropped from the sample. The common support option is imposed, meaning that average propensity scores of supported and non-supported firms is only performed for non-supported firms with a propensity score above the minimum or below the maximum of that of the supported. If a test of similar means can be accepted and the balancing property is satisfied, then the propensity score is used to estimate the *Average Treatment effect on the Treated* (ATT). ATT is computed as follows,

$$\tau_{ATT} = \Pr (C_i = 1 | P_i = 1) - \Pr (C_i = 0 | P_i = 1) \quad (2)$$

$$\tau_{ATT} = \Pr (C_{Ei} = 1 | P_i = 1) - \Pr (C_{Ei} = 0 | P_i = 1) \quad (3)$$

$$\tau_{ATT} = \Pr (C_{OEi} = 1 | P_i = 1) - \Pr (C_{OEi} = 0 | P_i = 1) \quad (4)$$

where C_i is a proxy for firm attitudes towards international research partnerships, equals 1 if a firm cooperates in innovation with a partner from abroad, and 0 otherwise. C_{Ei} is a binary variable coded 1 if a firm cooperates in joint R&D or other innovation projects with at least one partner from the European Union (EU) and from the European Free Trade Association (EFTA)¹⁵. C_{OEi} is a binary variable coded 1 if a firm cooperates in joint R&D or other

¹⁴ Busom and Fernández-Ribas (2008), Almus and Czarnitzki (2003) and Czarnitzki *et al.* (2007) use a similar specification. Our variables are described in appendix A-1. A correlation analysis for our explanatory variables reveals that we do not have significant multicollinearity problems (See appendix A-2).

¹⁵ Includes partners from EU member countries prior to the EU expansion of 2004 (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Sweden, and the United Kingdom) and EFTA countries (Iceland, Liechtenstein, Norway and Switzerland). There are 11 companies in the sample that cooperate with partners from new EU countries (members since 2004) and/or current candidate countries (e.g. Turkey). Most of these companies also cooperate with EU/EFTA partners.

innovation projects with at least one partners from outside the EU/EFTA region.¹⁶ To estimate the ATT effect, and check for robustness of model specification and results, three methods are employed: nearest neighbour matching, kernel matching, and stratification matching estimator.

5.2 Other factors affecting the propensity to receive public support to innovation

In addition to exploring the effects of public policy, previous literature (see section 2) has proposed other factors that influence the formation of international cooperation in innovation. We investigate these factors with a bivariate model that jointly explains the probability to receive public support and the probability to enter in an international cooperation in innovation. Such a model is informative about to what extend there are un-observed factors that affect both variables. Our specific hypotheses are the following:

Industrial technology level. The propensity to enter into an international agreement differs from industry to industry and varies significantly with the technological intensity of industries. To test for the effect of *activity* we use as a reference the technological intensity classification done by OECD¹⁷ and construct four binary variables: HIGH_TECH, MEDIUM_HIGH, MEDIUM_LOW and LOW_TECH. We construct another dummy for activities that follow under other categories OTHER.

Absorptive capacity. Firms with high levels of absorptive capacity will find easier to find appropriate international partners to develop research. In order to capture the level of absorptive capacity we consider a continuous variable about firms' human capital, measured by the number of researchers over non research persons in 2000, PINV. We also include a squared term of human capital to test for non-linearity of this variable, PINV_SQ.

¹⁶ Includes partners from the US, Japan and other countries not included in EU/EFTA.

¹⁷ For details see table A1 in the appendix.

Continuous research. Having previous experience in research activities is likely to contribute positively to the establishment of cooperation agreements with international partners. The variable RD_CON measures whether a firm does R&D continuously and is employed as a dummy variable to measure prior and ongoing experience in research.

Technological capabilities. Firms that have technological capital are better prepared to take advantage of cooperating with leading partners. To test this proposition we include a dummy for whether the firm invests in machinery and equipment and for whether it invests in other external technologies and technological knowledge, such as patents, licenses, know-how and trademarks, EXTERN.

Firm size. The relationship between firm size and international cooperation is likely to be positive. To control for firm dimension, a set of dummies is introduced in the regressions: SMALL, coded as 1 if a sample firm has more than 10 employees but less than 50 employees and sales up to €6 million in 2000, MEDIUM if a firm has 50-285 employees and sales up to €40 million, LARGE if a firm has more than 285 employees and sales over €40 million.¹⁸

Export intensity. Firm level of export capacity will have a positive influence on firm's ability to find and cooperate with international partners. The international character of the firm is proxied by the export intensity of a firm, EXPORTS, and is captured by exports over sales in 2000.

Patent granting. This variable signals to what extent firms value the use of protection methods to protect their proprietary knowledge. It can be indicating that firms that patent are doing more valuable inventions, that worth the cost of applying for a patent and the cost of maintaining those patents. But it could be also an indicator that firms are doing inventions with a commercial component that needs to be patented. To investigate this we include a dummy PATENT, coded 1 if a firm use patents to protect innovations.

¹⁸ This classification is similar to that proposed by the EU (see EU Commission Recommendation 2003/361/EC of 6 May 2003).

6 Data and programme overview

6.1 Firm-level data

Our dataset comes from the Spanish version of the Third Community Innovation Survey.¹⁹ This survey provides cross-sectional data on innovation for the period 1998 to 2000, for industrial and service firms with more than 10 employees. The survey covers a wide range of questions, including sources of public funding for innovation activities and cooperation agreements on innovation with other firms or organizations.

Firms are asked to report whether they have received financial assistance (in the form of subsidies or soft loans) from local/regional, national or EU authorities. In addition, there is a specific question about participation in the fourth (1994-1998) and fifth (1998-2002) Framework Program of the EU. The survey includes a set of questions about the type of organization involved in the partnership and the location of each partner. Innovation cooperation means active participation in joint innovation projects (including R&D) with other organisations. Contracting-out of research activities is not regarded as active cooperation. Information about the expenditure dedicated to cooperation activities is not included in the survey.

The sample used in this study is confined to firms that declare being engaged in an innovation activity in the period 1998-2000, operate in manufacturing sectors and are located in Catalonia.²⁰ Being engaged in an innovation activity means having introduced technologically new or improved products or process, having on-going innovation activities, or having undertaken innovation activities during the period even if these were subsequently abandoned. Keeping the sample homogeneous is the reason why we exclude from the initial sample firms that operate in services, in construction and in highly regulated sectors such as energy and water.

¹⁹ This survey was conducted by the *Instituto Nacional de Estadística* (INE) in 2002. CIS is not a survey specifically designed to evaluate innovation programmes. Consequently, it has several limitations in this regard. It does not include, for example, questions about past experience in applying for, and receiving public funding. However, one of its main advantages is its comparability across EU, given that core questions and methodology are harmonized among countries. Another advantage is that it allows analysis at the firm level and, as a result, consideration of heterogeneities in the impacts of public programmes.

²⁰ Catalonia is one of the core industrial regions in Spain. In 2006, Catalonia generated about one-quarter of Spain's industrial added value, according to IDESCAT, the Statistical Office of Catalonia (see <http://www.idescat.net/en/>).

Table 1 reports a breakdown of selected firms according to some response characteristics. Our sample size consists on 930 innovating firms, of which 41% have less than 49 employees. A large proportion of these firms claim to be highly innovative (almost 60 percent).²¹ However, less than one third of highly innovative firms operate in high-tech sectors. The systematic nature of R&D is also low: only 28% of firms claim to do R&D on a continuous base, but this is not linked to the technological intensity of manufacturing sectors.

[Table 1 about here]

Partnership indicators show that cooperation in innovation is not a widespread strategy among innovating firms. Only 17 percent of innovators declare having established a cooperative agreement to develop innovation activities.²² Cooperation with domestic partners is more common than cooperation with foreign organizations (16% vs. 11%).²³ Regarding the nationality of foreign partner, numbers indicate that EU-15 countries and other high-income countries as Iceland, Liechtenstein, Norway and Switzerland are favourite associates, and not Japan and the United States, even though these latter two countries are leaders in many key technologies.²⁴ Cooperation with foreign partners increases with firm size and with the technology intensity of industries.

Data indicate that about one-fifth of firms with innovation activities receive some sort of public support from national authorities, while the

²¹ True innovators introduce new or improved products new to the firm itself and new to the firm's market. Firms that only introduce new products new to the firm are more associated with imitation and catching up processes. As imitation tends to be cheaper than generation these second type of firms are considered to be weakly innovative.

²² Miotti and Sachwald (2003), using data from the second wave of the French CIS, report a higher proportion of cooperation ratios among innovating firms (33%). Tether (2002), for the UK, and Cassiman and Veugelers (2002), for Belgium, using CIS find that 45% of innovative firms cooperate in innovation. As for the case of Spain, Bayona *et al.* (2001) report that 45% of firms with R&D activities were involved in innovation cooperation during the period of 1996 to 1998. In a previous study done with a sub-sample of Catalan firms with R&D activities during 1996-1998, we also find that cooperation ratios were about 40% (Busom and Fernández-Ribas, 2008).

²³ This finding is similar to what has been reported by studies of other EU countries. For example, Kleinknecht and Reijnen (1992) find that 22% of Dutch firms conducting R&D cooperate with domestic partners while 13% do so with foreign partners. Miotti and Sachwald (2003) report that French firms cooperate mainly with domestic partners, and with EU partners to a lesser extend. Similar results are derived from the CIS-3 (EC, 2004).

²⁴ Unfortunately it is not possible to distinguish among which EU/EFTA countries firms cooperate.

corresponding proportion for regional-level programmes is 10% (or 95 firms).²⁵ Interestingly, half of the firms that participate in regional-level programmes also participate in nationally supported programmes. Less than 5% (or 43) of firms in the sample get support from EU sources during 1998-2000.²⁶ A high proportion of these firms get support from national sources as well. By contrast, less than 15 firms that are supported internationally are supported regionally. If we consider the relationship between cooperation and participation in research programmes, several interesting patterns can be observed. Table 2 shows that international cooperation is not higher for publicly-supported firm: only 23% (or 53) of firms that participate in national-and regional-level programmes cooperate in innovation with international partners. In addition, a Pearson chi-squared test for independence of cooperation status and public support cannot be rejected.²⁷

[Table 2 about here]

6.2 Programme context

During the period under study (1998-2000), the Third (1996-1999) and Fourth (2000-2003) National R&D Plans were in force in Spain. Two national programmes were specifically designed for helping firms to innovate:

- Programme for the Promotion of Industrial Technology (1997-1999) and
- Programme for the Promotion of Technical Research (PROFIT) (2000-2003).

The goals of these programmes were varied, including increasing private R&D expenditure and the number of researchers employed by firms, improving technology, security and industrial quality of firms, and promoting domestic cooperative research between firms and universities, public research centres or

²⁵ These numbers are lower than the EU average. As reported in EC (2004), 18% and 17% of industrial firms with innovation receive national and regional funding respectively.

²⁶ Sixteen firms not claiming EU funding during 1998-2000, claim to have received funding from the IV (1994-1998) or the V (1998-2002) Framework Program of the EU. Obviously, these firms received funding prior to 1998. According to EC (2004) 8% of European firms with innovation activity in the industrial sector received European Union funding during 1998-2000.

²⁷ Only 12 firms that received funding from regional sources entered in cooperation agreements with international partners. Most of these firms also participated in national funded programmes. By contrast, half of the firms (20) that participated in international research programmes cooperated with foreign partners.

technological centres.²⁸ To achieve these goals, several types of projects were sponsored, including:

- pre-competitive research projects, developed by domestic firms in-house or in collaboration with and national public research organizations or technological centres;
- technological development projects of an applied nature, not requiring cooperation; and
- technological innovation projects, intended to encourage the use of new technologies in the firm, not requiring cooperation.

At the regional level, the Second Research Plan (1997-2000) was in force. This plan did not have a firm-driven approach. It mostly focused on the promotion of academic research (Bacaria *et al.*, 2004). However, the plan included a program to facilitate the technological development of firms. Actions taken in this regard, referred mostly to the incorporation of PhDs in the industry.

National and regional innovation projects were restricted to national organizations. To judge by policy reports, selection criteria was based on scientific excellence, technical and commercial feasibility of projects as well as potential benefits generated for other firms and consumers. Territorial considerations did not seem to play a role in the selection of firms. Based on these considerations, we assume that firm specific variables relevant for being selected for funding include factors such as openness, firm size, previous experience in R&D, internal R&D and technological capabilities.²⁹

Firms could also get support from the European Union. During 1998-2000, firms could participate in several EU programmes, including the Fourth (1994-1998) and the Fifth (1998-2002) Framework Programmes, Multilateral Public Research and Technology Schemes (i.e. Eureka, Cost), as well as programmes financed by the European Regional Development Funds (ERDF). With the exception of some programmes funded by ERDF³⁰, participation in EU programmes typically required the establishment of transnational research

²⁸ For a detailed discussion of these programmes see Bacaria *et al.* (2004) and Fernández-Ribas (2003).

²⁹ These are the factors we use as explanatory variables in the public support equation.

³⁰ Firms in Catalonia are not eligible under the Objective 1 Program of the Structural Funds (least favored regions). During 1997-1999, Catalan firms could benefit from an Objective 2 Program. See inforegio:

partnerships. Obviously, if this is the case, the impact of public programmes will be due to selectivity issues rather than an effect of it. To ensure that this does not happen, we excluded from the initial sample those firms that participated in international research programmes.

7 Estimation and results

Table 3 reports estimation results of a series of bivariate probit models for the propensity to cooperate with foreign partners and the propensity to receive public support to innovation.³¹ It turns out that correlations of residuals between both equations are not very high and significant, suggesting that cooperation status and public support are not strongly associated with each other. This result reduces our concerns about the existence of common unobserved factors affecting both cooperation and public support, and supports matching on observable characteristics between the groups of supported and non-supported firms as an adequate approach.³²

[Table 3 about here]

Results indicate that larger firms have a higher propensity to cooperate with international partners than small firms. Firms that acquire technology (through purchase of machinery and equipment, patents, licenses or other know-how) also have a higher propensity to cooperate, reflecting the fact that that cooperation is complementary to other forms of external technology acquisition. Cooperation increases with a firm's absorptive capacity, as measured by number of R&D personnel over non R&D personnel. This result holds for each type of cooperation partner, being consistent with the idea that the capability of the firm to absorb external knowledge depends crucially on its own level of human capital and experience in R&D activities.

Sectoral dummies show positive signs relative to the reference sector (low tech industries and other activities with low technological content as extraction of minerals). This positive impact is significant when firms operate in

³¹ Pearson correlated matrix is shown in the appendix. We estimated an alternative model including as explanatory variables a set of interaction variables between intensity of researchers and firm's size, and between intensity of researcher and sector type. Results were very similar to those reported in table 3.

³² This also means that this specification fulfills the Conditional Independence Assumption (CIA) required to do the matching (see, Rosenbaum and Rubin, 1983).

high-tech sectors. By contrast, the hypothesis that export-intensity affects the likelihood to enter in an international cooperative agreement is not supported at statistically significant levels. One interpretation is that Spanish firms may have a revealed comparative advantage in mature sectors, and do not need to innovate or to develop R&D in cooperation with foreign partners. Patents as a proxy for the commercial success of inventions do not turn significant either. We interpret this result as suggesting that innovative firms under study may be introducing in the market incremental innovation rather than radical innovations. Some differences exist across types of partners. Firms that cooperate with partners from outside the EU/EFTA area are more likely to operate in high-tech sectors, while intra-EU/EFTA cooperation is also likely to occur in medium-low sectors.

The probit model used for calculating the propensity scores is presented in Table 3 (column 5). Results indicate that the probability to receive public support for innovation increases with size, continuous R&D and level of absorptive capacity, suggesting that the award process favours firms that are already performers of R&D. After estimating propensity scores, firms are classified in five groups of supported and non-supported firms. The balancing property of the propensity score is then tested. As it is satisfied, and average propensity score for supported and non-supported firms do not differ significantly on the observables in each group of firms, we use the proposed specification and proceed with the matching process.³³

Results from the propensity score matching are presented in Table 4.³⁴ Alternative matching methods are used to calculate the ATT, i.e. Kernel, Stratification and Nearest Neighbour (in its random draw and equal weighted versions). According to our results, public supported firms have on average 4% higher probability to develop innovation with a foreign partner than comparable firms that do not participate in public programmes. Interestingly, the impact of national public support is much larger when partners are from European countries, reaching almost 8% when using stratification matching. This

³³ Becker and Ichino's (2002) model selects five blocs to ensure that the mean propensity score is not different for treated and controls in each block. Difference in means between supported and non-supported firms are reported in table A3 in the appendix. As can be seen, there are no significant differences between both groups of firms, and the matching estimator succeeds in balancing out differences in observed characteristics. It is important to remark here that if the balancing property were not satisfied we could not use our specification to estimate the ATT.

³⁴ ATT are estimated using firms with propensity scores estimates inside the common support region.

percentage doubles the average effect on extra-EU cooperation, corroborating the idea that domestic innovation programmes prepare firms to do cooperative innovation at the European level, and to less extent cooperative relations with more technically advanced countries. This can be understood as a leverage effect that increases firms' chances of getting competitive funding from international sources, while increasing regional cohesion.

[Table 4 about here]

8 Conclusions and Policy Implications

A key challenge in science and technology policy is to ensure a long-lasting change in firms' attitudes towards knowledge creation and innovation. The ultimate goal of public policy is not merely to stimulate an automatic increase in private R&D expenditure or patent capacity, but also to ensure that public funding has a structuring effect on private incentives to innovate. Using data from the Spanish Community Innovation Survey our results suggest that national and sub-national innovation programmes change firms' behaviour in two directions: internationalisation of firms' innovation activities increase and, second, organizational aspects of innovation change.

These results have several policy implications. First, evaluation of innovation programmes should be extended by taking into account behavioural additionality and indirect outcomes. Second, multi-level approaches are needed for improving our understanding of science and technology policy effects (Borrás, 2003). Third, there is a further implication for European efforts to create a European Research Area (ERA). This is that national (and by extension) regional research and innovation policies remain important in stimulating international research collaboration.

The role of national and sub-national governments may be particularly important when firm capacities to participate in internationally-funded partnerships are limited. As several reports point out (i.e. Marimon, 2004) application and coordination costs associated with European projects often discourage enterprise participation. Even if these firms have scientific capabilities, they may not have managerial experience or incentives to deal with larger cross-border partnerships. By contrast, SMEs may be more familiar with application procedures at the national and regional levels, because these

programmes are often more flexible in terms of partnerships requirements. Our results signal that national and regional programmes are an effective pathway to gain managerial experience and familiarity with program participation rules. This finding is of utmost relevance for countries like Spain, where most firms are small and operate in medium-low tech sectors.

There are several potential extensions to our analysis. In further research, it would be useful to explore the relationship between public support and the intensity of international cooperation in innovation. In addition, “second round” effects could be investigated, for example whether initial international cooperation stimulated by public intervention leads to subsequent cooperation activities and, if so, whether those follow-on activities occur with reduced transaction costs, variations in scope, or other outcomes. More broadly, further research on the development and continuation of innovation partnerships could shed additional light from a new angle on how public intervention influences firm behaviour and strategies.

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Table 1 Descriptive data analysis of innovative firms, by class of firm

Class of firm	Number	Of which		Of which	
		High tech sector	Medium tech sector	Less than 50 employees	More than 50 employees
Innovative	930 ^a (100.00)	162 (17.42)	216 (23.23)	385 (41.40)	545 (58.60)
Highly innovative	412 ^b (59.71)	106 (25.73)	83 (20.15)	126 (30.58)	286 (69.42)
Continuous R&D	154 (28.15)	25 (16.23)	30 (19.48)	86 (55.84)	68 (44.16)
P _i = 1	238 (25.59)	68 (7.31)	48 (5.16)	60 (6.45)	178 (19.13)
C _i = 1	106 (11.4)	47 (44.34)	21 (19.81)	8 (7.55)	98 (92.45)
C _{Ei} = 1	92 (9.89)	40 (43.48)	18 (19.57)	5 (5.43)	87 (94.57)
C _{O_{Ei}} = 1	67 (7.20)	36 (53.73)	15 (22.39)	7 (10.45)	60 (89.55)
C _i = 1	767 (82.47) ^c	150 (19.56)	129 (16.82)	367 (47.85)	400 (52.15)

^a Firms with more than 10 employees that answer the questionnaire and report doing product and/or process innovation during 1998-2000. Firms in energy, water, construction and service sectors are not included.

^bFirms that report introducing innovations new to the market.

^cFirms that do not enter in any type of cooperation agreement, domestic or foreign. This table includes firms that participate in EU programmes.

Source: Analysis of Spanish Community Innovation Survey, Third Wave, data for Catalonia. Survey conducted by Instituto Nacional de Estadística (INE). N=930. Numbers in parentheses = percent of total.

Table 2 Frequencies between national-and regional level innovation programmes and types of international innovation cooperation

	$C_i = 0$	$C_i = 1$	$C_{Ei} = 0$	$C_{Ei} = 1$	$C_{OEi} = 0$	$C_{OEi} = 1$
$P_i = 0$	605	73	642	36	648	30
$P_i = 1$	139	53	163	29	170	22

	Pearson chi2(1)	Pr
(P_i, C_i)	14.2540	0.000
(P_i, C_{Ei})	20.7634	0.000
(P_i, C_{OEi})	13.1717	0.000

Source: Analysis of Spanish Community Innovation Survey, Third Wave, data for Catalonia. Survey conducted by Instituto Nacional de Estadística (INE). N=930.

Table 3 Determinants of cooperation with foreign partners and public support from national and regional level authorities

Variable	C _i ^a	C _{Ei} ^a	C _{OEt} ^a	P _i ^b	P _i ^c
Medium	0.69*** (0.22)	0.78** (0.25)	0.48** (0.25)	0.12*** (0.04)	0.40*** (0.13)
Large	1.27*** (0.23)	1.45*** (0.26)	1.07*** (0.26)	0.14*** (0.05)	0.45** (0.15)
RD_Con	0.38** (0.18)	0.29 (0.19)	0.49** (0.22)	0.07* (0.04)	0.23* (0.13)
Exports	0.28 (0.27)	0.41 (0.29)	0.20 (0.31)	0.08 (0.06)	0.28 (0.21)
Pinv	8.03** (4.06)	8.76** (4.29)	10.06** (4.37)	2.10*** (0.81)	7.39*** (2.87)
Pinv_Sq	-19.69 (14.27)	-19.64 (14.83)	-23.60 (15.01)	-4.50* (2.44)	-15.83* (8.61)
High_Tech	0.52*** (0.19)	0.48* (0.20)	0.65** (0.22)	-0.03 (0.04)	-0.12 (0.14)
Med_High	-0.13 (0.23)	-0.21 (0.25)	0.24 (0.26)	-0.02 (0.04)	-0.06 (0.15)
Med_Low	0.34* (0.20)	0.44** (0.22)	0.34 (0.27)	-0.07* (0.03)	-0.27* (0.14)
Patent	0.16 (0.15)	0.15 (0.16)	-0.01 (0.17)	-0.04 (0.03)	-0.16 (0.12)
Extern	0.35** (0.18)	0.37** (0.19)	0.35* (0.20)	0.03 (0.04)	0.10 (0.14)
Constant	-2.77*** (0.23)	-3.02*** (0.27)	-3.05*** (0.28)		-1.18*** (0.11)
Log L	-635.591	-602.86	-578.19	-429.01	-429.01
Obs.	870	870	870	870	870
Wald chi2(22)	136.69	124.22	117.38		
Rho	0.12	0.20	0.12		
Likelihood -ratio test of rho=0	0.2054	0.0440	0.2687		
LR chi2(11)				60.32	60.32

Standard errors in parenthesis.

*Significantly different from zero at 10% **at 5% *** at 1%.

Does not include firms that participate in international-level research programmes.

^a Estimates bivariate probit "cooperation status" and "public support".

^b Marginal effects univariate probit estimates.

^c Propensity score estimates public support to innovation.

Table 4 Average treatment effect on the treated (ATT) of participation in domestic innovation programmes on the probability to engage in international R&D partnerships.

Type of matching	Variable	P _i =1	P _i =0	ATT	Std. Error
Kernel	C _i	192	678	0.04	0.03
	C _{Ei}	192	678	0.06	0.03
	C _{O_{Ei}}	192	678	0.03	0.03
Stratification	C _i	190	680	0.06	0.03
	C _{Ei}	190	680	0.08	0.03
	C _{O_{Ei}}	190	680	0.05	0.02
Nearest	C _i	192	234	0.01	0.04
Neighbour	C _{Ei}	192	234	0.05	0.04
Random	C _{O_{Ei}}	192	234	0.02	0.03
raw					
Nearest	C _i	192	234	0.02	0.04
Neighbour	C _{Ei}	192	234	0.05	0.04
Equal weigh	C _{O_{Ei}}	192	234	0.02	0.03

The balancing property is satisfied, meaning that distributions between supported and non-supported firms do not differ within groups of firms. Only firms with estimated propensity score in the region of common support region (.05756455, .6195433) are used to compute the ATT. Standard errors bootstrapped with 100 replications.

Appendix

Table A1 Variables used in the matching and regression analysis.

C_i^a	Cooperation (in joint R&D or other innovation projects) with at least one foreign partner in 1998–2000 (N=80)
C_{Ei}^a	Cooperation (in joint R&D or other innovation projects) with at least one partner from the European Union (EU) and the European Free Trade Association (EFTA) in 1998–2000 (N=65)
C_{OEi}^a	Cooperation (in joint R&D or other innovation projects) with at least one partner from outside the EU/EFTA in 1998–2000 (N=52)
P_i^a	Participation in at least one innovation programme at national/regional or local levels in 1998–2000 (N=192)
Small ^a	Firm's size between 10–50 employees and sales up to €6 million in 2000 (N=374)
Medium ^a	Firm's size between 50–285 employees and sales up to €40 million in 2000 (N=310)
Large ^a	Firm's size more than 285 employees and sales over €40 million in 2000 (N=187)
Exports	Exports over sales in 2000
Pinv	Research personnel / non-research workers in 2000
Pinv_Sq	Square of research personnel / non-research workers
RD_Con ^a	Continuous R&D (N=347)
Patent ^a	Use of patents to protect innovations (N=233)
Extern ^a	Innovation expenditures in machinery and equipment and/or acquisition of other external technology or intellectual property linked to product and process innovations (N=123)
High_Tech ^a	Operating in a high-technology industry (includes NACE ^b : 24, 30, 32, & 33) (N=198)
Medium_High ^a	Operating in a medium-high technology industry (includes NACE: 31, 34, 35, & 29) (N=149)
Medium_Low ^a	Operating in a medium-low technology industry (includes NACE: 23, 25, 26, 27, & 28) (N=176)
Low_Tech ^a	Operating in a low-technology industry (includes NACE: 36, 37, 20, 21, 22, 15, 16, 17, 18, & 19) (N=340)
Other ^a	Extraction of metallic and non-metallic minerals (includes NACE: 10, 11, 14) (N=7).

^a Dummy variable that takes value 1 if the definition applies to the firm, 0 otherwise.

^b NACE ('Nomenclature statistique des Activités économiques dans la Communauté Européenne') is the statistical classification of economic activities in the European Community. Numbers in brackets refer to the sample of firms used for the matching and regression analysis (without including firms that participate in EU programmes).

Table A2 Correlation Matrix

	Small	Medium	Large	RD_Con	Exports	Pinv	Pinv_Sq	High_T	Med_High	Med_Low	Low_Tech	Other	Extern	Patent
Small	1.0000													
Medium	-0.6446	1.0000												
Large	-0.4533	-0.3893	1.0000											
RD_Con	-0.4068	0.1243	0.3452	1.0000										
Exports	-0.3253	0.1565	0.2095	0.2914	1.0000									
Pinv	0.0541	-0.0279	-0.0326	0.3781	0.1097	1.0000								
Pinv_Sq	0.0714	-0.0512	-0.0263	0.1670	0.0466	0.8722	1.0000							
High_Tech	-0.0437	-0.0032	0.0563	0.2241	0.0433	0.2514	0.1099	1.0000						
Med_High	-0.0548	-0.0579	0.1335	0.1157	0.2357	-0.0067	-0.0222	-0.2468	1.0000					
Med_Low	0.0263	0.0674	-0.1103	-0.1297	-0.0790	-0.1206	-0.0670	-0.2734	-0.2289	1.0000				
Low_Tech	0.0392	0.0042	-0.0521	-0.1761	-0.1476	-0.1125	-0.0207	-0.4348	-0.3641	-0.4033	1.0000			
Other	0.1040	-0.0670	-0.0471	0.0055	-0.0359	0.0048	-0.0080	-0.0489	-0.0409	-0.0454	-0.0721	1.0000		
Extern	-0.0382	0.0012	0.0447	0.0602	0.0354	-0.0023	-0.0117	-0.0157	0.0257	0.0010	-0.0005	-0.0365	1.0000	
Patent	-0.1568	0.0866	0.0879	0.2389	0.1791	0.1336	0.0838	0.0370	0.1385	0.0120	-0.1493	0.0036	0.0898	1

Table A3 Means of characteristics for supported and non-publicly supported firms after the matching

Variable	Sample Means	Block of P-scores			
		[0.053-0.2]	[0.2-0.3]	[0.3-0.4]	[0.4-0.6]
Small	Pi=1	0.708	0.140	0.108	0.150
	Pi=0	0.812	0.134	0.111	0.083
	P-value	0.095	0.907	0.945	0.499
Medium	Pi=1	0.208	0.579	0.446	0.450
	Pi=0	0.157	0.577	0.407	0.542
	P-value	0.364	0.980	0.620	0.556
Large	Pi=1	0.083	0.281	0.446	0.400
	Pi=0	0.032	0.289	0.481	0.375
	P-value	0.082	0.908	0.654	0.869
RD_Con	Pi=1	0.021	0.456	0.969	1.000
	Pi=0	0.032	0.498	0.926	1.000
	P-value	0.678	0.583	0.240	
Exports	Pi=1	0.122	0.270	0.325	0.483
	Pi=0	0.108	0.219	0.395	0.447
	P-value	0.613	0.146	0.103	0.726
Pinv	Pi=1	0.003	0.010	0.023	0.105
	Pi=0	0.004	0.013	0.028	0.077
	P-value	0.690	0.576	0.519	0.250
Pinv_Sq	Pi=1	0.000	0.000	0.001	0.020
	Pi=0	0.001	0.001	0.003	0.009
	P-value	0.692	0.583	0.322	0.197
High_Tech	Pi=1	0.167	0.228	0.262	0.650
	Pi=0	0.171	0.214	0.269	0.625
	P-value	0.940	0.820	0.920	0.868
Med_High	Pi=1	0.063	0.246	0.231	0.250
	Pi=0	0.125	0.179	0.269	0.125
	P-value	0.211	0.264	0.583	0.295
Med_Low	Pi=1	0.396	0.105	0.000	0.000
	Pi=0	0.319	0.189	0.028	0.000
	P-value	0.288	0.139	0.177	
Low_Tech	Pi=1	0.354	0.421	0.508	0.100
	Pi=0	0.374	0.408	0.435	0.250
	P-value	0.791	0.860	0.357	0.208
Other	Pi=1	0.021	0.000	0.000	0.000
	Pi=0	0.012	0.010	0.000	0.000
	P-value	0.095	0.452		
Patent	Pi=1	0.250	0.263	0.277	0.400
	Pi=0	0.246	0.274	0.315	0.208
	P-value	0.957	0.876	0.601	0.173
Extern	Pi=1	0.125	0.123	0.200	0.250
	Pi=0	0.107	0.164	0.167	0.167
	P-value	0.713	0.448	0.582	0.506

The hypothesis being tested is that the mean difference between supported and non-supported firms is zero. Reported P-values of two side t-test. Only two firms are classified in the upper bound (predicted probability larger than 0.6).