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ABSTRACT

European Cooperative R&D and Firm Performance: Evidence Based on Funding Differences in Key Actions*

The Framework programmes created by the European Union are the main financial tools used to support cooperative R&D activities in the EU. Unlike previous empirical studies, this paper suggests that their impact on firms' competitiveness is significant. We analyze industry-oriented research joint ventures supported by the Fifth European Framework Programme between 1998 and 2002. A key feature of this Programme is that funding is available to the firms based on social and economic concerns instead of pure performance criteria, which guarantees that financial support is not granted conditional on technological opportunities. This allows us to identify the causal effect of the programme on firms' performance using the funding available to the firms in their respective industries as a source of exogenous variation in the decision to participate in the programme. Our results suggest that participation in large research projects raises labor productivity by at least 35 percent and profit margin by up to 8 percentage points.

JEL Classification: C3, L2 and O3
Keywords: firm performance, R&D cooperation and treatment effect

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1 Introduction

Research and development (R&D) investments are flawed by two important characteristics that make their equilibrium levels less than socially desirable in a freely competitive market. First, the knowledge generated by a firm's R&D effort is non-rival: To the extend that this knowledge cannot be kept secret, its use by a firm does not preclude its use by another. Second, R&D is characterized by spillovers: A firm investing in R&D usually imposes a positive externality on the other firms which can appropriate the results of this investment.[1] This will lead firms to under invest and therefore to an under-provision of R&D investment in the economy.

Along with the establishment of an intellectual property system, two types of public policies are generally used to reduce this market failure. First, direct subsidies can be offered to firms. By modifying the marginal return of R&D investments, they encourage firms to invest more than they would in a free market equilibrium.[2] A second policy consists in encouraging firms to collaborate in R&D activities in order to partially internalize the externality they impose on other firms. In this paper we focus on this last type of policy. More specifically, we focus on the core instrument used by the European Union to support European cooperative R&D activities, the European Union Framework Programmes (EU-FPs in the remainder of the paper).

The main objective of European policies toward research joint ventures in the beginning of the 1980's was to fight the relative decline in the international competitiveness of high technology sectors.[3] Started in 1984, the first Framework Programme came in response to a situation where individual R&D activities were uncoordinated and required a large number of Council decisions (Georghiou, 2001).[4] The EU-FPs are the main fi-

[1] See De Bondt (1997) for a review.

[2] The government can also intervene and encourage R&D investments through tax incentives.

[3] Other factors specific to the European Community (EC) also influenced the need for these policies. For instance, there were large differences between the many country members in terms of industrial and technological capabilities. Some members also had an already well established policy infrastructure for Science and Technology while others totally lacked such infrastructures. Finally, there was no appropriate legal framework and institutions at the EC level for supporting a consistent technology policy. In 1981, these considerations led the European Commission to establish the pilot ESPRIT program with the endorsement of the twelve largest European producers of electronics (Hagedoorn et al., 2000).

[4] Also at that time arose the formal expression of the policy rationale for the Community action in the field of research and technological cooperation. This is embedded in the principle of subsidiarity, which states that support should come where the scale or cost of cooperation was beyond that affordable by a single country, where complementarity in national work could achieve results for the whole Community, and where research contributes to development of the common market, laws and standards, or to the unification of European science and technology (Georghiou, 2001).

nancial tools used by the EU Commission to support cooperative R&D activities, and the EU participation in the coordination and financing of RJVs has been increasing until today.[5] Due to the large amount of public funds raised by the different EU-FPs, it is crucial to have a clearer idea about their effect and the outcomes they generate. To help in accomplishing this task, the present paper analyzes the effect of participation in the Fifth Framework Programme (EU-FP5 in the remainder of the paper), which was allocated a total budget of 14.96 billion euros over the 1998-2002 period; this amounts to almost 2% of the total intramural R&D expenditures generated by the EU 27 countries over the same period (Source: Eurostat). More specifically, we focus on its effects on two firm level performance measures, labor productivity and profitability.

The predecessors of the EU-FP5 mostly aimed at stimulating the transnational collaboration in research, particularly between industry and universities (European Commission, 2000, 2001). The important role of these types of partners in shaping projects' objectives indicates that these were primarily oriented towards explorative research rather than market exploitation of research results.[6] In other words, most of the research carried before the EU-FP5 did not intend to develop specific products and processes on its own, which makes it "pre-competitive". Pre-competitive research concerns R&D for which commercial possibilities remain five to ten years in the future (Luukkonen, 1998). This characteristic has largely explained the poor direct effects on the economic results of participants found in previous studies (Benfratello and Sembenelli, 2002; Barajas et al., 2011).

Instead, the EU-FP5 includes an important thematic programme, namely the User-friendly Information Society (IST in the remainder of the paper) programme, which includes projects that remain mainly industry-driven (Fisher et al., 2009). As opposed to participants coming from research and academic communities, industry partners are more likely in this case to be driven by motives to commercially exploit rather than explore a given technology. Projects involving mainly industry partners, even if not targeted to the development of a particular marketable product or service, are consequently associated with objectives that are closer to the market. The mechanism through which performance could be enhanced by participating in the programme is not explicitly modeled here, but we have in mind that cooperative R&D agreements are part of an innovation activity that

[5]The 1st, 2nd, 3rd, 4th and 5th EU-FPs were allocated 3.75, 5.4, 6.6, 13.2, and 14.96 billion euros, respectively (Artis and Nixson, 2001).

[6]Exploration is understood as "the pursuit of knowledge, of things that might come to be known," and exploitation as "the use and development of things already known" (Levinthal and March, 1993).

provides access to external know-how and hence leads to gains in performance. This know-how is expected to have a more direct impact on performance when collaboration is more market-oriented.[7] We argue that focusing more specifically on the IST programme allows us to identify a significant effect of participation in the EU-FP5 on firms' performance.

The main econometric challenge of our study arises from the fact that participation in the EU-FP5 is not random. Participation is the result of a selection process involving decisions from both participants and the European Commission. Participants must first decide to joint an RJV and elaborate a proposal. The Commission then decides whether to fund (part of) the project. Hence, showing that participating firms perform better than non-participating ones is not sufficient to prove a positive impact of programme participation. This self-selection problem is crucial and recurrent when estimating the impact of government sponsored R&D. Not taking it into account would severely bias the results (Klette et al., 2000). To get rid of this self-selection effect, we use a two step estimation method where we first estimate a selection equation. For this purpose we need at least one instrumental variable that provides randomness in the participation decision but that is otherwise unrelated to firms' performance.

We use the funding available to the firms in their respective industries as a source of exogenous variation in the decision to participate in the programme. We expect this variable to be an important determinant of the participation status of each firm, since the higher the funding available the higher the willingness to participate and/or the higher the likelihood that the project is accepted and funded. A relevant concern is that the European Commission might allocate its support partly in line with technological opportunities, which could in turn differ across industries and affect firms' performance. We take advantage of a key feature of the EU-FP5 which is that funding is available to the firms through key actions based on social and economic concerns instead of pure performance criteria. The idea of the key actions is precisely to bring together the contributions of specialists from very differing scientific fields, together with industrial researchers, users, and political and economic decision-makers in order to allow, for instance, people to choose, order, and pay electronically in complete safety, or to design a system to provide users with a full range of transport-related information such as parking availability, traffic jams, recommended routes, public transport, and so on. Since funding is not motivated

[7] In general, the empirical literature corroborates that a more market-oriented collaboration is more likely to bring along positive economic effects (Belderbos et al., 2004; Cincera et al., 2003).

by performance, it can be used as a tool to solve the selection issue. This instrumental variable has to our knowledge never been used in the analysis of these programmes nor in the context of RJV studies. It has however been used to identify the effects of specific contracts on firms' R&D investments (Lichtenberg, 1988) and in the context of R&D subsidies (Wallsten, 2000; Gelabert et al., 2009). In a recent paper, Einiö (2012) follows a similar approach and uses geographic differences in R&D support allocation as an instrumental variable to assess the effects of government R&D subsidies on company performance.

We evaluate the effect of participation in the programme on performance across two important dimensions. First, R&D collaboration remains an activity with long-term objectives, and this is a crucial feature that needs to be taken into account. In our analysis, we make sure to identify the long-term effect of participation in the programme on the economic performance of firms. In particular, our database allows us to consider lags of up to 4 years after the start of each project. Second, we account for the heterogeneity in the projects' size to better understand how participation may affect firms' performance. If RJV size and diversity increase knowledge complementarity and therefore spillover effects among participants, it would also lead to a larger increase in R&D efforts (Sakakibara, 2001). Moreover, if higher R&D expenditures increase a firm's absorptive capacity and learning capability, participation in an RJV should as well increase a firm's R&D effort (Cohen and Levinthal, 1989). Thus, participation in large RJVs will lead to larger impacts in terms of productivity and profit gains since they induce participants to put more effort in them.

Our results suggest that the long-term effect of participation is an increase in labor productivity by, at least, 35 percent. We also find a positive long-term effect of participation on the profit margin, with increases of 4 to 5 percentage points. The large magnitude of our estimates will be put into perspective. In particular, our results will be interpreted as the average impact of the programme for those firms induced to participate as a result of the change in the funding available to them (the "marginal" participants).

The remainder of the paper is organized as follows. Section 2 summarizes the relevant literature on the subject. It presents the results of the main empirical studies on the effects of participation in the EU-FPs and relates them to the programmes' characteristics. Section 3 presents the EU-FP5 in more detail as well as the IST programme. The empirical strategy for identifying the causal effect of participation in the IST programme on economic performance is presented in section 5, while section 4 presents the data and the different variables used in the estimation. Section 6 is devoted to the presentation and discussion of our results. Finally, section 7 draws some policy implications and concludes.

2 Related literature

Our paper shares features with two important categories of empirical studies on R&D collaboration. It is first related to the empirical analysis of the determinants of RJV formation and participation. As an important part of this rather thin literature, Hernán et al. (2003) analyze the determinants of participation in European RJVs and find that sectorial R&D intensity, industry concentration, firm size, technological spillovers, and past RJV participation positively influence the probability of forming RJVs. Marín and Siotis (2008) extend this analysis by exploiting the differences in institutional design of two European collaboration programmes (EUREKA and the EU-FPs) and find that past experience in the EU-FPs is an important factor explaining participation. For the case of US RJVs, Röller et al. (2007) take asymmetries in firms' size into account and show that these are important determinants of participation. They find that larger firms are less willing to share their economic knowledge with smaller rivals.

Second, our work relates to empirical studies analyzing the effect of cooperation on firm's economic performance, such as productivity or profits.[8] Even though this literature has resulted in quite mixed results, it has supported the existence of a positive relationship between close-to-the-market R&D cooperation and economic performance.

An early work analyzing the effect of RJV participation on firm economic performance is the one by Siebert (1996). Analyzing 314 US joint ventures, he shows that cooperation has no direct impact on profit margin, but he finds that the effect of R&D intensity on the profit margin is larger for cooperating than for non-cooperating firms. In a very influential paper analyzing the effects of collaboration in Europe, Belderbos et al. (2004) study the impact of cooperation on Dutch firms' productivity. They differentiate between the type of R&D partner (competitors, suppliers, customers, and universities and research institutes) and find that supplier and competitor cooperation has a significant impact on labor

[8]Another part of the literature has analyzed the effects of R&D cooperation on *innovative* performance, like sales of innovative products or patenting activity (Branstetter and Sakakibara, 1998, 2002; Dekker and Kleinknecht, 2008; Czarnitzki et al., 2007).

productivity growth. They do not, however, find any significant impact of cooperation with universities or research institutes on labor productivity, highlighting the importance of market orientation for the effects of collaboration on economic performance. Cincera et al. (2003) take the view that cooperation in R&D gives access to external know-how and use it to explain performance at the firm level. Using data on R&D and productivity for Belgian firms, they find that on top of own R&D expenditures, international R&D cooperation significantly increases a firm's productivity growth. Just as in Belderbos et al. (2004), they put forward the fact that firms may benefit differently from different types of cooperation and find that the main benefits come from international cooperation with customers, suppliers or other companies, which reflects more applied international cooperative activities. Their results therefore give further evidence on the positive relationship between the degree of market orientation of the cooperation and its impact on economic performance.

The empirical literature concerning the effects of collaboration taking place in the EU-FPs has shown rather disappointing results, mainly explained by the pre-competitiveness nature of the projects. Benfratello and Sembenelli (2002) carry an analysis to evaluate the impact of European collaboration programs on participating firms' productivity. They study the impact of two different programs, EUREKA and the (3rd and 4th) EU-FPs in the 1992-1996 period. They find that firms participating in EUREKA have experienced a significant improvement in their performance measures, while firms participating in RJVs under the EU-FP scheme do not show any significant change in performance. They attribute this result to the fundamental differences between the two programmes. The EUREKA programme has a decentralized funding source where research projects are proposed and defined by the participants themselves. It therefore shows a bottom-up structure which has much more market-oriented projects, as opposed to the top-down structure of the EU-FPs and their pre-competitive projects. In a recent study, Barajas et al. (2011) analyze the impact of participation in the EU-FP on the productivity of Spanish manufacturing firms between 1995 and 2005.[9] They show that participation has a positive impact on firms' technological capabilities, which in turn have an effect on firms' labor productivity. In other words, they do not find a direct effect of participation on economic performance, but they find an indirect effect through the generation of new

[9]Their analysis therefore covers parts of EU-FP4, all of EU-FP5 and part of EU-FP6.

knowledge.

The characteristics of the EU-FPs (pre-competitiveness, participation of universities and research institutes) have lead their impact to be mainly set on firms' technological development and capacity. Luukkonen (1998) shows that their main impact has indeed been intangible effects, such as learning new skills or creating new network relations.[10] Other studies have also found these impacts to differ with firms' characteristics, and in particular with respect to size. Fisher et al. (2009) analyze the relationship between participation in the EU-FP5 and EU-FP6 and the innovative activity of firms using data from the Community Innovation Survey and a large database composed from other sources. They find that, as opposed to large companies, small and medium enterprises demonstrate more economically-driven objectives (innovation, commercialization and market-related) and generally join a project looking for complementary resources to achieve a specific objective that will typically be a new or improved product/service or process. This translates into more positive results in terms of innovation. They also notice that, due to their limited size and resource level, SMEs will engage in a small number of cooperative agreements each of which will be important for their immediate survival and growth. For these type of firms, the funding provided by the commission is therefore crucial. Finally, a relevant finding of their study is the positive effect on both product and process innovation for first-time participants in the EU-FPs.

The next section is now devoted to a more detailed presentation of the EU-FP5 on which we will concentrate our empirical analysis.

3 The EU-FP5, the IST Programme, and Key Actions

Since 1984, research and innovation activities from the EU are bundled into the EU-FPs. These have been the main financial tools with which the EU supports R&D activities covering almost all scientific disciplines. Six EU-FPs have already been completed and the seventh has started in 2007.[11] The aim of these EU-FPs is to support and encourage European research, but the detailed objectives of each programme vary from one funding period to another. All of the RJVs that are formed under this programme are eligible for an EU subsidy, which varies according to the nature of the project.

[10] Skills refer to the technical and scientific skills rather than to the social skills needed in collaboration.

[11] The seven EU-FPs cover the periods 1984-1987, 1987-1991, 1990-1994, 1994-1998, 1998-2002, 2002-2006, and 2007-2013.

The EU-FP5 comprises several thematic programmes, which are themselves decomposed into a total of 23 Key Actions. The thematic programmes are "Quality of Life and Management of Living Resources", "User-friendly Information Society (IST)", "Competitive and Sustainable Growth", "Energy, Environment and Sustainable Development", and "Nuclear Energy". In this paper we focus on the IST programme. Two main reasons motivated our choice. First, with a budget of 3.6 billion euros, the IST programme represents the lion's share of the EU-FP5 in terms of budget allocation. The second reason is tightly linked to the objectives set by the commission in the design of the EU-FPs' projects. The pre-competitiveness of a project, as argued above, is recurrently mentioned in the empirical literature as being the reason for the poor economic effects observed on the firms participating in the EU-FPs. Our view is that the cooperation taking place in the projects of the IST programme have an impact on economic performance through the sharing of knowledge and the learning of new skills. Given their more industry-oriented nature, these projects are more likely to be driven by motives to commercially exploit rather than explore a given technology. We therefore believe the relationship between access to knowledge and firm performance to be of a more direct nature in the IST programme.

The IST programme contains four Key Actions: Key Action 1 is called "Systems and services for the citizen"; it aims at improving information and communications technologies in a wide variety of domains such as health, education, culture, social services, the needs of elderly and handicapped people, the environment, transportation and leisure. An example is the project directed by Nokia which leads to the development of a portable terminal combining mobile telephony and PDA (Personal Digital Assistant) technology. The system is designed to provide users with a full range of transport-related information such as parking availability, traffic jams, recommended routes, public transport, and so on. Six towns in Finland, Sweden, the United Kingdom, the Netherlands, France and Germany have hosted tests for this innovation, in conjunction with several major European telecommunications firms, car manufacturers and GIS (geographical information system) providers. Key Action 2 is denoted "New methods of work and electronic commerce"; its objective is to develop telework and electronic commerce and investigate an in-depth reorganisation of social relations and labour legislation, both for business and for individuals. An example is the SEMPER Project (Secure Electronic Marketplace for

Europe) which has developed one of the first operational architectures tailored for commerce on the Internet. Using the web, consumers can access a database of catalogues of goods and services, and fill in order forms on their computer screens. Payment is by credit card, using the SET protocol (Secure Electronic Transaction), or by an e-cash smart card. Key Action 3 is related to "Multimedia content and tools". Multimedia technologies are opening new ways of mastering information, acquiring knowledge, and transferring know-how available to a broad public. An example is the project SAVIE (Support Action for Videoconferences In Education) which has produced several training modules which have permitted teachers to prepare and produce lessons that are adapted to the new teaching tools. Finally, Key Action 4 is called "Essential technologies and infrastructures"; it focuses on essential components involving micro-electronics and software engineering, which deal with processing, storing and transmitting information in many types of products and services. A project example is the one of ASML, which has become a lead player in the domain of photolithography - a strategic technology for printing the integrated circuits found in micro-processors. ASML is developing a technology of scan photolithography, which is revolutionising productivity and the cost of printing integrated circuits one tenth of a micron insize.

The design of Key Actions is an important novelty of the EU-FP5 in the history of the EU-FPs. They aim at identifying socio-economic stakes and concentrating research funds in order to develop research activities that are organized around key issues. Thus, promoting research focused on performance for its own sake is not relevant here. This is a very important property since it suggests that the funds invested in the EU-FP5 by the European Commission are not targeting specific industries based on their performance. At the time of identifying the causal effect of participation in the IST programme on firms' performance, the funds made available by the programme in each industry is an excellent source of exogenous variation. Note, however, that we still expect participation in the IST programme to help firms to potentially improve their performance as we picture cooperative R&D agreements as part of an innovation activity that provides access to external know-how and hence leads to gains in performance. This know-how is expected to have a more direct impact on performance when collaboration is more market-oriented.

The European Commission does not itself undertake or participate in the EU-FP projects. Its role is to offer financial or other support to private and public research bodies, and companies and institutions wishing to embark on a research project. Each year throughout the period of the EU-FP5, the commission publishes so-called workprogrammes that contain different calls for proposals that describe the objectives planned (Zobel, 1999). The proposal of a project must then be submitted in response to these specific calls. This means that unsolicited project proposals are not allowed and the project's content must correspond to the objectives set out by the commission. Also, several eligibility criteria must be satisfied by the different partners involved in the project. One of them is that the project must involve at least two legal entities (e.g. individuals, industrial and commercial firms including SMEs, universities, research bodies, technology dissemination bodies) independent of each other and established in two different Member States or in a Member State and an associated country.[12] The financial contribution from the Commission consists in the reimbursement of a set percentage of the participants' eligible expenses, although sometimes flat-rate contributions are made. In order to be reimbursed by the Commission, participants must identify and report their eligible expenses by submitting interim and final statements. In particular, the expenses must be necessary for the action in question, provided for in the contract, actually incurred and recorded in the accounts. Finally, it is important to note that participants cannot establish intellectual property rights over their discoveries: all research must be shared among partners.

4 Data

Conducting a study on the impact of participation in the IST programme requires a database that contains both information on the different projects included in the programme and on the economic performance of firms for a period long enough to capture the long term effects of collaboration. The empirical analysis will therefore be carried out using a database constructed from two different sources. The data from the IST projects is taken from the Community Research and Development Information Service (CORDIS) web page, where a total number of 2522 projects is available.[13] The second source of information is the one about the participating firms. Once the information about each project is recovered, we can look at each participating firm individually in order to obtain firm-level data. This latter task will be done using Amadeus (Analyse MAjor Databases

[12] This means that entities established outside the EU and international organizations can also participate.

[13] All the projects' fact sheets are available at http://cordis.europa.eu/ist/projects/projects.htm.

from EUropean Sources), a database produced by BUREAU VAN DIJK, a specialist provider of firm-level data. Firms participating in the projects recovered from the CORDIS web page are therefore linked to the AMADEUS database in order to retrieve their relevant information. The AMADEUS database contains balance sheet information on the top 250,000 firms in Europe, while the CORDIS database provides information on each project, i.e. its description, its reference, the starting and ending dates of the project, its status and its acronym, the contract type offered to the participants, the cost of the project as well as the funding provided by the European Commission. The name of the coordinator of the project and of the participating firms are given as well.

We were able to retrieve 961 firms that participated in at least one FP5 RJV from AMADEUS. Table 1 gives the different number of RJVs the firms participate in and shows how some firms were often involved in more than one project. In our analysis, we decided to focus on the firms that participate in one project only. This corresponds to a total of 620 firms participating in 466 projects. After cleaning the dataset, we end up with a total of 379 participants that correspond to 315 projects.

Table 2 presents some average values for the projects included in the database. The column *All Projects* represents all the projects we could recover from the CORDIS webpage for the EU-FP5 (2359 projects), while the column *Single Part* contains the projects in which only single participants (in our data set, that is) are involved (466 projects). The last column *Sample* contains information on the projects that correspond to the participating firms present in our final sample (315 projects). The projects that we are able to analyze seem to be larger in terms of number of participants and cost. Unless otherwise stated, the next tables will present statistics of the projects included in our final sample.

Table 3 reports the characteristics of the projects in our database according to their starting dates. The vast majority of the projects were initiated between 2000 and 2002, and only a few in 2003. Table 4 provides summary statistics on the number of participants by project, showing that projects are more or less evenly distributed, with a higher proportion incorporating 6 to 10 participants. The duration is on average lower when projects have few participants (0 to 3) and the cost of each RJV is increasing with the number of participating firms. Regarding the projects' costs, table 5 reveals that the majority of RJVs have costs between 0 and 6 millions euros, with a peak for the ones with costs between 1 and 3 millions. We can also observe that both the number of participants and their diversity in terms of industry increase with the cost of the project. When carrying our analysis on the effects of participation taking project's size into account, we will define a large RJV as being one with a total budget of more than 2.8 million euros, which is the median value of the distribution of the projects' cost in our sample. Table 6 presents projects' characteristics when classified according to our definition of size. Again, note that large projects not only involve more participants, but that they involve more participants coming from different industries (defined at the 4-digit level). Large projects are therefore more diverse than small ones in terms of participants' industry of origin.

An important problem one has to deal with when evaluating the impact of government-sponsored R&D is the one of selection bias since it is hard to think of RJV participation as being randomly assigned or decided. This inevitably creates a potentially important bias in the estimated impact parameters. Table 7 provides us with a glimpse of this potential problem by reporting summary statistics on some variables for both the participants and non-participating firms in Amadeus for 1999. Participants have significantly larger figures for most of the variables considered, confirming the fact that the programme selects larger firms for participation. Further evidence of this fact is given in figure 1, which shows the distributions of the log transformation of sales, employees and fixed assets for both participants and firms contained in Amadeus. In all cases the participants' distribution is similar to the one of the outsiders, only shifted to the right.

To perform our empirical test, we use three different samples. The first one is composed of the participating firms and of non-participating firms randomly picked from Amadeus. After cleaning the data, we are left with 2134 observations for participants and 6638 for the selected non-participants over the years 1997 to 2006. This sample is referred to as the Random sample throughout the text. An alternative control group is constructed by selecting non-participating firms from Amadeus so as to replicate the cross-tabulation of participants by country and industry. After cleaning the data, we are left with 2134 observations for participants and 3531 for the selected non-participants over the years 1997 to 2006. In our estimations, we call this sample IC-Rep (for Industry Country Replication). Last, we use a third control group constructed so as to replicate the distribution of the sales variables of the participants for 1999 (i.e. before the start of any project). The final kernel density estimates of the control group for 1999 are presented in figure 1. After cleaning the data, we are left with 2134 observations for participants and

3726 for the selected non-participants over the years 1997 to 2006. We call this sample Sales-Rep in our estimations.

A potential concern is that firms belonging to our control group may be involved in other RJVs. Another important programme under which pan-European RJVs have been formed in the last two decades is the EUREKA programme, another initiative aimed at enhancing cross-border technological cooperation. In order to further support the validity of our samples, we would therefore like to verify that the non-participating firms present in our control groups are not participating in other R&D collaboration programmes such as EUREKA. We were able to do so for some of the firms in our database, as we were given access to information on the French firms that participated in the EUREKA programme during the years 1998 to 2005. We were therefore able to check whether French non-participants from our control groups had participated in the EUREKA programme during this same period.[14] Although our control groups are not only composed of French firms, the latter still represent a non-negligible share of the non-participants with 16.4 percent, 19.3 percent and 23.6 percent in our three different samples. The results showed that only 5 firms did participate in EUREKA during he same period for one of the samples, while for the other two control groups, only 1 and 4 firms participated. This means that more than 95 percent of the French firms in our samples have not participated in the EUREKA programme.

Finally, the repetitive nature of the Framework Programmes rises a concern as well. Indeed, if firms currently participating in the EU-FP5 have been involved in previous Framework Programmes, identifying the sole effects of a participation in the EU-FP5 on firms' performance becomes tricky. This concern is specially relevant since the previous literature has found that many participants tend to repeat their participation in consecutive editions of the programme (Hernán et al., 2003; Barajas et al., 2011). We do not have any information on the EU-FP4; however, we have data on the EU-FP6 which allows us to check whether participants in the IST programme of the EU-FP5 are also involved in the IST programme of the EU-FP6. The result of this exercise revealed that out of the 379 participants present in our final sample, less than 14 percent (51 firms) took part in the IST programme of the EU-FP6. It suggests that our sample includes a small share of firms that are prone to repeat the experience. As for the non-participating firms, only a

[14] We are grateful to Aminata Sissoko for allowing us to do so.

very small fraction (less than 0.01 percent for each of the three different samples) turned out to be participating in the EU-FP6, giving further support to the validity of our control groups.

5 Empirical strategy

We provide an empirical test of the effect of participation in the IST programme on the firms' economic performance. Let $P_{it} = 1$ be the event of firm i participating in a project at time t and let y_{it} be the measure of firm i's performance. Denote by y^0_{it} and y^1_{it} the performance of firm i at time t when it does not and when it does participate in EU-FP5 respectively. Hence we write

$$y_{it} = \begin{cases} y^1_{it} & \text{if } P_{it} = 1 \\ y^0_{it} & \text{if } P_{it} = 0. \end{cases}$$

Equivalently, y_{it} can be expressed as

$$y_{it} = y^0_{it} + (y^1_{it} - y^0_{it})P_{it}. \tag{1}$$

We want to identify the effect of participation at time t on the firm's performance y_{it}. This effect can be expressed as $\Delta_{it} \equiv y^1_{it} - y^0_{it}$. It measures the difference between the observed performance of participant i and the performance it would have reached had it not participated in the project. Since the counterfactual outcome y^0_{it} can never be observed for a participating firm, Δ_{it} cannot be computed directly and needs to be estimated. If we consider a constant treatment effect, i.e. $\Delta_{it} = y^1_{it} - y^0_{it} = \delta$, we can rewrite (1) as

$$y_{it} = \alpha + \delta \cdot P_{it} + \varepsilon_{it}, \tag{2}$$

where α is a constant and ε_{it} is an error term. A direct approach to circumvent the missing counterfactual problem is to replace the missing counterfactual outcome by the mean performance of the non-participating firms. This would be a simple treatment-control comparison (TCC) estimator as it mimics the analysis in an experimental setting. The estimator of δ, $\widehat{\delta}^{TCC}$, would then be the mean difference in performance between participants and non-participants.

A simple treatment-control comparison in the form of equation (2) is most likely to yield inconsistent estimates. As mentioned above, $\widehat{\delta}^{TCC}$ will suffer from a selection bias since it is hard to think of participation in the programme as being random. Selection bias comes from the existence of firms' characteristics (be they observable or not) that are correlated with participation in the programme. To the extend that the programme attracts bigger and more productive firms, we have to deal with a positive selection bias. We therefore also control for observable characteristics x that affect both the decision to participate (treatment) and the productivity of the firm (outcome). Doing so leads to the following specification:

$$y_{it} = x'_{it}\beta + \delta \cdot \text{PARTS}_{it} + \varepsilon_{it}. \tag{3}$$

Estimation of δ from equation (3) allows to control at least for selection on observable characteristics (all included in the vector x) such as firm size, capital intensity, absorptive capacity, industry concentration as well as country, industry and time fixed effects.

To the extend that firms self-select in the programme based on some *observable* characteristics, the above estimation strategy allows us to solve for the selection problem. It is, however, most likely that firms decide on participation based on *unobservable* characteristics included in ε_{it} as well, in which case the endogeneity problem will remain and estimators will still be inconsistent. We can, for example, think of firms as having heterogeneous "managerial" or "innovative" ability that may influence their decision to participate in an RJV. Participation decisions (from the firms or from the programmes' organization) may also be based on past outcomes of y_{it}. Klette et al. (2000) give an example from the study of Klette and Moen (1999) in which the Norwegian government was supporting large firms facing severe problems when the IT industry was restructured towards the end of the 1980's. In this case, we would have that $\text{COV}(\varepsilon_{is}, \text{PARTS}_{it}) \neq 0$ for $s < t$, leading to inconsistent estimation results of the impact of participation.

When identification is jeopardized because the participation (or treatment) variable is endogenous, a standard solution is to look for an instrumental variable. The main idea is for the instrument to generate some exogenous variation in the participation decision of firms, which would allow to mimic a randomly assigned treatment. Finding a valid instrumental variable is not easy, as it amounts to finding a variable that simultaneously determines the participation decision of the firms and does not appear as a determinant of the outcome variable y_{it}.

Instrumental Variables estimation

The empirical strategy then consists in two steps. In the first one, we specify an equation explaining the participation decision. In particular, we assume that the probability that firm i decides to engage in an RJV of the IST programme is given by

$$\Pr(\text{PART}_i = 1 \mid \mathbf{z}) = \text{F}(z'_{it}\gamma). \tag{4}$$

The variables in the vector x in (3) are a subset of the variables in z. That is, at least one element of z (call it z_1) is unique and is a non-trivial determinant of PART_i. Hence z_1 is an instrument correlated with the endogenous dummy variable PART_{it} but that has no direct effect on the outcome y_{it} (it only has an effect through PART_{it}). We will specify $F(\cdot)$ to be the cumulative distribution function of the logistic distribution.

The methodology consists in estimating (4) first and subsequently using the estimated $\widehat{\text{PARTS}}_i$ to correct for the endogenous participation dummy variable in Equation (3). In order to mitigate further endogeneity issues, our strategy is to use pre-determined observations to explain programme participation. For this purpose, we use observations for years 1997 to 1999 to estimate equation (4) and obtain an estimate of $\hat{\gamma}$. We then use observations for years 2000 to 2006 to predict participation decisions using $\hat{\gamma}$ and subsequently use the predicted values to identify the impact of participation estimating equation (3) for years 2000 to 2006.

The variables

Our econometric specification requires the construction of a set of variables that measure or proxy the determinants of participation in the IST programme as well as the determinants of our outcome variables (labor productivity and profit margin). The performance measures that will be considered are labor productivity, measured as added value per employee, and profit margin, measured as the profit (before taxation) over the operating revenue.

The most important explanatory variable is the one that we use as a source of exogenous variation to explain participation. Our approach is based on the idea that differences in available funding across industries induce variation in the likelihood of participating in the programme. Indeed, the participation in a project is the result of two decisions. The initial decision comes from the firms, which must choose whether to apply or not for funding. Conditional on the result of this first decision, the European Commission then decides whether to fund the project or not.[15] The budget dedicated to the funding of RJVs is therefore likely to be correlated with the participation decision of firms for at least two (non-exclusive) reasons. First, firms will be more willing to participate if they know that more funds are available. Second, a project is more likely to be accepted if the commission has more funding to offer.

An important concern is that the Commission might allocate its support partly in line with technological opportunities, i.e., the projects that are selected are those which involve industries that perform badly. As explained in detail above, the exogeneity of our instrument relies on the creation of the key actions in the EU-FP5. Indeed, Edith Cresson, the then European Commissioner in charge of research and innovation stated that "*We are moving from research based on performance for its own sake to research which focuses on the social and economic problems which face society today*".[16] Thus, the objective underlying the Fifth Framework Programme differs radically from that of its predecessors.

Since any industry could potentially be represented in any of the Key Actions, the latter provide exogenous variation in the availability of funding in each industry. Optimally, we would like to observe the part of the budget of each KA that goes to each industry so as to build a measure of available budget at the industry level. Since we do not observe these shares, we need to build our available funding variable based on the awarded funds in each industry:

$$AvailableFunding_j = \sum_{k \in KAs} \sum_{RJV_r^k} d_{jr}^k \cdot \text{Funding}_r^k$$

where d_{jr}^k is a dummy equal to 1 if a firm from industry j participates in RJV r in key action k, and Funding_r^k is the funding received by RJV r in key action k from the EU-FP5.

[15] Unfortunately, we only observe the accepted projects in our dataset. The firms that applied for funding but were denied can therefore not be distinguished from those that did not apply.

[16] See "A turning point for community research", RTD Info 21, p.3 at http://ec.europa.eu/research/rtdinf21/en/edito.html.

To compute our two steps estimation procedure, we use additional explanatory variables. First, we introduce a measure of firms' size to take into account the existent asymmetries across firms. As noted by Röller et al. (2007), differences in firms' sizes reflect differences in efficiency. This variable may also have an important effect on participation in case specific fixed costs for the creation of an RJV exist. For example, large firms would be able to spread these costs more easily across a larger volume of sales and would therefore be more willing to participate in the programme. Another measure of size that must be taken into account is the *relative* size of a firm within its industry. As noted by Hernán et al. (2003), relative size may matter if RJVs are used as a vehicle for pursuing "technology watch", i.e. to monitor innovative activity in their segment. As they point out, the largest firms (which are also the technology leaders), have most to lose from the emergence of new, technologically advanced rivals (see also Laredo (1998)). This measure is proxied by the introduction of a variable measuring market share, calculated as firm size over industry size, both measured by the amount of sales.[17]

R&D expenses are an important determinant of firm's participation in the programme as they are a good measure of a firm's "absorptive capacity". This idea was first introduced by Cohen and Levinthal (1989), who argue that external knowledge is more effective for the innovation process when the firm engages in own R&D. Performing R&D would therefore increase a firm's value of cooperation and increase its willingness to participate in such agreements.[18] One main shortcoming of our dataset, however, is the unavailability of R&D expenses at the firm or even at the industry level. Although R&D expenses are not explicitly reported in AMADEUS, they are, in most countries, booked under intangible assets. In order to partially overcome this availability problem, we use the ratio of intangible fixed assets over employees (in logarithm) as a proxy for the intensity of the firm's innovative activity. We realize that this variable also contains information on patents, copyrights, trademarks and other similar items and may therefore not give a perfect measure of R&D intensity. This variable is however likely to be highly correlated with a firm's absorptive capacity, increasing the likelihood of participation in an RJV.

Industry concentration has an ambiguous effect on the incentives to participate in R&D collaboration. On the one hand, a highly concentrated industry can facilitate the

[17]This index is constructed over the entire AMADEUS database at the four-digit industry level.

[18]See Cassiman and Veugelers (2002) for a discussion on the effects of absorptive capacity on the probability of cooperating in R&D.

identification of suitable partners and spillovers to non-participants are limited because of their reduced number. Also, an RJV may well be created in order to weaken competition or increase the market power of its participants. In all of these cases, more concentration would increase the incentives for firms to participate in RJVs. On the other hand, one could also expect a negative impact of concentration on the likelihood of RJV formation since strict limits are imposed by competition policy on collaborative projects in concentrated industries.[19] To construct a measure of industry concentration, we include the Herfindähl-Hirschman Index (HHI) for each four-digit sector present in our sample.[20] The HHI is defined as:

$$\mathrm{HHI}_j = \sum_{i=1}^{n} (MarketShare_{i,j})^2.$$

Further control variables include a set of 2-digit industry dummies as well as country dummies and the ratio of tangible fixed assets over employees (in logs) as a proxy of physical capital intensity.

With these covariates properly defined, we can now respectively rewrite equations (4) and (3) as

$$\begin{aligned}\Pr(\mathrm{PART}_i = 1 \mid \mathbf{z}) =& \mathrm{F}(z'_{it}\gamma) \\ =& \mathrm{F}\Bigg(\gamma_0 + \gamma_1 \log(Employees)_{it} + \gamma_2 \log\left(\frac{FixedAssets}{Employees}\right)_{it} \\ &+ \gamma_3 \log\left(\frac{IntangibleAssets}{Employees}\right)_{it} + \gamma_4 \mathrm{HHI}_{jt} + \gamma_5 \mathrm{MktShare}_{it} \\ &+ \gamma_6 \log(AvailableFunding)_j \\ &+ \sum_{p=1}^{P} \gamma_{7p} Country_{ip} + \sum_{g=1}^{J} \gamma_{8g} Industry_{ig} + \sum_{s=98}^{99} \gamma_{9s} ds_t \Bigg) \end{aligned} \tag{5}$$

and

$$y_{it} = x'_{it}\beta + \delta \cdot \mathrm{PARTS}_i + \varepsilon_{it}, \tag{6}$$

[19] An example is the EU's block exemption which automatically allows ventures between firms that collectively represent less than 25 percent of the relevant anti-trust market but requires authorization for values above that threshold.

[20] Similarly to our market share measure, this index is constructed over the entire Amadeus database.

where x'_{it} contains all the variables of z'_{it} excluding $AvailableFunding$. We estimate Equation (5) with a logit procedure and obtain $\widehat{\text{PARTS}}_i$; in a second step, $\widehat{\text{PARTS}}_i$ is used as an instrument in (6). Since the residuals are likely to be correlated within industries, our calculation of standard errors controls for this correlation by clustering at the four-digit industry level.

6 Results

We now present the results of our estimations. We first discuss the results concerning the determinants of participation in the programme and then turn to the effects of the programme on economic performance.

Determinants of participation in the IST programme

Table 8 presents the results of the logit estimation (5) of the determinants of participation in the IST programme, controlling for residual correlation among observations from the same industry. For each of our different samples (Random, IC-Rep and Sales-Rep), we present two alternative specifications in order to assess whether the results are sensitive to the inclusion of the intangible assets intensity as a proxy for R&D intensity in determining participation. The results appear to be robust to the inclusion of this variable as the other coefficients are not significantly affected.

Our main attention is set on the parameter associated to our instrumental variable $AvailableFunding$. The coefficient turns out to be positive and strongly significant in both specifications for our three different samples, corroborating the fact that the available funding is indeed an important predictor of participation in the programme. As explained above, two possible non-exclusive explanations can explain this result. One is the fact that firms are more willing to participate (i.e. to apply for a subsidy) when the available funding is larger. Another possibility is that, all else equal, firms that are willing to participate (i.e. that already applied for participation) are more likely to be accepted for a subsidy if the funding is larger. Although we are not able to identify which is the true mechanism driving this correlation with the data at hand, either one of them serves our purpose by confirming the relevance of our instrument.

The coefficient associated with firm size is positive and highly significant in the IC-Rep and Random samples.[21] As already noted by Hernán et al. (2003), several non-exclusive explanations can explain this finding. First, controlling for industry concentration, large firms may have a preference to collaborate with other large firms in order to maximize the internalization of spillovers (see Röller et al. (2007) for a theoretical model). Second, it may reflect the existence of large fixed costs associated with RJV formation (for example large administrative and negotiation efforts necessary to reach agreements with partners, the establishment of specific facilities). Third, for projects involving partners from different and complementary industries, a preference to cooperate with a larger partner may simply reflect a preference to cooperate with a more efficient partner. Finally, the positive coefficient associated with firm size may also be the result of a certain exogenous preference for large firms on the part of the EU-FP5 organization.

The coefficient associated with firm market share, a measure of the firm's relative size, is positive and significant in both specifications for our three samples. This results corroborates the "technology watch" explanation presented above, according to which relatively large firms in an industry (i.e. leaders) have an incentive to participate in the programme to monitor the innovative activity in their segment. Indeed, technological leaders have a lot to lose from the emergence of technologically advanced rivals.

Although significant in only two of the samples, the HHI variable shows a positive impact on the probability of participation[22], indicating that firms coming from more concentrated (or less fragmented) industries are more likely to participate. As argued above, this result is consistent with the fact that firms find it easier to identify suitable partners in such industries. Also, the latter provides greater scope for the internalization of spillovers.

The fixed assets intensity, a measure of capital intensity, is a positive predictor of participation, but turns out to be significant in the Random sample, and only when the intangible fixed assets intensity is not included as a regressor, see specification (1). When the latter is included, its corresponding coefficient is positive and significant, showing the important correlation between the fixed assets and intangible fixed assets variables.

Finally, the coefficient on the intangible assets intensity variable shows up to be positive

[21] This coefficient is not significant in the case of the Sales-Rep sample given that we constructed the latter replicating the participants' sales, a variable highly correlated with firms' number of employees.

[22] Just as in the case of firm size for the Sales-Rep sample (see footnote 21), the non-significance of the concentration index for the IC-Rep sample is most probably due to the way we constructed the latter (i.e. replicating the cross tabulation of participants by country and industry).

in our three samples, but only marginally significant for the RANDOM sample. Although the sign is the one expected, we can therefore not affirm that R&D activities proxied by the intangible fixed assets are a significant determinant of programme participation.

Impact of the IST programme on economic performance

In the second step of our procedure, we replace the participation dummy by the predicted value $\widehat{\text{PARTS}}_i$ obtained from the participation equation. The impact of participation on the firms' performance is then estimated using observations from years 2000 to 2006.

Before turning to the discussion of the results, it is important to recall the interpretation that must be given to the instrumental variable estimates in our setting. To the extent that the treatment effects are heterogeneous among different firms, our strategy allows us to estimate the average treatment effect for the firms whose treatment status (participant or not) is affected by changes in the instrumental variable. In this case we are therefore not able to identify the average treatment effect on all the treated, but only for the *marginal* participants. For this effect to be identified, an additional monotonicity assumption still needs to be met, which says that while the instrument might have no effect on some firms, all of those who are affected in their participation decision must be affected in the same way, see Imbens and Angrist (1994). Our results should therefore be interpreted as the average impact of the programme for those firms induced to participate as a result of the change in the funding available to them.

Tables 9 and 10 present the estimation results for Equation (6). In each of the tables and for the three different samples used, the columns (OLS) report the OLS estimates, while columns (IV1) and (IV2) show the results of our two-stage procedure. The OLS estimates suggest a positive effect of participation on the labor productivity, whereas the effect on profit margin is mainly non significant. Since OLS ignores the endogeneity of participation in the programme, these estimates are likely to be biased if selection into the programme is based on unobservable characteristics. Columns (IV1) and (IV2) present the results of estimating Equation (6) correcting for the endogeneity of participation. We find that the average effect of participation on labor productivity is positive and significant in our three samples. Firms engaging in an RJV enjoy an average increase in labor productivity of about 25 to 34 percent. At the same time, Table 10 suggests that the effect of participation on profit margin is nil.

As R&D collaboration is an activity with long term objectives, we also attempt to identify lagged effects of participation on firms' performance over time.[23] As the mean duration of a project in the sample is 27 months, we may expect the effects of a project to appear at least 2 years after its start. Hence, we re-estimate Equation (6) as follows:

$$y_{it+\tau} = x'_{it}\beta + \delta_\tau \cdot \text{PARTS}_{it} + \varepsilon_{it+\tau},$$

where the dependent variable $y_{it+\tau}$ refers to the $(t+\tau)$th period after the starting year of the observed project. The coefficient δ_τ must then be interpreted as the average impact of programme participation on economic performance, starting τ years after entering the project. Comparing the coefficients δ_τ for different values of τ will therefore help to see the evolution and distribution of the impact of participation over time. Tables 11 and 12 report the δ_τ coefficients (for $\tau = 0, \ldots, 4$) for each of our estimations. Each line therefore shows a point estimate resulting from a different regression estimation.[24]

We first discuss the results in table 11, which refer to labor productivity as a measure of economic performance. Except for the Random sample which presents slight drops in the point estimates, we observe an increase in the magnitude of the δ_τ coefficients when τ increases. This suggests that, overall, the effects of participation in the programme on labor productivity are significant and should be measured from a long-term perspective. On average, participation leads to a significant increase in labor productivity of about 30 percent to 38 percent three to four years after starting the project. Turning to the effects on the profit margin (table 12), our results only show significant impacts in the IC-Rep and Sales-Rep samples. In particular, the point estimates indicate that participation leads to an increase of 4 to 5 percentage points in the profit margin. As in the case of labor productivity, the evolution of the coefficients shows that the effect of participation becomes significant several years after the start of a project.

Analysis by RJV size

The size of the project may influence the magnitude of the impact of firms' participation in the EU-FP5 on their performance; indeed, the size of a project is related to the RJV

[23] The need to measure the long term impact of participation in EU-FP has already been noted by most empirical analysis (Dekker and Kleinknecht, 2008; Benfratello and Sembenelli, 2002; Barajas et al., 2011).

[24] The first line of each table therefore reports the coefficients on the participation dummies from tables 9 and 10 respectively (i.e. when $\tau = 0$).

diversity, which in turn affects the R&D effort of participants and increases knowledge sharing among partners.

Sakakibara (2001) highlights three possible channels through which the diversity of an RJV could positively affect the R&D effort of participants: The first channel relates to the spillover effect of a firm's own R&D on others' R&D productivity. Assuming that RJV size and diversity increase knowledge complementarity among participants, a higher degree of knowledge complementarity implies a larger spillover effect, and would also lead to a larger increase in R&D efforts. Second, RJVs provide firms with new learning opportunities. If higher R&D expenditures increase a firm's learning capability, and assuming that better learning opportunities arise when the size and the diversity of the RJV increases, participation in a large RJV will lead to larger R&D efforts by each RJV participant. Finally, when cooperative R&D reduces firms' marginal costs of production, the resulting increase in competition (and decrease in profits) will lead to a lower level of R&D effort. Large RJV are more likely to involve participants coming from different industries, reducing the risk of an increase in competition which, in turn, decreases the likelihood of a reduction in the R&D effort.

We therefore test whether heterogeneity in projects' size translates into heterogeneous effects in terms of economic performance. To do so, we separate large projects from small projects in the following specification:

$$y_{it} = x'_{it}\beta + \delta^L \cdot \mathrm{PARTS}_{Lit} + \delta^S \cdot \mathrm{PARTS}_{Sit} + \varepsilon_{it}, \tag{7}$$

where $\mathrm{PARTS}_{Lit} = 1$ if firm i participates in a large (L) project and $\mathrm{PARTS}_{Sit} = 1$ if firm i participates in a small (S) project. The vector x includes the same covariates as in equation (6). Since participation in a project of a given size is again endogenous, we use our instrumental variables approach to estimate the effect of participation in the two different kinds of RJVs. Our strategy is similar to the one we followed in section 5 with the difference that we explain now participation in the two types of projects (large versus small): Each firm i can therefore choose among three alternatives, participate in an large project, participate in a small project or participate in neither of them (i.e. stay out of the programme). We define the dependent variable PART_{ic} to take value 1 if project c is ever chosen, where $c \in \{\mathrm{Large}, \mathrm{Small}, \mathrm{Out}\}$. We therefore assume that the probability that firm i chooses project c is given by

$$\Pr(\text{PART}_{ic} = 1 \mid \mathbf{z}) = \text{F}(z'_{it}\gamma_c), \tag{8}$$

where $\text{F}(\cdot)$ is now the multinomial logistic cumulative distribution function. The estimation strategy is identical to the one we pursue in section 5. In order to mitigate endogeneity issues, we use pre-programme observations ($t = 1997, 1998, 1999$) to explain the participation choices in the several categories specified above. We then use observations for years 2000 to 2006 to predict participation decisions using the results from the first step and subsequently use the predicted values to identify the impact of participation in the two types of RJVs by estimating equation (7) with the 2000-2006 period. Again, we control for residual correlation among observations from the same industry.

Table 13 reports the results of the multilogit estimation (8). Regardless of the sample used and the methodology (including or not the intangible assets intensity), the coefficient of our instrumental variable is positive and strongly significant for both types of RJVs (although larger for big projects). The available funding is therefore a relevant determinant of participation in the programme, irrespectively of the size of the project considered. Almost all of the remaining explanatory variables have the same sign as in our simple logit model. The coefficient on firm size is quite similar for large and small projects, and is always positively related to participation.[25] The coefficient on the HHI variable again shows a positive relationship between industry concentration and participation in the two different types of projects. The results for the Random sample are, however, not significant anymore for either type of RJV.[26]

Capital intensity is a positive predictor of participation, and always a more important one for larger projects. Although not significant, it even shows to be negative for small projects in two of our samples. On the contrary, the intangible assets intensity is a stronger positive predictor for participation in smaller project, although only significantly so in the Random sample. Finally, an interesting result appears for the variable referring to firms' relative size. As in the simple logit case, it is again positively related to participation, but is now significant only for larger RJVs. This again corroborates our "technology watch" interpretation and further suggests that for a leading firm, monitoring the innovative activity in its sector is more relevant when the projects are of an important size. These

[25] Again, the coefficients appear non significant for the Sales-Rep sample, see footnote 21.
[26] For the same reason presented in footnote 22, they are neither significant for the IC-Rep sample.

kinds of projects are indeed the ones where competing firms could gain the most and possibly take the technological lead.

In the second step of our procedure, we replace the participation dummies (one for each type of project) by the predicted values obtained with the information from the first step. Tables 14 and 15 present the estimation results for equation (7) when residual correlation among observations from the same industry is accounted for. The OLS estimates suggest a positive effect of participation on the labor productivity, for both small and large projects. This effect is however greater for large projects. No significant effect is obtained if profit margin is the explained variable. The IV estimation results suggest that the average effect on productivity over the years following the start of the projects is positive and significant in our three samples. The average gains in labor productivity come mainly from the larger projects and range from 35 percent to close to 50 percent. The results regarding the profit margin show no significant impact of participation in either type of project.

Instead of an average effect, we may as well evaluate how the impact of participation is distributed across years after the start of the project. Table 16 focuses on labor productivity and suggests that, in the Random sample, the effect of participation in small projects is insignificant from 3 years after the start of the project, while it is larger and significant for the large projects. The same pattern is observed for the remaining two samples, although the impact for the small projects is never significant. According to these estimates, the long-term effect of participation in a large project from the IST programme is an increase in labor productivity in about 37 percent to up to 60 percent.

Table 17 presents the results when performance is measured by the profit margin. The results reveal a positive and significant impact from participating in large RJVs, while participation in small projects leads to negative and significant effects on the profit margin. Participation in large projects leads to increases in as much as 8 percentage points, while participation in small projects leads to decreases to up to 6 percentage points in one of our samples.

The results obtained when taking the size of the projects into account give support to the underlining mechanism that we expect to be at work: Cooperative R&D agreements are part of an innovation activity that provides access to external know-how which leads to gains in performance. In this respect, large projects provide many advantages that may lead to increases in participants' R&D efforts compared to small projects. In particular, their more diverse composition in terms of industry origin offers RJV participants better learning opportunities and increases spillover productivity.

7 Discussion and conclusion

In this paper we analyze the effects of R&D collaboration within the EU-FP5 on firms' economic performance. Previous literature has shown that participation in RJVs supported by the EU-FPs has had little direct relevant impact on firms' economic outcomes, a fact mainly explained by the pre-competitiveness of the programme. By concentrating on the IST programme, we focus our analysis on the projects that involve more market-oriented collaboration, and which are therefore more likely to result in direct positive economic effects. We also account for the fact that R&D collaboration remains an activity with long-term objectives and therefore identify the long-term effect of participation in the programme.

As a mean to address the self-selection effect of participation, we follow a two-step method and use the funding available to the firms as an instrumental variable to provide randomness in the firms' participation status. Our results show that the long-term effects of participation is an increase in labor productivity by, on average, almost 40 percent. Taking projects' size into account, this increase appears to be mainly driven by gains in the large projects, as we find that entering a large RJV raises labor productivity by up to 60 percent. We also find a positive effect of participation on the profit margin, with increases of 4 to 5 percentage points. These positive effects are again the result of the important impact of participation in the larger projects, which leads to gains of up to 8 percentage points.

The large magnitude of our estimates has to be put into perspective. Indeed, our results should be interpreted as the average impact of the programme for those firms induced to participate as a result of the change in the funding available to them. Our results should therefore not necessarily be taken as evidence of the aggregate effectiveness of the EU-FP5, but as the average effect on the "marginal" participants. Though we are not able to identify these particular firms, our results on the determinants of participation may give us a hint about their characteristics. We found absolute firm size to be an important determinant of participation, pointing to the fact that RJVs involve large fixed costs. The "marginal" participants, whose participation in the programme is more dependent on the funding available and received, are most likely to be smaller, first-time participants. This is in line with the results of Fisher et al. (2009) which found first-time participants and medium-sized companies to benefit the most from participation in the EU-FP5 and EU-FP6 in terms of innovation. We see participation in the IST programme as a way of obtaining access to new knowledge and resources which in turn positively affect economic performance.

It is also important to note that participation in the IST programme actually involves two simultaneous actions, namely cooperation with other firms or institutions (i.e. the formation of an RJV) and the granting of a subsidy to help financing the project pursued by the RJV. We are unfortunately not able to disentangle these two effects separately, and can *a priori* only identify a joint effect of both cooperation and subsidy granting. Our results on the impact of participation by project size indicate that cooperation within an RJV and the sharing of know-how is a crucial factor to explain the gains in performance from the IST programme. This, however, is not informative on the direct effect of the funds received by the RJV. One may argue that our results would be consistent with a scenario in which RJV are beneficial (the mere fact of cooperating with other firms) but the subsidy itself is not, meaning that the gains from cooperation would have been obtained regardless of the granting of the subsidy. We stress, however, that some firms (in particular small or financially constrained firms) would not be able to participate in an RJV if there was no subsidy, and that our results show that the benefits of participation can be very substantive for these specific firms.

Raising the available funding for the small first-time participants would encourage them to participate in projects that would benefit them greatly. This could be accomplished, for instance, by covering a substantial part of their fixed costs, such as the administrative costs for the project's proposal or for the research project itself. In any case, and as suggested by Barajas et al. (2011), policy makers should take these costs into account and distinguish between firms with previous experience in cooperative projects and other firms. In particular, participation in large projects would lead to important gains in competitiveness.

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8 Appendix

8.1 Tables

Table 1: Number of RJVs per firm

Number of RJVs	Number of firms	Per cent	Cumul.
1	620	64.52	64.52
2	140	14.57	79.08
3	64	6.66	85.74
4	34	3.54	89.28
5	21	2.19	91.47
6	14	1.46	92.92
7	8	0.83	93.76
8	7	0.73	94.48
9	7	0.73	95.21
10 or more	46	4.79	100.00

Table 2: Mean statistics by project

Variable	All Projects	Single Part	Sample
Nb of Participants	7.00	8.58	8.77
Duration (in months)	27.04	27.93	27.40
Cost (thousand €)	2376.54	2999.21	3002.23
Funding (thousand €)	1380.21	1663.37	1638.60
Nb of Projects	2359	466	315

Table 3: Projects' characteristics by starting year

Starting Year	Number of RJVs	Number of participants	Duration in months	Cost in thousand €	Funding in thousand €
2000	96 (30.5 %)	8.23	27.55	3096.99	1683.81
2001	108 (34.3 %)	8.69	27.62	2761.45	1502.80
2002	104 (33.0 %)	9.33	26.68	3240.63	1786.52
2003	7 (2.22 %)	9.29	32.57	1875.71	916.29
All	315	8.77	27.40	3002.23	1638.60

Table 4: Projects' characteristics by number of participants

Number of participants	Number of RJVs	Duration in months	Cost in thousand €	Funding in thousand €
3 or less	14 (4.4 %)	17.21	631.56	444.35
4 to 5	36 (11.4 %)	28.19	2429.06	1345.53
6 to 7	89 (28.2 %)	27.94	2657.61	1476.00
8 to 10	105 (33.3 %)	27.12	2874.11	1581.15
11 to 15	48 (15.2 %)	29.25	4163.96	2167.86
16 or more	23 (7.3 %)	27.65	4836.39	2611.22
All	315	27.40	3002.23	1638.60

Table 5: Projects' characteristics by cost

Cost in millions	Number of RJVs	Duration in months	Number of participants	Nb of different industries	Funding in thousand €
0 to 1	53 (16.8%)	18.49	6.68	1.55	430.35
1 to 3	122 (38.7%)	28.35	8.13	1.81	1191.41
3 to 6	111 (35.2%)	29.91	9.33	2.59	2145.41
6 to 8	21 (6.7%)	30.48	13.00	3.43	3394.76
more than 8	8 (2.5%)	29.00	13.63	4.38	4821.25
All	315	27.40	8.77	2.21	1638.60

Table 6: Projects' characteristics by size†

Size of RJV	Number of RJVs	Number of participants	Duration in months	Cost in thousand €	Funding in thousand €	Nb of different industries
Small	162 (51.4%)	7.73	24.83	1523.66	909.75	1.73
Large	153 (48.6%)	9.88	30.12	4567.78	2410.33	2.72
All	315	8.77	27.40	3002.23	1638.60	2.21

† An RJV of small size is defined as one with a total cost of less than 2.8 million €.

Table 7: Comparison of participants and AMADEUS for 1999

	PARTICIPANTS			AMADEUS		
	Mean	Median	N	Mean	Median	N
Sales	1,617,717.1	61,192.0	560	76,461.5	12,648.0	91475
Employees	7,833.5	441.0	522	482.4	87.0	102273
Fixed Assets	1,295,842.3	15,400.5	598	60,009.1	2,112.0	146753
Intangible Fixed Assets	147,837.6	381.5	582	5,413.6	2.0	140781
Labor Productivity	317.9	63.2	380	141.7**	49.0	71872
Costs of Employees	366,136.9	20,507.0	508	14,431.1	1,882.0	106638
Mean Wage	49.6	42.5	448	57.5***	31.1	91759
Profit Margin	5.8	4.9	560	5.0***	3.0	124496
Gross Profit Margin	40.1	35.9	140	69.0***	18.3	42718

** Cannot reject the null hypothesis (equality of the means) in a two-tailed t-test at the 5% level between the participants and the corresponding control group in each column.

*** Cannot reject the null hypothesis (equality of the means) in a two-tailed t-test at the 10% level between the participants and the corresponding control group in each column.

Table 8: First stage estimation results (logit)[†]

Sample	Random		IC-Rep		Sales-Rep	
	(1)	(2)	(1)	(2)	(1)	(2)
Constant	-6.795***	-6.153***	-8.635***	-8.357***	-6.917***	-9.288***
	(1.49)	(1.51)	(2.10)	(2.16)	(1.64)	(2.05)
log(Employees)	0.427***	0.451***	0.501***	0.502***	0.012	0.013
	(0.09)	(0.09)	(0.08)	(0.08)	(0.07)	(0.07)
log(Fixed Assets Intensity)	0.201***	0.134*	0.104	0.085	0.055	0.037
	(0.07)	(0.08)	(0.07)	(0.07)	(0.08)	(0.08)
log(Intang Assets Intensity)		0.120**		0.039		0.033
		(0.05)		(0.05)		(0.05)
log(Available Funding)	0.507***	0.499***	0.459***	0.455***	0.515***	0.513***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)	(0.07)
Market Share	6.229***	6.044***	6.621***	6.452***	3.123**	3.047**
	(2.18)	(2.32)	(2.35)	(2.38)	(1.61)	(1.60)
HHI	2.271**	2.303**	1.216	1.181	4.238***	4.237***
	(1.12)	(1.11)	(0.82)	(0.82)	(1.20)	(1.19)
Industry dummies	YES	YES	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES
Pseudo-R^2	0.436	0.443	0.291	0.292	0.370	0.370
Number of obs.	1667	1667	1545	1545	1362	1362

[†] The dependent variable is equal to 1 for participants and 0 for non-participants. Standard errors in parenthesis and clustered at the four-digit industry level.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 9: Second stage estimation results: Labor Productivity†

Sample	Random			IC-Rep			Sales-Rep		
	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)
Constant	2.570***	2.712***	2.687***	2.908***	2.844***	2.911***	2.130***	2.076***	2.179***
	(0.21)	(0.21)	(0.21)	(0.24)	(0.21)	(0.21)	(0.23)	(0.23)	(0.23)
log(Employees)	-0.148***	-0.165***	-0.162***	-0.118***	-0.137***	-0.136***	-0.103***	-0.104***	-0.106***
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
log(Fixed Assets Intensity)	0.266***	0.268***	0.263***	0.253***	0.254***	0.251***	0.268***	0.280***	0.267***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
log(Intang Assets Intensity)	0.015**		0.010	0.006		0.004	0.019**		0.018**
	(0.01)		(0.01)	(0.01)		(0.01)	(0.01)		(0.01)
Market Share	2.322***	2.498***	2.456***	0.955	0.939	0.925	0.708*	0.781**	0.726**
	(0.57)	(0.59)	(0.58)	(0.66)	(0.70)	(0.70)	(0.36)	(0.36)	(0.35)
HHI	0.232	0.159	0.186	0.091	-0.024	-0.014	-0.055	-0.162	-0.148
	(0.15)	(0.16)	(0.16)	(0.12)	(0.12)	(0.12)	(0.14)	(0.15)	(0.15)
PARTS	0.181***	0.370***	0.317***	0.161***	0.353***	0.337***	0.092**	0.276**	0.247*
	(0.04)	(0.09)	(0.09)	(0.03)	(0.08)	(0.08)	(0.04)	(0.11)	(0.11)
Industry dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Adjusted-R^2	0.712	0.710	0.711	0.502	0.501	0.501	0.579	0.577	0.580
Number of obs.	7105	7105	7105	5879	5879	5879	4498	4498	4498

† The dependent variable is the logarithm of labor productivity. Standard errors in parenthesis and clustered at the four-digit industry level. In specifications (OLS), the variable PARTS is a simple dummy equal to 1 if the firm participates in EU-FP (Pooled OLS is used). The variable PARTS for columns (IV1) and (IV2) corresponds to the predicted values of the first stage logit estimations (1) and (2) in table 8 respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 10: Second stage estimation results: Profit Margin†

Sample	Random			IC-Rep			Sales-Rep		
	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)
Constant	0.001	-0.007	-0.008	0.004	0.06	0.009	-0.018	0.004	-0.012
	(0.02)	(0.02)	(0.02)	(0.04)	(0.04)	(0.04)	(0.03)	(0.02)	(0.03)
log(Employees)	0.003	0.003*	0.003*	0.002	0.001	0.001	0.005***	0.004**	0.005**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
log(Fixed Assets Intensity)	0.009***	0.008***	0.009***	0.006**	0.003	0.006**	0.006***	0.004*	0.006***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
log(Intang Assets Intensity)	-0.002**		-0.002**	-0.004***		-0.004***	-0.002**		-0.003**
	(0.00)		(0.00)	(0.00)		(0.00)	(0.00)		(0.00)
Market Share	0.038	0.023	0.030	0.027	0.013	0.027	-0.009	-0.013	-0.005
	(0.05)	(0.04)	(0.04)	(0.04)	(0.03)	(0.04)	(0.03)	(0.03)	(0.03)
HHI	-0.004	0.001	-0.002	0.001	0.000	-0.002	0.017	0.008	0.007
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
PARTS	-0.015**	-0.019	-0.017	-0.005	0.001	0.006	-0.006	0.018	0.021
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
Industry dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Adjusted-R^2	0.039	0.036	0.038	0.037	0.029	0.036	0.036	0.033	0.037
Number of obs.	7105	7105	7105	5879	5879	5879	4498	4498	4498

† The dependent variable is the profit margin. Standard errors in parenthesis and clustered at the four-digit industry level. In specifications (OLS), the variable PARTS is a simple dummy equal to 1 if the firm participates in EU-FP (Pooled OLS is used). The variable PARTS for columns (IV1) and (IV2) corresponds to the predicted values of the first stage logit estimations (1) and (2) in table 8 respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 11: Second stage estimation results, long-term effects: Labor Productivity[†]

Sample	Random			IC-Rep			Sales-Rep		
	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)
δ_0	0.181***	0.370***	0.317***	0.161***	0.353***	0.337***	0.092**	0.276**	0.247*
	(0.04)	(0.09)	(0.09)	(0.03)	(0.08)	(0.08)	(0.04)	(0.11)	(0.11)
δ_1	0.138***	0.289**	0.243**	0.115***	0.347***	0.325***	0.055	0.291**	0.268*
	(0.04)	(0.10)	(0.10)	(0.04)	(0.09)	(0.09)	(0.04)	(0.12)	(0.12)
δ_2	0.146***	0.337***	0.293**	0.115***	0.371***	0.354***	0.071	0.327***	0.310**
	(0.04)	(0.10)	(0.11)	(0.04)	(0.10)	(0.10)	(0.04)	(0.12)	(0.13)
δ_3	0.134***	0.329**	0.287**	0.111**	0.370***	0.358***	0.075	0.359**	0.348**
	(0.04)	(0.11)	(0.12)	(0.04)	(0.11)	(0.11)	(0.05)	(0.13)	(0.13)
δ_4	0.111**	0.347**	0.308*	0.086*	0.378***	0.368***	0.050	0.396***	0.385**
	(0.05)	(0.13)	(0.13)	(0.05)	(0.12)	(0.12)	(0.05)	(0.14)	(0.14)

[†] The table presents the estimated coefficients in the regression $y_{it+\tau} = x'_{it}\beta + \delta_\tau \text{PARTS}_{it} + \varepsilon_{it+\tau}$, with $\tau = 0, \ldots, 4$. Standard errors in parenthesis and clustered at the four-digit industry level. In specifications (OLS), the variable PARTS is a simple dummy equal to 1 if the firm participates in EU-FP (Pooled OLS is used). The variable PARTS for columns (IV1) and (IV2) corresponds to the predicted values of the first stage logit estimations (1) and (2) in table 8 respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 12: Second stage estimation results, long-term effects: Profit Margin[†]

Sample	Random			IC-Rep			Sales-Rep		
	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)
δ_0	-0.015**	-0.019	-0.017	-0.005	0.001	0.006	-0.006	0.018	0.021
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
δ_1	-0.013*	-0.016	-0.013	-0.003	0.011	0.014	-0.008	0.021	0.022
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
δ_2	-0.011	0.002	0.004	-0.001	0.027	0.030	-0.005	0.032*	0.033*
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
δ_3	-0.006	0.003	0.004	0.000	0.034	0.038*	-0.004	0.040**	0.040**
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
δ_4	-0.004	-0.001	0.000	0.005	0.037*	0.042*	0.002	0.051**	0.053**
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)

[†] The table presents the estimated coefficients in the regression $y_{it+\tau} = x'_{it}\beta + \delta_\tau \text{PARTS}_{it} + \varepsilon_{it+\tau}$, with $\tau = 0, \ldots, 4$. Standard errors in parenthesis and clustered at the four-digit industry level. In specifications (OLS), the variable PARTS is a simple dummy equal to 1 if the firm participates in EU-FP (Pooled OLS is used). The variable PARTS for columns (IV1) and (IV2) corresponds to the predicted values of the first stage logit estimations (1) and (2) in table 8 respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 13: Analysis by RJV Size: First stage estimation results (Multinomial logit)†

Sample	Random		IC-Rep		Sales-Rep	
(1)	Large	Small	Large	Small	Large	Small
Constant	-8.889***	-4.166**	-9.593***	-4.989***	-7.284***	-3.130
	(2.78)	(1.98)	(1.92)	(1.50)	(1.82)	(1.73)
log(Employees)	0.365***	0.452***	0.465***	0.508***	0.018	-0.038
	(0.11)	(0.10)	(0.10)	(0.09)	(0.08)	(0.09)
log(Fixed Assets Intensity)	0.257***	0.110	0.160**	0.030	0.126	-0.067
	(0.09)	(0.09)	(0.08)	(0.08)	(0.09)	(0.09)
log(Available Funding)	0.799***	0.367***	0.668***	0.271***	0.823***	0.373***
	(0.11)	(0.05)	(0.10)	(0.04)	(0.12)	(0.05)
Market Share	10.670***	3.775*	8.405***	2.947*	5.811***	1.590
	(2.62)	(2.09)	(1.86)	(1.62)	(2.09)	(2.33)
HHI	1.840	1.879*	0.751	0.917	4.086***	4.372***
	(1.42)	(1.13)	(0.96)	(0.98)	(1.34)	(1.27)
Pseudo-R^2	0.381		0.261		0.326	
Number of Obs.	1667		1550		1362	
(2)	Large	Small	Large	Small	Large	Small
Constant	-9.393***	-5.528***	-9.380***	-5.639***	-9.260***	-3.582***
	(2.03)	(1.84)	(1.71)	(1.61)	(1.74)	(1.55)
log(Employees)	0.386***	0.475***	0.467***	0.507***	0.018	-0.034
	(0.11)	(0.10)	(0.10)	(0.10)	(0.08)	(0.09)
log(Fixed Assets Intensity)	0.204**	0.030	0.143*	-0.001	0.127	-0.111
	(0.10)	(0.10)	(0.09)	(0.09)	(0.10)	(0.11)
log(Intang Assets Intensity)	0.093	0.140**	0.037	0.060	0.003	0.072
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
log(Available Funding)	0.789***	0.356***	0.665***	0.265***	0.829***	0.369***
	(0.11)	(0.05)	(0.10)	(0.04)	(0.13)	(0.05)
Market Share	10.571***	3.586	8.239***	2.737*	5.877***	1.326
	(2.70)	(2.23)	(1.87)	(1.65)	(2.10)	(2.43)
HHI	1.792	1.887*	0.725	0.847	4.029***	4.370***
	(1.41)	(1.15)	(0.96)	(1.00)	(1.35)	(1.28)
Pseudo-R^2	0.387		0.262		0.328	
Number of Obs.	1667		1550		1362	

† Standard errors in parenthesis and clustered at the four-digit industry level. All specifications include time, industry and country dummies. The reference outcome is not participating in the EU-FP5 IST programme.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 14: Analysis by RJV size, second stage estimation results: Labor Productivity†

Sample	Random			IC-Rep			Sales-Rep		
	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)
Constant	3.776***	3.600***	3.641***	3.988***	3.916***	3.929***	2.565***	2.660***	2.749***
	(0.28)	(0.29)	(0.30)	(0.29)	(0.29)	(0.29)	(0.21)	(0.23)	(0.23)
log(Employees)	-0.154***	-0.172***	-0.169***	-0.118***	-0.139***	-0.138***	-0.100***	-0.101***	-0.102***
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
log(Fixed Assets Intensity)	0.272***	0.277***	0.269***	0.257***	0.255***	0.252***	0.279***	0.287***	0.278***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)
log(Intang Assets Intensity)	0.018**		0.012	0.006		0.004	0.012		0.011
	(0.01)		(0.01)	(0.01)		(0.01)	(0.01)		(0.01)
Market Share	2.282***	2.542***	2.466***	0.920	0.931	0.911	0.760**	0.847**	0.800**
	(0.55)	(0.60)	(0.59)	(0.59)	(0.63)	(0.63)	(0.37)	(0.38)	(0.37)
HHI	0.215	0.133	0.159	0.061	-0.083	-0.076	-0.070	-0.228	-0.205
	(0.15)	(0.15)	(0.15)	(0.12)	(0.12)	(0.12)	(0.15)	(0.16)	(0.15)
$PARTS_{Large}$	0.256***	0.379**	0.352**	0.243***	0.506***	0.497***	0.161***	0.340**	0.340**
	(0.05)	(0.13)	(0.13)	(0.05)	(0.12)	(0.12)	(0.05)	(0.13)	(0.13)
$PARTS_{Small}$	0.146***	0.461**	0.376**	0.090**	0.228	0.201	0.022	0.347	0.222
	(0.05)	(0.17)	(0.17)	(0.04)	(0.21)	(0.22)	(0.05)	(0.23)	(0.22)
Industry dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Adjusted-R^2	0.699	0.697	0.698	0.493	0.493	0.493	0.559	0.559	0.559
Number of obs.	7105	7105	7105	5898	5898	5898	4498	4498	4498

† The dependent variable is the logarithm of labor productivity. Standard errors in parenthesis and clustered at the four-digit industry level. In specifications (OLS), the variable $PART_r$ is a simple dummy equal to 1 if the firm participates in a RJV of size c (Pooled OLS is used). The variable $PART_c$ for columns (IV1) and (IV2) corresponds to the predicted values of the first stage multilogit estimations (1) and (2) in table 13 respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 15: Analysis by RJV size, second stage estimation results: Profit Margin†

Sample	Random			IC-Rep			Sales-Rep		
	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)
Constant	0.038	0.057**	0.053**	-0.021	-0.005	-0.014	0.012	0.029	0.021
	(0.02)	(0.03)	(0.02)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.03)
log(Employees)	0.003	0.004**	0.004**	0.002	0.002	0.002	0.005***	0.004**	0.005**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
log(Fixed Assets Intensity)	0.009***	0.007***	0.009***	0.006**	0.003	0.006**	0.006***	0.003*	0.005**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
log(Intang Assets Intensity)	-0.002**		-0.002*	-0.004***		-0.004***	-0.002**		-0.003**
	(0.00)		(0.00)	(0.00)		(0.00)	(0.00)		(0.00)
Market Share	0.040	0.003	0.012	0.023	0.003	0.018	-0.008	-0.015	-0.009
	(0.05)	(0.05)	(0.05)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
HHI	-0.005	0.000	-0.003	0.003	0.002	0.000	0.023	0.017	0.016
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.03)
PARTS_{Large}	-0.018**	-0.008	-0.007	-0.005	0.008	0.011	-0.008	0.020	0.025
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
PARTS_{Small}	-0.012	-0.048**	-0.042**	-0.004	-0.024	-0.015	-0.003	-0.007	-0.012
	(0.01)	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)	(0.03)	(0.03)
Industry dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Time dummies	YES	YES	YES	YES	YES	YES	YES	YES	YES
Adjusted-R^2	0.034	0.031	0.033	0.03	0.024	0.031	0.031	0.029	0.032
Number of obs.	7105	7105	7105	5898	5898	5898	4498	4498	4498

† The dependent variable is the profit margin. Standard errors in parenthesis and clustered at the four-digit industry level. In specifications (OLS), the variable PARTS_c is a simple dummy equal to 1 if the firm participates in a RJV of size c (Pooled OLS is used). The variable PARTS_c for columns (IV1) and (IV2) corresponds to the predicted values of the first stage multilogit estimations (1) and (2) in table 13 respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 16: Analysis by RJV size, second stage estimation results, long-term effects: Labor Productivity†

Sample	Random			IC-Rep			Sales-Rep		
	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)
δ_0^L	0.256***	0.379**	0.352**	0.243***	0.506***	0.497***	0.161***	0.340**	0.340**
	(0.05)	(0.13)	(0.13)	(0.05)	(0.12)	(0.12)	(0.05)	(0.13)	(0.13)
δ_0^S	0.146***	0.461***	0.376**	0.090**	0.228	0.201	0.022	0.347	0.222
	(0.05)	(0.17)	(0.17)	(0.04)	(0.21)	(0.22)	(0.05)	(0.23)	(0.22)
δ_1^L	0.224***	0.313**	0.293**	0.206***	0.522***	0.512***	0.130**	0.254	0.266*
	(0.05)	(0.14)	(0.13)	(0.05)	(0.13)	(0.12)	(0.05)	(0.14)	(0.14)
δ_1^S	0.095*	0.380**	0.301	0.033	0.199	0.161	-0.015	0.464*	0.347
	(0.05)	(0.19)	(0.18)	(0.04)	(0.24)	(0.24)	(0.05)	(0.25)	(0.24)
δ_2^L	0.228***	0.370***	0.349**	0.206***	0.605***	0.599***	0.146***	0.306*	0.314**
	(0.06)	(0.14)	(0.14)	(0.05)	(0.14)	(0.14)	(0.06)	(0.14)	(0.14)
δ_2^S	0.101*	0.372*	0.306	0.029	0.172	0.136	0.004	0.400	0.316
	(0.05)	(0.19)	(0.18)	(0.05)	(0.26)	(0.26)	(0.05)	(0.25)	(0.24)
δ_3^L	0.229***	0.385***	0.371**	0.202***	0.634***	0.633***	0.155***	0.364**	0.376**
	(0.06)	(0.15)	(0.15)	(0.06)	(0.15)	(0.15)	(0.06)	(0.15)	(0.14)
δ_3^S	0.084	0.336	0.252	0.033	0.151	0.110	0.004	0.275	0.195
	(0.06)	(0.20)	(0.20)	(0.05)	(0.27)	(0.28)	(0.05)	(0.27)	(0.26)
δ_4^L	0.180***	0.409**	0.388**	0.130**	0.624***	0.624***	0.096	0.440**	0.445**
	(0.07)	(0.16)	(0.16)	(0.07)	(0.17)	(0.17)	(0.07)	(0.16)	(0.16)
δ_4^S	0.068	0.320	0.264	0.024	0.312	0.276	-0.005	0.190	0.122
	(0.06)	(0.24)	(0.24)	(0.06)	(0.33)	(0.34)	(0.06)	(0.30)	(0.29)

† The table presents the estimated coefficients in the regression $y_{it+\tau} = x'_{it}\beta + \delta_\tau^L \cdot \mathrm{PARTS}_{Lit} + \delta_\tau^S \cdot \mathrm{PARTS}_{Sit} + \varepsilon_{it+\tau}$, with $\tau = 0, \ldots, 4$. Standard errors in parenthesis and clustered at the four-digit industry level. In specifications (OLS), the variable PARTS_c is a simple dummy equal to 1 if the firm participates in a RJV of size c (Pooled OLS is used). The variable PARTS_c for columns (IV1) and (IV2) corresponds to the predicted values of the first stage multilogit estimations (1) and (2) in table 13 respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 17: Analysis by RJV size, second stage estimation results, long-term effects: Profit Margin[†]

Sample	Random			IC-Rep			Sales-Rep		
	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)	(OLS)	(IV1)	(IV2)
δ_0^L	-0.018**	-0.008	-0.007	-0.005	0.008	0.011	-0.008	0.020	0.025
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)
δ_0^S	-0.012	-0.048**	-0.042**	-0.004	-0.024	-0.015	-0.003	-0.007	-0.012
	(0.01)	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)	(0.03)	(0.03)
δ_1^L	-0.017	-0.001	0.001	-0.004	0.022	0.024	-0.011	0.025	0.029
	(0.01)	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)	(0.02)	(0.02)
δ_1^S	-0.010	-0.049**	-0.042**	-0.002	-0.016	-0.010	-0.005	0.000	-0.008
	(0.01)	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)	(0.03)	(0.03)
δ_2^L	-0.014	0.021	0.023	0.000	0.056*	0.058*	-0.006	0.045*	0.049**
	(0.01)	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)	(0.02)	(0.02)
δ_2^S	-0.009	-0.050**	-0.045**	-0.002	-0.029	-0.023	-0.003	-0.014	-0.021
	(0.01)	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)	(0.04)	(0.04)
δ_3^L	-0.007	0.027	0.030	0.003	0.065**	0.067**	-0.005	0.046**	0.049**
	(0.01)	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)	(0.02)	(0.02)
δ_3^S	-0.006	-0.055**	-0.054**	0.000	-0.023	-0.020	-0.001	-0.005	-0.012
	(0.01)	(0.03)	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)	(0.05)	(0.05)
δ_4^L	-0.009	0.032	0.034	0.003	0.080**	0.082***	-0.002	0.062**	0.065**
	(0.01)	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)	(0.01)	(0.02)	(0.02)
δ_4^S	0.001	-0.060**	-0.058**	0.008	-0.033	-0.027	0.008	-0.014	-0.019
	(0.01)	(0.03)	(0.03)	(0.01)	(0.04)	(0.04)	(0.01)	(0.05)	(0.05)

† The table presents the estimated coefficients in the regression $y_{it+\tau} = x'_{it}\beta + \delta_\tau^L \cdot \text{PARTS}_{Lit} + \delta_\tau^S \cdot \text{PARTS}_{Sit} + \varepsilon_{it+\tau}$, with $\tau = 0, \ldots, 4$. Standard errors in parenthesis and clustered at the four-digit industry level. In specifications (OLS), the variable PARTS_c is a simple dummy equal to 1 if the firm participates in a RJV of size c (Pooled OLS is used). The variable PARTS_c for columns (IV1) and (IV2) corresponds to the predicted values of the first stage multilogit estimations (1) and (2) in table 13 respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

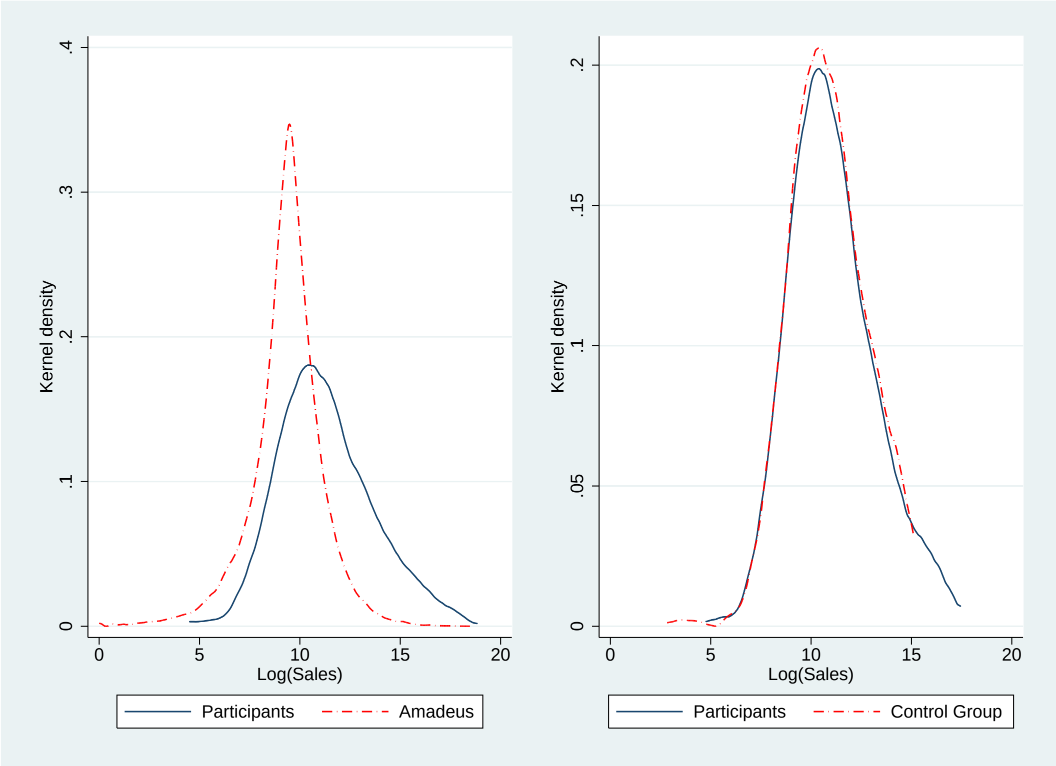

Figure 1: Sales distributions for participants, Amadeus and Control Groups in 1999.

8.2 Replication of the participants' distribution

In order to construct the control group, we'll try to replicate the distribution of participants according to their size (measured by the number of employees, sales and fixed assets). The idea is as follows. For each percentile of the participants' distribution, we count the number of firms and try to reconstruct a similar distribution with the firms in Amadeus . For example, we have 6 participants below the first percentile (i.e. 6 firms with less or equal than 627'000 € of sales). In order to replicate the distribution, we count the number of Amadeus firms that have less or equal than this value (this gives 5219 observations) and draw randomly 6 observations (firms) from this group.

We then count the number of participants between the first and second percentile, i.e. the number of firms with more than 627'000 and less or equal than 1'441'000 € of sales. This gives us 6 firms. We again count the number of Amadeus firms that have more than 627'000 and less or equal than 1'441'000 € of sales (this gives 4076 observations) and randomly draw 6 observations from them. After the procedure is replicated until the last percentile, we end up with a control group that has a similar distribution of firms in terms of sales.