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

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Abstract

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 research projects may raise labor productivity by at least 44.4 percent while it has very limited effect on profit margin.

Keywords: R&D cooperation, Firm Performance, EU Framework programme, Policy evaluation.

JEL classification: H81, L2, O31, O32, O38.

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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 a public policy that combines these two types of interventions. In particular, this policy aims at encouraging collaboration in R&D activities through the granting of subsidies to groups of firms that engage in Research Joint Ventures (RJVs).[3] 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.[4] Started in 1984, the first Framework Programme came in response

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

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

[3]Note that while this type of intervention also entails the granting of a subsidy, the latter is not provided to specific firms directly but to the whole RJV. This policy is therefore not equivalent to the granting of direct R&D subsidies to firms.

[4]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).

to a situation where individual R&D activities were uncoordinated and required a large number of Council decisions (Georghiou, 2001).[5] The EU-FPs are the main financial 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.[6] 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.[7] 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

[5]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).

[6]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).

[7]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).

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 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.[8] 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 follow Wooldridge (2001) and use a two-step estimation method where we first estimate a selection equation, and then estimate the impact of participation on firms' performance with a 2SLS-IV procedure that uses the fitted probabilities of participation from the first stage as instrument. For this purpose we need at least one exogenous 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

[8] 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).

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. According to the European Commission, "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." This would lead to the development of projects that 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 by performance, it can be used as a tool to solve the selection issue. This specific 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.

Our results suggest that the long-term effect of participation is an increase in labor productivity by, at least, 44.4 percent. Differences in profit margins between participating and non-participating firms are found to be non-significant. The large magnitude of our estimates related to labor productivity should not come as a surprise. Indeed, they should not be seen as the average impact of participation for all firms, but instead 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). It is plausible that the impact of participation itself varies across firms. We follow Imbens and Angrist (1994) and interpret our estimates as a Local Average Treatment Effect (LATE). Thus, the estimation results show the average impact of participation for the sample of firms which have been affected by the instrument, namely those firms which would have not participated in R&D activities without the subsidies of the EU-FP5. As R&D collaboration remains an activity with long-term objectives, 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.

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.[9] 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 coopera-

[9]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).

tion 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 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.[10] 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 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.[11] 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.

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

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

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.[12] 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.

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

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

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. According to the European Commission's webpage, "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 reorganization of social relations and labor legislation, both for business and for individuals. An example is the SEMPER Project (Secure Electronic Marketplace for Europe). As described on the European Commission's webpage, it "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.* The European Commission highlights the importance of multimedia technologies as they are "opening new ways of mastering information, acquiring knowledge, and transferring know-how available to a broad public." As an example, their website presents 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, also taken from the European Comission's webpage, 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."

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. 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 is performed using AMADEUS (Analyse MAjor Databases 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. If the main motivation of firms participating in multiple RJVs is to facilitate collusive practices, the choice to drop them may lead to an overestimation of the effect of participation on performance given that improving productivity is not their main concern. A the same time, firms participating in multiple RJVs may be precisely the ones interested in improving their performance; discarding them may therefore lead to an underestimation of the impact of participation. Whether one effect or the other prevails is hard to tell with our data. We discard firms participating in several RJVs because the interpretation of their decision is more problematic.[13] Hence, we 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)[14], 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 much less so in 2003-2004. 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 the number of participants increases with the cost of the project.

A simple comparison of the average labor productivity before and during participation can be performed for each participant of our sample. We present here descriptive statistics for the firms that are observed before and during participation in the EU-FP5. Our empirical exercise will include firms that are observed before and during participation in the EU-FP5, but also firms that are observed during the participation period only. On average, labor productivity increases by 23.6 percent between both periods; one observes moreover large differences across firms: On the lower end of the spectrum, Chantiers de

[13]In any case, note that accounting for firms participating in only one project plus those involved in several projects yields empirical results very similar to those presented in Tables 8 and 9 below. See Tables A1-A3 in the online appendix.

[14]Due to some technical restrictions related to our data collection procedure, we were not able to recover the information on all of the 2522 projects available on the CORDIS webpage.

l'Atlantique, Sony Spain, or Hewlett Packard Italy face a change in labor productivity equal to -19.5, -16.7, and -13.8 percent respectively. On the other other side of the spectrum, firms like MR Fabrication, Miniconf, or Instytut Spawalnictwa enjoy large labor productivity increases of 123.6, 129.4, and 137.6 percent respectively. Our empirical objective consists in determining to which extend this increase in labor productivity is due to the participation of firms in the EU-FP5 or other exogenous shocks which affect participants and non-participants simultaneously. The same type of comparison can be made with firms' profit margins before and during participation and suggests that the average increase is almost nil. Again, an empirical model which helps identifying the effect of participation in the EU-FP5 will prove particularly fruitful in this case.

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 6 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 3, which shows the distribution of the log transformation of sales for both participants and firms contained in Amadeus. The participants' distribution is similar to the one of the outsiders, only shifted to the right.

To perform our empirical test, we use a sample composed of the participating firms and of non-participating firms randomly picked from Amadeus.[15] 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.[16]

Using all non participating firms from Amadeus to construct the control group would entail a very high number of firms. Note that this would be perfectly acceptable for the purpose

[15]An ideal control group would comprise firms that applied for funding through the EU-FP5 but were eventually rejected. Unfortunately, we only observe accepted projects in our dataset. Firms that applied for funding but were denied can therefore not be distinguished from those that did not apply.

[16]Two alternative control groups, which are constructed by (i) selecting non-participating firms from Amadeus so as to replicate the cross-tabulation of participants by country and industry, and (ii) replicating the distribution of the sales variables of the participants for 1999 (i.e. before the start of any project), were also considered. The empirical results are similar in each one of the three cases.

of our estimation. However, it would not allow us to check that all firms belonging to our control group are not 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 sample, we would therefore like to verify that the non-participating firms present in our control group 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 group had participated in the EUREKA programme during this same period.[17] Although our control group is not only composed of French firms, the latter still represent a non-negligible share of the non-participants with 16.4 percent in our sample. The results showed that only 5 firms did participate in EUREKA during the same period, meaning that more than 95 percent of the French firms in our sample have not participated in the EUREKA programme.

Additionally, 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 very small fraction (less than 0.01 percent) turned out to be participating in the EU-FP6, giving further support to the validity of our control group.

Finally, note that firms may as well participate in private R&D cooperation, i.e., any form of collaboration not supported by governmental subsidies. Siebert (2016) suggests

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

for instance that firms engage in a large number of pre-discovery licensing agreements. We acknowledge that we may still include in the control group firms that are considered as noncooperative but do participate in private cooperation. Unfortunately, we do not have the possibility to identify these firms. Although this is a potential caveat, we believe that a worst case scenario were many of those firms were present in our control group would simply undermine the magnitude of our results. Hence, the estimates we present here should be seen as conservative ones.

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 may attract those firms which would have not participated in R&D activities without the subsidies of the EU-FP5, we have to deal with a potentially negative selection bias. Röller et al. (2007) suggest for instance that less efficient firms have incentives to cooperate with more efficient firms in order to keep the market structure more symmetric. 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:

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

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 $\text{COV}(\varepsilon_{is}, \text{PART}_{it}) \neq 0$ 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 a variable that generates some exogenous variation in the participation decision of firms, which would allow to mimic a randomly assigned treatment. Finding such a 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}.

Identification

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. 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."[18] Thus, the objective underlying the Fifth Framework Programme differs radically from that of its predecessors.

If the available funding is larger for industries that also report greater productivity, identification is undermined. To confirm that we should not expect any positive correlation between ex ante performance and available funding, Figure 1 (Figure 2 resp.) plots the average labor productivity (profit margin resp.) before participation against the available funding in each industry, defined at the 4-digit level. The figures illustrate well that funds allocated to each industry are not systematically related to industry performance. As a robustness check in the course of the estimation of the empirical model, we also exploit the

[18] See "A turning point for community research," RTD Info 21, p.3.

time series dimension of the data and measure performance before and after firms enter the EU-FP5; this procedure is described in more details in what follows. Of course, we do 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.[19]

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. 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. Our discussion above, together with the evidence depicted in Figures 1 and 2, leads us to conclude that the funds made available by the EU-FP5 in each industry is an excellent source of exogenous variation to identify the causal effect of participation in the IST programme on firms' performance.

[19]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. 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.

Two-steps estimation

Equation (3) is a standard endogenous dummy variable model. Following Wooldridge (2001), 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 will engage in an RJV of the IST programme is given by

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

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_{it}. Hence z_1 is a variable 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) using pre-determined observations to explain programme participation. Notice that this amounts to using pre-programme firm characteristics as instruments for the endogenous variable PART_{it}. Given that the IST programme starts in the year 2000, we want to prevent firms' characteristics from being affected by the programme. In essence, the first step of our estimation strategy therefore tries to define the profile of a typical participating firm right before the start of the IST programme. For this purpose, we use observations for years 1997 to 1999 to estimate equation (4) and obtain an estimate of $\hat{\gamma}$. Notice that in order to do so we use as a dependent variable a dummy indicating whether the firm will be a participant in the programme. We then construct the predicted probabilities of participation using the subsequent years of data and our estimate $\hat{\gamma}$ to obtain $\widehat{PART}_{it} = F(Z_{it}\widehat{\gamma})$. Notice that although we use past firms' characteristics as instruments, the current firms' characteristics variables are used to construct the predicted probabilities of participation. The second step of our strategy consists in using these predicted values as an intrument in a 2SLS-IV procedure to identify the impact of participation estimating equation (3) using years 2000 to 2006. To summarize, our estimation strategy therefore entails three different stages, the second stage being a regression of PART_{it} on $\widehat{PART}_{it}$ plus the observable characteristics included in the vector x. Note that the second and third stages are estimated simultaneously in a single step.

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. As discussed above, our approach is based on the idea that differences in available funding across industries induce variation in the likelihood of participating in the programme. 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 Key Action 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.

To follow our two steps estimation procedure, we use additional explanatory variables that are relevant determinants of RJV participation. 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.[20] 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.

We introduce a measure of firms' size to take into account the existent asymmetries across firms. This variable may 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.

The concern that firms may use RJV participation as a means toward product market collusion has long been identified in the literature (Brodley, 1990; Shapiro and Willig, 1990; Katz and Ordover, 1990).[21] Naturally, this concern is particularly relevant in markets where participants have significant market power or in more concentrated industries. While determining whether anti-competitive motives drive firms to participate in the EU-FP RJVs is beyond the scope of our study, we are still able to assess whether the determinants of participation are consistent with such behavior.[22] In particular, we can look at how participation decisions depend on a firm's market share and on the concentration of the industry it operates in.

A firm's market share naturally also provides us with a measure of its *relative* size within

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

[21]The theoretical literature has highlighted several channels through which RJVs could facilitate anti-competitive behavior. For instance, interactions between firms that participate in RJVs may increase the possibility to sustain collusion in the product market compared to firms interacting in a unique market (Martin, 1996; Cabral, 2000). RJVs may also reduce cost asymmetries among participating firms following the sharing of research findings, which could in turn facilitate collusion (Miyagiwa, 2009). See also Levy (2012) for a treatment of tacit collusion through RJVs and through licensing.

[22]Recent empirical studies indeed find support for the fact that firms may participate in RJVs as a means to reach collusive agreements. See, for instance, Goeree and Helland (2009) and Duso et al. (2014).

its industry. As noted by Hernán et al. (2003), relative size may also 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). A measure of relative size is therefore proxied by the introduction of a variable measuring market share, calculated as firm size over industry size, both measured by the amount of sales.[23]

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 identification of suitable partners and spillovers to non-participants are limited because of their reduced number. Likewise, and as discussed above, an RJV may well be created to weaken competition and facilitate collusion in the product market. In 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.[24] To construct a measure of industry concentration, we include the Herfindähl-Hirschman Index (HHI) for each four-digit sector present in our sample.[25] 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

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

[24] 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.

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

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

and

$$
y_{it}=x'_{it}\beta+\delta\cdot\mathrm{PART}_{it}+\varepsilon_{it}, \qquad (6)
$$

where x'_{it} contains all the variables of z'_{it} excluding $AvailableFunding$. We estimate Equation (5) with a logit procedure and obtain $\widehat{\mathrm{PART}}_{it}$; in a second step, $\widehat{\mathrm{PART}}_{it}$ is used as an instrument in a 2SLS-IV estimation of (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

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 7 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. 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 the variable $AvailableFunding$. The coefficient turns out to be positive and strongly significant in both specifications, corroborating the fact that the available funding is indeed an important predictor of participation in the programme.[26] 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 exogenous variable.

The coefficient associated with firm size is positive and highly significant. 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 (for a theoretical model, see Röller et al., 2007). 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). 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. This results corroborates the "technology watch" explanation presented above, according to which relatively large firms in an

[26]Table 7 presents the χ^2 statistics for the coefficient on the $AvailableFunding$ variable in each specification. The values of the test are all above 50 and strongly reject the null of the available funding not affecting participation in the programme. Since we are explaining future participation in the programme with data from 1997 to 1999, it could nevertheless be that the available funding does not predict participation that well in the years following 2000. To check for that possibility we used the data from 2000 to 2006 to run regressions of our participation variable on the predicted values $\widehat{PART}_{it}$ and all the variables included in the vector x in (3). The results present positive and highly significant coefficients on our predicted participation variable. See Table A4 in the online appendix.

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.

The HHI variable shows a positive impact on the probability of participation, 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.

As discussed above, our results relating HHI, market share, and participation are relevant to the potential concern that RJVs may be used as a collusive device. While we cannot determine whether anti-competitive motives drive firms to participate in EU-FP RJVs, we note that our coefficients of interest are consistent with such behavior, as firms from more concentrated industries and firms with larger market shares are more likely to participate in these projects.

The fixed assets intensity, a measure of capital intensity, is a positive and strongly significant predictor of participation 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 at the 10% level, 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, but is only marginally significant, suggesting that R&D activities proxied by the intangible fixed assets are a potential determinant of programme participation.

Impact of the IST programme on economic performance

We now use $\widehat{\text{PART}}_{it}$ as an instrument in a 2SLS-IV estimation of (6), and the impact of participation on the firms' performance is estimated using observations from years 2000 to 2006. Tables 8 and 9 present the estimation results for Equation (6). In each of the tables, 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. Firms engaging in an RJV, enjoy an average increase in labor productivity of at least 44.4 percent.[27] At the same time, Table 9 suggests that the effect of participation on profit margin is nil.

As a robustness check, we have also run our program using lagged data for all the explanatory variables. The results show positive and significant effects of participation on labor productivity, while the effect of participation on firms' profit margins is not statistically different from zero.[28]

It is important to recall the interpretation that must be given to our estimates. 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 variable $AvailableFunding$. 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 exogenous variable 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.

The results presented in Table 8 shed light on the fact that the IV estimates of the effect of participation in the EU-FP5 are larger in magnitude than the OLS estimates. This suggests the presence of negative selection, i.e., the marginal participant, who would have not participated in R&D activities without the subsidies of the EU-FP5, is characterized by a lower labor productivity ex ante, compared to the average firm of the control group. To shed light on this effect, we rank all the participants according to their level of labor productivity *before* participation, and construct two new samples where we discard

[27] Table 8 indicates the effect of participation on the logarithm of labor productivity. The direct effect on labor productivity is just $exp\,(\delta) - 1$.

[28] See Tables A5-A7 in the online appendix.

observations for firms with a labor productivity lower than 35 and 52, which correspond to the 25th percentile and the median of the sample respectively. The estimation results show that the effect of participation becomes smaller in magnitude when considering firms with higher labor productivity ex ante.[29] Taken together, these results seem to coincide with our interpretation of negative selection, although we are aware that a more detailed investigation, which exploits more thoroughly additional data on the characteristics of participating firms, would be useful.

Our sample of participants allows us to observe only a small fraction of the same individuals before and during participation, which makes it more difficult to implement alternative estimation procedures which exploit the time series dimension of the data on participants. We have nevertheless attempted to recover an average effect of participation for all participants with a Difference-in-Differences model as well.[30] The average effect on labor productivity and profit margin is not significantly different from zero in this case, which goes in line with the previous results obtained by the literature, and suggests that a methodology which aims at identifying distinct effects of participation for various groups of participants is probably more adequate.

We also tried to challenge the results of our two-step estimation procedure, which is solely based on cross sectional variation, and estimated Equation (6) with the additional information on the participants before 2000 for the participants that are observed before and during participation. The empirical results are similar to those that are presented in Table 8 and Table 9.[31]

One may as well question the relevance of our explained variables, labor productivity and profit margin, as good proxies for firms' performance. These variables have the advantage that they are directly available from our database and are reported by the firms. They may however present two potential drawbacks: On the one hand, a measure of total factor productivity could be more accurate than a simple measure of labor productivity, especially in capital intensive industries. On the other hand, our profit margin variable is an accounting measure and may not proxy adequately the profitability of firms. Therefore, as a robustness check, we consider two additional explained variables, namely a measure

[29] The estimation results are presented in Tables A8 and A9 of the online appendix.
[30] See Tables A10-A13 of the online appendix.
[31] The estimation results are presented in Tables A14 and A15 of the online appendix.

of total factor productivity, and an estimation of price-cost margins obtained from firm level data in the spirit of Hall (1988) or, more recently, De Loecker and Warzynski (2012). The construction of both variables relies on the initial estimation of a production function that accounts for firms individual output and input quantities. When estimating our production function, we follow the procedure proposed by Levinsohn and Petrin (2003) in order to solve for unobserved productivity as a function of observed firm-level decisions to deal with the endogeneity of inputs. The estimation results confirm that our initial results are robust since our new estimates are very similar to those presented in Tables 8 and 9.[32]

Finally, 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.[33] 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:

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

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 10 and 11 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.[34]

We first discuss the results in Table 10, which refer to labor productivity as a measure of economic performance. 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

[32] The estimation results are presented in Tables A16 and A17 of the online appendix.

[33] 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).

[34] The first line of each table therefore reports the coefficients on the participation dummies from Tables 8 and 9 respectively (i.e. when $\tau = 0$).

perspective. Turning to the effects on the profit margin (Table 11), our results show again non-significant effects.

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 exogenous 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, at least, 44.4 percent. The effect of participation on the profit margin is more limited.

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 directly these particular firms, our empirical results results have provided a few hints 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 first-time participants. When we discard the less productive participants from the initial sample, the magnitude of the impact of participation on labor productivity shrinks and may even become nil. 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. One may argue that our results could 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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A Figures and Tables

Figure 1: Industry Labor Productivity and Available Funding.

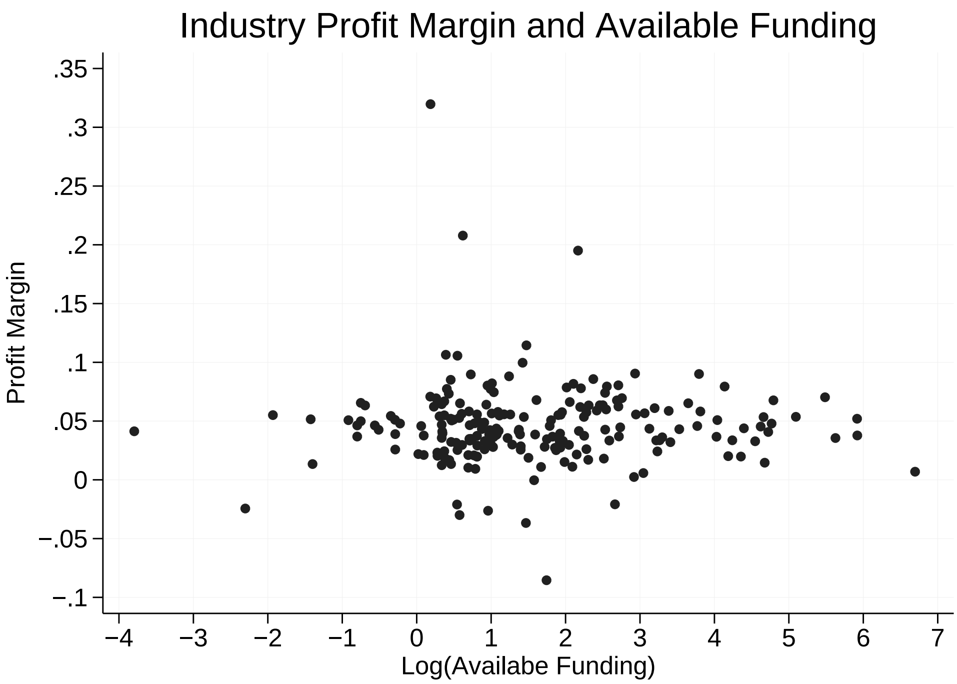

Figure 2: Industry Profit Margin and Available Funding.

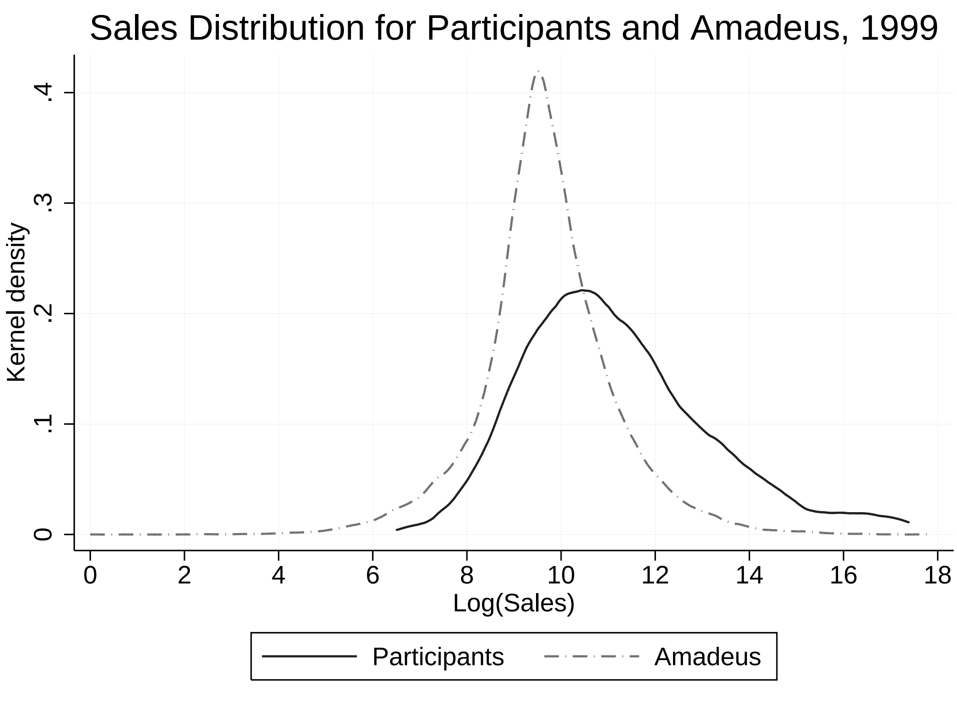

Figure 3: Sales distributions for participants and Amadeus in 1999.

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	
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	65 (20.63 %)	8.15	29.32	3639.40	1933.65
2001	79 (25.08 %)	8.28	26.32	2384.29	1353.19
2002	131 (41.59 %)	9.13	27.15	3098.01	1692.80
2003	34 (10.79 %)	9.71	26.38	3045.70	1664.43
2004	6 (1.90 %)	9.00	32.00	1898.33	870.67
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	Funding in thousand €
0 to 1	53 (16.8%)	18.49	6.68	430.35
1 to 3	122 (38.7%)	28.35	8.13	1191.41
3 to 6	111 (35.2%)	29.91	9.33	2145.41
6 to 8	21 (6.7%)	30.48	13.00	3394.76
more than 8	8 (2.5%)	29.00	13.63	4821.25
All	315	27.40	8.77	1638.60

Table 6: Comparison of participants and AMADEUS for 1999.

	PARTICIPANTS (N=277)		AMADEUS (N=49915)			
	Mean	s.d.	Mean	s.d.	Diff.	t-stat
Sales	1589164	6955203	67710.8	574461.3	1521453***	32.76
Employees	8135.2	33971.8	376.9	3294.9	7758.3***	31.1
Fixed Assets	1617851	7733962	33900.5	526179.8	1583950.5***	33.82
Intangible Fixed Assets	203775.4	1917582	3978.1	81767.9	199797.4***	20.23
Labor Productivity	209.2	2166.8	102.2	1709.2	107	1.04
Cost of Employees	335137.7	1394598	11179.1	152837.4	323958.7***	29.19
Mean Wage	44	34.4	39.5	570.8	4.5	0.13
Profit Margin	4.6	10.8	3.9	9.9	0.6	1.07

*** Significant at the 1% level.

Table 7: First stage estimation results (logit)†

	(1) Coef./s.e.	(2) Coef./s.e.
Constant	-8.732***	-7.838***
	(1.323)	(1.338)
log(Employees)	0.431***	0.455***
	(0.090)	(0.095)
log(Fixed Assets Intensity)	0.202***	0.136*
	(0.062)	(0.076)
log(Intang Assets Intensity)		0.119**
		(0.055)
log(Available Funding)	0.505***	0.498***
	(0.064)	(0.063)
Market Share	6.106***	5.921**
	(2.173)	(2.310)
HHI	2.278**	2.312**
	(1.074)	(1.067)
χ^2 test on log(Available Funding)	62.75	63.26
Pseudo-R^2	0.433	0.440
No. of Observations	1667	1667

† The dependent variable is equal to 1 for participants and 0 for non-participants. All specifications include year, industry, and country fixed effects. 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 8: Second stage estimation results: Labor Productivity†

	(OLS) Coef./s.e.	(IV1) Coef./s.e.	(IV2) Coef./s.e.
Constant	3.667***	3.534***	3.600***
	(0.208)	(0.219)	(0.212)
log(Employees)	-0.147***	-0.170***	-0.166***
	(0.017)	(0.020)	(0.020)
log(Fixed Assets Intensity)	0.262***	0.265***	0.259***
	(0.014)	(0.015)	(0.014)
log(Intang Assets Intensity)	0.014**		0.011
	(0.007)		(0.007)
Market Share	2.287***	2.234***	2.218***
	(0.593)	(0.607)	(0.602)
HHI	0.238	0.185	0.203
	(0.175)	(0.182)	(0.182)
PART	0.175***	0.505***	0.440***
	(0.040)	(0.156)	(0.157)
Adjusted-R^2	0.715	0.705	0.709
No. of Observations	7105	7105	7105

† The dependent variable is the logarithm of labor productivity. All specifications include year, industry, and country fixed effects. Standard errors in parenthesis are clustered at the four-digit industry level. Specifications (OLS) use OLS. Specifications (IV1) and (IV2) instrument the dummy variable PART with the predicted values obtained from the logit estimations (1) and (2) in Table 7, respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 9: Second stage estimation results: Profit Margin†

	(OLS) Coef./s.e.	(IV1) Coef./s.e.	(IV2) Coef./s.e.
Constant	0.038	0.050	0.039
	(0.042)	(0.041)	(0.042)
log(Employees)	0.003*	0.004*	0.004*
	(0.002)	(0.002)	(0.002)
log(Fixed Assets Intensity)	0.009***	0.008***	0.009***
	(0.002)	(0.002)	(0.002)
log(Intang Assets Intensity)	-0.002**		-0.002**
	(0.001)		(0.001)
Market Share	0.036	0.031	0.037
	(0.048)	(0.049)	(0.049)
HHI	0.001	0.004	0.001
	(0.019)	(0.018)	(0.019)
PART	-0.014**	-0.023	-0.020
	(0.007)	(0.019)	(0.018)
Adjusted-R^2	0.045	0.042	0.045
No. of Observations	7105	7105	7105

† The dependent variable is the profit margin. All specifications include year, industry, and country fixed effects. Standard errors in parenthesis are clustered at the four-digit industry level. Specifications (OLS) use OLS. Specifications (IV1) and (IV2) instrument the dummy variable PART with the predicted values obtained from the logit estimations (1) and (2) in Table 7, respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 10: Second stage estimation results: Labor Productivity†

	(OLS) Coef./s.e.	(IV1) Coef./s.e.	(IV2) Coef./s.e.
δ_0	0.175***	0.505***	0.440***
	(0.040)	(0.156)	(0.157)
δ_1	0.136***	0.409**	0.352**
	(0.040)	(0.171)	(0.177)
δ_2	0.141***	0.480**	0.431**
	(0.044)	(0.190)	(0.197)
δ_3	0.133***	0.510**	0.457**
	(0.048)	(0.217)	(0.229)
δ_4	0.112**	0.601**	0.546*
	(0.054)	(0.275)	(0.291)

† The table presents the estimated coefficients in the regression $y_{it+\tau} = x'_{it}\beta + \delta_\tau \text{PART}_{it} + \varepsilon_{it+\tau}$, with $\tau = 0, \ldots, 4$. Standard errors in parenthesis are clustered at the four-digit industry level. In specifications (OLS), the variable PART is a simple dummy equal to 1 if the firm participates in EU-FP (Pooled OLS is used). Specifications (IV1) and (IV2) instrument the dummy variable PART with the predicted values obtained from the logit estimations (1) and (2) in Table 7, respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 11: Second stage estimation results: Profit Margin†

	(OLS) Coef./s.e.	(IV1) Coef./s.e.	(IV2) Coef./s.e.
δ_0	-0.014**	-0.023	-0.020
	(0.007)	(0.019)	(0.018)
δ_1	-0.013*	-0.020	-0.015
	(0.008)	(0.022)	(0.022)
δ_2	-0.011	0.004	0.008
	(0.008)	(0.025)	(0.025)
δ_3	-0.006	0.005	0.008
	(0.009)	(0.028)	(0.028)
δ_4	-0.004	-0.005	-0.002
	(0.009)	(0.033)	(0.034)

† The table presents the estimated coefficients in the regression $y_{it+\tau} = x'_{it}\beta + \delta_\tau \text{PART}_{it} + \varepsilon_{it+\tau}$, with $\tau = 0, \ldots, 4$. Standard errors in parenthesis are clustered at the four-digit industry level. In specifications (OLS), the variable PART is a simple dummy equal to 1 if the firm participates in EU-FP (Pooled OLS is used). Specifications (IV1) and (IV2) instrument the dummy variable PART with the predicted values obtained from the logit estimations (1) and (2) in Table 7, respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Online Appendix to

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

Table A1: First stage estimation results (logit). Firms participating in multiple RJVs Included.[†]

	(1) Coef./s.e.	(2) Coef./s.e.
Constant	-9.915***	-8.832***
	(1.299)	(1.310)
log(Employees)	0.500***	0.527***
	(0.089)	(0.093)
log(Fixed Assets Intensity)	0.199***	0.120
	(0.062)	(0.074)
log(Intang Assets Intensity)		0.136**
		(0.054)
log(Available Funding)	0.591***	0.580***
	(0.069)	(0.067)
Market Share	6.956***	6.953***
	(2.156)	(2.371)
HHI	2.375**	2.345**
	(1.035)	(1.039)
Industry Fixed Effects	✓	✓
Country Fixed Effects	✓	✓
Year Fixed Effects	✓	✓
χ^2 test on log(Available Funding)	73.43	74.21
Pseudo-R^2	0.507	0.514
No. of Observations	1900	1900

[†] 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 A2: Second Stage Estimation Results: Labor Productivity. Firms participating in multiple RJVs Included.†

	(OLS) Coef./s.e.	(IV1) Coef./s.e.	(IV2) Coef./s.e.
Constant	3.597***	3.538***	3.585***
	(0.168)	(0.167)	(0.167)
log(Employees)	-0.120***	-0.144***	-0.139***
	(0.016)	(0.018)	(0.018)
log(Fixed Assets Intensity)	0.275***	0.277***	0.272***
	(0.015)	(0.016)	(0.014)
log(Intang Assets Intensity)	0.012*		0.009
	(0.006)		(0.006)
Market Share	1.617***	1.649***	1.619***
	(0.585)	(0.572)	(0.575)
HHI	0.117	0.049	0.071
	(0.154)	(0.161)	(0.161)
PART	0.211***	0.477***	0.415***
	(0.041)	(0.132)	(0.132)
Industry Fixed Effects	✓	✓	✓
Country Fixed Effects	✓	✓	✓
Year Fixed Effects	✓	✓	✓
Adjusted-R^2	0.702	0.695	0.698
No. of Observations	8056	8056	8056

† The dependent variable is the logarithm of labor productivity. Standard errors in parenthesis are clustered at the four-digit industry level. Specifications (OLS) uses OLS. Specifications (IV1) and (IV2) instrument the dummy variable PART with the predicted values obtained from the logit estimations (1) and (2) in Table A1, respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table A3: Second Stage Estimation Results: Profit Margin. Firms participating in multiple RJVs Included.†

	(OLS) Coef./s.e.	(IV1) Coef./s.e.	(IV2) Coef./s.e.
Constant	0.064*	0.076**	0.064*
	(0.038)	(0.037)	(0.038)
log(Employees)	0.005***	0.005***	0.005***
	(0.002)	(0.002)	(0.002)
log(Fixed Assets Intensity)	0.010***	0.009***	0.010***
	(0.002)	(0.002)	(0.002)
log(Intang Assets Intensity)	-0.002**		-0.002**
	(0.001)		(0.001)
Market Share	0.062	0.054	0.062
	(0.041)	(0.039)	(0.041)
HHI	-0.010	-0.007	-0.010
	(0.017)	(0.016)	(0.016)
PART	-0.017**	-0.019	-0.017
	(0.007)	(0.016)	(0.015)
Industry Fixed Effects	✓	✓	✓
Country Fixed Effects	✓	✓	✓
Year Fixed Effects	✓	✓	✓
Adjusted-R^2	0.043	0.041	0.043
No. of Observations	8056	8056	8056

† The dependent variable is the profit margin. Standard errors in parenthesis are clustered at the four-digit industry level. Specifications (OLS) uses OLS. Specifications (IV1) and (IV2) instrument the dummy variable PART with the predicted values obtained from the logit estimations (1) and (2) in Table A1, respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table A4: Actual RJV Participation and Participation Probability.†

	(1) Coef./s.e.	(2) Coef./s.e.
Constant	0.458***	0.398**
	(0.16)	(0.16)
log(Employees)	0.011*	0.011
	(0.01)	(0.01)
log(Fixed Assets Intensity)	-0.004	-0.002
	(0.01)	(0.01)
log(Intang Assets Intensity)		-0.004
		(0.00)
Market Share	0.435**	0.451**
	(0.19)	(0.19)
HHI	-0.047	-0.031
	(0.09)	(0.09)
$Pr(\widehat{PART})$	0.741***	0.727***
	(0.07)	(0.06)
Industry Fixed Effects	✓	✓
Country Fixed Effects	✓	✓
Year Fixed Effects	✓	✓
Adjusted-R^2	0.377	0.378
No. of Observations	7094	7094

† The dependent variable is equal to 1 for participants during participation and 0 for non-participants. Column (1) uses the predicted values obtained from specification (1) in Table 7 of the main text. Column (2) uses the predicted values obtained from specification (2) in Table 7 of the main text. 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 A5: First Stage Estimation Results (logit). Lagged Explanatory Variables.†

	(1) Coef./s.e.	(2) Coef./s.e.
Constant	-9.041***	-7.834***
	(1.223)	(1.244)
log(Employees) in t-1	0.435***	0.472***
	(0.102)	(0.112)
log(Fixed Assets Intensity) in t-1	0.254***	0.145
	(0.084)	(0.114)
log(Intang Assets Intensity) in t-1		0.181**
		(0.071)
log(Available Funding)	0.517***	0.510***
	(0.079)	(0.077)
Market Share in t-1	5.605***	5.406**
	(2.086)	(2.261)
HHI in t-1	3.066**	3.048**
	(1.266)	(1.308)
Industry Fixed Effects	✓	✓
Country Fixed Effects	✓	✓
Year Fixed Effects	✓	✓
χ^2 test on log(Available Funding)	43.09	43.76
Pseudo-R^2	0.440	0.454
No. of Observations	884	884

† 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 A6: Second Stage Estimation Results: Labor Productivity. Lagged Explanatory Variables.†

	(OLS) Coef./s.e.	(IV1) Coef./s.e.	(IV2) Coef./s.e.
Constant	3.453***	3.297***	3.389***
	(0.232)	(0.225)	(0.201)
log(Employees) in t-1	-0.121***	-0.138***	-0.133***
	(0.024)	(0.022)	(0.022)
log(Fixed Assets Intensity) in t-1	0.240***	0.243***	0.238***
	(0.025)	(0.018)	(0.016)
log(Intang Assets Intensity) in t-1	0.012		0.010
	(0.008)		(0.008)
Market Share in t-1	1.778***	1.762***	1.749***
	(0.542)	(0.469)	(0.464)
HHI in t-1	0.291**	0.260	0.273
	(0.130)	(0.193)	(0.195)
PART	0.157***	0.390**	0.323*
	(0.051)	(0.180)	(0.182)
Industry Fixed Effects	✓	✓	✓
Country Fixed Effects	✓	✓	✓
Year Fixed Effects	✓	✓	✓
Adjusted-R^2	0.684	0.679	0.682
No. of Observations	6021	6021	6021

† The dependent variable is the logarithm of labor productivity. Standard errors in parenthesis are clustered at the four-digit industry level. Specifications (OLS) uses OLS. Specifications (IV1) and (IV2) instrument the dummy variable PART with the predicted values obtained from the logit estimations (1) and (2) in Table A5, respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table A7: Second Stage Estimation Results: Profit Margin. Lagged Explanatory Variables.†

	(OLS) Coef./s.e.	(IV1) Coef./s.e.	(IV2) Coef./s.e.
Constant	-0.186*	-0.163*	-0.181*
	(0.097)	(0.088)	(0.094)
log(Employees) in t-1	0.002	0.003	0.003
	(0.002)	(0.002)	(0.002)
log(Fixed Assets Intensity) in t-1	0.009***	0.008***	0.009***
	(0.002)	(0.002)	(0.002)
log(Intang Assets Intensity) in t-1	-0.002**		-0.002**
	(0.001)		(0.001)
Market Share in t-1	0.028	0.025	0.030
	(0.055)	(0.057)	(0.057)
HHI in t-1	0.008	0.011	0.009
	(0.019)	(0.019)	(0.019)
PART	-0.013*	-0.029	-0.025
	(0.007)	(0.022)	(0.022)
Industry Fixed Effects	✓	✓	✓
Country Fixed Effects	✓	✓	✓
Year Fixed Effects	✓	✓	✓
Adjusted-R^2	0.051	0.046	0.049
No. of Observations	6021	6021	6021

† The dependent variable is the profit margin. Standard errors in parenthesis are clustered at the four-digit industry level. Specifications (OLS) uses OLS. Specifications (IV1) and (IV2) instrument the dummy variable PART with the predicted values obtained from the logit estimations (1) and (2) in Table A5, respectively.
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

Table A8: First Stage Estimation Results Discarding Lower Labor Productivity Firms.†

	Remove Bottom 25^{th} Percentile		Remove Below Median	
	(1)	(2)	(3)	(4)
	Coef./s.e.	Coef./s.e.	Coef./s.e.	Coef./s.e.
Constant	-4.955***	-3.856***	-6.803***	-6.278***
	(1.298)	(1.340)	(1.386)	(1.359)
log(Employees)	0.476***	0.501***	0.560***	0.601***
	(0.109)	(0.110)	(0.126)	(0.126)
log(Fixed Assets Intensity)	0.146*	0.066	0.053	-0.034
	(0.085)	(0.103)	(0.110)	(0.136)
log(Intang Assets Intensity)		0.169***		0.169**
		(0.062)		(0.078)
log(Available Funding)	0.468***	0.460***	0.402***	0.393***
	(0.068)	(0.066)	(0.071)	(0.068)
Market Share	10.137*	10.119	18.860***	20.388***
	(5.406)	(6.288)	(6.157)	(6.140)
HHI	2.439*	2.495**	1.633	1.836
	(1.284)	(1.239)	(1.519)	(1.448)
Industry Fixed Effects	✓	✓	✓	✓
Country Fixed Effects	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓
χ^2 test on log(Available Funding)	47.12	47.99	32.25	33.39
Pseudo-R^2	0.448	0.461	0.459	0.473
No. of Observations	1274	1274	723	723

† 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 A9: Estimation Discarding Lower Labor Productivity Firms.†

	Remove Bottom 25^{th} Percentile			Remove Below Median		
	(OLS) Coef./s.e.	(IV1) Coef./s.e.	(IV2) Coef./s.e.	(OLS) Coef./s.e.	(IV1) Coef./s.e.	(IV2) Coef./s.e.
Constant	4.125***	4.080***	4.083***	4.372***	4.356***	4.362***
	(0.248)	(0.248)	(0.247)	(0.228)	(0.225)	(0.225)
log(Employees)	-0.092***	-0.111***	-0.109***	-0.083***	-0.093***	-0.089***
	(0.015)	(0.019)	(0.020)	(0.017)	(0.022)	(0.022)
log(Fixed Assets Intensity)	0.180***	0.180***	0.180***	0.154***	0.155***	0.155***
	(0.013)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
log(Intang Assets Intensity)	-0.002	-0.004	-0.004	-0.001	-0.002	-0.002
	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)
Market Share	1.373***	1.357***	1.358***	1.262***	1.254***	1.257***
	(0.422)	(0.433)	(0.431)	(0.450)	(0.456)	(0.452)
HHI	0.206	0.187	0.188	0.211	0.198	0.203
	(0.135)	(0.132)	(0.133)	(0.156)	(0.156)	(0.155)
PART	0.118***	0.331**	0.315**	0.087**	0.190	0.151
	(0.032)	(0.147)	(0.148)	(0.036)	(0.147)	(0.151)
Industry Fixed Effects	✓	✓	✓	✓	✓	✓
Country Fixed Effects	✓	✓	✓	✓	✓	✓
Year Fixed Effects	✓	✓	✓	✓	✓	✓
Adjusted-R^2	0.364	0.345	0.348	0.329	0.324	0.327
No. of Observations	5157	5157	5157	3303	3303	3303

† The dependent variable is the logarithm of labor productivity. Standard errors in parenthesis are clustered at the four-digit industry level. Specifications (OLS) use OLS. Specifications (IV1) and (IV2) instrument the dummy variable PART with the predicted values obtained from the logit estimations (1) and (2) in Table A8, respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table A10: Difference-in-Differences Estimates: Labor Productivity. Control Group 1.†

	(2000) Coef./s.e.	(2001) Coef./s.e.	(2002) Coef./s.e.	(2003) Coef./s.e.	(2004) Coef./s.e.	(Pooled) Coef./s.e.
log(Employees)	-0.474***	-0.471***	-0.408***	-0.454***	-0.469***	-0.409***
	(0.054)	(0.056)	(0.061)	(0.055)	(0.057)	(0.052)
log(Fixed Assets Intensity)	0.166***	0.146***	0.173***	0.146***	0.148***	0.182***
	(0.032)	(0.026)	(0.030)	(0.028)	(0.028)	(0.029)
log(Intang Assets Intensity)	0.017**	0.015**	0.013*	0.016**	0.017**	0.013**
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)
Market Share	4.253***	2.691***	2.649***	3.608***	3.671***	2.571***
	(1.189)	(1.038)	(0.742)	(0.769)	(0.931)	(0.776)
HHI	-0.037	-0.114	0.048	-0.000	-0.039	0.026
	(0.120)	(0.115)	(0.097)	(0.118)	(0.132)	(0.080)
PART	0.142	0.046	-0.016	0.033	-0.040	0.022
	(0.110)	(0.050)	(0.048)	(0.054)	(0.054)	(0.035)
Adjusted-R^2	0.870	0.875	0.868	0.876	0.877	0.861
No. of Observations	4114	4234	4683	3962	3771	5860

† The table presents the estimation results of running OLS on $y_{it} = x'_{it}\beta + \delta PART_{it} + \theta_i + \lambda_t + \varepsilon_{it}$, where θ_i and λ_t are firm and year fixed effects, respectively, and $PART_{it}$ is equal to 1 for participating firms after entering the programme. The dependent variable is the logarithm of labor productivity. The control group is constructed so as to replicate the participants' sales distribution in 1999 (i.e. before the start of any project). Specifications (2000) to (2004) include the control firms as well as participating firms that started their first project in the corresponding year. Specification (Pooled) includes all participating firms. All specifications include data on years 1997 to 2006. Standard errors in parenthesis are clustered at the firm level.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table A11: Difference-in-Differences Estimates: Profit Margin. Control Group 1.†

	(2000) Coef./s.e.	(2001) Coef./s.e.	(2002) Coef./s.e.	(2003) Coef./s.e.	(2004) Coef./s.e.	(Pooled) Coef./s.e.
log(Employees)	-0.000	0.002	0.001	0.001	0.001	0.000
	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)	(0.006)
log(Fixed Assets Intensity)	-0.001	-0.001	-0.003	-0.001	-0.000	-0.004
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.004)
log(Intang Assets Intensity)	-0.002	-0.003*	-0.003*	-0.002	-0.002	-0.003***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Market Share	0.140*	0.002	0.140**	0.133**	0.111	0.079
	(0.073)	(0.115)	(0.065)	(0.064)	(0.074)	(0.089)
HHI	-0.016	-0.019	0.005	0.002	-0.003	-0.006
	(0.017)	(0.017)	(0.015)	(0.017)	(0.018)	(0.014)
PART	-0.009	-0.013	0.004	-0.018	0.004	-0.005
	(0.020)	(0.012)	(0.010)	(0.014)	(0.029)	(0.007)
Adjusted-R^2	0.491	0.525	0.513	0.497	0.493	0.536
No. of Observations	4114	4234	4683	3962	3771	5860

† The table presents the estimation results of running OLS on $y_{it} = x'_{it}\beta + \delta PART_{it} + \theta_i + \lambda_t + \varepsilon_{it}$, where θ_i and λ_t are firm and year fixed effects, respectively, and $PART_{it}$ is equal to 1 for participating firms after entering the programme. The dependent variable is the logarithm of labor productivity. The control group is constructed so as to replicate the participants' sales distribution in 1999 (i.e. before the start of any project). Specifications (2000) to (2004) include the control firms as well as participating firms that started their first project in the corresponding year. Specification (Pooled) includes all participating firms. All specifications include data on years 1997 to 2006. Standard errors in parenthesis are clustered at the firm level.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table A12: Difference-in-Differences Estimates: Labor Productivity. Control Group 2.[†]

	(2000) Coef./s.e.	(2001) Coef./s.e.	(2002) Coef./s.e.	(2003) Coef./s.e.	(2004) Coef./s.e.	(Pooled) Coef./s.e.
log(Employees)	-0.419***	-0.423***	-0.386***	-0.410***	-0.416***	-0.390***
	(0.043)	(0.045)	(0.046)	(0.043)	(0.045)	(0.042)
log(Fixed Assets Intensity)	0.182***	0.168***	0.183***	0.170***	0.171***	0.188***
	(0.026)	(0.024)	(0.024)	(0.024)	(0.025)	(0.024)
log(Intang Assets Intensity)	0.014**	0.012*	0.011*	0.013*	0.013*	0.012**
	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)	(0.006)
Market Share	2.731*	1.530**	1.749**	2.304**	2.041**	1.976***
	(1.456)	(0.741)	(0.733)	(0.951)	(1.015)	(0.752)
HHI	0.018	-0.013	0.072	0.037	0.025	0.051
	(0.117)	(0.116)	(0.106)	(0.117)	(0.125)	(0.089)
PART	0.139	0.029	-0.039	0.003	-0.062	0.008
	(0.113)	(0.050)	(0.048)	(0.052)	(0.046)	(0.035)
Adjusted-R^2	0.799	0.805	0.804	0.803	0.802	0.806
No. of Observations	5702	5822	6271	5550	5359	7448

[†] The table presents the estimation results of running OLS on $y_{it} = x'_{it}\beta + \delta PART_{it} + \theta_i + \lambda_t + \varepsilon_{it}$, where θ_i and λ_t are firm and year fixed effects, respectively, and $PART_{it}$ is equal to 1 for participating firms after entering the programme. The dependent variable is the logarithm of labor productivity. The control group is constructed by selecting non-participating firms from AMADEUS so as to replicate the participants' cross-tabulation by country and industry in 1999 (i.e. before the start of any project). Specifications (2000) to (2004) include the control firms as well as participating firms that started their first project in the corresponding year. Specification (Pooled) includes all participating firms. All specifications include data on years 1997 to 2006. Standard errors in parenthesis are clustered at the firm level.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table A13: Difference-in-Differences Estimates: Profit Margin. Control Group 2.†

	(2000) Coef./s.e.	(2001) Coef./s.e.	(2002) Coef./s.e.	(2003) Coef./s.e.	(2004) Coef./s.e.	(Pooled) Coef./s.e.
log(Employees)	-0.004	-0.003	-0.003	-0.004	-0.004	-0.003
	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)
log(Fixed Assets Intensity)	0.003	0.002	0.001	0.003	0.003	-0.000
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
log(Intang Assets Intensity)	-0.005***	-0.006***	-0.005***	-0.005***	-0.005***	-0.005***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Market Share	0.142**	0.001	0.140**	0.136**	0.115**	0.074
	(0.061)	(0.108)	(0.057)	(0.055)	(0.055)	(0.083)
HHI	0.007	0.005	0.016	0.016	0.014	0.006
	(0.021)	(0.022)	(0.020)	(0.022)	(0.023)	(0.017)
PART	-0.001	-0.006	0.011	-0.008	0.010	0.002
	(0.020)	(0.012)	(0.011)	(0.014)	(0.027)	(0.007)
Adjusted-R^2	0.566	0.585	0.570	0.573	0.573	0.577
No. of Observations	5702	5822	6271	5550	5359	7448

† The table presents the estimation results of running OLS on $y_{it} = x'_{it}\beta + \delta PART_{it} + \theta_i + \lambda_t + \varepsilon_{it}$, where θ_i and λ_t are firm and year fixed effects, respectively, and $PART_{it}$ is equal to 1 for participating firms after entering the programme. The dependent variable is profit margin. The control group is constructed by selecting non-participating firms from AMADEUS so as to replicate the participants' cross-tabulation by country and industry in 1999 (i.e. before the start of any project). Specifications (2000) to (2004) include the control firms as well as participating firms that started their first project in the corresponding year. Specification (Pooled) includes all participating firms. All specifications include data on years 1997 to 2006. Standard errors in parenthesis are clustered at the firm level.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table A14: Second Stage Estimation Results: Labor Productivity. All Years Included.†

	(OLS) Coef./s.e.	(IV1) Coef./s.e.	(IV2) Coef./s.e.
Constant	3.664***	3.446***	3.507***
	(0.205)	(0.224)	(0.219)
log(Employees)	-0.135***	-0.164***	-0.160***
	(0.016)	(0.019)	(0.019)
log(Fixed Assets Intensity)	0.265***	0.265***	0.260***
	(0.014)	(0.015)	(0.014)
log(Intang Assets Intensity)	0.014**		0.009
	(0.007)		(0.007)
Market Share	1.897***	1.920***	1.898***
	(0.432)	(0.442)	(0.437)
HHI	0.179	0.113	0.128
	(0.151)	(0.160)	(0.160)
PART	0.148***	0.644***	0.576***
	(0.038)	(0.184)	(0.184)
Industry Fixed Effects	✓	✓	✓
Country Fixed Effects	✓	✓	✓
Year Fixed Effects	✓	✓	✓
Adjusted-R^2	0.707	0.688	0.693
No. of Observations	8760	8760	8760

† The dependent variable is the logarithm of labor productivity. Standard errors in parenthesis are clustered at the four-digit industry level. Specifications (OLS) uses OLS. Specifications (IV1) and (IV2) instrument the dummy variable PART with the predicted values obtained from the logit estimations (1) and (2) in Table 7 of the main text, respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table A15: Second Stage Estimation Results: Profit Margin. All Years Included.†

	(OLS) Coef./s.e.	(IV1) Coef./s.e.	(IV2) Coef./s.e.
Constant	0.050	0.063	0.054
	(0.043)	(0.043)	(0.043)
log(Employees)	0.004**	0.004**	0.004**
	(0.002)	(0.002)	(0.002)
log(Fixed Assets Intensity)	0.008***	0.007***	0.008***
	(0.002)	(0.002)	(0.002)
log(Intang Assets Intensity)	-0.002**		-0.002**
	(0.001)		(0.001)
Market Share	-0.004	-0.009	-0.004
	(0.042)	(0.042)	(0.043)
HHI	0.005	0.008	0.006
	(0.017)	(0.016)	(0.017)
PART	-0.014**	-0.028	-0.025
	(0.006)	(0.021)	(0.020)
Industry Fixed Effects	✓	✓	✓
Country Fixed Effects	✓	✓	✓
Year Fixed Effects	✓	✓	✓
Adjusted-R^2	0.043	0.040	0.042
No. of Observations	8760	8760	8760

† The dependent variable is the profit margin. Standard errors in parenthesis are clustered at the four-digit industry level. Specifications (OLS) uses OLS. Specifications (IV1) and (IV2) instrument the dummy variable PART with the predicted values obtained from the logit estimations (1) and (2) in Table 7 of the main text, respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table A16: Second Stage Estimation Results: Total Factor Productivity.†

	(OLS) Coef./s.e.	(IV1) Coef./s.e.	(IV2) Coef./s.e.
Constant	4.439***	4.406***	4.410***
	(0.281)	(0.285)	(0.283)
log(Employees)	0.296***	0.268***	0.271***
	(0.023)	(0.029)	(0.029)
log(Fixed Assets Intensity)	0.140***	0.135***	0.135***
	(0.016)	(0.016)	(0.016)
log(Intang Assets Intensity)	0.026***	0.021**	0.022**
	(0.008)	(0.009)	(0.009)
Market Share	3.970***	3.868***	3.879***
	(1.075)	(1.094)	(1.090)
HHI	0.210	0.158	0.164
	(0.205)	(0.212)	(0.212)
PART	0.118**	0.512***	0.468**
	(0.047)	(0.195)	(0.198)
Industry Fixed Effects	✓	✓	✓
Country Fixed Effects	✓	✓	✓
Year Fixed Effects	✓	✓	✓
Adjusted-R^2	0.598	0.583	0.586
No. of Observations	7094	7094	7094

† The dependent variable is the logarithm of the total factor productivity. Standard errors in parenthesis are clustered at the four-digit industry level. Specification (OLS) uses OLS. Specifications (IV1) and (IV2) instrument the dummy variable PART with the predicted values obtained from the logit estimations (1) and (2) in Table 7 of the main text, respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table A17: Second Stage Estimation Results: Price-cost Margin.†

	(OLS) Coef./s.e.	(IV1) Coef./s.e.	(IV2) Coef./s.e.
Constant	17.021*	15.468	14.926
	(9.556)	(11.084)	(11.694)
log(Employees)	-9.195	-10.553	-11.028
	(6.338)	(7.257)	(7.700)
log(Fixed Assets Intensity)	7.032	6.799	6.717
	(6.160)	(5.956)	(5.877)
log(Intang Assets Intensity)	1.843	1.607	1.525
	(1.529)	(1.362)	(1.287)
Market Share	237.231	232.339	230.630
	(211.081)	(206.683)	(205.125)
HHI	-0.742	-3.234	-4.104
	(6.495)	(6.471)	(6.739)
PART	12.299	31.170	37.763
	(11.430)	(26.740)	(32.396)
Industry Fixed Effects	✓	✓	✓
Country Fixed Effects	✓	✓	✓
Year Fixed Effects	✓	✓	✓
Adjusted-R^2	0.031	0.028	0.025
No. of Observations	7094	7094	7094

† The dependent variable is the price-cost margin. Standard errors in parenthesis are clustered at the four-digit industry level. Specification (OLS) uses OLS. Specifications (IV1) and (IV2) instrument the dummy variable PART with the predicted values obtained from the logit estimations (1) and (2) in Table 7 of the main text, respectively.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.