Research Policy 31 (2002) 493–507

research policy

www.elsevier.com/locate/econbase

Research joint ventures and firm level performance

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Received 18 May 2000; received in revised form 1 February 2001; accepted 15 March 2001

Abstract

In this paper, we test whether participation in EU sponsored research joint ventures (RJVs) has a positive impact on participating firms' performance. We apply our statistical methodology to RJVs sponsored under two different programs: EUREKA and (3rd and 4th) Framework Programs for Science and Technology (FPST). Overall results show quite a different impact for firms participating in the two programs: a positive association between participation, labour productivity and price cost margin in the case of EUREKA, while firms participating FPST RJVs do not show any clear pattern.

JEL classification: O31; O38

Keywords: Research joint ventures; European Union; Economic performance

1. Introduction

In recent years, EU policy makers have been deeply concerned with European competitiveness vis-à-vis the US and Japan. In particular, the policy debate has focused on the relatively poor performance of EU firms in high-tech industries. In turn, this unsatisfactory result has been attributed, among other things, both to the small amount of resources invested in R&D activities in Europe and to the low productivity of these resources.

In the economic literature, research joint ventures (RJVs, hereafter) are commonly seen as a potential solution to both problems. On the one hand, they allow firms to internalise spillovers and then to reduce free riding problems, thus raising overall R&D incentives. On the other hand, after joining a RJV, firms can pool their resources and, as a consequence, can share R&D costs and avoid wasteful duplications.

Not surprisingly, the EU Commission involvement in the co-ordination and in the financing of RJVs, and more generally of co-operative research programs, has substantially increased over the years. However, despite this substantial public effort, the available evaluations of these publicly financed programs—mainly based on case studies and interviews with the management of participating firms—have added fairly little to our understanding of their contribution to the competitiveness of European industries.[1] This is rather unsatisfactory not only because it is obviously

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[1] Luukkonen (1998) points out that the main reasons for the lack of satisfactory empirical evidence have to be found in the general nature of the objectives pursued by the EU research funding system and in the ensuing difficulty in measuring its attainment. Also, EU evaluation studies are part of the political process which formulates these schemes, this in turn leading to internal less critical evaluation.

PII: S0048-7333(01)00122-6

important to assess the efficacy of alternative research policy schemes but also because RJVs can lead to monopolistic practices to the extent that the co-operation among firms carries forward to the product market. [2]

The main purpose of this paper is to start filling this gap by providing novel empirical evidence on the impact of different EU policy schemes on several firm level accounting measures of productivity and profitability. Thus, contrary to most previous literature on this subject this paper does focus neither on R&D intensity and/or R&D productivity nor on other intangible effects such as learning new skills, creating new network relations, or promoting common standards. [3] One of the main advantages of our approach is to employ performance measures which are more directly related to European competitiveness. However, it must be taken into account that the choice of broad accounting measures makes it more difficult to disentangle the impact of the policy programs under study from other economic phenomena. In this paper, we try circumvent this problem by assessing the economic performance of firms involved in publicly funded RJVs both over time and against other firms located in the same country and operating in the same industry.

In particular, the analysis carried out in this paper focuses on the policy schemes supported by the European Union under the 3rd and 4th Framework Program for Science and Technology (FPST, hereafter) and on the EUREKA program in the 1992–1996 period. Interestingly, from a policy perspective, FPST and EUREKA differ with respect to a number of relevant characteristics. Broadly speaking, the public involvement is larger in FPST since projects are funded and co-ordinated by the European Commission whereas EUREKA projects have a decentralised funding source and research projects are proposed and defined by the participants themselves. Also, research carried out within the FPST framework is more pre-competitive compared with EUREKA where co-operative research projects are targeted to the development of marketable products and services.

The main finding of the analysis is that the two programs have quite a different impact. In fact, firms participating in EUREKA show a significant improvement in labour productivity and price cost margin, while firms participating in RJVs under the FPST scheme do not show any significant change in performance. These results prove to be robust with respect to firms' size, the time span used in the analysis and the deletion of extreme observations.

The remainder of the paper is organised as follows. In Section 2, the empirical literature on this subject is briefly surveyed. Section 3 describes the data-sets used for the empirical exercise whereas in Section 4 our empirical strategy is outlined. Section 5 is the core of the paper where our main results are summarised and discussed. Section 6 gives some concluding remarks.

2. A survey of the relevant empirical literature

In RJVs firms agree to integrate, at least partly, their operations in R&D activities. Compared to joint ventures in other fields, such as production or selling activities, RJVs are a relatively new phenomenon. However, in the last 25 years or so they have become more widespread. Also as a consequence of this increased diffusion, economic literature has started to investigate their determinants and effects.

According to theory, RJVs can have both positive and negative effects on social welfare. Very broadly, as pointed out by Spence (1984), RJVs can be the solution to a double market failure in R&D activities. On the one hand, they can ensure enough appropriability of the results of innovative efforts to induce firms to align R&D investment to the social optimum and then to improve technological performance. On the other hand, RJVs can perform better than other legal protection systems, such as patents, in the diffusion stage since they allow more information disclosure, at least among member firms. [4] A legal regime

[2] In a special issue of this journal, Pavitt (1998) underlines the "inevitable limits of EU R&D funding" and highlights the potential role of more indirect instruments—such as policies for competition and other forms of regulation, trade and investment—in promoting private R&D in Europe. Furthermore, Larédo (1998) questions the prevailing "top-down" approach of EU R&D funding, suggesting instead that a "bottom-up" approach could lead to more satisfactory results.

[3] On this issue see also footnote 11.

[4] In addition to this, economic literature provides other, often complementary, motives for RJVs formation, including firms' access to complementary assets, avoiding cost duplications in R&D activities, and sharing financial costs and risks in large R&D investment projects. A review of the theoretical models on RJVs determinants and effects is in Vonortas (1997), chapter 3 and Hagedoorn et al. (2000).

favouring RJVs formation allows firms to co-operate in R&D activities while constraining them to compete in the post-innovation product market. However, if co-operation in the pre-innovation stage makes it more likely for firms to collude in pricing and output decisions, the aforementioned benefits have to be compared and contrasted with these non-voluntary anti-competitive effects.

While theoretical economists have provided formal theoretical justifications for the determinants and consequences of RJVs, empirical evidence on these issues is scant and somewhat contradictory. This unsatisfactory situation depends on a number reasons. Firstly, it is difficult to relate the predictive sharpness of theoretical models to the vagueness of the policy objectives of the actual programs under study. Secondly, in principle the performance analysis can be conducted at the RJV, at the member firms, or at the country level. Thirdly, also as a consequence of the existence of different levels of analysis, the impact of RJVs on "performance" can be assessed in different ways and existing studies are not easily comparable.[5] Fourthly, some of the relevant theoretical variables, including appropriability and spillovers, are very difficult to measure and consequently necessary data are often missing.

As far as methodology is concerned, studies focusing on RJVs' effects can be usefully classified in three categories: descriptive case studies, statistical/ econometric case studies and large scale econometric studies.[6]

In the first category, qualitative studies looking at the characteristics and focusing on the effects and shortcomings of industry specific RJVs can be grouped. Examples include Odagiri et al. (1997) who study the fifth generation computer system project, promoted by the Japanese government between 1982 and 1995; Martin (1996) on the RJVs' impact on European computer and semiconductor firms; Katz and Ordover (1990), who focus on three large RJVs: Semiconductor Manufacturing Technology Consortium (SEMATECH) and Microelectronics and Computer Corporation (MCC) in the US and the Very Large Scale Integration (VLSI) Consortia in Japan.[7] While rich in anecdotal evidence, these papers have two shortcomings: they lack of rigorous statistical tests and they focus only on very large, well-known RJVs. Whereas policy relevant they are unlikely to be representative of the entire population of publicly funded RJVs.

Also papers in the second category look at industry specific RJVs. However, they differ from the previous group since they make use of statistical methods to test specific hypotheses, such as the impact of RJVs participation on profitability, R&D expenditures, innovation, and other performance variables. In particular, two recent papers falling in this category focus on SEMATECH. Link et al. (1996) study the effect of SEMATECH on participating firms' profitability. After selecting a sample of 11 research projects carried out within the program framework and surveying managers of participating firms in order to quantify the benefits of participation, they find that participating firms earn a positive return higher than the normal return—i.e. the average return in the semiconductor industry. However, the positive difference between project and normal returns is found to depend on government funding. Hence, the authors stress the importance of government funding in the functioning of these joint ventures.

The result of a positive effect of participation in SEMATECH on profitability is also found and further explored by Irwin and Klenow (1996) in the context of a broader study. These authors use a panel of approximately 80 US firms in the semiconductor industry over the 1970–1993 period, including firms participating in the research program. Their main objective is to discriminate between two alternative hypotheses

[5] For instance: (i) RJV productivity (number of patents, ...); (ii) member firms R&D amount and productivity; (iii) member firms total factor productivity and profitability; (iv) other more qualitative firm level effects (learning new skills, creating network relations, promoting common standards); (v) country level effects including social welfare and dynamic competitiveness.

[6] Of course, this distinction is somewhat arbitrary. Moreover, alongside with these studies in the Industrial Organisation tradition, there is also a very limited strand of literature that employs the so-called "event studies methodology", commonly used in Financial Economics. For instance, Zantout (1995) works on a sample of 48 co-operative RJVs announced in the 1983–1990 period and finds that venturing firms earn statistically significant positive abnormal returns, greater than those resulting from the announcement of an increase of in-house R&D expenditures. This result supports the hypothesis of a positive effect of RJVs on firms' performance.

[7] Other descriptive studies on RJVs are surveyed in Vonortas (1997), chapter 2.

concerning the RJVs' impact on total R&D expenditures: the "commitment" hypothesis, according to which participation incentives firms to spend R&D resources in addition to in-house R&D activities, and the "sharing" hypothesis, which asserts that participation—allowing firms to avoid duplication of research—has a negative effect on firms' total R&D expenditures. The main finding is that participating firms decrease their R&D expenditures, thus supporting the "sharing" hypothesis. Consistently with this finding, the authors also report a positive and significant impact on participating firms' profitability, due to the reduction in R&D costs, while the impact on labour productivity is positive but insignificant. [8]

The last group of studies employs large scale databases, covering RJVs in different industries. Branstetter and Sakakibara (1998) study the impact of participation in Japanese government sponsored RJVs on firms' R&D expenses, patenting activities and spillovers. Using a sample of 226 Japanese firms observed from 1983 to 1989, these authors find that participation in RJVs has a positive impact on R&D expenses and R&D productivity (measured by the number of patents granted to each firm). Interestingly, they are also able to attribute this positive result to a theoretically consistent factor, that is knowledge spillovers. [9]

Finally, both Vonortas (1997) and Siebert (1996) have exploited the rich source of information on US-based RJVs provided by the 1984 National Cooperative Research Act (NCRA) and its 1993 amendment (National Co-operative Research and Production Act (NCRPA)). Vonortas (1997) analyses the RJVs notified in the 1985–1995 period and finds the existence of a negative relation between profitability and RJVs intensity, both at the firm and at the industry level. The author explains this result with "discretionary" differences among firms, where low profitability firms are more willing to engage in RJVs. On the other hand, the impact of participation in RJVs on R&D expenditures is less clear: at the industry level it is negative but not significant. At the firm level, instead, results are mixed depending both on the frequency of RJVs participation and on the specific industries firms belong to. Also Siebert (1996) finds that firms participating in a RJV in the 1985–1992 period have lower profitability than the control sample; however, he shows that this result is due to a size effect (participating firms are much larger than non-participating firms) and that the effect of R&D on profitability is larger for participating than for non-participating firms, suggesting that the former are able to internalise spillovers stemming from joint R&D.

Summing up, the scant but growing empirical evidence on the impact of RJVs on various measures of firms' performance shows that participation in research consortia seems to produce benefits for participating firms; unfortunately, this literature refers only to research partnership in US and Japan, while no evidence for European collaboration programs exists at present. To start filling this gap is the main purpose of the present paper.

3. Data issues and descriptive statistics

The empirical investigation performed in this paper is made possible by the joint exploitation of three data sources. As far as RJVs are concerned we make use of two databases provided by the EU Commission which give detailed information (starting year, duration, venture members, objective, etc.) on EU sponsored RJVs. In the first data-set 1031 RJVs sponsored under the EUREKA framework over the 1985–1996 period are included. Analogously, the second database provides information on 3874 RJVs financed by the EU under the 3rd and 4th Framework Programs for Science and Technology (FPST) over the 1992–1996 period. These two data-sets include all RJVs with at least one manufacturing firm among the participants. A total of 750 manufacturing firms from EUREKA and 1339 manufacturing firms from FPST have been identified and their balance sheet data have been searched over the 1992–1996 period by using the AMADEUS database

[8] See Klette et al. (2000) for a critical review of these works.

[9] In a subsequent paper, Branstetter and Sakakibara (2000) analyse the impact of participating firms' technological proximity and product market competition on knowledge spillovers within the consortia. Consistently with theoretical predictions, the authors find that technological proximity positively affects knowledge sharing among the firms participating in the consortium while the degree of product market competition has a negative impact. See also Sakakibara (1997) for a related analysis—based on questionnaires—on firms' motives to enter RJVs and on their expected and perceived effects.

(release 44, May 1998).[10] After disregarding firms with either no or incomplete financial data we ended up with a sample of 411 manufacturing firms.[11] Of those, 101 firms entered at least one RJV sponsored under the EUREKA framework (but no FPST RJVs) over the period under study, 253 firms at least one RJV financed under the FPST program (but no EUREKA RJVs) and 57 at least one RJV in both programs. The cross-tabulation of these firms by country and industry is reported in Table 1. By comparing the distribution of our sample firms with the complete distribution of firms entering EUREKA and/or FPST programs, an overrepresentation of Belgian and Italian firms at the expenses of German and French firms is observed. This bias depends on the limited availability of the required financial data for firms located in these two countries (see footnote 10).

To compare the performance of our sample of firms with other firms located in the same country and operating in the same industry we also extracted a control sample of firms from AMADEUS according to the following criteria: (i) similar cross-tabulation of firms by country and industry[12]; (ii) firms not involved in the RJVs covered in the two data-sets EUREKA and FPST; (iii) firms with complete balance sheet data.[13] At the end of this selection process we were left with a sample of 3621 firms, whose cross-tabulation by country and industry is reported in Table 2.

In the empirical analysis, we focus on three performance measures: labour productivity, total factor productivity, and price cost margin. The first two variables obviously measure productivity. In particular, the former is only a partial measure but it is less likely to suffer from serious measurement errors. In principle, the latter is more satisfactory since it takes into account both production factors (labour and capital). On the other hand, the capital stock is difficult to measure, also because some of the relevant data, including investment flows, are not available in AMADEUS and consequently have to be estimated. Finally, price cost margin can be considered, admittedly rather crudely, a proxy for firm's market power.

Labour productivity has been constructed as the ratio of the value added at constant prices to the average number of employees. To deflate value added a country/three digit industry specific price deflator has been used (source: DEBA, *Data for European Business Analysis*, an Eurostat database). The price cost margin variable is simply computed as the ratio of value added net of labour costs to sales. Finally, total factor productivity is computed as the ratio of deflated value added to a weighted average of two input factors: labour and capital. To recover factor shares we estimated standard Cobb–Douglas production functions with constant returns to scale for 21 two-digit manufacturing industries. In Table 3, we report the results of our estimates of the following model:

$$\log\left(\frac{Y_{it}}{K_{it}}\right) = \beta \times \log\left(\frac{L_{it}}{K_{it}}\right) + \alpha_i + \alpha_t + \varepsilon_{it} \qquad (1)$$

where Y_{it} denotes value added at constant prices, L_{it} and K_{it} are the average number of employees and the net capital stock at replacement value, respectively (see below for details about capital construction), α_i is a firm specific and α_t a time specific fixed effect. Total factor productivity (TFP) for firm i at time t has then been computed as

$$\mathrm{TFP}_{it} = \frac{Y_{it}}{L_{it}^{\beta} K_{it}^{1-\beta}} \qquad (2)$$

[10] The AMADEUS data-base, distributed by Bureau Van Dijk, contains balance sheet data for a sample of approximately 200,000 European firms. The country coverage of the database is not homogeneous, as the availability of financial information differs across countries, so that firms from some countries (such as Italy or Belgium) are overrepresented while others, in particular German firms, are underrepresented. Moreover, every release contains information for at most 5 contiguous years and 1996 was the most recent year at the time the data collection process was completed. Also, the opportunity to link our database with more recent releases is hampered by changes in the sample composition and potential discordances in accounting criteria.

[11] A firm has been included in our sample only when 5 years data were available for the following variables: fixed capital stock, employees, labour costs, value added, sales. All financial data were converted in ECUs by using monthly exchange rates provided by AMADEUS. Unfortunately, data on R&D expenditures are not available in the AMADEUS data-base. This has precluded us from measuring relevant variables such as R&D intensity and R&D productivity. We made an attempt to recover these missing informations from a companion data-base (WORLDSCOPE). Unfortunately, we were able to recover consecutive R&D data only for 41 out of our sample of 411 firms. Furthermore, only 29 of those joined an RJV in the first 3 years, i.e. in the 1992–1994 period (see Section 4).

[12] Because of accounting data availability problems German firms are underrepresented in the control sample.

[13] We also excluded a few firms with negative value added and/or price cost margin greater than one.

Table 1
Firms participating in RJVs by country and industry (NACE REV. 1)

Industry	Country								Total
	Italy	Belgium	Germany	France	UK	Netherlands	Austria	Ireland	
Food and beverage	3	3	1	2	2	5	0	3	19
Tobacco	0	0	0	0	0	1	0	0	1
Textile	5	6	1	2	2	0	0	0	16
Leather and leather goods	0	0	0	0	4	1	0	1	6
Wood products	1	0	0	1	1	0	0	0	3
Paper and paper products	0	0	0	1	2	3	0	1	7
Publishing and printing	3	0	2	1	1	0	0	0	7
Chemical products	12	12	16	11	8	3	0	0	62
Rubber and plastics	0	5	1	0	0	3	0	0	9
Non-ferrous production	6	5	4	2	3	1	0	0	21
Ferrous production	1	4	4	3	5	2	0	0	19
Ferrous products, except machinery	3	1	0	4	2	4	0	0	14
Machinery products	35	5	15	7	9	2	0	0	73
Office machinery and computer	2	0	4	3	3	0	0	1	13
Electrical machinery	8	3	4	4	4	1	0	0	24
Radio, TV and telecommunication equipment	12	3	7	6	8	2	0	0	38
Medical equipment, measuring instruments and watches	7	4	9	6	6	1	1	0	34
Motor vehicles	3	1	8	3	3	2	0	0	20
Other transportation equipment	5	3	5	7	2	0	0	0	22
Furniture and other manufacturing goods	2	0	0	0	1	0	0	0	3
Total	108	55	81	63	66	31	1	6	411

Finally, given data constraints, we adopted a very simple procedure for the construction of the net capital stock at replacement value. Since data on investment flows are not available in the AMADEUS database we used the difference between the accounting stock of fixed capital at time t and $t-1$ as a proxy for investment at time t. We then adopted the standard perpetual inventory technique by using the first year in the sample—i.e. 1992—as benchmark:

$$K_t = K_{t-1}(1-\delta) + I_t\left(\frac{p_{92}^{\mathrm{I}}}{p_t^{\mathrm{I}}}\right) \tag{3}$$

This strategy implies considering the accounting value of fixed capital stock in 1992 a reasonable proxy for the "true" replacement value in that year. For years posterior to 1992, the value of the net capital stock at replacement value is recursively obtained as the sum of the preceding year capital stock net of depreciation and the deflated (estimated) investments occurred during the year. Finally, we set the depreciation rate, δ, equal to 0.0625 and we used country specific investment goods price indexes as price deflators, p_t^{I} (source: DEBA).

Descriptive statistics of the three performance variables are reported in Table 4 for both our sample of 411 firms and the control sample of 3621 firms. Summary data are also provided separately for firms entering only EUREKA (101 firms), only FPST (253), and both programs (57). If we focus on mean values, RJVs participating firms show higher TFP, labour productivity and price cost margin values than control sample firms. Also, the ranking is confirmed for all variables but TFP, if the median is used instead as ranking criteria. Interestingly, by comparing FPST with EUREKA firms the latter group is characterised by higher labour and total factor productivity but by lower price cost margins.

Table 2
Firms in the control group by country and industry (NACE REV. 1)

Industry	Country										Total
	Italy	Belgium	Germany	France	UK	Netherlands	Austria	Luxembourg	Ireland	Portugal	
Food and beverage	77	53	11	30	49	10	0	3	3	1	237
Tobacco	1	3	1	0	2	0	0	0	0	0	7
Textile	144	22	2	20	36	6	0	0	2	1	233
Clothing	11	2	0	2	5	1	0	0	0	1	22
Leather and leather goods	74	2	0	4	16	0	0	0	0	0	96
Wood products	20	9	0	9	7	3	0	0	1	0	49
Paper and paper products	32	8	3	16	24	5	0	0	0	0	88
Publishing and printing	32	14	2	17	44	7	0	1	0	0	117
Chemical products	244	63	26	79	127	22	0	0	7	1	569
Rubber and plastics	83	25	4	24	51	7	0	1	0	0	195
Non-ferrous production	85	30	7	17	26	14	0	0	1	0	180
Ferrous production	133	24	15	24	52	8	1	1	1	0	259
Ferrous products, except machinery	99	28	5	47	42	9	0	0	0	0	230
Machinery products	239	26	32	76	117	23	1	1	2	1	518
Office machinery and computer	6	0	2	4	18	3	0	0	1	0	34
Electrical machinery	61	18	6	23	43	6	0	0	4	0	161
Radio, TV and telecommunication equipment	50	7	7	28	60	1	0	1	4	0	158
Medical equipment, measuring instruments and watches	72	13	5	29	59	5	0	0	0	0	183
Motor vehicles	45	13	5	25	33	8	0	0	0	2	131
Other transportation equipment	26	3	6	10	34	7	0	0	0	0	86
Furniture and other manufacturing goods	33	9	1	5	17	2	1	0	0	0	68
Total	1567	372	140	489	862	147	3	8	26	7	3621

Table 3
Estimates of Eq. (1) by industry

Sector	Number of firms	Number of observations	β
Food and beverage	256	1280	0.841
Tobacco	8	40	0.893
Textile	249	1245	0.729
Clothing	22	110	0.847
Leather and leather goods	102	510	0.843
Wood products	52	260	0.822
Paper and paper products	95	475	0.879
Publishing and printing	124	620	0.933
Chemical products	631	3155	0.829
Rubber and plastics	204	1020	0.630
Non-ferrous production	201	1005	0.560
Ferrous production	278	1390	0.589
Ferrous products, except machinery	244	1220	0.785
Machinery products	591	2955	0.755
Office machinery and computer	47	235	0.955
Electrical machinery	185	925	0.800
Radio, TV and telecommunication equipment	196	980	0.712
Medical equipment, measuring instruments and watches	217	1085	0.822
Motor vehicles	151	755	0.685
Other transportation equipment	108	540	0.621
Furniture and other manufacturing goods	71	355	0.977
Total	4032	20160	

Table 4
Labour productivity (LP), TFP and price–cost margins (PCM) for firms participating in RJVs (EUREKA, FPST and both) and for the control sample (5 years arithmetic averages)

	N	TFP			LP			PCM		
		Mean	S.D.	Median	Mean	S.D.	Median	Mean	S.D.	Median
RJVs sample	411	24.855	14.681	21.510	57.209	29.033	51.855	0.107	0.077	0.092
EUREKA	101	26.079	15.323	22.973	56.897	27.234	51.767	0.101	0.069	0.086
FPST	253	24.754	14.317	21.510	56.090	30.096	50.504	0.111	0.082	0.102
Both	57	23.136	15.183	20.349	62.729	27.091	59.030	0.103	0.070	0.083
Control sample	3621	24.136	14.616	21.707	51.877	31.992	46.191	0.098	0.067	0.089

4. Empirical strategy

While suggestive, descriptive statistics presented in the previous section are clearly inadequate as a statistical basis for any serious attempt to test for the impact of RJVs participation on firm performance. Firstly, it is at best naïve to assume that participation in an RJV has an instantaneous impact on performance, also bearing in mind that the average length of EUREKA (FPST) projects is 48 (31) months whereas the median length is only slightly lower (42 and 36 months, respectively). Furthermore, according to a survey conducted on EUREKA project leaders "project results were expected within 2 years by 8% of respondents and within 3–5 years by 49%" (Peterson, 1993). The bottom line is that joining a RJV in 1995 is very unlikely to have any impact whatsoever as soon as 1995 or even 1996. Secondly, if the impact of RJVs participation is additive also the number of RJVs a firm participates in is likely to matter. Thirdly, as already mentioned, the control sample is constructed in order to mimic the industry/country distribution of our sample of 411 firms.

Table 5
Number of firms by RJV type and sub-periods[a]

Program	Period		
	1985–1991	1992–1994	1995–1996
FPST	0	199 (187)	183 (172)
EUREKA	94	55 (43)	42 (31)
FPST or EUREKA	94	242	214

[a] In brackets number of firms participating only to the specific program.

However, given a possibly different industry/country composition of the EUREKA and the FPST samples of firms, comparisons between the different rows in Table 4 do not take fully into account industry and/or country specific differences.

To circumvent the first problem we split the sample period (1992–1996) covered by our data in two sub-periods, labelled as "pre" (1992–1994) and "post" (1995–1996), respectively. The idea here is to focus only on firms participating to RJVs in the "pre" period and to test whether this participation has had an impact on performance in the "post" period. On average, this implies allowing a 2-year period between the RJVs start and the performance evaluation time. Even if the time span is perhaps still too short [14], data limitations preclude us from taking a longer time interval (see footnote 10). Table 5 shows the number of firms participating to at least one RJV in each period. What is relevant for the present paper is to observe that in the 1992–1994 period 242 firms (out of 411 firms) have entered at least one RJV. Of those, 55 firms entered at least one RJV sponsored under the EUREKA framework, 199 one RJV financed under the FPST program and 12 at least one RJV in both programs.

As far as the number of RJVs per firm is concerned, whereas in principle it might be potentially quite an important issue, it is likely to be negligible in the present context. In fact, if we focus on the relevant period (1992–1994) about two thirds of our 242 firms have entered only one RJV. Furthermore, this figure is much higher if we restrict our analysis to EUREKA RJVs (78.2%), whereas it is slightly lower for RJVs under the FPST framework (65.8%) (see Tables 6–8 for the details).

[14] Notice, however, that Branstetter and Sakakibara (2000) find a positive significant impact of participation in research consortia as soon as 2 years after the beginning of the RJV. Moreover, Peterson and Sharp (1998, p. 202) report that according to a survey among EUREKA project leaders "40% of finished EUREKA projects had already achieved some type of commercial impact before completion."

Table 6
Number of RJVs by firm (conditional on positive number of RJVs) in 1992–1994 (all firms in the sample)

Number of RJVs	Frequency	Percent	Cumulative percent
1	160	66.1	66.1
2	37	15.3	81.4
3	11	4.5	86.0
4	8	3.3	89.3
5	9	3.7	93.0
6	4	1.7	94.6
7	2	0.8	95.5
9	1	0.4	95.9
12	2	0.8	96.7
14	1	0.4	97.1
15	1	0.4	97.5
16	1	0.4	97.9
18	1	0.4	98.3
20	1	0.4	98.8
23	1	0.4	99.2
27	1	0.4	99.6
44	1	0.4	100.0
Total	242	100.0	

Table 7
Number of RJVs by firm (conditional on positive number of RJVs) in 1992–1994 (FPST sample only)

Number of RJVs	Frequency	Percent	Cumulative percent
1	131	65.8	65.8
2	29	14.6	80.4
3	8	4.0	84.4
4	6	3.0	87.4
5	10	5.0	92.4
6	3	1.5	93.9
7	1	0.5	94.4
8	1	0.5	94.9
12	2	1.0	95.9
14	1	0.5	96.4
15	1	0.5	96.9
16	1	0.5	97.4
18	1	0.5	97.9
20	1	0.5	98.4
23	1	0.5	98.9
26	1	0.5	99.4
39	1	0.5	100.0
Total	199	100.0	

Table 8
Number of RJVs by firm (conditional on positive number of RJVs) in 1992–1994 (EUREKA sample only)

Number of RJVs	Frequency	Percent	Cumulative percent
1	43	78.2	78.2
2	7	12.7	90.9
3	2	3.6	94.5
4	1	1.8	96.3
5	2	3.6	100.0
Total	55	100.0	

The third methodological point refers to the role played by country and industry specific effects. In order to control for these effects, we regressed each performance variable separately in each year (i.e. 15 regressions with 4032 observations for each regression) against a constant and two sets of dummy variables, one to control for industry effects [21 (minus 1) industries] and one to control for country effects [10 (minus 1) countries]. The residuals of these regressions can be interpreted as differences between the value of each observation and its conditional mean given the country and the industry the firm belongs to. [15] These adjusted variables have been used in the empirical exercise presented in Section 5.

Finally, to perform the comparison between "pre" and "post" performances, we used two different statistical tests: a standard parametric *t*-test on differences and the non-parametric Wilcoxon test. As it is well known, the parametric test relies on a specific distribution (in our case, the normal distribution) from which observations are assumed to be drawn. If this underlying assumption is not rejected by the data, the parametric test is more powerful than its non-parametric counterpart. On the contrary the non-parametric test is less powerful but does not rely on distribution specific assumptions. Since the Kolmogorov–Smirnov (KS) test of the normality assumption gives discordant results depending both on the sub-sample and on the performance variable used, we prefer to present and comment upon both tests (showing the *P*-value of the KS test) in order to provide a consistency check on the robustness of our results.

5. Results

5.1. Overall results

The basic results of our statistical tests are presented in Tables 9–11. In particular, Table 9 refers to the pre-post comparisons conducted on the full sample of 242 firms. Instead, Tables 10 and 11 focus on the sub-samples of firms participating in FPST (199 firms) and EUREKA (55 firms) RJVs, respectively. [16] The main result of our analysis is that firms participating EUREKA have experienced a significant improvement in their "adjusted" performance measures between the "pre" and the "post" period. Furthermore, for two of the variables (labour productivity and price cost margins) participating firms also show a lower than average in the pre-period but an higher than average performance in the post-period. On the contrary, firms participating FPST RJVs do not show any clear pattern.

In more details, statistical tests conducted on the full sample (Table 9) give rather negative results. In fact, all tests are statistically insignificant with the only exception of the parametric test on total factor productivity which point out at a positive and significant effect. [17]

As already mentioned, more interesting conclusions can be drawn by comparing the results of the FPST (Table 10) and EUREKA (Table 11) samples. Both parametric and non-parametric tests do not suggest any impact of FPST RJVs on firm performance. In fact, all tests are not significantly different from zero. Furthermore, if we focus only on the sum of

[15] We did not include interaction terms, i.e. country/industry specific effects. However, this omission is likely to be negligible since industries (at least at two-digit levels) seem to be fairly synchronised across European countries. Furthermore, since the quality of the estimates of the conditional means depends on the number of observations, micronumerosity does not allow the inclusion of the interaction term at least in some specific country/industry sub-samples. We thank an anonymous referee for raising this point.

[16] Note that firms participating in EUREKA (FPST) can also be members of FPST (EUREKA) RJVs. To check that our results are not biased by this "double" participation, we rerun all the tests after excluding firms involved in both programs. All our conclusions are virtually unaltered.

[17] A graphical analysis reveals that this is likely to depend both on the skewness of the empirical distribution of the TFP variable and on the presence of a small number of extreme observations.

Table 9
Statistical tests on performance measures (full sample, 242 firms)[a]

	Parametric *t*-test					KS test (*P*-value)	Wilcoxon test		
	μ (pre)	μ (post)	$\Delta\mu$	*t*	*P*-value		Sum of positive ranks	Sum of negative ranks	*P*-value
LP	2.85	4.96	2.10	1.53	0.127	0.000	15911 (126)	13492 (116)	0.267
TFP	−0.93	−0.05	0.88	1.89	0.061	0.000	14857 (118)	14546 (124)	0.887
PCM	0.01	0.01	0.00	1.04	0.301	0.007	14999 (113)	14404 (129)	0.785

[a] Number of positive and negative ranks in brackets.

Table 10
Statistical tests on performance measures (FPST sample, 199 firms)[a]

	Parametric *t*-test					KS test (*P*-value)	Wilcoxon test		
	μ (pre)	μ (post)	$\Delta\mu$	*t*	*P*-value		Sum of positive ranks	Sum of negative ranks	*P*-value
LP	3.95	5.26	1.32	0.82	0.415	0.000	10123 (96)	9777 (103)	0.832
TFP	−0.78	−0.13	0.66	1.24	0.217	0.000	9591 (93)	10309 (106)	0.659
PCM	0.01	0.01	0.00	0.52	0.603	0.023	8999 (84)	10901 (115)	0.242

[a] Number of positive and negative ranks in brackets.

Table 11
Statistical tests on performance measures (EUREKA sample, 55 firms)[a]

	Parametric *t*-test					KS test (*P*-value)	Wilcoxon test		
	μ (pre)	μ (post)	$\Delta\mu$	*t*	*P*-value		Sum of positive ranks	Sum of negative ranks	*P*-value
LP	−0.83	4.56	5.39	2.92	0.005	0.133	1023 (36)	517 (19)	0.034
TFP	−1.75	−0.02	1.73	2.06	0.045	0.065	892 (30)	648 (25)	0.307
PCM	−0.01	0.03	0.03	3.20	0.002	0.028	1117 (35)	423 (20)	0.004

[a] Number of positive and negative ranks in brackets.

positive and negative ranks used for the construction of the Wilcoxon tests, the sum of negative ranks is larger than that of positive ranks for total factor productivity and price–cost margin, suggesting that a deterioration of these variables has occurred. On the contrary, firms participating in EUREKA RJVs show a general increase in the values of the three performance variables. Also, for the labour productivity and price cost margin variables this increase is (rather comfortingly) significant in both the parametric and the non-parametric approach. On the contrary, as far as total factor productivity is concerned we are able to reject the null hypothesis only in the parametric test.[18]

[18] Measurement errors of the capital stock are a further possible explanation for the inconsistency in TFP variable results.

5.2. Robustness checks

Since it might be argued that our results are sensitive to a number of factors including the chosen timing structure, the omission of relevant observable variables and the presence of extreme observations, we also performed several robustness checks of the results obtained for the sample of firms participating in EUREKA.[19]

First, it might be argued that the time span is too short (1992–1994 versus 1995–1996).[20] As already discussed in footnote 10, data constraints preclude

[19] We performed the same robustness checks also for the sample of firms participating in FPST. The conclusion of no significant impact of participation on firms' performance measures is unchanged. In order to save space, we present only the results for the EUREKA sample.

[20] On this point see also footnote 14.

Table 12
Statistical tests on performance measures (EUREKA sample, 55 firms, 1993 vs. 1996)[a]

	Parametric t-test					KS test (P-value)	Wilcoxon test		
	μ (pre)	μ (post)	$\Delta\mu$	t	P-value		Sum of positive ranks	Sum of negative ranks	P-value
LP	−1.47	6.37	7.83	2.58	0.013	0.036	951 (31)	589 (24)	0.129
TFP	−2.14	0.65	2.79	1.85	0.070	0.023	868 (31)	672 (24)	0.412
PCM	−0.01	0.03	0.04	2.86	0.006	0.005	1061 (31)	479 (24)	0.015

[a] Number of positive and negative ranks in brackets.

Table 13
Statistical tests on performance measures (EUREKA sample, small firms)[a]

	Parametric t-test					KS test (P-value)	Wilcoxon test		
	μ (pre)	μ (post)	$\Delta\mu$	t	P-value		Sum of positive ranks	Sum of negative ranks	P-value
LP	−4.69	1.86	6.55	2.35	0.026	0.531	279 (19)	127 (9)	0.084
TFP	−1.83	0.05	1.88	1.50	0.144	0.554	253 (16)	153 (12)	0.255
PCM	−0.03	0.01	0.04	2.46	0.021	0.089	293 (17)	113 (11)	0.040

[a] Number of positive and negative ranks in brackets. Small firms are those whose turnover in 1992 is smaller than 219.372 million ECUs.

Table 14
Statistical tests on performance measures (EUREKA sample, large firms)[a]

	Parametric t-test					KS test (P-value)	Wilcoxon test		
	μ (pre)	μ (post)	$\Delta\mu$	t	P-value		Sum of positive ranks	Sum of negative ranks	P-value
LP	3.17	7.37	4.20	1.73	0.096	0.321	242 (17)	136 (10)	0.186
TFP	−1.66	−0.08	1.57	1.37	0.181	0.096	202 (14)	176 (13)	0.792
PCM	0.015	0.04	0.023	2.12	0.043	0.375	276 (18)	102 (9)	0.032

[a] Number of positive and negative ranks in brackets. Large firms are those whose turnover in 1992 is larger than 219.372 million ECUs.

us from extending our sample period. However, as consistency check, we rerun all tests considering as year "pre" 1993 and year "after" 1996, 3 years being slightly less than the median duration of the EUREKA projects in our sample (42 months). As it can be seen in Table 12 all our previous results are virtually unaltered, the only exception being labour productivity in the non parametric test, which is now significant only at the 0.13 statistical level.

As a second robustness check, we divided our sample according to firm initial size (as proxied by total sales in 1992). Small and large firms clearly have different characteristics. For instance, they are likely to differ in the ability to react to changing competitive conditions or in the access to financial resources to devote to internal R&D. The impact of participation in EUREKA might therefore be different according to firm size. Moreover, during the early nineties large European firms in many industries undertook rationalisation programs aimed at increasing productivity and profitability. As our control sample does not explicitly control for size and the likelihood of participation in EUREKA (but not in FPST) increases with firm size, it might be argued that our results are spurious.[21] To avoid this criticism, we rerun our tests on two subsamples, including respectively smaller firms (those whose turnover in 1992 was below the median—219.372 million ECUs) and larger firms (those whose turnover in 1992 was above the median). Inspection of Tables 13 and 14

[21] We thank an anonymous referee for raising this point.

Table 15
Statistical tests on performance measures (EUREKA sample without "outliers", 48 firms)[a]

	Parametric *t*-test					KS test (*P*-value)	Wilcoxon test		
	μ (pre)	μ (post)	$\Delta\mu$	*t*	*P*-value		Sum of positive ranks	Sum of negative ranks	*P*-value
LP	−0.27	3.86	4.13	2.22	0.031	0.347	737 (30)	439 (18)	0.126
TFP	−1.53	−0.38	1.15	1.47	0.149	0.087	626 (25)	550 (23)	0.697
PCM	−0.0005	0.0257	0.026	2.69	0.010	0.108	826 (30)	350 (18)	0.015

[a] Number of positive and negative ranks in brackets.

Table 16
Statistical tests on performance measures (EUREKA sample without "outliers", small firms)[a]

	Parametric *t*-test					KS test (*P*-value)	Wilcoxon test		
	μ (pre)	μ (post)	$\Delta\mu$	*t*	*P*-value		Sum of positive ranks	Sum of negative ranks	*P*-value
LP	−5.03	−0.93	4.10	1.60	0.124	0.694	192 (16)	108 (8)	0.230
TFP	−1.47	−0.83	0.65	0.70	0.492	0.798	166 (13)	134 (11)	0.648
PCM	−0.02	0.01	0.03	1.94	0.065	0.212	204 (14)	96 (10)	0.123

[a] Number of positive and negative ranks in brackets. Small firms are those whose turnover 92 is smaller than 232.220 million ECUs.

Table 17
Statistical tests on performance measures (EUREKA sample without "outliers", large firms)[a]

	Parametric *t*-test					KS test (*P*-value)	Wilcoxon test		
	μ (pre)	μ (post)	$\Delta\mu$	*t*	*P*-value		Sum of positive ranks	Sum of negative ranks	*P*-value
LP	4.50	8.65	4.15	1.52	0.143	0.372	184 (14)	116 (10)	0.331
TFP	−1.59	0.07	1.66	1.29	0.209	0.126	154 (12)	146 (12)	0.909
PCM	0.02	0.04	0.022	1.867	0.075	0.406	216 (16)	84 (8)	0.059

[a] Number of positive and negative ranks in brackets. Large firms are those whose turnover 92 is larger than 232.220 million ECUs.

shows that both smaller and larger firms improved their performance between the 1992–1994 and the 1995–1996 period. Furthermore, smaller firms are found to have improved their performance more than larger firms. In turn, these results suggest that our main finding is not driven by the aforementioned size effect.

Finally, in order to check whether our results were driven by extreme observations, we performed our tests after excluding those firms with anomalous growth rates of the original variables in at least 1 of the 5 years. As cut-off points we adopted ±100% for employment, labour costs and turnover and ±200% for value added and capital stock. By adopting this procedure we excluded from the sample mainly small firms, whose performances are usually more variable than those of large firms, and in particular *rapidly growing* small firms, which show quite brilliant performances in the period under study. Notwithstanding this, our previous results are only slightly modified: Table 15 (for the whole sample) and Tables 16 and 17 (respectively, for small and large firms)[22] report that the differences in performance between the 1992–1994 and the 1995–1996 period maintain their signs, even if their significance is lower—in particular for small firms—as it could have been expected since we have excluded several above average performing

[22] We have modified the subsamples of small and large firms according to the median of the new sample (232.220 million ECUs).

small firms from our sample. Note that in the latter experiment the KS test never rejects the normality assumption and therefore the more powerful *t*-test is reliable.

5.3. Discussion

How should these results be interpreted? In particular, does giving a causal interpretation to our statistical tests make sense? On the one hand, empirical findings are broadly consistent with the common wisdom on EUREKA and FSPT overall objectives.[23] In fact, the main objective of EUREKA is to promote firms' competitiveness and sponsored RJVs are usually more "market" oriented than their FPST counterparts. From this perspective, it is not unreasonable to assume that EUREKA RJVs are more likely to have a direct, or at least faster, impact on firm performance. On the other hand, a more radical explanation on the same venue is that FPST pursue, alongside with the improvement of firm level competitiveness, also more general and indirect objectives such us promoting co-operation between firms, universities and research centres or stimulating the development of European networks. Therefore, FPST can have no significant impact on firms' competitiveness just because they also pursue different objectives.

A different, and perhaps competing, explanation is grounded instead on the institutional differences occurring between the two programs. FPST RJVs broad objectives are defined by EU officials—in collaboration with Member States—which also directly finance accepted projects. On the contrary, within the EUREKA framework, RJVs objectives are defined by participating firms and projects are much more based on decentralised funding. FPST institutional characteristics might then induce an adverse selection process, where firms carry out less profitable, long term and very risky projects only if they can have access to public money through FPST funding. This in turn might explain our results.[24]

[23] Our results are also consistent with the conclusions of evaluations studies on EUREKA and FPST impact (see Peterson and Sharp, 1998, chapter 9) which report that firms involved in EUREKA generally expressed a high level of satisfaction with the program, while firms involved in FPST projects showed less contentment.

[24] On this issue see also Luukkonen (2000).

6. Conclusions

The present paper is the first attempt to assess, on a large scale and using firm level measures, the impact of FPST and EUREKA on firms' competitiveness.

The main result of this paper is that whereas a positive statistical association is found between participation in RJVs sponsored under the EUREKA framework and improvement in standard accounting performance measures, the same finding does not occur for firms joining RJVs sponsored under the FPST framework in the same sample period. Obviously, giving a causal interpretation to our statistical tests is tempting, also because of the interesting policy implications which directly would follow. On the one hand, it is certainly true that, at least to a certain extent, our findings are hardly surprising given the different aims of the two programs. On the other hand, however, our findings seem indeed to suggest that European competitiveness, at least as measured in this paper, can directly benefit from the implementation of applied, bottom-up, market oriented, co-operative research programs. A word of caution is however needed since other competing explanations might exist where participation in RJVs and performance improvement are both explained by other firm level unobservable variables such as managerial capabilities. Also for this reason the results presented here are not fully conclusive and have to be supplemented by more detailed case studies which can be of great help in deepening our understanding of the causal relations underlying the phenomenon under study.

Acknowledgements

We thank the participants to the "Science and Technology Policy to Research Joint Ventures" network and three anonymous referees for helpful comments on previous drafts.

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