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Pedro L Marín and Georges Siotis

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Pedro L Marín, Universidad Carlos III de Madrid and CEPR
Georges Siotis, Universidad Carlos III de Madrid

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Centre for Economic Policy Research
90–98 Goswell Rd, London EC1V 7RR, UK
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999
Email: cepr@cepr.org, Website: www.cepr.org

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ABSTRACT

Public Policies Towards Research Joint Venture Formation: Designs and Outcomes*

We use a large firm-level dataset on Research Joint Ventures (RJVs) formed under the umbrella of the Eureka and European Union's Framework Programmes for Science and Technology (EU-FP). Based on the results presented in Hernán, Marín, and Siotis (2003), we focus on firms that are known to have a high probability of forming RJVs, with the latter identified as firms with a previous experience with collaborative research. This allows us to gain insights regarding the influence of the programmes' institutional design on the process of RJV formation. The findings pertaining to EU-FP RJVs are consistent with a 'top-down' and 'mission oriented' research policy. By contrast, Eureka RJVs appear as more market driven and 'bottom-up'.

JEL Classification: C25, L13 and O31
Keywords: EU framework programme, Eureka, R&D, Research Joint Ventures and spillovers

Pedro L Marín
Departamento de Economía
Universidad Carlos III de Madrid
C./ Madrid, 126
28903 Getafe (Madrid)
SPAIN
Tel: (34 91) 624 9646
Fax: (34 91) 624 9875
Email: marin@eco.uc3m.es

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Georges Siotis
Departamento de Economía
Universidad Carlos III de Madrid
C./ Madrid, 126
28903 Getafe (Madrid)
SPAIN
Tel: (34 91) 624 9312
Fax: (34 91) 624 9875
Email: siotis@eco.uc3m.es

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=119325

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1. Introduction

Research Joint Ventures (RJVs) are agreements whereby firms decide to share technological knowledge while, in principle, continuing to compete against each other in the product market. During the last two decades, specific public policies towards RJVs have been developed. On the one hand, competition law determines the nature of inter-firm cooperation that is legally accepted. On the other hand, subsidies are sometimes granted to encourage RJV creation, as these arrangements are believed to have some socially beneficial characteristics, such as the reduction in the duplication of R&D costs and the internalisation of spillovers (Klette, Moen, and Griliches (2000)).

Recent contributions have highlighted the complex mechanisms that underlie RJV participation.[1] First, these models show that strategic interactions in the product market affect the decision to participate in RJVs. Second, RJVs involve the internalisation of technological spillovers, R&D cost-sharing, and the assimilation of knowledge that may be of strategic importance. Third, the degree of size-related asymmetries between firms influences participation decisions. Finally, the research paths (complementary versus substitute R&D) affect the incentives to form an RJV.[2]

[1] See, amomg other, Kamien, Mueller, and Zang (1992), Poyago-Theotoky (1995), Katsoulacos and Ulph (1998), Röller, Tombak, and Siebert (1998), and Petit and Towlinsky (1999).

[2] The theoretical literature on RJVs is extensive, and the review provided here is very partial. See De Bondt (1997) for an in depth treatment.

Given the complexity of the problem, empirical research has been hampered by a two-fold constraint: lack of micro data, and the unobservability of a key number of parameters highlighted by theoretical models (such as the level of technological spillovers or differences in absorptive capacity across firms). Benfratello and Sembenelli (2002) identify four broad categories of empirical papers analysing RJVs. The first consists of case studies and interviews with participants, surveys, or a combination of both. While not denying their added value, these exercises suffer from a number of drawbacks: they only deal with a subset of RJVs, the findings are highly idiosyncratic to the research design, and *ex-post* evaluations are often part of a complex political process (Luukkonen (1998)). More importantly, they lack rigorous statistical treatment. The second category applies econometric techniques, but the analysis is limited to RJVs within a single industry. For instance, Irwin and Klenow (1996) provide evidence on the effect of participation in the US Semiconductor Manufacturing Technology Consortium (SEMATECH) on firms' profitability. A third branch of the literature applies event study techniques to assess the impact of RJV participation on performance (Zantout (1995)). Last, there is a limited number of papers that use large firm level datasets that span a diverse number of industries. Röller, Tombak , and Siebert (1998) exploit US data and show that size symmetry between participants and complementarity in the product market enhance the likelihood of two firms pairing in an RJV. Branstetter and Sakakibara (1998) study RJVs sponsored by the Japanese government, and report that membership of these consortia significantly increased participants' patenting activity. From a methodological point of view, these papers allow to draw conclusions that go beyond a single industry. More importantly, the findings are obtained by applying hard statistical techniques.

To the best of our knowledge, the contributions that use European data and

apply adequate econometric techniques are few. Pan-European RJVs launched during the last two decades fall into two broad categories. These RJVs have been formed under the umbrella of either the Eureka Programme or the EU Framework Programme for Science and Technology (EU-FP in the remainder of the paper). Benfratello and Sembenelli (2002) focus on the effect of RJV participation on firms' performance, as proxied by three statistics: labour productivity, total factor productivity growth, and accounting price-cost margins. Their findings indicate that participation in Eureka RJVs has improved firms' performance on all three counts, while there is no discernible effect stemming from EU-FP RJVs.

Hernán, Marín, and Siotis (2003) analyse the determinants of participation in European RJVs. Their findings confirm the importance of R&D intensity and the fixed costs associated with forming an RJV. Their results also serve to highlight the role played by knowledge flows in the process of RJV formation. A dummy picking-up the effect of past participation in collaborative projects turns to be highly significant, indicating that firms most likely to form an RJV today are the ones with a previous RJV experience.

In this paper we make an additional contribution to fill the gap between theory and empirical testing by making use of a large firm level data-set. Based on the results presented in Hernán *et al.* (2003), we focus on firms that are known to have a higher probability of forming RJVs, with the latter identified as firms with a previous experience with collaborative research.[3] The sample identifies Eureka and EU-FP RJVs, which allows us to unearth marked differences between firms participating in each of these two policy initiatives. The results provide insights regarding the influence of the programmes' institutional design on the process of RJV formation.

[3]As will be discussed below, focusing on firms with a previous RJV experience allows us to deal with some complex methodological issues.

The remainder of the paper is organised as follows. The next section briefly outlines the salient features of Eureka and the EU-FP programmes, describes the data, identifies testable hypotheses, and presents our empirical specification. Section 3 contains the empirical results, while section 4 provides concluding remarks.

2. Programme design and empirical specification

The set of RJVs which are analysed in this paper are retrieved from the "STEP to RJV" database, constructed as part of an EU financed TSER project (see Hernán *et al.* for a comprehensive description). These RJVs have been formed under the umbrella of either the Eureka Programme or the EU-FP. While the declared aim of these two programmes is pretty similar (foster cross-border technological cooperation), their operation differ substantially.

2.1. The research programmes

Eureka was launched in the mid-eighties as a European "response" to the US's Strategic Defence Initiative (also known as "Star Wars"), with France as its main sponsor.[4] Initially, Eureka was viewed with much suspicion by the EU Commission, which was at the time trying to lay the basis of an EU research policy endowed with its own resources (Georghiou (2001)). Despite its original aim, Eureka quickly evolved into a decentralised structure coordinated by a small secretariat. In general terms, survey evidence strongly indicate that firms' appreciate the light bureaucratic burden associated with participation to an Eureka project (Georghiou (2001)). The bulk of ventures consist of civilian applications, and are "close to the market". Participating countries include EU and EFTA members as well as Turkey. Eureka RJVs have to involve firms from more than one partic-

[4]Eureka is not an acronym, but the name was chosen when ministerial discussions focused on the creation of an European Research Co-ordination Agency.

ipating country. Apart from this requirement, firms are pretty free to design the project they wish, that is the approach is very much "bottom-up". For instance, Eureka allows for "variable geometry", which means that it is not necessary to include participants from peripheral countries. An important aspect of Eureka is that individual participants can establish intellectual property rights (IPRs) on their contribution(s) to the RJV, and strong confidentiality clauses can be negotiated among partners. In addition, Eureka does not focus on a particular set of technologies. Obtaining the Eureka label does not entitle firms to European subsidies (it should also be noted that Eureka is not an EU programme). However, obtaining the Eureka "seal of approval" enhances firms' ability to receive subsidies from their respective national authorities.

The EU developed its own technology policy during the early 1980's. Prior to that, with the exception of (civilian) nuclear technology, EU policy had been limited to coordination tasks (e.g. through the COST initiative).[5] Since then, the EU has established its own research policy in the form of the EU Framework Programmes for Science and Technology (EU-FP), that are endowed with a substantial budget.[6] RJVs formed under EU-FP programmes are eligible for an EU subsidy, which varies according to the nature of the project. However, some fairly strict criteria must be met before funding can be obtained. First, EU-FP projects are much more technologically oriented, with information technologies representing the lion's share of appropriations. Second, EU-FP projects have to be "pre-competitive" in order to avoid conflict with EU competition law. Third, a

[5]COST stands for European Co-operation in the field of Scientific and Technical Research.

[6]It is true that the EU-FP only represents between 5% and 10% of national public R&D budgets, which may suggest that it is of secondary importance for firms. However, the EU-FP's resources are focused on a set of specific priorities. For less advanced EU countries, EU research funds represent a large proportion of R&D funding. In addition, the EU-FP has been found to involve the most R&D active firms, suggesting that its role on the European research scene is not negligible (see Larédo (1998) for a discussion).

fair representation of firms originating from peripheral countries must be ensured. Concretely, this implies that the probability of funding increases with the number of firms originating in so-called Less Favoured Regions. Fourth, and contrary to Eureka, the EU-FP pursues the attainment of various, sometimes contradictory, objectives. For instance, one of the declared aim is to foster the competitiveness of EU firms, while at the same time, projects must be "pre-competitive".[7] Fifth, participants cannot establish IPRs over their discoveries: all research must be shared among participants. Last, the EU-FP is characterised by heavy, some would say burdensome, administrative requirements. In contrast to Eureka, all projects have to go through complex, uniform, and time consuming tendering procedures (Luukkonen (1998), (2002)).

To sum-up, Eureka is a more decentralised programme with few eligibility requirements. The main drawback identified by participants is that national funding differs substantially across countries, sometimes generating delays in getting projects started (Georghiou (2001)). By contrast, EU-FP projects, if accepted, are ensured of public funding. However, the programme's eligibility criteria are much more rigid, the administrative burden is larger compared to Eureka, and the approach is much more "oriented" in the sense that it is EU authorities that set priorities.

2.2. Data sources

The data set is constructed using three separate sources. First, we use data on individual Eureka and EU-FP RJVs. Information on Eureka RJVs was obtained directly from the latter's web page. Information on EU-FP projects has been retrieved from CORDIS (an EU database which centralises information on all EU financed projects in a raw format). In both cases, we have a brief description of

[7]See Luukkonen (2002) for descriptive evidence on the tension between these two objectives.

the project, a sectorial acronym, and the name of the participating firms. Some projects were launched in the mid eighties, but the bulk of them were initiated in the nineties. We have data on RJVs till 1996.

The second source of information pertains to participating firms. Data was obtained from Amadeus, a database produced by Bureau Van Dijk, a specialist provider of firm-level data based on balance sheet information. In the version of the database that we used, the total number of entries exceeds 200,000 firms for the period 1991-1996, with detailed information on ownership structure, and a fine sectorial affiliation. Geographical coverage pertains to Europe (including Central and Eastern Europe). We retrieved the relevant information on firms that appear both in Amadeus and in our RJV database, and dropped firms which had formed EU-FP or Eureka RJVs, but for which no data was available in Amadeus. We retrieved unconsolidated balance sheets in order to make use of data pertaining to the relevant business establishment. We have been extremely careful in identifying the relevant business unit, as many conglomerates participate in these RJVs.

The third source of information we use is the Worldscope database. The latter provides R&D expenditures for about 1500 large firms. The data is available for the period 1991-1996 at the four digit level of aggregation. This allowed us to construct industry R&D intensity at the four digit level.

2.3. Variables, testable hypotheses and econometric specification

2.3.1. Variable definition and testable hypotheses

Our sample is formed by firms that had participated in at least one RJV project prior to 1995, that is the universe consists of firms that have a previous experience with European RJVs. Some of them repeat the experience during the period 1995-96, while others do not. The advantages of this strategy are threefold. As indicated by Klette, Moen and Griliches (2000), the choice of control group raises

some important methodological issues. In particular, Heckman, Ichimura, Smith and Todd (1998) have shown that biases are most likely to be minimised when the "treated" units share some characteristics with "non-treated" units. In our context (which involves non-experimental data), identifying the control group as firms with a past experience, but that do not repeat the experience, appears as a natural choice. Indeed, these firms share some important characteristics.[8] Second, we are able to identify the influence of economic variables beyond threshold effects.[9] Last, this ensures that we focus on firms most likely to form an RJV, hopefully allowing us to obtain more precise estimates.[10] Our results shed light on two research questions: once we focus on likely participants, 1) which firms do repeat the experience, and which ones do not?, and 2) among those that form a new RJV in 1995-96, which programme do they choose?

As for the regressors, we need to construct a set of variables that measure or proxy the determinants of RJV formation identified in the theoretical literature. To construct the variables, we take four digit sectors and Europe as representing the relevant market. Given that information (obtained from Amadeus and Worldscope) on business units and industry R&D spans the period 1991-1996, we deal with possible issues of endogeneity by using lagged values for the independent variables (i.e., pre 1995 values). We briefly describe how the variables relate to

[8] In Hernán *et al.* (2003), the estimation is carried out by considering all potential RJV participants. A dummy indicating the number of past RJV participations turned to be highly significant.

[9] For instance, concentration may be such a variable, that is firms belonging to less fragmented industries are more likely to form RJVs. However, once a minimum level of concentration is reached, the latter variable stops exerting an influence on the likelihood of RJV formation. With a sample pertaining to the entire set of firms, we find a positive and significant coefficient. By contrast, if we focus on firms most likely to form RJVs, and the coefficient is not different from zero, we would conclude that concentration only exerts an influence below a certain threshold.

[10] All the results we present below are consistent with those that obtain when we consider all potential participants (instead of focusing on firms with a past experience in either Eureka or the EU's FP). The advantage of focusing on firms with a previous experience allows us to obtain additional results, and minimse the likely biases identified by Heckman *et al.* (1998).

the theoretical hypothesis and how they were constructed, and refer the reader to Hernán *et al.* (2003) for more details. All industry level variables are defined for the sector in which the RJV is formed.

First, the existence of technological spillovers generates a free-rider problem, since the innovator cannot fully appropriate the returns from its investment. Establishing an RJV mitigates this problem, as spillovers are internalised within the project. However, if the RJV is not all encompassing, that is all competitors do not form part of it, spillovers will continue to flow from the RJV to firms not belonging to it. Theory thus predicts that RJVs are more likely to be found in sectors where spillovers are important, and they can be effectively internalised.

We capture the importance of involuntary knowledge flows by constructing two proxies. The first is based on data taken from Mansfield (1985) which measures the speed at which innovations -unwillingly- diffuse within an industry. It is expressed as the average number of months that lapse before an innovation leaks to competitors within the industry. The information is available at two to four digits, depending on the industry. We assigned values for this variable accordingly (for instance, in some sectors, we have a perfect correspondence; in others, we assigned the value associated to the higher level of aggregation for which the spillover variable was available). This variable acts as a proxy for the "spillover lag", and we label it *SPL*. Another concurrent interpretation pertaining to this variable is that it reflects the importance of lead time in R&D intensive industries. We expect this variable to exert a negative influence on the likelihood of RJV formation, since a slow diffusion of innovations within an industry is indicative of limited spillovers.

The second proxy is built using the data reported by Levin, Klevorick, Nelson, and Winter (1987) that measure the effectiveness of patents in eighteen industrial

sectors. We expect "patent effectiveness"(denoted *PATEF*) to appear with a negative sign, as firms that operate in sectors where patents are effective do not need to rely on RJVs in order to internalise spillovers. Note that, while both these proxies (*SPL* and *PATEF)* are related to knowledge flows, the original sources of information and their interpretation are quite distinct.[11]

Second, R&D outlays may be large and have to be paid upfront, and the outcome is often uncertain. RJVs potentially allow participants to share R&D costs, as duplication is avoided. To control for differences in the extent and magnitude of potential cost reductions across industries, we include R&D intensity at the level of the industry, calculated as total R&D expenditures over total sales, reported by firms belonging to that four-digit sector. We retrieved this data from Worldscope, and we call this variable *RDI*. All else equal, costs reductions resulting from a successful RJV will be more important in R&D intensive industries, thus affecting firms' incentives to join in the first place.

Third, *absolute* firm size may be important when there are specific fixed costs associated with the creation of an RJV (such as paper work and/or the establishment of specific facilities). Consequently, large firms may be more willing to join, as they can spread these costs across a larger volume of sales. In addition, size is likely to be highly correlated with "absorptive capacity", thus increasing the likelihood of forming an RJV.[12] Last, it may be the case that size may influence the public authority responsible for these programmes. This may possibly result from exogenous preferences "for" or "against" big business, or a process of regulatory capture. *Relative* size within an industry may also matter. For instance, RJVs

[11]Both variables suffer from the same drawback, that is there are some sectors for which these variables are not available. In those instances, we assigned the average value of the variable for these industries (see Hernán *et al.* for a justification of this choice).

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

may be an effective vehicle for pursuing "technology watch", that is monitor and anticipate developments that may displace industry leaders' existing products (see Cohen and Levinthal (1989), and Larédo (1998) for descriptive evidence).

Accordingly, we introduce a measure of *absolute* firm size, namely the natural logarithm of the average number of employees during the period 1991-1994, that we denote *log(FS)*. We proxy *relative* asymmetries among participants with market share (denoted *MS*), calculated as firm over industry size, both measured by the number of employees.

Industry concentration has an ambiguous effect.[13] On the one hand, high concentration facilitates the identification of suitable partners, and a smaller number of rivals limits residual spillovers to non-participants. In addition, if the RJV is undertaken to weaken competition/leverage market power, concentration will positively affect the likelihood of RJV formation. Both the spillover and market power motives predict a positive coefficient on this variable. On the other hand, competition policy imposes strict limits on collaborative projects in concentrated industries.[14] In order to measure market concentration, we constructed the Hirschman-Herfindähl index (*HHI*) for each four-digit sector present in our sample. The value taken by the *HHI* is the average for the 1991-94 period.

For some firms, willingness to join a specific type of policy may be influenced by past experience with either Eureka or EU-FP RJVs. This may reflect the success or failure of past ventures, the existence of once-for-all fixed costs associated

[13]In the theoretical literature, attention has focused on three types of market structures. The first is a duopoly where firms compete in quantities and may or may not be symmetric (e.g. Roeller *et al.*(1998)). The second is a symmetric oligopoly with a finite number of firms (Kamien, Mueller, and Zang (1992)). In both cases, if an RJV is formed, it will encompass the entire industry. Last, Greenlee and Cassiman (1999) analyse the formation of coalitions. They find that RJVs will only be formed by a subset of firms (i.e. the "grand coalition" found in the other class of models does not occur).

[14]For instance, the EU's block exemption automatically allows ventures between firms that collectively represent lass than 25% of the relevant anti-trust market. Above that threshold, firms have to request authorisation.

with RJV formation, as well as a learning process in achieving successful cooperation. We have thus constructed two dichotomous variables that take into account whether the firm has had experience with either Eureka or with the EU Framework Programme for the period 1986-92, which we respectively label *EXP-Eur* and *EXP-FP*. These variables also provide information on the success of these programmes (in terms of firms' willingness to take part in them).

Last, the origin of firms may introduce a country specific effect. Indeed, it seems that national idiosyncracies influence the attitude of firms towards formal cooperation (Nelson (1993)). The data will itself reveal whether geographic origin is an important determinant behind the decision to form a project. Country fixed effects may be related to national attitudes towards cooperation, country size, or differences in funding criteria.[15]

2.3.2. Econometric specification

As mentioned above, we focus on firms that have a higher probability of forming RJVs, and our interest lies in identifying the salient features of Eureka and the EU Framework Programme. To this end, we estimate a multinomial logit. The universe consists of firms that had participated at least once in an Eureka or EU-FP RJV prior to 1995. Thus, the dependent variable takes value 0 if the business unit has participated in at least one EU-FP or Eureka RJV initiated prior to 1995, but does not repeat the experience in either programme in 1995-1996. The dependent variable takes value 1 if the business unit joined a Eureka project in 1995-1996, 2 if it participated in an EU-FP RJV during 1995-96, and 3 if it is present in both programmes. The sample of business units that had

[15]As indicated above, Eureka is truly pan-European, while the EU-FP is an EU programme. Firms originating in non-EU countries who have a partnership agreement can participate in EU-FP RJVs; however they must obtain funding from their national government. These rules could possibly generate country fixed effects in the data. Also, in the context of Eureka, some governments may be more or less "generous" and "swift" in responding to funding applications.

formed an EU-FP or Eureka RJV prior to 1995, and for which balance sheet and industry level data is available, yields a total of 1031 observations. Table I reports descriptive statistics for the variables that we used in the estimation.

<Place Table I approximately here>

We estimate the following expression:

$$
\begin{aligned}
(1) \quad \Pr(RJV_{i,j,t} &= 1|RJV_{i,j,t-k}=1) = F(\beta_0 + \beta_1 RDI_{j,t-2} + \beta_2 SPL_j + \beta_3 PATEF_j \\
&+\beta_4 HHI_{j,t-2} + \beta_5 log(FS)_{i,t-2} + \beta_6 MS_{i,t-2} \\
&+\beta_7 EXP\text{-}FP_{i,t-2} + \beta_8 EXP\text{-}Eur_{i,t-2} + \sum_{m=1}^{M} \gamma_m Country_{m,i})
\end{aligned}
$$

where $F(.)$ is the multinomial logistic cumulative distributive function. The sub-indices i, j, t, and m respectively denote firm, sector, time, and country, and $k > 0$. As indicated previously, we have lagged our independent variables by two periods in order to mitigate the endogeneity problem from our estimation. Since the residuals are likely to be correlated within the industries, and especially given the industry level variables (Moulton (1990)), our calculation of standard errors controls for this correlation by clustering at the four-digit level.

3. Econometric results

Table II presents the results of estimating (1) using the multinomial logit estimation technique and controlling for residual correlation among observations from the same industry. This first batch of results compares firms that have not formed an RJV during 1995-96 to business units that formed an RJV under Eureka or the EU-FP, and to those that were present in both programmes. For each type of RJV behaviour, we present two alternative specifications in order to assess

whether the results are sensitive to the exclusion/inclusion of the past experience variables. The estimation contains industry variables (R&D intensity, spillovers, patent effectiveness, and concentration), and firm specific variables (absolute and relative size, and past participation in Eureka and EU-FP projects). We include dummies for all countries (and drop the constant), whose point estimates are presented in Table III.

< Place Tables II and III approximately here>

We first comment on the result common to all specifications. An industry's *HHI* reflects the degree of concentration, or conversely, the extent of fragmentation. The coefficient for the *HHI* is not significant, irrespective of the programme. This result stands in contrast to that reported in Hernán *et al.* (2003), where concentration was found to be positive and marginally significant. Clearly, the difference lies in the fact that we focus on firms that have had a previous RJV experience, while the aforementioned paper considered all potential participants. We interpret this as indicating that there may be threshold effects, that is concentration positively influences the probability of forming RJVs at low levels. Once a threshold is reached (our results pertain to firms belonging to concentrated industries), then concentration becomes inconsequential. None of the results presented below are sensitive to the exclusion/inclusion of the *HHI* variable. With respect to the country dummies, a pattern emerges with respect to some identifiable variables such as country size or GDP per capita. It appears that firms originating in peripheral EU Members States (Spain, Greece, Ireland, and Portugal), very small countries (Luxemburg and Iceland), and in Eastern Europe (Czech Republic and Hungary) are less likely to repeat the experience. Overall, the goodness of fit (measured by the pseudo R^2) is quite satisfactory, hovering around 0.5.

The first two columns of Table II pertain to firms that formed a Eureka RJV

in 1995-96, with the difference consisting in the inclusion of the "past experience" dummies. In addition to the *HHI*, three variables are clearly not significant. Both coefficients for the size variables (*logFS* and *MS*) are not different from zero, indicating that Eureka participants during 1995-96 were not markedly larger (in relative or absolute terms) than firms that had participated in RJV projects in the past, but do not repeat the experience. Perhaps surprisingly, R&D intensity is not significant, confirming that Eureka projects are not clustered around a set of R&D intensive industries. We interpret these findings as indicating that authorities responsible for Eureka do not specifically target R&D intensive industries, and that large firms show no specific tendency to repeat the experience with Eureka. With regard to the knowledge diffusion variables (*SPL* and *PATEF*), their coefficient have the expected sign and are significant. This is evidence that the formation of Eureka RJVs is sensitive to the market failures identified in the theoretical literature. Indeed, both variables indicate that Eureka RJVs are more likely to be found in sectors where appropriability of knowledge is problematic.[16] Comfortingly, all the results presented above continue to hold when we introduce the past experience variables, with the latter being significant and of the expected sign. Not surprisingly, a past experience with Eureka has a stronger influence than one with the Framework Programme.

The results pertaining to firms forming an EU-FP RJV during 1995-96 are quite distinct. As before, we present two specifications, with and without past experience dummies. As is the case with Eureka, neither coefficients for *MS* nor *HHI* are significant. Howver, in sharp contrast to Eureka, *logFS* and sectorial *RDI*

[16]As mentioned earlier, Eureka allows firms to establish a division of intellectual property rights within a project. However, it is reasonable to think that firms belonging to sectors where patents are effective will be reluctant to participate in an Eureka RJV. Close collaboration may result in the leakage of information that could permit other participants to establish their own, competing, patents.

are associated with positive and highly significant coefficients, indicating that it is primarily large firms in R&D intensive sectors that are frequent participants in EU-FP RJVs. This may reflect the preference of EU authorities for firms sharing these characteristics. This may also suggests that an EU-FP RJV is an attractive option for projects involving large R&D outlays because of the cost sharing element.

Of the knowledge diffusion variables, the coeffcient for *PATEF* is only significant (at 5%) when experience dummies are *not* included (and fades into insignificance when past experience is controlled for). As mentioned earlier, all results have to be shared among participants, which explains the negative sign associated with patent effectiveness. The weak significance possibly reflects the fact that firms belonging to sectors where patents are effective may undertake projects within the EU-FP as long as they are unlikely to yield economically valuable patents.[17] As for *SPL*, it is never significant at conventional levels. Both results suggest that the market failures associated with uncontrolled knowledge flows within an industry play a minor, if not insignificant, role in the process of EU-FP RJV formation. Last, the past experience dummies have the expected sign and are significant (and predictably, past experience with the EU-FP has a larger effect).

Klette *et al.* (2000) put forward an attractive conjecture that could be useful to interpret these results. Based on evidence provided by Levin (1988), they note that the focus of public R&D programmes has been on sectors where innovations

[17]Survey evidence points in that direction. Luukkonen (2002) reports that in the pharmaceutical industry "EU projects have to deal with matters that cannot be patented and this restricts the possibilities of participating" (p. 448), and in general, that firms "did the confidential part of the R&D in their in-house project and the less confidential part in the EU project" (p. 447), and finally, "in some telecom projects (...) partners (...) came to perceive that the results could be commercially exploited. Their willingness to co-operate then disappered and they limited their contribution to a minimum" (p. 446).

tend to be complementary. Under such circumstances, firms have few incentives to limit spillovers, and may well want to foster them.[18] Note that this dissipates the apparent paradox regarding the existence of high spillover industries that undertake significant amounts of R&D (communications equipment, aerospace, semi-conductors, and electronics). Katsoulacos and Ulph (1998) provide a theoretical treatment of RJV formation among firms that pursue complementary research paths. In such cases, no subsidies are required to induce firms to form an RJV. Firms that repeat the EU-FP RJVs experience seem to fall in this category: industry R&D is markedly higher, and the extent of spillovers is inconsequential. This conjecture is also supported by the sign and significance of the coefficient associated with size (*logFS*): strategic rivalry is more likely to be present among the largest players.[19]

The last two columns of Table II present the results pertaining to firms that participate in both programmes. Consequently, these firms have both "Eureka" and "EU-FP" characteristics. The coeffcient for absolute firm size is highly significant and positive, while that for *PATEF* is of the expected sign, but statistically insignificant. This reflects the influence of "EU-FP" determinants. By contrast, *RDI* is positive but insignificant, while *SPL* is highly significant, a finding compatible with the results pertaining to Eureka. Both past experience variables have the expected sign and are significant. The finding specific to firms that participate in both programmes pertains to market share (*MS*), that is positive and significant. This can be interpreted as evidence that firms participate in both programmes

[18]Luukkonen (2002, pp. 450-51) provides evidence pointing in that direction for a sector that has been "targeted" by EU authorities, namely telecommunications. Concretely: "IPR issues were regarded as vital and the companies wanted to secure patent rights. However, in the telecommunications field, European firms have agreed to pool their patents and to cross-license in order to advance development in the field".

[19]Very similar results obtain for *MS* when *logFS* is excluded. Concretely, *MS* turns out to be positive and significant, while the other coefficients are barely affected. This is not surprising, since both variables account for similar economic phenomena.

in order to monitor innovative activity in their segment (a sophisticated form of "technology watch").

Clearly, there are marked differences across Eureka and the EU-FP, for instance in terms of absolute firm size and R&D intensity. However, these results do not allow us to reach a definite conclusion as to whether some of the other parameters have a statistically differentiated effect across programmes. The first two columns in Table IV provide tests for differences across programmes. The last row clearly confirm that, overall, the two sets of results are significantly different at less than the 1% level. As for individual variables, the results confirm that, compared to Eureka, EU-FP RJVs involve larger firms in more R&D intensive industries. Concentration and market share do not exert a differentiated impact across programmes. By contrast, *SPL*, and to a lesser extent, *PATEF*, have a statistically stronger effect in the case of firms that repeat the Eureka experience. Combining these findings with the previous set of results indicates that the knowledge diffusion variables exert no influence on the probability of repeating the experience with an EU-FP RJV, while the reverse holds for Eureka.

Columns (3) to (6) compare the characteristics of firms that only joined one type of RJVs versus firms that are present in both programmes. Compared to firms that only participate in Eureka during 1995-96, RJVs involving business units that are present in both programmes are only differentiated along the dimension of absolute firm size. It reflects the fact that firms involved in both programmes are larger, since they also participate in EU-FP RJVs. With respect to firms that only participate in EU-FP RJVs, entities that are present in both programmes appear to be both larger (absolute terms) and leaders in their industry segment. However, the effect of firm size is not robust to the introduction of the past experience variables. Overall, these results are consistent with the

conjecture that firms that participate in both programmes do so for the purpose of monitoring industry developments. Indeed, industry leaders have most to lose from the emergence of new products or processes that could displace them.[20] Last, the past experience dichotomous variables reveal an interesting pattern. For the case of Eureka RJVs (columns (3)-(4)) neither dummy is significant. By contrast, *EXP-Eur* is highly significant and positive when EU-FP RJVs are considered (columns (5)-(6)). Combining these two results suggest that it is principally firms that had an experience with Eureka that also decide to launch an additional EU-FP project, while the reverse is not true (i.e., firms that were only involved in the EU-FP do not decide to join a Eureka project).

4. Discussion and concluding remarks

The results presented in this paper pertain to firms' participation decision in pan-European RJVs. The focus is on firms that are most likely to participate in the first place, with the latter identified as firms that had previous experience with an Eureka or EU-FP RJVs.

Some interesting patterns emerge when the two programmes are compared. The findings pertaining to EU-FP RJVs are consistent with a "top-down" and "mission oriented" research policy.[21] Clearly, EU authorities have favoured projects in R&D intensive industries. Second, absolute size matters. This is indicative of important R&D fixed costs linked to the establishment of an EU-FP RJV. It may also reflect the heavy bureaucratic procedures involved in the functioning of EU

[20]Luukkonen (2000) reports that: "For instance, the Nokia Group got involved in EU collaboration with rather vague objectives regarding internalisation strategies and wishing to monitor development in other companies".

[21]The OECD has established the difference between "diffusion oriented" and "mission oriented" science and technology policies. The former are more market driven and focus on the adoption of existing technologies within the economic fabric, while the latter involve a set of goals established by public authorities.

research policy, of which participants have often complained about.[22] It may also be associated with a bias in favour of large firms on the part of EU authorities. In addition, EU-FP ventures do not appear to respond to the market failures associated with knowledge diffusion variables identified in the literature. These results are consistent with several interpretations that are not necessarily competing among themselves. The first is that the EU-FP is truly focused on basic, pre-competitive research, primarily in sectors where patent effectiveness and the extent of spillovers do not represent an impediment to RJV formation. Participants belong to R&D intensive industries, and large firms have the resources to participate in such projects. Under this scenario, public subsidies are required to induce firms' participation, as these projects involve huge commercial risks (in the terminology christened by Martin and Scott (2000), these are "complex systems innovation" projects). The second is that EU subsidies are somewhat redundant, since participants belong to sectors were innovations are primarily complementary. In addition, the impossibility of establishing IPRs ensures that research undertaken within these RJVs is non-crucial. The third is that the main purpose of EU-FP is to solve coordination problems. Concretely, EU-FP RJVs serve to identify and select the most promising trajectories. The clearest example is that of telecommunications. Indeed, mobile telecommunication technologies were fairly well known; the EU-FP served to select and establish the GSM standard.

The results pertaining to Eureka differ sharply. Both knowledge diffusion variables have the expected sign and are significant. Also, size and sectorial R&D intensity do not influence the probability of repeating the experience with an Eureka RJV. This probably reflects the fact that Eureka authorities have not targeted

[22]Concrete examples include: large amount of paper work, very precise eligibility criteria (which require extra effort in project design), the requirement to have firms originating in "peeripheral" or "cohesion" countries, rigid deadlines for project submission, slow evaluation procedures on the part of EU authorities etc...

firms in terms of their absolute size, nor by their sectorial affiliation. Overall, it seems that Eureka serves the purpose for which it was designed, namely to correct the market failures associated with the generation of economically valuable knowledge.

The conjecture that Eureka is more market driven and "bottom-up" as compared to the EU-FP is further corroborated by the ex-post performance of firms. Using the same data sources, Benfratello and Sembenelli (2002) report that firms with an Eureka experience do improve their ex-post performance (the latter being measured by both productivity and profitability). By contrast, parties to an EU-FP RJVs do not experience an improvement in their measured performance.

It may appear somewhat surprising that the Eureka programme has been fast "losing ground" to the EU-FP in the sense that the latter has attracted many more participants. Part of the answer must lie with the subsidies that the EU provides. It may also be the case that each programme addresses different types of market failures. What is clear is that the institutional design of these research programmes influence outcomes. A potentially interesting research avenue consists in estimating a structural model of "supply" (determined by public authorities) and firms' "demand" for RJVs.

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Table I

Descriptive Statistics

Variables	Mean	Std. Dev.	Min	Max
Prob(RJV_i)	0.35	0.48	0	1
Prob($RJV\text{-}EU\text{-}FP_i$)	0.32	0.47	0	1
Prob($RJV\text{-}Eureka_i$)	0.06	0.24	0	1
$R\&D\ Intensity_j$	0.04	0.03	0.0000125	0.1044
$Spillover\ lag_j$	12.09	1.58	7.815	16.545
$Patents\ effectiveness_j$	3.90	0.45	2.95	5.70
HHI_i	0.05	0.08	0.003	0.678
$Firm\ size_i$	3151	13275	2	229161
$Market\ Share_i$	0.02	0.05	$11.5*10^{-6}$	0.58
$EXP\text{-}FP_i$	0.48	0.50	0	1
$EXP\text{-}Eur_i$	0.65	0.48	0	1

Table II

Econometric Results

	Eureka		Framework Programme		Both	
Variables	(1)	(2)	(3)	(4)	(5)	(6)
R&D Intensity$_j$	-2.21	-4.14	12.57	12.71	7.28	4.70
	(0.29)	(0.51)	(4.00)	(4.25)	(1.30)	(0.79)
Spillover lag$_j$	-0.50	-0.48	-0.06	-0.07	-0.38	-0.36
	(3.56)	(3.45)	(1.18)	(1.36)	(3.14)	(2.93)
Patents effectiveness$_j$	-0.78	-0.87	-0.24	-0.13	-0.40	-0.34
	(1.82)	(1.99)	(2.05)	(1.20)	(2.53)	(0.94)
HHI$_i$	-0.27	-0.48	-0.05	0.30	-3.08	-2.55
	(0.21)	(0.37)	(0.03)	(0.18)	(0.87)	(0.65)
Log (Firm size)$_i$	0.12	0.07	0.44	0.42	0.64	0.52
	(1.02)	(0.65)	(6.84)	(7.15)	(5.52)	(4.36)
Market Share$_i$	5.62	5.34	1.91	1.31	8.69	7.97
	(1.00)	(1.10)	(0.80)	(0.62)	(2.65)	(2.61)
EXP-FP$_i$		1.35		2.16		2.15
		(2.27)		(7.11)		(4.49)
EXP-Eur$_i$		2.63		0.56		2.38
		(4.38)		(2.45)		(5.64)
Pseudo R^2	0.48	0.52	0.48	0.52	0.48	0.52
Number of observations	1031	1031	1031	1031	1031	1031

Note: *t*-statistics in absolute values in parentheses.

All regressions include country dummies.

Table III

Country Dummies Coefficient Estimates

Country dummies	Eureka	Framework Programme	Both
Austria	-29.16 (11.15)	-1.76 (1.96)	-36.21 (18.36)
Belgium	5.53 (2.19)	-2.20 (2.92)	-1.08 (0.61)
Switzerland	6.20 (2.13)	-2.77 (2.84)	-36.30 20.45
Germany	4.92 (1.90)	-2.98 (3.92)	-3.13 (1.50)
Denmark	4.52 (1.74)	-1.45 (2.04)	-0.88 (0.54)
Spain	-29.90 (11.75)	-2.58 (1.90)	-36.27 (21.79)
Finland	6.10 (2.24)	-2.17 (3.30)	-0.81 (0.35)
France	4.19 (1.72)	-2.63 (3.45)	-0.83 (0.46)
UK	4.67 (1.93)	-2.25 (2.97)	-36.37 (20.17)
Greece	-29.27 (11.47)	-1.80 (2.43)	-35.64 (20.66)
Ireland	-29.59 (11.57)	-2.14 (2.34)	-35.71 (20.10)
Iceland	-30.42 (11.72)	-39.49 (42.59)	-35.88 (20.70)
Italy	3.28 (1.12)	-2.63 (3.54)	-2.99 (1.59)
Luxemburg	-29.96 (11.27)	-2.87 (2.31)	-36.84 (20.64)
Netherlands	5.36 (2.32)	-2.22 (2.29)	-35.69 (20.24)
Norway	5.40 (2.19)	-2.97 (3.67)	-0.75 (0.42)
Portugal	-29.58 (11.11)	-2.47 (2.69)	-35.95 (19.85)
Sweden	5.41 (2.05)	-2.47 (3.31)	-0.89 (0.48)
Czeck Republic	-30.06 (11.47)	-38.28 (32.80)	-34.18 (18.52)
Hungary	-29.74 (9.12)	-41.81 (40.11)	-38.61 (16.10)

Notes:

These columns correspond to regressions (1), (3) and (5) in Table II.

t-statistics in absolute values in parentheses

Table IV

Differences across programmes: χ^2 tests on the equality of the coefficients

	Eureka *vs.* Framework Programme		Eureka *vs.* Both Programmes		Framework Programme *vs.* Both Programmes	
Variables	(1)	(2)	(3)	(4)	(5)	(6)
R&D Intensity$_j$	3.98 (0.05)	4.28 (0.04)	0.91 (0.34)	0.67 (0.41)	1.09 (0.30)	2.05 (0.15)
Spillover lag$_j$	11.99 (0.00)	9.56 (0.00)	0.69 (0.41)	0.55 (0.46)	7.84 (0.00)	5.75 (0.02)
Patents effectiveness$_j$	1.62 (0.20)	2.86 (0.09)	0.46 (0.50)	0.90 (0.34)	0.24 (0.63)	0.35 (0.55)
HHI$_i$	0.02 (0.89)	0.18 (0.67)	0.68 (0.41)	0.27 (0.60)	1.00 (0.32)	0.72 (0.40)
Log (Firm size)$_I$	6.08 (0.01)	7.10 (0.01)	12.98 (0.00)	9.70 (0.00)	2.91 (0.09)	0.61 (0.43)
Market Share$_i$	0.46 (0.50)	0.76 (0.38)	0.34 (0.56)	0.35 (0.55)	4.52 (0.03)	4.91 (0.03)
EXP-FP$_i$		1.46 (0.23)		1.45 (0.23)		0.00 (1.00)
EXP-Eur$_i$		11.95 (0.00)		0.12 (0.73)		14.62 (0.00)
Joint significance	32790.26 (0.00)	35154.20 (0.00)	17388.87 (0.00)	10421.02 (0.00)	40254.09 (0.00)	41765.04 (0.00)

Notes:

One degree of freedom for individual variables, twenty five degrees of freedom for columns (1), (3), and (5), and twenty seven degrees of freedoms for the remaining columns.

Significance level in parentheses.