Public Policies towards Research Joint Venture: Institutional Design and Participants' Characteristics*

Pedro L. Marín† and Georges Siotis‡

Universidad Carlos III de Madrid
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Abstract

In this paper, we present several insights regarding the influence of institutional design on the process of Research Joint Venture formation (RJV). Our results are obtained with a firm level data-set on RJVs formed under the umbrella of the Eureka initiative and of the European Union's Framework Programmes for Science and Technology (EU-FP). We focus on firms that are known to have a high probability of forming RJVs, with the latter identified as firms with a past experience in collaborative research. The results indicate that EU-FP RJVs are consistent with a "top-down" and

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†Universidad Carlos III de Madrid, Economic Bureau of the Spanish Prime Minister, and CEPR.

‡Universidad Carlos III de Madrid and CEPR. Corresponding author: Georges Siotis, Departamento de Economía, Universidad Carlos III de Madrid, Calle Madrid 126, 28903 Getafe (Madrid), Spain, siotis@eco.uc3m.es, tel: + 34-91-624 93 12, fax: + 34-91-624 98 75.

"mission oriented" research policy. By contrast, Eureka RJVs appear as more market driven and "bottom-up".
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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)).

In this paper, we exploit institutional differences between two pan-European programmes aimed at promoting RJV formation. These two policy initiatives are the Eureka initiative and the EU Framework Programme (EU-FP). In short, Eureka is a fairly decentralised programme with few eligibility requirements, and public funding tends to be limited in the majority of cases. By contrast, the EU-FP's eligibility criteria are more rigid and the administrative burden is larger compared to Eureka, but the amount of subsidisation is larger. These differences

allow us to relate programme design with RJV participants' characteristics.

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]

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. As a result, a limited number of papers apply econometric techniques to the analysis of RJV formation. A first set of papers analyse the determinants of RJV participation. Röller, Tombak, and Siebert (1998) exploit a large US firm level dataset that spans various industries. They show that size symmetry between participants and complementarity in the product market enhance the likelihood of two firms pairing in an RJV. 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

[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.

are the ones with a previous RJV experience.

The second set of contributions focus on the relationship between RJV formation and firm performance. For instance, Branstetter and Sakakibara (1998, 2002) study RJVs sponsored by the Japanese government, and report that membership of these consortia significantly increased participants' patenting activity. Irwin and Klenow (1996) focus on RJVs within a single industry, and provide evidence on the effect of participation in the US Semiconductor Manufacturing Technology Consortium (SEMATECH) on firms' profitability.

Publicly supported pan-European RJVs launched during the last two decades fall into two broad categories, as they have been formed under the umbrella of either the Eureka Programme or the EU Framework Programme for Science and Technology (EU-FP). As far as we know, the only paper that exploits the existence of two distinct pan-European programmes is Benfratello and Sembenelli (2002). They 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.

In this paper, we extend the analysis of Hernán, Marín and Siotis (2003) by exploiting differences in institutional design and relate them to RJV participants' characteristics. 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. 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 "diffusion" and "bottom-up" (the distinction between "mission" and "diffusion" oriented science and technology policies has been popularised by

Ergas (1987)).[3] These results are consistent with those of Branstetter and Sakakibara (2002) who also find that the design of Japanese research consortia influences outcomes.

The remainder of the paper is organised as follows. The next section briefly outlines the salient features of Eureka and the EU-FP programmes and describes the data. Section 3 identifies testable hypotheses, and presents our empirical specification. Section 4 contains the empirical results, while section 5 provides concluding remarks.

2. Programme design and data sources

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 sec-

[3] "Diffusion oriented" science and technology policies are more market driven and focus on the adoption of existing technologies within the economic fabric, while "mission oriented" policies involve a set of goals established by public authorities.

[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.

retariat. 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 participating 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, this initiative does not focus on a particular set of technologies. Obtaining the "Eureka label" does not entitle firms to EU 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 support 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

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

[6]It is true that the EU-FP represents less than 5% 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).

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 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 aims 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 (2002), p. 447).

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.

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

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 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 that contains 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. We obtained 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.

3. Variables, testable conjectures and econometric specification

3.1. Variable definition and testable conjectures

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. The information on business units and industry R&D spans the period 1991-1996. The dependent variable is constructed with data pertaining to the years 1995-96. Thus, we are able to 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 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 where it is possible to internalise them effectively.

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 near 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 accordingly. 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. *A priori*, the sign of the coefficient on *Patent effectiveness* is not clear-cut. On the one hand, firms that operate in sectors where patents are effective do not need to rely on RJVs in order to internalise spillovers. If this is the case, we expect the coefficient to be zero or negative. On the other hand, patent effectiveness may be the outcome of an endogenous process whereby firms and public authorities have invested large resources to limit (but not eliminate altogether) knowledge leakages. In that case, that variable would be acting as a proxy for the importance of spillovers, and would therefore exert a positive influence on the probability of forming an RJV. Note that, while both these proxies (*Spillover lag* and *Patent effectiveness)* are related to knowledge flows, the original sources of information and their interpretation are quite distinct.[8]

Second, R&D outlays may be large and may have to be paid up-front; in

[8]Both variables suffer from the same drawback, namely that 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. An alternative would consist of introducing a dummy for the sectors for which these proxies are unavailable. Hernán *et al.* (2003) report that these coding choices do not affect the qualitative nature of the results.

addition the outcome of R&D effort 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 *R&D intensity*. 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.[9] 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 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(Firm size)*. We proxy *relative* asymmetries among participants with market share (denoted *Market share*), calculated as firm over market size, both

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

approximated by the number of employees.

Industry concentration has an ambiguous effect.[10] 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.[11] 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 with RJV formation, as well as a learning process in achieving successful cooperation. We have thus constructed two dichotomous (0-1) variables that take into account whether the firm had participated in either a Eureka or EU-FP RJV launched prior to 1995, which we respectively label *Experience-Eur* and *Experience-FP*. These variables provide information on the success of these programmes (in terms of firms' willingness to repeat the experience), and also account for unobservable

[10] 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).

[11] During the period analysed in this paper, the EU block exemption that was in force (Commission Regulation 418/85, OJ 1985 L 53, 5) automatically allowed ventures between firms that collectively represented less than 20% of the relevant anti-trust market. Above that threshold, firms required authorisation. Since January 1 2001, this threshold has been raised to 25%.

firm characteristics associated with participation in each of these programmes.

Last, the origin of firms may introduce a country specific effect. Indeed, it seems that national idiosyncrasies 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 particular type of project. Country fixed effects may be related to national attitudes towards cooperation, country size, or differences in funding criteria.[12]

3.2. Econometric specification

In Hernán, Marín and Siotis (2003), the sample encompasses both actual and potential participants (firms forming one or more RJV(s) as well as firms not participating in any RJV during our window). The approach adopted in this paper is different, as we use a restricted sample formed only by firms having participated at least once in a RJV during our sample period. This empirical strategy is driven by the issue at hand, namely to unearth the differences between frequent participants to the EU-FP as compared to Eureka.

More precisely, our restricted sample is formed by firms that had participated in at least one RJV project prior to 1995. Some of them repeat during the period 1995-96, while others do not. Consequently, 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 form or join any new project in 1995-1996. The dependent variable takes value 1 if the business unit joined a new Eureka project that started in 1995 or 1996, and 2 if it did so in an EU-FP RJV.[13] In other words,

[12] 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.

[13] In an earlier version of the paper, we also created a third group that included firms that launched both a Eureka and EU-FP RJV in 1995-96 (see Marín and Siotis, 2002). Including

we focus on the determinants of repeated participation in these programmes.

The advantages of this strategy are twofold. First, as indicated by Klette, Moen and Griliches (2000), the choice of reference group raises some important issues. In particular, Heckman, Ichimura, Smith and Todd (1998) have shown that biases are most likely to be minimised when the units being analysed share some characteristics with the units that form part of the reference group. In our context, identifying the reference group as firms with a past experience, but that do not participate in a RJV in 1995-96, appears as a natural choice. Indeed, these firms share some important characteristics, as indicated by the sign and significance of the "past experience" dummy in Hernán *et al.* (2003). Second, since participants to either programmes are likely to share some common unobserved characteristics as compared to non-participant firms, it would be difficult, in a statistical sense, to unearth differences between Eureka and EU-FP if they were compared to a reference group formed by all non-participants.[14]

The sample of business units that had 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 987 observations. Table I reports descriptive statistics for the variables.

<Place Table I approximately here>

We estimate the following equation:

these few additional cases does not alter the essence of the results reported in this paper.

[14]The results obtained with the full sample (i.e., including firms that do not participate in any RJV during our window) are similar to those found in Hernán *et. al* (2003), and are available upon request. As indicated in the text, differences between Eureka and FP participants are blurred when they are compared to the entire sample.

$$
\begin{aligned}
(1) \quad \Pr(RJV_{i,j,t} &= 1|RJV_{i,j,t-k}=1) = F(\beta_0 + \beta_1 R\&D\ intensity_{j,t-2} \\
&+\beta_2 Spillover\ lag_j + \beta_3 Patent\ effectiveness_j \\
&+\beta_4 HHI_{j,t-2} + \beta_5 log(Firm\ size)_{i,t-2} + \beta_6 Market\ share_{i,t-2} \\
&+\beta_7 Experience\text{-}FP_{i,t-2} + \beta_8 Experience\text{-}Eur_{i,t-2} \\
&+\sum_{m=1}^{M} \gamma_m Country_{m,i})
\end{aligned}
$$

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 given that we use the industry level variables, our calculation of standard errors controls for this correlation by clustering at the four-digit level (Moulton (1990)).

This exercise sheds 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?

4. Econometric results

Table II and III present the results of estimating expression (1) using the multinomial logit estimation technique and controlling for residual correlation among observations from the same industry. These results pertain to firms that formed at least one new RJV under either Eureka or the EU-FP to firms that had not formed an RJV during that time period, conditional on at least one participation prior to 1995-96. 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 country dummies in all specifications. The point estimates for these variables are presented in Table III, and have to be interpreted with respect to the fixed effect pertaining to Germany.[15]

< Place Tables II and III approximately here>

We first comment on the result common to columns (1)-(4) of Table II. Comfortingly, all the results commented below hold irrespective of whether we introduce the past experience variables. The latter are significant and of the expected sign. Not surprisingly, a past experience with Eureka has a stronger influence on the probability of forming an Eureka RJV as compared to an experience with the Framework Programme. The converse applies to EU-FP RJVs. The coefficient associated to concentration (*HHI*) is statistically insignificant. Given that we focus on firms that have had a previous experience, we interpret this as indicating that there may be threshold effects, that is concentration positively influences the probability of forming RJVs at low levels. None of the results presented below are sensitive to the exclusion/inclusion of the *HHI* variable. Overall, the goodness of fit (measured by the pseudo R^2) is acceptable, standing at 0.14 (specification without past experience variables) and 0.21 (when the past experience variables are included).

With respect to country dummies (Table III), no clear-cut pattern emerges in

[15] With n countries, it is not possible to have n country dummies and a constant: one country dummy has to be dropped (in this paper, the dummy for Germany). Despite the fact that the constant picks-up more than the country fixed effect associated with German firms, the dummies for the other countries have to be interpreted as differences with respect to Germany.

the case of the Eureka programme. It appears that firms originating in Southern countries (Greece, Portugal, Spain) and some small countries (Austria, Luxemburg and Ireland) are less likely to form Eureka RJVs compared to German firms, while the opposite holds for Belgian and Finnish firms. With respect to Framework Programme RJVs, firms originating in small countries have a higher propensity to participate compared to German firms (and this difference is statistically significant in the case of Belgium, Switzerland, Denmark, Finland, Greece, the Netherlands and Sweden). Perhaps surprisingly, firms based in the UK and France are more likely to have formed an EU FP RJV in 1995-96 as compared to their German counterparts (and the coefficient for Italy is also positive and "almost" significant). Overall, German firms have a lower propensity to form a EU-FP RJV in 1995-96 as compared to their European counterparts (all the country dummies are positive, although not all of them are significant).

Overall, the estimates of the remaining coefficients are in line with what theory predicts. The first two columns of Table II pertain to firms that formed an Eureka RJV in 1995-96, with the difference consisting in the inclusion of the "past experience" dummies. In addition to the coefficient on *HHI*, three estimates are clearly not significant. Both coefficients for the size variables (*logFirm size* and *Market share*) 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 that did not repeat the experience. Perhaps surprisingly, R&D intensity is not significant, a finding compatible with the conjecture that Eureka projects are not clustered around a subset of R&D intensive industries.[16] The coefficients on R&D intensity and firm

[16]Note that this is not incompatible with Eureka participants belonging to R&D intensive industries. Indeed, results obtained with the entire sample clearly show that R&D intensity positively influences the probability of forming an Eureka RJV. What the results indicate is that firms that repeat the Eureka experience are not clustered in R&D intensive industries.

size probably reflect the existence of threshold effects (this sample, made-up of firms with a past participation, consists of large firms in R&D intensive sectors). 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, the coefficient on *Spillover lag* has the expected sign and is significant. For *Patent effectiveness*, we also report a negative and significant coefficient which is consistent with the conjecture that firms belonging to sectors were patents effectively limit leakages do not have to rely on RJVs to internalise spillovers. 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.[17]

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 *Market share* nor *HHI* are significant. However, in sharp contrast to Eureka, *logFirm size* and sectorial *R&D intensity* 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 suggest that an EU-FP RJV is an attractive option for projects involving large R&D outlays because of the cost sharing element.

[17] 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.

Of the knowledge diffusion variables, the coefficient for *Patent effectiveness* is negative and significant at 5% when experience dummies are not included and fades into insignificance when past experience is controlled for. 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 (recall that in EU-FP projects, all results have to be shared among participants).[18] As for the coefficient on *Spillover lag*, it is of the expected sign but never significant at conventional levels. Both results suggest that the market failures associated with uncontrolled knowledge flows within an industry have a minor, if not insignificant, influence on the probability of repeating the experience of forming an EU-FP RJV. 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 tend to be complementary. Under such circumstances, firms have few incentives to limit spillovers, and may well want to foster them.[19] Note that this dissipates the apparent paradox regarding the existence of high spillover industries that undertake significant amounts of R&D (communications equipment, aerospace,

[18] 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).

[19] 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".

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 of lesser importance.

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. Table IV provide tests for differences across programmes. The last two rows, that report joint significance tests for equality between the two programmes, clearly confirms that, overall, the two sets of results are significantly different from each other at less than the 1% level. As for individual variables, the results indicate 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, *Spillover lag*, and to a lesser extent, *Patent effectiveness*, 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 little influence on the probability of repeating the experience with an EU-FP RJV, while the reverse holds for Eureka.

< Place Table IV approximately here>

Last, the past experience dichotomous variables reveal an interesting pattern. A previous experience with Eureka has much stronger influence on the likelihood

of repeating the Eureka experience. By contrast, having a past experience with the EU-FP does not exercise a statistically different effect across the two programmes.

5. Discussion and concluding remarks

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

The results that obtain with this sample yield insights regarding the profile of firms participating in these RJVs. The findings pertaining to EU-FP RJVs are compatible with a "top-down" and "mission oriented" research policy. 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 research policy, of which participants have often complained about.[20] 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

[20] 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 "peripheral" or "cohesion" countries, rigid deadlines for project submission, slow evaluation procedures on the part of EU authorities, etc...

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. 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 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 differentiated institutional design of these research programmes results in attracting participants with distinct characteristics.

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Table I

Descriptive Statistics (987 observations)

Variables	Mean	Std. Dev.	Min	Max
R &D Intensity$_i$	0.036	0.030	0.000013	0.1044
Spillover lag$_i$	12.03	1.58	7.815	16.545
Patents effectiveness$_i$	3.91	0.44	2.95	5.70
HHI$_i$	0.05	0.08	0.003	0.678
Firm size$_i$	2708	10642	2	185733
Market Share$_i$	0.02	0.04	0.000012	0.55
Experience-FP$_i$	0.46	0.50	0	1
Experience-Eur$_i$	0.65	0.48	0	1
	Firms with a past experience forming an RJV in 1995-96			
# RJV$_i$	320			
# RJV-EU-FP$_i$	295			
# RJV-Eureka$_i$	25			

Table II
Econometric results

	Eureka		Framework Programme	
Variables	(1)	(2)	(3)	(4)
R&D Intensity	-3.47 (0.66)	-6.23 (0.44)	13.04 (0.00)	13.40 (0.00)
Spillover lag$_j$	-0.49 (0.00)	-0.49 (0.00)	-0.06 (0.24)	-0.07 (0.17)
Patents effectiveness	-0.91 (0.04)	-1.06 (0.04)	-0.23 (0.05)	-0.11 (0.30)
HHI$_i$	-0.47 (0.73)	-0.67 (0.65)	-0.19 (0.91)	0.12 (0.94)
Log (Firm size)$_i$	0.13 (0.25)	0.08 (0.49)	0.44 (0.00)	0.42 (0.00)
Market Share$_i$	4.70 (0.38)	5.00 (0.26)	2.03 (0.39)	1.96 (0.33)
Experience-FP$_i$		1.36 (0.02)		2.21 (0.00)
Experience-Eur$_i$		2.67 (0.00)		0.59 (0.01)
Constant	5.31 (0.05)	3.47 (0.22)	-3.11 (0.00)	-5.36 (0.00)
Pseudo R^2	0.14	0.21	0.14	0.21
Number of observations	987	987	987	987

Notes:
Significance levels in parentheses.
All regressions include country dummies.
The results have been obtained with Stata 9.

Table III

Country Dummies Coefficient Estimates

Country dummies	Eureka	Framework Programme
Austria	-32.32 (0.00)	1.70 (0.00)
Belgium	1.46 (0.08)	0.75 (0.02)
Switzerland	1.35 (0.25)	1.34 (0.10)
Denmark	0.10 (0.93)	1.50 (0.00)
Spain	-33.07 (0.00)	0.22 (0.88)
Finland	1.30 (0.09)	1.26 (0.00)
France	-0.64 (0.32)	0.62 (0.02)
UK	0.27 (0.76)	0.79 (0.02)
Greece	-31.78 (0.00)	1.06 (0.01)
Ireland	-32.00 (0.00)	0.79 (0.20)
Italy	-1.40 (0.24)	0.36 (0.17)
Luxemburg	-33.16 (0.00)	0.41 (0.63)
Netherlands	0.77 (0.55)	1.24 (0.02)
Norway	0.41 (0.63)	0.73 (0.15)
Portugal	-31.71 (0.00)	0.45 (0.53)
Sweden	0.32 (0.73)	0.84 (0.09)

Notes:
These columns correspond to regressions (2) and (4) in Table II.
Significance levels in parentheses.
The country dummies have to be interpreted with respect to Germany.
In the case of Eureka participation, the country dummies for Austria, Spain, Greece, Ireland, Luxemburg, and Portugal yield very similar values (and significance levels). This is due to the fact that no firm originating in these countries formed a Eureka RJV during 1995-96. However, we maintained firms from these countries, as they do form EU-FP RJVs. Completely excluding these firms does not affect the essence of the results; the latter are available upon request.

Table IV

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

	Eureka *vs.* Framework Programme	
Variables	(1)	(2)
R&D Intensity$_j$	5.05 (0.02)	5.94 (0.01)
Spillover lag$_j$	11.87 (0.00)	9.42 (0.00)
Patents effectiveness$_j$	2.39 (0.12)	3.52 (0.06)
HHI$_i$	0.03 (0.87)	0.16 (0.68)
Log (Firm size)$_I$	6.34 (0.01)	7.34 (0.01)
Market Share$_i$	0.24 (0.62)	0.55 (0.46)
Experience-FP$_i$		1.78 (0.18)
Experience-Eur$_i$		12.08 (0.00)
Constant	9.52 (0.00)	9.15 (0.00)
Joint significance (excluding country dummies)	20.07 (0.00)	48.29 (0.00)
Joint significance (including country dummies)	17026 (0.00)	17827 (0.00)

Notes:

One degree of freedom for individual variables, six (eight) degrees of freedom for the joint significance test that excludes country dummies in column 1 (2), and twenty two (twenty four) degrees of freedom for the test that includes country dummies in column 1 (2).

Significance levels in parentheses.