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STEP TO RJVs

Scientific Coordinator of the project: Yannis Caloghirou, Ass . Professor
National Technical University of Athens
Department of Chemical Engineering
Laboratory of Industrial and Energy Economics

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Written by

Yannis Caloghirou and Nicholas Vonortas [*]

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Partners:
Strategic Industrial Research Networks (SIRN).

Fondazione Eni Enrico Mattei (FEEM).

Institut de l' Audiovisuel et des Telecommunications (IDATE).

Stockholm School of Economics (SSE).

Universidad Carlos III de Madrid (U:Carlos III).

The Victoria University of Manchester,Policy Research in Engineering, Science and Technology (PREST).

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The STEP TO RJVs project was undertaken by the following research teams:

Laboratory of Industrial and Energy Economics, National Technical University of Athens:
Yannis Caloghirou, Nicholas Vonortas, Ioanna Kastelli, Aggelos Tsakanikas, George Hondroyannis.
Strategic Industrial Research Networks (SIRN): Yannis Katsoulacos, David Ulph, Assimina Christoforou.

Fondazione Eni Enrico Mattei (FEEM): Giorgio-Barba Navaretti, Patrizia Bussoli, Virginia Recchia.

Institut de l' Audiovisuel et des Telecommunications (IDATE): Jacques Arlandis, Olivier Dartois.

Stockholm School of Economics (SSE) : Lars-Gunnar Mattsson, Dimitrios Ioannidis, Eva Wikstrand.

Universidad Carlos III de Madrid (U:Carlos III): Praveen Kujal, Pedro Marin, George Siotis, Roberto Hernan, Elena Revilla.

The Victoria University of Manchester,Policy Research in Engineering, Scienc e and Technology (PREST): Kate Barker, Hugh Cameron, Carole Mac Kinlay.

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ABSTRACT

Although inter-firm collaboration may take many forms, studies show that a high number of cooperative agreements focus on technological issues. This project studied a subset of Strategic Technical Alliances that are described as research joint ventures (RJVs). The examined RJVs are contract based agreements between independent entities. Member entities may include firms, universities and other government organisations. The empirical analysis only involved RJVs with at least one participant from the private sector. The project aimed to study the phenomenon of RJVs, on the basis of the different theoretical perspectives that have been put forth in the literature in order to explain inter-firm technological cooperation. More specifically, it draws insights from three theoretical perspectives on inter-firm technological collaboration: a) the one that stems from mainstream Industrial Organization literature, b) the one put forth by Transaction Cost Economics and c) the perspective that has grown out of the literature on Strategic Management.

The project dealt with a data set of over 8,000 RJVs in the European Union, which have received funding through the Framework and EUREKA programmes at the European level, as well as by various national programmes. The result was the creation of the STEP TO RJVs databank made of several different databases and a large number of case studies carried out by the partners of the consortium. Empirical evidence was obtained from databases, surveys and case studies. Different methods have been used for processing this information: statistical techniques, econometric techniques and a review of existing policies at the country level. On this basis, the project explored the following issues: a) What is the scope and extent of subsidised R&D collaboration in Europe? b) Why and how firms and other organizations collaborate? c) What is the outcome and the overall economic impact of R&D collaboration? d) How can R&D collaboration serve specific S&T policy objectives (and vice versa)?

Building on the analysis carried out, the project suggests a number of interesting implications both for policy and for future research. Evidence from the project shows that the public funding of RJVs has given this activity a major boost in the last two decades. Given that there seems to be a fixed cost involved in collaboration, public programmes are especially important for the "cohesion" countries that often lack significant resources for initiating research activities. Even more importantly, the encouragement of RJVs seems to be the appropriate vehicle for the improvement of research links between universities, public research institutions and industry that may prove to be of critical importance for European technological development.

With regard to future research, the project highlights, among other things, the need to better understand the factors that determine pairs of cooperating firms. We still lack standardized indicators of prospective pairs of collaborators forming in particular technological areas; such indicators would greatly help in designing public programmes. A further line for future research relates to the importance of subjective measures of performance, for any assessment of success in collaborative R&D. The findings of the project strongly suggest that, when queried about their objectives to participate in collaborative R&D, firms tend to rank high issues like the establishment of new relationships, access to complementary resources, technological learning, etc. The subjective character of such aims makes their quantification and, thus, their empirical analysis difficult. On the other hand, however, such objectives must be taken into account in any analysis that attempts to reasonably approximate the true extent of the diverse benefits and costs involved in technological cooperation.

1. EXECUTIVE SUMMARY

1.1 Focus of the Study – Research Questions

This study appraises cooperative resea rch and development in the European Union. The analysis is empirical, based on a large body of data specifically built for it. The research questions relate to the motives of firms to participate in research joint ventures and the private and social impact s of these ventures. The results of the study have direct policy implications. While policy considerations permeate the report, the policy suggestions resulting specifically from this research are laid out at the end of this section and at the last section of the concluding chapter of this document.

The project dealt with various forms of cooperative research activity:

i. EU-funded cooperative R&D, primarily of a pre -competitive nature, generated by a top-down procedure, activated by the Commission, and imple mented through the Framework Programmes for RTD.

ii. Cooperative R&D for the development of marketable products and services, generated by a bottom-up procedure, selected by EUREKA, and usually subsidised by national governments. Getting the "Eureka label" for a project and granting public funding for its implementation differs between EU countries.

iii. Nationally-funded cooperative R&D, generated by a top -down procedure, where part of the subsidies may be EU funds channelled through national agencies.

The partnerships in the first two categories involve partners based in two or more European countries. The majority of the partnerships in the third category involve partners based in the same country. An important characteristic of all examined partnerships is that a t least one partner is an industrial firm. A significant number of these partnerships also include academic institutions and other public research organisations.

A very extensive data collection enterprise was launched to support the multi -faceted empirical analysis. The result was the creation of the **STEP TO RJVs Databank** made of several different databases and a large number of case studies carried out by the partners of the consortium. Based on such data, the project explored the following issues:

- What is the scope and extent of subsidised R&D collaboration in Europe?
- Why firms and other organisations collaborate?
- How firms and other organisations collaborate in R&D activities?

- What is the outcome and the overall economic impact of R&D collaboration?
- How can R&D collaboration serve specific S&T policy objectives (and vice versa)?

The fundamental questions this research project dealt with are the following:

- To what extent does R&D cooperation promote technological progress?
- Do cooperative R&D agreements, considered as a strategic tool, assist firms to redefine industrial boundaries and create new market opportunities?
- Do the institutional set-up, the market organisation and other structural factors facilitate cooperation in R&D?
- To what extent do cooperative R&D agreements promote the transfer and creation of knowledge across organizations?
- What type of policy initiatives may improve the effectiveness of R&D cooperative schemes?
- What is the importance of public funding in undertaking the R&D cooperation? In other words what if public funding was not available?
- What has been the role of cooperative R&D in advancing the competitiveness of European industry and European socio-economic cohesion?

1.2 Policy Development Background and Study Rationale

About a couple of decades ago, the debate about international economic competitiveness started focusing on what was considered to represent a new form of business self-organization for undertaking uncertain and complex business activities. Cooperation was considered to offer new capabilities to the private sector, especially in the form of allowing greater flexibility in an era of increasing international competition. Soon, economists and policy makers were proclaiming that cooperation allowed society to break free from the long recognized market failure in R&D by restoring (at least partly) the incentives of firms to engage in an activity that is uncertain, risky, increasingly expensive, and whose results are usually only imperfectly appropriable by any single organization.

Everybody agreed that basic research is pretty close to a public good and that its funding is the obligation of the government. Almost everybody also agreed that development research, meaning the very applied part of the research activity leadin g to specific products and process, is largely the responsibility of the private sector. Where there was (and still is) disagreement is in the gray area between the two, a murky space that some say is small, some say it is large, and many believe that it i s of variable proportions that change with the characteristics of the industry and technology. This area was appropriately named pre -competitive, or generic, research. This research was considered imperative for competitiveness but subject for serious mark et failures.

The debate was thus fairly clearly cast on the basis of competitiveness and market failure. It resulted in a series of very important policy changes on both sides of the Atlantic. In 1984, the European Union officially put in place what would become its main instrument of science, technology, and innovation policy: the 4 -year Framework Programmes for Research and Technological Development. The cornerstone of these programmes has been support for cooperative R&D, since the beginning proclaimed to be focused on precompetitive R&D. A year later, the much publicized EUREKA programme was set up in Europe in which all EU member states, the EU Commission, and other countries became members. Again collaborative R&D was the objective, only that this time the D was emphasized much more than the R. In contrast to the Framework Programmes for RTD, EUREKA did not subsidize R&D. EUREKA selected worthy collaborative R&D projects – thus, raising their chances for getting funded at the national lev el or by the private sector. EUREKA projects were supposed to focus on the development of specific products and processes and, thus, be complementary to those funded by the Framework Programmes. Independently, national governments across Europe also increa sed their support of cooperative R&D.

Also in 1984, and exactly on the same conceptual grounds, the Congress of the United States passed the National Cooperative Research Act (NCRA) that provided antitrust protection to cooperative (generic) research. At the same time (early 1980s), the United States embarked on a serious effort to overhaul its competition system – trying to make it less punishing to cooperation that, even though somewhat suspect at present, alluded to

greater innovation efficiency and bet ter “future markets” – and its intellectual property rights system – in terms of strengthening the protection of intellectual property ownership. Both changes facilitated inter -firm collaboration.

The basic policy changes have remained. Significant politi cal and economic events during the intervening time period, however, have affected the raison d’etre of these policies. On the one hand, the European Union already has five additional members and is currently preparing to accept several more. Economic cohesion between the “center” and the “periphery” has thus become a larger issue in the Union than ever before. Moreover, several years of economic upturn have not managed to eliminate high rates of unemployment in Europe. Employment of Europeans has become a major policy concern. Overall , then, as competitiveness concerns receded somewhat in the European Union, concerns of employment and economic cohesion between member states have strengthened.

On the other hand, the United States has enjoyed the longest time period of continuous, stron g economic growth in its history, achieving full employment for the largest part of the 1990s. Meanwhile, Japan, projecting the major competitive threat for both European and American industry in the late 1970s and throughout 1980s, has reeled under prolon ged economic recession during the 1990s. In other words, the “competitiveness lobby” has lost ground in the United States without any other significant replacement.

The rationale for cooperative R&D has changed accordingly. In the European Union, the competitiveness and market failure rationales have been joined with the cohesion and employment rationales for supporting RJVs. This has created some uneasiness among policy analysts who have argued that there may be a trade -off between competitiveness and coh esion which may decrease the effectiveness of the Framework Programmes for RTD. Only the market failure rationale remains in the United States. Japan, a staunch supported of cooperative R&D in its catch -up phase, has been distracted by its economic problems and has not paid much attention to the potential impact of cooperation on the needed structural change beyond facilitating the link between industry and universities and the strengthening of the latter.

Such a time is actually good for taking stock. Thi s study has tried to create a large source of data and use it to appraise the motives for and effects of cooperative R&D in the European Union and several of its member countries. In finalizing our research hypotheses, we took into consideration the main p olicy concerns above and the important questions raised in the economics and business literature.

1.3 Definitions

The research project concentrated on one kind of strategic technical alliances that we call research joint ventures (RJVs). RJVs are defin ed as (temporary) organisations, jointly controlled by at least two participating entities, whose primary purpose is to engage in cooperative R&D. Equity investment may or may not be an issue and usually it is not

Most of the examined RJVs are essentially contract based agreements between independent entities. Member entities may include firms, universities and other government organisations.

The project only dealt with RJVs involving at least one participant from the private sector. When more than one firms are involved, both horizontal RJVs (between competitors) and non-horizontal RJVs – vertical (upstream-downstream) and conglomerate (other combinations not vertically related – were included. While this definition is broad enough to include both governme nt-subsidized and private, non-subsidised cooperative R&D agreements, in practice our data sets include RJVs subsidised by government funds, at least in part.

1.4 Analytical Approach

The empirical analysis in this project was firmly based on prior economic, business, and policy literature. This literature has indicated a long list of potential benefits and costs to cooperative R&D. Potential benefits to participating organizations include:

- R&D cost sharing;
- Reduction of R&D duplication;
- Risk sharing, uncertainty reduction;
- Spillover internalisation;
- Continuity of R&D effort, access to finance;
- Access of complementary resources and skills;
- Research synergies;
- Effective deployment of extant resources, further develop ment of resource base;
- Strategic flexibility, market access, and the creation of investment “options”;
- Promotion of technical standards;
- Market power, co-opting competition;
- University and research institute research better attuned with private sector inte rests.

Potential costs to RJV participants include:

- Actual resources devoted to the cooperative R&D activity;

- Incompatibility with company (or university) interests;
- Delay of technological advance (due to collusion);
- Loss of control to a vital technology.

Cooperative R&D also creates social benefits (and costs) that accrue to non-participating organizations and the rest of society. Social benefits may be the result of:

- Knowledge spillovers to non-participants;
- Increased industrial competitiveness;
- Increased levels of competition;
- Favorable changes in investment behavior;
- More efficient establishment of technology standards;
- Broad socio-economic benefits as a result of structural adjustment, employment, etc.;
- Increased economic cohesion between European regions.

Potential social costs may be the result of:

- Anti-competitive behavior;
- Limiting the number of R&D approaches to uncertain technological problems;
- Creating dependencies on public resources;
- Wasting taxpayers' money.

The insights of prior research were synthesised in five broad topical areas that this research project dealt with:

- Trends in RJV formation in Europe; characteristics of RJVs and participating organisations.
- Determinants of RJV formation.
- Performance of the RJV per se.
- Impact on firms participating in the RJV.
- Meso- and macro-economic level impacts for Europe, including competitiveness and cohesion.
- Development and comparison of policies promoting RJVs in Europe, the United States, and Japan.

The research methodology involved four kinds of activities.

- First, an extensive bibliographic analysis of policies regarding RJVs at the EU level, the seven represented EU-member countries, the United States, and Japan. This analysis covered current policies as well as their recent historical development in three areas: science and technology policy, competition policy, and intellectual property rights policy.

- Second, a very extensive data collection exercise was launched that resulted in what could be the largest and most detailed single source of inf ormation on subsidised RJVs in the world (see below).
- Third, this data was used for extensive empirical analysis, including (a) statistical analysis of RJVs and RJV participants' characteristics, objectives and strategies, and (b) econometric analysis of t he determinants and impacts of RJVs. In addition, a large number of case studies of individual RJVs were carried out.
- Fourth, the results of the empirical analysis were used to assess the overall effectiveness of policies regarding RJVs in Europe and to dr aw lessons for future policies.

One of the most formidable undertakings in this project involved a multi -faceted data collection exercise, which, arguably, proved one of the project's most successful undertakings. The outcome is the **STEP TO RJVs databank**, which contains seven databases, three international and a set of four national databases.

EU-RJV database. It contains information on transnational RJVs established under the first four Framework Programmes for RTD up to the end of 1996. It contains info rmation on all RJVs with at least one participant from the private sector supported by 64 different programmes that include all commonly known programmes and many more. When all is told, the current version of the database includes 6,300 usable RJVs with 1 2,730 participating organisations from 42 countries. It also contains information for a large number of the identified private sector participants.

EUREKA-RJV database. The EUREKA-RJV database includes all RJVs that have been chosen and promoted under the EUREKA label during 1985-1996. RJVs with a member from the private sector have been included in the database. They amount to 1,031 RJVs, which have been set up by 4,261 organisations from 36 countries.

National RJV databases. Four national databases have been created with information on RJVs sponsored (fully or partially) by national sources since the mid -1980s in Greece,

Spain, Sweden, and the United Kingdom. Coverage of publicly funded RJVs in these countries is not exhaustive (with the possible exception of Greece), however, which limited the use for comparative purposes in this project. Nonetheless, the four national databases can be considered however as a unique source for these countries.

RJV Survey database. This database contains the results of a wide-ranging survey of firms that have engaged in one or more RJVs. The survey sample firms that have participated in a mixture of EU-funded, EUREKA, and nationally funded projects. It was conducted in the seven countries represented in this project – France, Greece, Ireland, Italy, Spain, Sweden, and the United Kingdom. In all, completed responses were obtained from 504 firms relating to 636 RJVs. The available information relates to strategic motives to cooperate in R&D, factors that affect the choice of partners, the type of knowledge created, learned, and transferred between partners as well as the learning mechanisms, expected benefits from collaboration and the extent to which they were fulfilled.

A fifth source of information was also used in this project. This information came from 21 case studies of RJVs led by firms based in the seven countries represented in this consortium. The case studies provided important detailed information addressing the context of collaboration and the process and timing of events. In particular, case studies focused on the origins and objectives of the RJV and participating organisations, RJV organisation and relationship to member firm strategy, working relationship among partners; RJV results and impact on participants, and commercial exploitation of cooperative R&D outcomes,

1.5 Main Results and Policy Implications

Chapters 3 and 4 of this report provide detailed accounts of the study results, listed in terms of the five broad topical areas addressed by this research: trends and determinants of RJV formation, RJV performance, impact on participating firms, industries and regions, and policies across the European Union as well as in the United States and Japan. In the remainder of this section we recount from Chapter 4 the synthesis of the empirical results with an eye on policy.

1. It is time to take stock of the widespread cooperative R&D in Europe.

Support for cooperative R&D in high-technology industrial activities is widespread in Europe. This compounds the already widespread practice of strategic technical alliances under private initiative. The process has created high expectations for increased competitiveness that has proven very difficult to show quantitatively until now. New policy expectations for cooperative R&D have also been introduced in the form of achieving social and economic cohesion among the EU's many different member countries and regions. This study took a first, bold step in the direction of empirical appraisal by employing a multi-faceted methodology to create and systematically analyze large amounts of empirical information. More needs and can be done.

2. Policy analysts need to consider long lists of benefits and costs to cooperative R&D.

Cooperative R&D creates private and social benefits and costs, listed in section 4 above. There are also direct and indirect benefits and costs from R&D cooperation. Direct benefits and costs are those linked directly to a cooperative R&D activity – e.g., the introduction of a new innovation, or the transaction costs involved in this activity. Indirect benefits and costs are the unintended by-products that often turn out to be very significant. For example, engaging in an RJV may not only result in the introduction of a new product but also the maintenance of certain capabilities internally that will allow the firm's presence in that technological area for time to come. Or, increased competitiveness in a particular industry segment may also boost the chances of client industries. It may also have other socio-economic benefits like employment and regional upgrading. The latter might be an interesting issue for future investigation.

Policy analysts should try to account for as many as possible of these in cost-benefit appraisals. Unfortunately, it is the private, and direct, benefits and costs that are relatively easier to determine within some acceptable range of accuracy. Social, and indirect, benefits and costs – that are, of course, in the interest of policy makers – are much harder to appraise.

3. The recently introduced approach of appraising the socio-economic effects of policy seems appropriate in the case of RJVs.

As a result of the fact that RJVs create direct and indirect, private and social benefits and costs, the analysis of the incentives of firms and other organizations to participate and the impacts of these RJVs necessitates multi-faceted and interdisciplinary approach. A strong case can be made for both objective and subjective measures of performance. Essentially, this means that socio-economic appraisal of incentives and impacts, is the most reasonable way to proceed.

4. Benefits (and costs) of cooperative R&D cannot be appraised solely on the basis of objective measures of performance – such as financial data for firms. Subjective measures of performance are at least as necessary.

Experts have struggled with thorny issues regarding both methodology and measurement of the outcomes of collaboration. The long-standing debate on whether financial or other objective measures of performance – such as partnership survival, duration, and stability – should be preferred over subjective measures of performance has been at the forefront of attention. Much of the problem resides in the controversy concerning the measurement of organisational performance in general. Difficulties get compounded in the case of hybrid organisational forms where, not surprisingly, there is no consensus concerning both the definition and measurement of performance. There is no clear definition of partnership success. There is disagreement on whether objective (e.g., profitability, growth, duration) or subjective measures of success are more appropriate in appraising success. Objective measures are more widely available. However, objective measures may not adequately reflect the extent to which a partnership achieved its short and long-term objectives, which are often diverse. Even when subjective measures can be constructed, there is difficulty in assigning values to individual measures of success for the partnership as a whole. Various partners usually have different expectations from the same partnership, thus making several authors argue against generalising from one partner's evaluation. "Triangulation" of partner evaluations has thus been suggested.

When queried, firms often tend to rank their objectives to participate in collaborative R&D quite differently than standard theory would anticipate. In fact, they rank "soft" objectives pretty highly; of the kind that economic theory has had problems to appraise them. For example, highly ranked objectives by firms in this study include: (a) establishment of new relationships; (b) access to complementary resources and skills; (c) technological learning; (d) keeping up with major technological developments. Such objectives are difficult to quantify accurately.

All in all, problems in combining objective and subjective measures of partnership performance abound. It is beyond doubt, however, that the use of subjective measures of performance is unavoidable if we are to reasonably approximate the true extent of the

diverse benefits and costs involved in cooperative R&D agreements (and strategic alliances more generally).

5. As it occurred from the analysis of the project results, the most frequent participants in RJVs are large firms although the majority of participating firms are basically SMEs. It was also evident from the survey results that firms participating in RJVs tend to operate in a business environment characterised by technology and product-features based competition.

6. There is a fixed cost involved in collaboration. Government programmes can assist creating the preconditions for new comers – especially smaller firms – to be successfully integrated into RJVs.

The parties willing to enter a transaction must be able to create a mechanism to provide the necessary incentives to perform to expected standards. The way RJVs may achieve such a mechanism is by creating a "mutual hostage" situation through the commitment of resources by all partners. To the extent that the agreement is one of a kind for the specific partners, the RJV will require significant commitments of specialized resources by each and every one of them. Smaller firms, often lacking reputation and market credibility when trying to enter their first RJV, will need to compensate with a significant resource commitment. On the contrary, the presence of multimarket and multiproject contact between partners (firms "meeting" each other in many markets and many partnerships) may easily create the necessary preconditions for mutual forbearance between partners, freeing them from the burden of significant resource commitment. Such conditions require diversified and larger firms with presence in various present and future markets. The implication is that firms that lack significant resources need them the most in order to be accepted in RJVs. Cooperative R&D programmes could be tailored to assist SMEs create the necessary "capital" in their first steps to collaboration.

There is also a fixed cost involved in R&D activity. This is especially important for the "cohesion" countries that often lack significant resources for initiating research activities. Funded cooperative agreements offer the possibility for achieving a critical mass of R&D, not only because of subsidizing this fixed cost but also because actors from Southern Europe become networked with other organizations and establish channels for knowledge transfer and for keeping up with technological developments.

7. Benefits obtained from collaborative R&D increase with the internal (independent) capabilities and research activities of firms.

Evidence in this study strongly confirms earlier results indicating that knowledge in the public domain does not benefit everyone equally. Two conditions are required: (a) a willingness to learn and (b) an ability to learn. Earlier work has shown that, in addition to creating new knowledge, R&D is useful for maintaining/increasing the ability to learn from others. Translated in the context of RJVs, internal R&D, perhaps even parallel R&D projects, increase the benefits from R&D undertaken cooperatively. Active monitoring (willingness to learn) also works in the same direction.

By offering the possibility to the different organizations to achieve a critical mass of R&D resources, funded cooperations help them to improve their capabilities, at least in doing R&D. Considering the positive correlation between capabilities of the firm and benefits obtained from the R&D undertaken

through cooperation, it might be correct to argue that the participation for the first time in a subsidized RJV may become a positive factor for continuation in successful R&D cooperations.

8. Learning capabilities and objectives of R&D cooperation.

In an effort to account for the apparently differential benefits that some partners in RJVs are able to obtain compared to others, this study related each of three broad categories of benefits (product development, process, knowledge base) to a long list of learning mechanisms. The mechanism of undertaking internal, independent, and related R&D was strongly correlated with all three types of benefits. Benefits to the knowledge base correlated with all other learning mechanisms. [1] Similarly for product development benefits (with only one exception), particularly so with developing formal and informal relationships with users and/or suppliers. Process development benefit was positively correlated with learning by imitating other firms. In all cases, ability to learn was important for reaping benefits from cooperative R&D. The lesson for public policy is that innovation involves complex processes that require attention not only to "technology push" factors – the traditional focus of technology policy – but also to "technology pull" factors (technology user).

9. Trust is a major factor in inter-organizational collaboration. Mutual trust among prospective partners lowers transaction costs and increases the desirability of an RJV. Tailoring government programmes to "underwrite" trust can prove a real booster for R&D cooperation, particularly for firms with lesser amounts of market reputation and goodwill (such as new technology-based firms (NTBFs)

Trust between partners plays a crucial role in cooperation. By lowering transaction costs, trust makes partnerships more desirable. Trust-building, however, is a process dependent on reputation and prior interaction. It is not accidental that this and other studies have found a strong, positive relationship between prior engagements in collaborative R&D activities and tendency to do it again. The reason is that frequent RJV participants use their reputation as good, trustworthy for lowering their direct resource commitment in later deals and in enticing new partners. It is also not accidental that firm size has a strong, positive relationship with RJV participation – the effect comes through reputation. Governments may have a critical role to play in assisting newcomers (especially SMEs) create the necessary "reputation capital" and obtain the necessary resources in order to be accepted to the club.

10. There is a great need to better understand the factors that determine pairs of cooperating firms. While studies like this one are all about this subject, we still lack standardized indicators of prospective pairs of collaborators forming in particular technological areas. Such indicators would greatly help in designing public programmes.

This project pointed out some of the variables that could be used to create standardized indicators of likely pairs of collaborators. Such essentially variables match the characteristics of pairs of firms that have ended up collaborating in the past trying to extrapolate future collaboration patterns. They include the sector(s) of the firms in the pair, the relationship between their products, and the extent to which the firms are symmetric. Several other characteristics could also be tested. A particularly useful exercise may be to test the extent to which the defined relationships between characteristics hold as firms tie up more and more often within individual technological

[1] Thus, confirming from a different angle the argument for direct and indirect benefits, requiring both objective and subjective measures of performance to be properly accounted for.

areas. Being able to anticipate more accurately the likely participants to RJVs should promote better delivery of public programmes to the targeted populations.

11. The design and governance of government programmes supporting co operative R&D is important in determining the effects on industry.

The different design and governance of Framework Programmes and EUREKA have resulted in different sets of RJVs and differential effects on industry. While the evidence in this project cannot be considered conclusive, there was evidence nonetheless of: (a) relatively different features between the two sets of RJVs, (b) pairs of collaborating firms with differential objectives, and (c) confirming expectations, more short term productivity effects for EUREKA RJVs than Framework Programme RJVs. National programmes also seemed to owe their relative success to their particular institutional set-up and clear delineation of objectives. Such findings underline the importance of the design and governance of a programme for achieving its objectives. Indirectly, it also underlines the importance of using differential approaches to appraise programmes with different objectives.

12. **Is public funding necessary? This perennial question of government policy was answered positively in this study with respect to the formation of RJVs.**

A total 456 firms answered the question in the survey relating to alternatives, had public funding for the specific RJV not materialised. Almost two thirds reported that they would not have undertaken the specific research without government funding. For between two thirds and three quarters of the respondents, the specific cooperative R&D related to their core business activity.

Standing on its bottom, this information may be significantly discounted because it is based on the subjective evaluations of the respondents to the survey. It gets additional weight when combined with the discussion on points 4 and 5 above. Public funding may be more important for some kinds of firms than others. The finding also receives additional credibility when there is evidence that the R&D supported by public funds has latent public good characteristics. Public funding is more important for some kinds of research than others. Attention to SMEs and focus on pre-competitive research would seem to fit the bill.

Government funding is not only important for its resource aspect, however. Confirming earlier work in the United States, case studies showed that larger, more sophisticated firms frequently participate in publicly underwritten cooperative R&D programmes not for the money as such but for the ability to reach partners considered valuable. In other words, public programmes may create the institutional framework that makes collaboration possible. One way this can happen is through the implicit guarantee of acceptable behavior by all partners in the presence of the public authority as an arbitrator.

Such a guarantee could, for example, allay the fears of smaller firms that may feel intimidated to collabo rate with much larger counterparts, being afraid of losing control of critical knowledge to them. Another way this can happen is by making available the minimum necessary resources for enticing smaller, valued partners to participate in the RJV.

13. Established networks have been observed in the European area between participating firms. It can be argued that network formation is an effective mechanism for transforming the European knowledge and for promoting economic cohesion. Three major networks in European industry thus emerged in the auto industry, the aerospace industry and the electronics /telecommunications industry.

14. Improving research links between universities and public research institutes and industry has become a policy priority in Europe. RJVs are an appropriate vehicle for such interaction.

When it comes to research, there is a difficult trade -off in the relationship between industry and universities. On the one hand, they do not usually see each other as direct competitors and consider that they have complementary capabilities and resources. On the other hand, the extensive differences in the incentive systems of the two kinds of organizations make collaboration difficult. Complementarities induce cooperation: knowledge and experiences are exchan ged more easily among non -competing organizations. While there is never going to be a perfect match for as long as the incentive systems remain so different, industry and universities already collaborate extensively on R&D and more of it is expected in the future.

15. Firms often react to the opportunities (constraints) provided (imposed) by the institutional set -up and regulations (environmental, technical standards, etc.). Policy affecting these is also expected to indirectly affect R&D cooperation.

Firms try to adapt to their environment. One mechanism of adaptation is cooperation – indeed, strategic alliances are said to increase the flexibility of the private sector. Earlier research in the United States has shown that, in fields like environmental technologies,

RJVs are formed in reaction to (or anticipation of) regulatory changes. The case studies conducted in this project also found evidence to that effect.

16. Firms realize the value of complementary resources, strengths, and needs for reaping benefits from cooperative R&D.

The frequency of collaboration between firms with complementary resources, strengths and needs was underlined in this study as it has been before. An important reason tends to be the complexity of the product under development that requires complementary capabilities. Cooperation among firms operating in different, but related, sectors (such as telecommunications services and semiconductors) with different strategies and corporate cultures also facilitates the exchange of assets, skills, and experiences. In addition, it has long been understood that interaction between technology users and producers increases innovation efficiency. Moreover, firms that are not direct competitors will exchange information much more willingly than if they were. And so forth. The lesson for policy analysts is that they should look for such complementarities in designing and implementing cooperative R&D programmes as they are a major determinant of the success of collaboration.

That is not to say that competitors do not ever cooperate. Rather, it is to say that they will tend to cooperate in the limited set of circumstances that economic theory has predicted, including the establishment of technical standards and the undertaking of research that is subject to severe problems of appropriability. Standards and knowledge appropriability problems would, then, provide more appropriate foci for programmes aiming at horizontal cooperation between firms.

17. Firms do not appreciate cumbersome reporting requirements to public authorities and frequent policy changes.

Not surprisingly, several case studies showed complicated proposal submission procedures, cumbersome reporting requirements, and frequent policy changes to discourage collaboration.

18. Widespread collaboration in R&D can also have a downside in that it may promote anti-competitive behavior. Competition policy authorities must be vigilant.

Several results in this study indicated that the examined RJVs are largely the domain of large firms. While this may partially reflect exogenous preferences and/or capture, the finding is robust enough to suggest that absolute size facilitates RJV formation. The reasons may be many but they certainly include the existence of high fixed costs, learning (how to cooperate) costs, and transaction costs in setting up collaborative agreements. RJVs were also found to take place in more concentrated industries. While cooperative R&D agreements enjoy block exemption from antitrust consideration in the European Union, we feel that competition authorities would do well to actively monitor them.

A potential source of anti-competitive behavior, which this study did not explore systematically but some recent literature has called attention to, is the combination

of multimarket and multiproject contact. The idea is straightforward. Multimarket contact – referring to the fact that large, diversified firms often "meet" (compete) in many markets – increases the possibilities of anti-competitive behavior as both the benefits from collusion and the ability to enforce collusion increase with the number of markets in which two firms "meet". Multiproject contact – referring to firms "meeting" (collaborating with) each other multiple times through RJVs and other technical alliances – could also raise the chances for anti-competitive behavior. The argument is similar: both the benefits from collusion and the ability to enforce collusion increase with the number of future markets in which two firms expect to "meet". Importantly, however, whereas multimarket contact refers to existing markets multiproject contact refers to future markets (those to be opened as a result of current R&D). Compounded, multimarket and multiproject contact can have deleterious effects on competition.

It is our understanding that the possibilities of multimarket and multiproject contact have not been picked up by competition authorities around the world. This is partly a matter of availability of adequate information given that the analysis necessitates having the picture of the whole nexus of collaborative agreements of individual firms. Such a picture is what the STEP TO RJVs databank may help provide.

2. BACKGROUND AND OBJECTIVES

There is by now a large body of theoretical and empirical research establishing a relation between economic growth and technological innovation and providing a strong rationale for an active public policy to support industrial innovation. This has been partly reflected in the widespread interest shown by member states of the European Union in activities to support science and technology at both the national and the supra-national (EU) levels. In the latter case, such support has included direct subsidization of research and development (R&D) through the structural programmes and, since 1984, through the Framework Programmes for research and technological development.

A large body of economic and business literature since the early 1980s has argued that R&D cooperation can correct market failures and increase the rate of technology creation and diffusion in industry. [3] The basic rationale has rested on traditional market failure arguments emphasizing insufficient incentives for individual firms to undertake uncertain and imperfectly appropriable research at the socially optimal level. Other arguments have included better access to resources and markets. More specifically, frequently advocated *advantages* of cooperative R&D to private sector participants include:

1. R&D cost sharing;
2. Reduction of R&D duplication;
3. Risk sharing, uncertainty reduction;
4. Spillover internalisation;
5. Continuity of R&D effort, access to finance;
6. Access of complementary resources and skills;
7. Research synergies;
8. Effective deployment of extant resources, further development of resource base;
9. Strategic flexibility, market access, and the creation of investment "options";
10. Promotion of technical standards;
11. Market power, co-opting competition;
12. Legal and political advantages.

Some economists have also cautioned that collaboration may have a downside for the interests of individual private sector participants and for society's aggregate welfare. Potential *disadvantages* of R&D cooperation include:

1. Lack of compatibility with firm core technological interests;

[3] See Vonortas (1997a) for a review.

2. If subsidised, moral hazard raising doubts about the use of taxpayer money;
3. Limiting parallel approaches to uncertain technological problems;
4. Blocking competition and new mark et entry.

The evidence one-way or the other, however, has not been conclusive. With relatively few exceptions, theoretical analysis has not led to systematic, long ranging empirical work. A chronic problem has been the lack of extensive data sets on the r ate of partnership formation and the main partnership characteristics. This problem provided the initial motivation for the project. It was considered that the European and other countries' programmes to promote cooperative R&D have, by now left a trail of rich information that could be tapped to study the phenomenon of R&D collaboration in depth. The partners agreed to work towards:

(a) Creating possibly the largest publicly available source of empirical information on subsidized cooperative R&D; and
(b) Using th is source to investigate (i) the incentives and the strategic intent of European firms and other main actors to participate and (ii) the effects of the collaboration, and to contribute to the debate concerning the public policies promoting cooperative R&D activities.

The general objectives of the project were the following:

- To describe the evolution of RJV formation and of the related policies in:
  (a) The European Union as a whole;
  (b) A representative sample of seven EU member states and compare the experience wi th that of the USA and of Japan.
- To examine the impact of the European research joint ventures (RJVs) on individual enterprises, industrial clusters and sectors, regions and countries. Such findings were to create the basis for an overall assessment of the interplay between EU and the national policies towards RJVs.
- To evaluate the effectiveness of the implemented RJV policies in promoting a number of policy objectives such as competitiveness in high-tech industries, employment creation, skills upgrading, s mall and medium-sized enterprises (SMEs) access to the RTD system, economic and social cohesion.
- To examine the relationship between policies directly related to RJVs and other policies at the European and national levels and, again, provide comparative an alysis with the USA and Japan. Special attention was to be paid to policies towards competition and intellectual property rights (IPRs) protection.

The project dealt with various forms of cooperative research activity:

iv. EU-funded cooperative R&D, primarily of a pre-competitive nature, generated by a top-down procedure, activated by the Commission, and implemented through the Framework Programmes for RTD.

v. Cooperative R&D for the development of marketable products and services, generated by a bottom-up procedure, selected by EUREKA, and usually subsidised by national governments. Getting the "Eureka label" for a project and granting public funding for its implementation differs between EU countries.

vi. Nationally funded cooperative R&D, generated by a top-down procedure, where part of the subsidies may be EU funds channelled through national agencies.

The partnerships in the first two categories involve partners based in two or more European countries. The majority of the partnerships in the third category involv e

partners based in the same country. An important characteristic of all examined partnerships is that at least one partner is an industrial firm. A significant number of these partnerships also include academic institutions and other public research organ isations.

Based on such data, the project explored the following issues:

- What is the scope and extent of subsidised R&D collaboration in Europe?
- Why firms and other organisations collaborate?
- How firms and other organisations collaborate in R&D activities ?
- What is the outcome and the overall economic impact of R&D collaboration?
- How can R&D collaboration serve specific S&T policy objectives (and vice versa)?

The fundamental questions this research project dealt with are the following:

- To what extent does R&D cooperation promote technological progress?
- Do cooperative R&D agreements, considered as a strategic tool, assist firms to redefine industrial boundaries and create new market opportunities?
- Do the institutional set-up, the market organisation and othe r structural factors facilitate cooperation in R&D?
- To what extent do cooperative R&D agreements promote the transfer and creation of knowledge across organizations?
- What type of policy initiatives may improve the effectiveness of R&D cooperative schemes?
- What is the importance of public funding in undertaking the R&D cooperation? In other words what if public funding was not available?
- What has been the role of cooperative R&D in advancing the competitiveness of European industry and European socio -economic cohesion?

3. METHODOLOGY AND RESULTS

This section has four parts. The first defines the examined research partnerships. The second summarizes the theoretical approaches that were used to provide the basic working hypotheses. The third lays out the methodology that underlies the construction of the extensive databases that supported the empirical analysis. Finally, the fourth section summarizes the main empirical findings of the project on the basis of the major research questions.

3.1 Definitions

In the mid 1980s, an OECD publication gave what could be considered a classic economic definition of joint ventures. Joint ventures were defined as activities "…in which the operations of two or more firms are partially, but not totally, functionally integrated in order to carry out activities in one or more of the following areas: (i) buying or selling operations; (ii) natural resource exploration, development and/or production operations; (iii) research and development operations; and, (iv) engineering and construction operations." (OECD, 1986). Joint ventures had been generally considered to involve equity participation by the parents of the new organisation.

The proliferation of inter-firm cooperative agreements since the early 1980s, however, required new definitions of cooperation. The term inter-firm "strategic alliance" was invented. According to one definition, a strategic alliance is a web of agreements whereby two or more partners share the commitment to reach a common goal by pooling their resources together and coordinating their activities (Teece, 1992). An alliance denotes some degree of strategic and operational coordination and may also include things such as technology exchanges, exclusionary market and manufacturing rights, and co-marketing agreements. Strategic alliances **may, or may not, involve equity investments** and include JVs as a special form. Oster (1994) defines a strategic alliance "quite broadly to include any arrangement in which two or more firms combine resources outside the market in order to accomplish a particular task or set of tasks." A narrower set

of alliances are the so-called strategic technical alliances (STAs), focusing on the generation, exchange, and/or adaptation of technical advances.

This project concentrated on a subset of STAs that we call research joint ventures (RJVs). RJVs are defined as organisations, jointly controlled by at least two participating entities, whose primary purpose is to engage in cooperative R&D. Equity investment may or may not be an issue and usually it is not. Most of the examined RJVs are essentially contract based agreements between independent entities. Member entities may include firms, universities and other government organisations. The empirical analysis only involved RJVs with at least one participant from the private sector. When more than one firms are involved, both horizontal RJVs (between competitors) and non-horizontal RJVs – vertical (upstream-downstream) and conglomerate (other combinations not vertically related – were included. While this definition is broad enough to include both government-subsidized and private non-subsidised cooperative R&D agreements, in practice our data sets include RJVs subsidised by government funds, at least in part.

Thus, this project concentrated on a certain kind of R&D partnerships, i.e. government-funded cooperative R&D agreements involving the generation/adaptation (but not simple exchange) of new technological advances, broadly defined to include both pre-competitive (generic) and development (near market) knowledge as well as the definition of standards. Accordingly, the results are not strictly comparable to the results in the much wider literature on strategic technical alliances [4].

3.2 Conceptual Foundation of RJVs

One of the major aims of this project was to utilize different theoretical perspectives and to create different data sets using a variety of data collection tools and sources of information (data bases, surveys, case-studies) in order to study the multidimensional

[4] Even a partial list of this literature would be a long one. Some of the better known references include Alic (1990), Chesbrough and Teece (1996), Contractor and Lorange (1988), Coombs et al. (1996), Culpan (1993), Dodgson (1993), Doz (1992), Gerlach (1992), Gomes-Casseres (1996), Hagedoorn (1990, 1995), Hagedoorn and Schakenraad (1990, 1992), Harrigan (1986), Hladik (1985), Kogut (1988), Lewis (1990),

phenomenon of the RJV formation from different angles. This combined approach aimed at achieving a better understanding of the creation of RJVs as well as the relevant policy implications. In this context, the starting point of our research effort was the development of the conceptual foundation of RJVs based on a survey of different theoretical approaches to the collaborative R&D activity. The following sections are based on two working papers prepared by Caloghirou, Vonortas, Kastelli (1998) and Katsoulacos and Ulph (1998) respectively (see Annex).

3.2.1 Theoretical Perspectives of R&D Collaboration

The theoretical approaches to the formation, development, and impact of R&D cooperation can be categorised into three main streams:

- The mainstream microeconomics paradigm, including the formal industrial organisation literature and the transaction cost perspective.
- The evolutionary approach, emphasising the role of institutional, structural and historical factors that influence the behaviour and performance of the firm. In this context, the importance of technological and organisational learning and networking is being stressed.
- The business management and strategy literature, emphasising the role of resources, capabilities and competencies of the firm in creating competitive advantage.

These three theoretical approaches combined with the research policy literature related to the effectiveness of EU R&D funding policy [5], provided the basis for identifying the key issues to be studied in this project.

The distinction between these three categories is not always as sharp as it may seem at first. For example, one cannot ignore the significant overlaps especially between the second and third approaches. In addition, there is significant overlap of "intent" between the first and the second approaches, meaning that, besides the focus on the firm as a unit of analysis, they share a strong interest on conclusions regarding market/industry

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Link and Bauer (1989), Narula (1998), Mody (1993), Mowery (1988), Mytelka (1991, 1995), Rothwell (1991), Rothwell and Dodgson (1991), Yoshino and Rangan (1995).

structure and policy implications. The following two subsections summarise some important conclusions of the mainstream economic and management approaches with respect to these alleged RJV advantages and disadvantages. The pertinent basic concepts from the evolutionary approach have been subsumed in the strategic management subsection.

3.2.1.1 Mainstream Microeconomic Theory on RJVs

Transactions Cost Approach

A natural starting point for explaining the existence of RJVs is the theory of the firm. A formidable branch of the theory of the firm is transaction cost economics that was founded on the classic question of Coase (1937) concerning the determinants of the boundary between the market allocation of resources among firms and the administrative allocation of resources within a firm (Williamson 1975, 1985). According to this school of thought, entrepreneurs will try different ways to organise a transaction, including displacing the market by an administrative hierarchy (internalisation). The most economically efficient organisational design will ultimately prevail, assuming a market with no external interference. The boundary between the market and the firm will be determined by the relative costs of carrying out a transaction under each organisational structure. Where an administrative organisation (a "hierarchy") is expected to produce the highest return, arm's-length markets will be displaced and vice versa. Markets adapt with the help of prices. Hierarchies adapt mainly by command.

More recently, theorists have begun to explore alternative forms of adaptation involving cooperation among organisations (Menard, 1996a, 1996b; Williamson, 1996). These hybrid forms of organisation are subject to mild forms of command based on mutual agreements. RJVs fall into this hybrid organisational category.

[5] See, e.g., the special issue of Research Policy on EU Research funding policy (issue 27, 1998) and the Peterson and Sharp (1998).

In order to explain RJVs one must determine why such organisations may have a cost advantage over either the market or a hierarchical mode of operation for the specific type of activity. The students of transaction cost theory postulate that the underlying reason relates to transaction costs, referring to the expense incurred for writing and enforcing contracts, for haggling over terms and contingent claims, for deviating from optimal kinds of investments in order to increase dependence on a party or to stabilize a relationship, and for administering a transaction." (Kogut, 1988, p.320). Transaction costs increase steeply when contracts are incomplete, that is, when they do not specify fully the actions of each party in every contingency. A frequent cause of incomplete contracts is small number bargaining, usually a result of high asset specificity and high switching costs (Hart and Holmstrom, 1987; Williamson, 1975, 1985), which generates bilateral dependency, lock-in situations, and can induce opportunistic behaviour. Therefore, a basic prediction of this theory is that "in order to circumvent opportunism, the more specific assets are, the stronger is the incentive to integrate" (Menard, 1996a, p. 286). Interestingly, a firm might find it optimal to think strategically and internalise a transaction even if carrying out the transaction through the market is currently the cheapest way.

A form of assets that has frequently made it very hard, or even impossible, to write complete contracts is the intangible assets belonging to a firm. The most formidable intangible asset is technological knowledge. Such knowledge can be explicit, in the form of a patent or design, or implicit (tacit) in the form of know-how shared among the firm's employees.

A voluminous literature has shown that transactions in technological knowledge are subject to externalities, impactedness and opportunism, and significant uncertainty. All these factors will often inhibit writing complete contracts, making such knowledge a good candidate for market failure. The question then becomes whether markets are expected to fail to the same extent for all kinds of S&T knowledge. It does not take much to come up with a negative answer: different S&T markets will not fail to the same extent. In particular, generic (pre-competitive) research is expected to suffer from severe

appropriability problems (knowledge spillovers) turning it into a latent public good. The research to create generic knowledge is also typically very uncertain and is characterised by extreme impactedness. Such a combination of characteristics inhibits writing complete contracts. Specific practices, on the other hand, are on average much more appropriable, much less uncertain, much better focused, and have a much shorter time horizon for completion. Such characteristics have prompted the conventional wisdom that the market will work sufficiently well for them.

Mainstream Industrial Organisation Literature

Recent formal industrial organisation theory dealing with technological competition can perhaps be divided into two major methodological streams. One stream emphasises the "timing of innovation" where the winner of a "technology race" earns the right to some monopolistic return (tournament models). The analytical focus has been on determining the number of firms that enter the race, the aggregate R&D investment and its distribution across firms and time, as well as the effects of market power, technological advantage and technological uncertainty (Reinganum, 1989).

The second stream has concentrated on the "extent of innovation" (non-tournament models), usually approximated by the degree of cost reduction (Dasgupta and Stiglitz, 1980; Brander and Spencer, 1983; Spence, 1984) and, occasionally, product differentiation (Spence, 1976; Dixit and Stiglitz, 1977). Firms are assumed to invest in R&D in order to, for example, decrease costs and then compete in terms of prices or outputs in the product market. A large number of static (atemporal) analyses of both cooperative and noncooperative industrial set-ups with imperfectly appropriable, cost-reducing R&D have become available since d'Aspremont and Jacquemin (1988) published their seminal paper following this stream of thought. They include, for example, Spence (1984), Katz (1986), de Bondt and Veugelers (1991) , de Bondt, Slaets and Cassiman (1992), Kamien, Muller and Zang (1992), Suzumura (1992), De Bondt (1997), De Bondt and Wu (1994), Simpson and Vonortas (1994), and Vonortas (1994).

These papers investigate the relative efficiencies of competition and cooperation in R&D in raising final output production and enhancing social welfare.

In a nutshell, the major strengths of tournament models are the explicit role of time and uncertainty and their ability to handle both product and process innovations. An important weakness is that, by nature, these models relate more to discrete technical advances – which are in the minority – and may not be able to accommodate sufficiently well technological competition in cases where technologies are continuously upgraded but are not radically different than their predecessors. Technological knowledge accumulates over time and there is usually more than one winner in the race in the sense that at least part of the outcome of R&D is dispersed among or somehow benefits the different players. Relatively few of the available tournament models incorporate knowledge spillovers.

The strengths and weaknesses of the non-tournament models are almost the reverse. They link better to the case of continuously upgraded technologies. A large number of these models incorporate knowledge spillovers. Unfortunately, the bulk of the non-tournament literature has been confined to static (even though multistage) models of strategic interaction like those mentioned above and "naive" dynamic games (supergames) (Shapiro, 1989). While multiple-stage models constitute a useful first approximation, they cannot substitute for an explicitly dynamic framework. Supergames, where a one-stage game is repeated either eternally or for a fixed number of times while nothing carries from one period to the next, have also been proven less than entirely satisfactory. The relative scarcity of formal dynamic analysis of cooperative R&D seems to be a rather serious drawback of the non-tournament literature. Another is the sparse number of such models explicitly dealing with uncertainty.

On the whole, the mainstream industrial organisation literature has been concerned mainly with the following questions with respect to inter-firm cooperation in R&D:

- Are there any R&D characteristics that may induce inter-firm cooperation?
- To what extent are firms willing to exchange information in an RJV?

- Do firms prefer to collaborate in carrying out complementary or substitutive R&D?
- How do competition and cooperation in R&D compar e in terms of promoting technological progress?
- Do RJVs help bring us closer to the socially optimal level of R&D expenditure?
- Should we worry about the extent of permissible collaboration? When would encouragement (e.g., a subsidy) be appropriate?

The results have been sensitive to the modelling technique. This should be expected given the focus on oligopolistic industries that which differ in terms of market organisation and in terms of the process of technological advance. The latter extensively affect the industrial organisation, the strategic interaction between firms, and the objectives of inter-firm collaborative agreements. It is improbable that the one-fits-all theoretical model will be built any time soon. The rest of this subsection compiles so me important results in the literature by using four papers as a guide, including two tournament and two non-tournament models, that are fairly representative of the theoretical work until now.

In a tournament model of cooperation and competition in R&D, Martin (1994) assumes that symmetric firms "race" for the returns of a drastic/nondrastic innovation. They can pursue the innovation on their own or they can join an RJV. A major finding of this model is that the formation of an RJV will delay the expecte d time of successful innovation, as a result of a drop of overall R&D expenditures. However, given that the RJV participants compete in the product market following the innovation, the formation of an RJV will, in general, be socially beneficial by passin g more of the gains to the consumers. This is a direct outcome of the increased competition achieved through the RJV by requiring that the race winner shares all available information with the losers. Which, in turn, means that there are not sufficient in centives ex ante for firms to participate in such an RJV. In order to obtain the social benefits, the RJV must essentially be subsidised.

In a static non-tournament model of competition and cooperation in R&D, Simpson and Vonortas (1994) generalized the findings in much of the static literature on competition and cooperation in a context of imperfectly appropriable R&D and a two-stage Cournot setup. In this atemporal model, an arbitrary number of firms undertake R&D in the first stage and compete in outputs in the second stage. Again, only knowledge spillovers are considered.

It is found that aggregate investment in innovation in the noncooperative industrial setup can be excessive (more than socially optimal) in the absence of spillovers (see also Dasgupta ans Stiglitz, 1980). Even small spillovers, however, may lead to suboptimal private investment in R&D. Aggregate industry investment in innovation is found to be unambiguously suboptimal when rival firms form an RJV, that is, an organisation that allows them to cooperate in R&D while they continue to compete in the output market. An RJV may, however, lead to greater output and, hence, welfare than obtains under the noncooperative solution. This depends on the degree of convexity of the demand curve. The implied cost savings from the prevention of duplication in R&D expenditures may also be significant.

In a dynamic non-tournament model of competition and cooperation in R&D, Joshi and Vonortas (1997) have taken the non-tournament approach one step further. Their model introduces explicitly the element of time and more complicated firm strategies – whereby firms can react mid-way of the game to prior actions of their rivals – while maintaining the generality of the functional forms and the central role of knowledge spillovers. This dynamic framework is differentiated between the case where firms compete in R&D (as well as production) and the case where firms cooperate in R&D (and either compete or cooperate in production). Cooperation is studied under three different cooperative setups: one where firms simply decide jointly the level of their R&D investment (secretariat RJV); one where they also share completely the results of R&D (operating entity RJV); and one where firms cooperate in both R&D and output production.

The model demonstrates that some basic results from the static non-tournament literature concerning the impacts of RJVs on the behaviour of individual participating firms and on social welfare carry over into a dynamic environment. To summarise, it is shown that the rate of knowledge spillovers is positively correlated to the aggregate investment in R&D. An operating entity RJV maintains a higher level of aggregate investment in R&D than a secretariat RJV in every time period: that is to say, the closer the cooperative interaction between RJV participants, the greater the aggregate R&D investment for any initial stock of technical knowledge. Finally, it is shown that the R&D expenditure over time is increasing in the initial stock of technical knowledge. In other words, firms with more technological capabilities continue to spend more on R&D in the future. Industries with high stocks of technological knowledge benefit from cooperative R&D.

Finally, in a tournament model of knowledge sharing in RJVs and public subsidies, Katsoulacos and Ulph (1994, 1997) introduce endogenous knowledge spillovers (information sharing) in RJVs, the possibility that firms contemplating collaboration undertake complementary or substitutive R&D, and the ability of firms to exchange information without collaborating formally.

The stylised model focuses on the simple case where there are just two firms that might potentially form an RJV. These firms are allowed to be located either in the same industry, or in different industries and to pursue either complementary or substitute research. Three types of equilibria are examined. In the non-cooperative equilibrium firms choose their R&D and spillover parameters independently. In the cooperative equilibrium firms choose their R&D and spillover parameters to maximise joint profits, but there is no subsidy to R&D. Third, the social optimum is considered where a social planner chooses the R&D levels and spillover parameters to maximise social surplus. The following results are obtained under plausible assumptions.

Case 1: Same Industry; Substitute Research; Information Sharing

(i) Noncooperative equilibrium. Spillovers will always be zero.

(ii) Cooperative equilibrium. In the absence of any subsidy, firms will agree to share information only if industry profits are higher when both firms have access to the discovery than if one firm alone has access to the discovery. If no information is shared, then we have a case where cooperation does not automatically lead to full information-sharing. Firms will always be better off in this equilibrium than in the noncooperative equilibrium. So, as long as R&D cooperation is allowed, firms will choose to cooperate – even in the absence of a subsidy.

(iii) Policy implications. The social optimum involves full information sharing. If the cooperative equilibrium also involves full information sharing, then obviously if firms can get an R&D subsidy provided they share information, they will always apply for the subsidy. Is the R&D subsidy warranted? The answer is yes given that, in the absence of the R&D subsidy, the cooperative equilibrium is below the socially optimal level. Indeed, in the special case of process innovation and linear demands, a 50% subsidy is exactly the right one to apply. In this case, then, the policy of subsidizing R&D cooperation achieves the full social optimum.

The more interesting case arises when the cooperative equilibrium involves no information sharing. Here in deciding whether to apply for the subsidy, conditional on agreeing to share information, firms have to decide whether the loss from having to share information exceeds the gain from the subsidy. If they do decide to apply for the subsidy then, assuming again linear demand curves, the 50% subsidy will achieve the optimum. However if it is not worth applying for the subsidy, then the government by insisting that firms share information cannot achieve the social optimum. For if it raises the subsidy to induce correct information sharing then it distorts the R&D decision. So while this policy may achieve the social optimum there is certainly no guarantee of this.

Case 2: Different Industries, Complementary Research, Research Coordination.

(i) Non-cooperative equilibrium. Full research coordination.

(ii) Cooperative equilibrium. Full research coordination. If a subsidy is available to firms conditional on full information sharing firms will always claim it.

(iii) Social Optimum and Policy Implications. Full research coordination. The questi on that arises is whether the subsidy is justified since firms would have fully coordinated even in the noncooperative equilibrium. The subsidy would be justified if firms were underinvesting in R&D in the cooperative equilibrium. It is hard to say wheth er in general firms underinvest. One case where private sector underinvestment is certain is where there is process innovation, firms are monopolists in their industry, and demand curves are linear. The subsidy required to correct this is 1/3 – implying that a 50% subsidy will lead to overinvestment. So we see then that a policy of providing a 50% subsidy to R&D provided firms agree to share information can lead to the social optimum, though it will not always do so. Incidentally it is worth noting that most of the joint ventures that have actually been supported by the European Commission's policy seem to involve firms in different industries pursuing complementary research.

The basic theoretical message of the industrial organisation literature should be clear. The nature and magnitude of the impacts of collaboration in R&D will vary with respect to the market organisation, the strategic motives and interaction between firms, and the process of technological accumulation in an industry. Thus, while the extent of knowledge spillovers seems to be an important determinant of the willingness to cooperate, it is not necessarily the case that firms will draw benefits from such cooperation. The extent to which firms are willing to exchange information in an R JV varies particularly with the nature of the R&D (substitutive, complementary). Some models indicate that firms prefer to collaborate in complementary R&D, while others show private benefits in substitutive R&D as well. Concerning the extent to which R& D cooperation promotes technological progress relative to competition, the answer seems to be positive in the existence of high knowledge spillovers. Again, however, it could also turn negative in a different strategic environment. Cooperative R&D could c ertainly lead to social benefits, by inducing higher levels of aggregate R&D in an industry and lower

product prices. But the extent to which these benefits are to be expected varies with respect to the nature of both market interaction and the R&D itself. Finally, while more extensive forms of cooperation resulted in higher overall levels of R&D expenditure in some of the models, others showed that cooperation may well retard the speed of innovation, and yet others qualified their answer on the basis of t he nature of R&D. Subsidization of cooperative R&D was shown to be more useful in some cases than others. It could occasionally result in a waist of public money as well.

3.2.1.2. Strategic Management Approaches to Inter -firm Cooperation

Strategic management literature has been concerned with the relationship between corporate strategies and technological collaboration in the context of strategic alliances in general. A common characteristic of all strategic management approaches to alliance formation is their attempt to relate the decision to form an alliance with the corporate vision, goals, mission and strategy. Technological collaboration is considered as an essential source of a firm's competitive advantage.

Firms are considered as living organ isms that can take offensive or defensive action in order to shape their business environment or react to changes occurring there. The formation of technical alliances in a modern business environment where co -operation coexists with competition is conside red as a means of strategic change and of shaping competition. The co -ordination and sharing of the value chain with other partners, the joint creation of new value, the accumulation and reconfiguration of resources, the building of new capabilities and co re competencies and the organisational learning are crucial issues in the formation and operation of technical alliances as well as in the assessment of their outcomes and in the analysis of their impact.

Conceptual models of strategy formulation for tec hnical alliances are necessarily of multidisciplinary character, as they need to accommodate diverse elements. Lee and Vonortas (1998) identified six perspectives on technical alliance formation in the broader business and strategic management literature (besides transaction costs) including the competitive force approach, the strategic behaviour approach, the strategic network

approach, the resource-based view of the firm, the dynamic capabilities approach, and the strategic options approach.

The competitive force approach is based on the work of Porter (1980, 1985 & 1990) and has been applied by Harrigan (1988), Porter (1986) and Hagedoorn (1993) in the study of inter-firm co-operation strategy. The essence of this approach is the consideration of inter-firm collaboration as a means of shaping competition and improving a firm's comparative competitive position, by sharing value chains with other partners in a way that broadens the effective scope of its chain. In this context, inter-firm technological collaboration permits firms to react swiftly to market needs and allows them to bring technology to the marketplace faster.

The strategic behaviour approach focuses on the strategic action that a firm takes in order to influence its market environment i.e. to reduce competition by actual or potential rivals. This approach has been used to study strategic decision-making for inter-firm technological cooperation (Vickers, 1985, Porter & Fuller, 1986 and Hamel, Doz & Prahalad, 1989).

The strategic network approach is based on the network model developed by Hakkansson and Johanson (1984). The essence of this approach can be summarised in the following argument, proposed by Hakansson (1985): "An innovation should not be seen as the product of only one actor but as the result of an interplay between two or more actors; in other words as a product of a "network" of actors". As technological development is being considered as "the result of the interaction between different corporations, organisations and individuals" and "an integrated part of the structure from which it arises" therefore "networks can enjoy collective strengths beyond those of single firms and technology can serve as the nexus of a network strategy" (Lee & Vonortas, 1998). In this context, multiple co-operative relations of a firm can be the source of its competitive strength. In fact, networks allow the exploitation of economies of scale and scope, can lower transaction costs or raise transaction benefits - especially in cases where a high level of trust among partners is being established - and give the opportunity for the joint

creation of new value through technological development. As Jarillo (1988) argues: “the network arrangement allows a firm to specialise in those activities of the value chain that are essential to its competitive advantage”. Last but not least, the complexity of new technology as well as the convergence among technologies impose in many cases the need for technological collaboration and the creation of networks for new technol ogical developments.

The resource-based view of the firm is grounded on Edith Penrose’s (1959) seminal work where she stressed the role of the firm’s resources (financial, physical, human, technological, reputation, organisational) as the foundation of t he firm’s strategy. In this context, “the essence of strategy formulation is to design a strategy that makes the most effective use of the firm’s core resources and capabilities” (Glaister, 1996). The value of this approach for explaining inter-firm co-operative agreements was exemplified early in the 1970’s by Richardson (1972). In the case of closely complementary but dissimilar activities, the necessary coordination requires the cooperation of those concerned.

According to the resource-based view of the firm, the sources of sustained competitive advantage are firm resources that are valuable, rare, non-substitutable, and cannot be easily imitated. Thus, firms within an industry or a strategic group may be heterogeneous with respect to the strategic resou rces they control. This heterogeneity can be long lasting, as these resources are not perfectly mobile across firms. In this context, firm’s performance is based on the strategic differentiation that it can achieve in the marketplace, i.e., the firm’s uniq ue capabilities and its competitors difficulty in imitating them. In order to fully exploit the existing stock of heterogeneous and immobile resources and to develop sustained competitive advantages, access to external complementary resources may be necess ary. According to Teece (1986), the “full commercial rewards from innovation can only be achieved if firms can access “complementary assets” such as competitive manufacturing, distribution and marketing.

Given that in a continuously changing business env ironment the development of the firm’s resource base is the only way to sustain a viable competitive advantage, a

fundamental question should be raised regarding the methods of developing the resource base of a firm. There are three methods for developing the resource base of a firm (Gleister, 1996): a) internal development of the resource base, b) external development through merger or acquisition and c) development of the resource-base through strategic alliances. In sum, the resource-based view of the firm establishes a rationale for strategic alliances- and in particular strategic technical alliances - as a method of sustaining competitive advantage.

A prominent representative of the dynamic capabilities approach, D. Teece (1982, 1986, 1992) has developed a similar framework stressing the need for coordinating complementary assets that he distinguishes in specialised or co-specialised. He also speaks about the capacity of one party to appropriate the rents or quasi-rents of the innovation. Appropriability depends on the degree of complementarity and on the "regime of appropriability" which means the ability to create and enforce property rights in the in the innovation. The ability to appropriate rents will determine the extent of internal organisation.

The dynamic capabilities approach is a further elaboration of the resource-based view of sustained competitive advantage through collaboration, by introducing the concept of firm's capabilities. A capability is the capacity for a group of resources to perform a specific task or activity, as productive activity requires the combination, co-operation and co-ordination of resources. In that line, Prahalad and Hamel (1990) have introduced the term "core competencies" to refer to the central strategic capabilities of a firm. These refer to the "collective learning in the organisation especially how to coordinate diverse production skills and to integrate multiple streams of technologies". In particular, Hamel (1991) promotes a skills-based view of the firm by considering the firm as a portfolio of core competencies and encompassing disciplines. Inter-firm collaboration can be viewed as a mechanism of skill acquisition and skill building and upgrading.

A rapidly expanding literature dealing with learning processes can be tied to the dynamic capabilities perspective of collaboration (e.g., Kogut 1988, Ciborra 1991, Imai 1992,

Teece, Rumelt, Dosi, Winter 1992). One view of cooperation in this literature is as a potentially efficient mechanism for transferring tacit and firm specific knowledge through close linkages between different organisations. Another view of cooperation is as a vehicle for overcoming difficulties in integrating competencies and knowledge from unfamiliar areas (Ciborra, 1991; Dodgson, 1991; Grans trand et al., 1990). Two dimensions can thus be assigned to the cooperation: a driving force for learning and creating new knowledge and new competencies and a mechanism for diffusing and implementing new knowledge (Llerena, 1997). Inter -firm cooperation c an amplify knowledge beyond the boundaries of the firm. Knowledge created by an organisation can mobilise knowledge of affiliated companies, customers, suppliers, competitors and others through dynamic interaction (Nonaka, 1995).

The strategic options app roach suggests that an alliance which permits the incremental commitment of resources based on prior intermediate positive results might be more beneficial than precommitting the full expected cost of developing a new technology in a highly uncertain marke t and technological environment (Dixit and Pindyck, 1995). This approach is based on viewing strategy as "strategic options optimisation" (Sanchez, 1995). An R&D project can be considered as a series of options. Therefore, a company can choose to stop buyi ng subsequent options contingent on prior outcomes. In addition, knowledge acquired through technological collaboration increases on the one hand the number of the future options available and on the other enhances the capability of the firm to evaluate an d choose among alternative options. Since the value of technology options increases with uncertainty, the benefit from participating in RJVs might then be higher in emerging and highly uncertain fields.

More recently, experts have called for an integrated perspective on alliances (Yoshino and Rangan, 1995; Osborne and Hagedoorn, 1997). Following this line of argument, it can be argued that the motives of a firm for joining a strategic technical alliance can be categorised into six closely related strategie s (adapted from Lee and Vonortas, 1998):

1. Positioning – position within a product value chain or product space and/or position within a strategic network;

2. Efficiency – transaction cost minimisation, net profit effect by considering cost and revenue flows;
3. Strategic motives – entry deterrence and strategic commitment, redefining the boundaries of firm's market through innovation;
4. Organisational capabilities – internal accumulation of resources and capabilities;
5. Resource complementarity;
6. Strategic flexibility.

Finally, one cannot disregard the acceleration of international competition as a result of globalisation of both markets and sources of technology. Increasing breadth, tempo and scale of technology, decreasing product life and design time, increasing complexity of product requirements, and dispersion of the sources of technological knowledge have created an environment conducive to the formation of networks of alliances (Badaracco, 1991).

3.2.2. Impact of RJVs

RJVs are expected to have a significant impact on the participating organisations, their respective industries, and society at large. There are both positive and negative aspects to R&D collaboration that a balanced analysis of RJVs must consider.

RJV impact can be considered in terms of:

- The beneficiary: private or public organisation;
- The effects: direct or indirect;
- The time horizon: short term or long term impact;
- The level of analysis: firm (micro-economic level), industry/network (meson-economic level), and national/European (macro-economic level).

This project was premised on a balanced analysis of the incentives for and impacts of RJVs at all three levels of analysis: micro-, meso- and macro-economic levels. The following impacts overall were considered in setting up the research questions.

1.1.1.1. Micro-economic level impact

The literature has argued for the following potential benefits to private sector firms:

1. *R&D cost sharing.* RJVs allow firms to pool their resources to achieve critical mass and pursue more and larger research projects than any single company could afford.
2. *Reduction of R&D duplication.* RJVs can free resources by reducing duplication of effort among member firms.
3. *Risk sharing, uncertainty reduction.* RJVs pool risk – i.e., increase chances that the outcome will fall within a certain range of a known probability distribution – and thus raise firm incentives to undertake a certain kind of R&D. Risk is pooled directly at the RJV level (as a result of both a larger number of participants in a research project) and at the individual member organisation level (free resources can allow undertaking additional projects). In addition, firms frequently confront significant market and technological uncertainty, particularly for longer-term, strategic research. High uncertainty, meaning the lack of a probability distribution of expected outcomes, has a detrimental effect on private sector incentives. RJVs may lower such uncertainties by both spreading them among partners and by limiting the exposure of each one.
4. *Spillover internalisation.* Horizontal RJVs internalise knowledge spillovers, thus lowering the disincentive of the private sector to undertake inappropriable R&D. Vertical RJVs, incorporating important producers of and beneficiaries from new technological knowledge of a certain kind, can internalise spillovers that would be unchecked by the market. They can also raise the frequency and accuracy of communication between the two sides, thus raising the efficiency of innovation (von Hippel, 1988). Closer communication in both horizontal and non-horizontal RJVs may increase the efficiency of technology transfer.
5. *Continuity of R&D effort, access to finance.* RJVs can be in a better position than single firms to maintain the necessary continuity of R&D effort, particularly for long-

term projects. They can also raise the visibility of a research project and attract public funds (including government subsidies). Access to external finance is especially important for smaller firms and startups.

6. *Access to complementary resources and skills.* The resource-based view of the firm has stressed that the firm is characterised by its sticky and unique (i.e., difficult to imitate) collection of resources and capabilities.[i] Often, the successful research leading to a new product/service or production process and its successful market introduction requires the "co-specialised" assets of other organisations (Teece, 1987).
7. *Research synergies.* RJVs can exploit synergies from the complementary research strengths of their members, creating a whole greater than the sum of its parts.
8. *Effective deployment of extant resources, further development of resource base.* Existing tangible and intangible assets (also including technological knowledge) can be re-deployed to new (for the firm) areas in the expectation of economies of scale and scope. Moreover, collaboration can assist a firm to further develop its resource base, capabilities, and technological and organisational knowledge.
9. *Strategic flexibility, market access, and the creation of investment "options".* In an era of increasing international competition, accelerated pace of technological innovation, and geographical dispersion of the sources of new technology, RJVs allow greater strategic flexibility by permitting firms to have a foothold in new technologies and markets with potential for profitability without requiring excessive resource commitment. RJVs can create new investment options in technologies out of the reach of individual firms due to high resource requirement, high market and technological uncertainty, insufficient appropriability of the research outcome, inadequacy of existing capabilities, and so forth. That is, RJVs can undertake the most uncertain part of the research, which is also generally subject to severe knowledge spillovers, and open up an "option" for investment in a new technological area for the firm. By limiting resource commitments to any individual project, firms can spread their bets to many.
10. *Promotion of technical standards*. Horizontal RJVs are often used to establish standards in areas with significant market and technological uncertainty in order to avoid costly wars among producers.

11. *Increased market power, co-opting competition*. Higher market power for RJV participants may be the outcome of locking-in technology standards, mutual forbearance (less competition) due to multimarket and multiproject contact with partners, and collusion to foreclose markets to new entrants. Market power translates to higher profit margins.
12. *Legal and political considerations.* Firms might participate in RJVs as a result of legal and political requirements. This, for example, can happen when a firm tries to prove being a "good citizen" by signalling its willingness to transfer technological knowledge to others in a particular geographical area.

One needs to stress here the dichotomy between large firms and small and medium-sized enterprises (SMEs) and the particular strengths and weaknesses of the latter. SMEs have relative disadvantages in terms of maintaining sophisticated management teams, attracting highly skilled technical specialists, maintaining large R&D facilities, amassing financial resources to support parallel research programs, connecting easily to external sources of finance and technical expertise, and benefiting from economies of scale and scope. Their relative advantages include the ability to respond quickly to changing market demand, organisational flexibility, and efficient internal communications depending on informal channels. The potential benefits of collaboration to SMEs have been praised frequently in the literature (e.g., Dodgson, 1993; Pisano et al., 1988; Rothwell, 1991; Rothwell and Dodgson, 1991). RJVs may provide significant benefits to small firms in high tech sectors, primarily in terms of raising the necessary finance and other complementary resources of their partners. Hence the special attention to SMEs in policies relating to collaborative R&D around the globe.

In contrast, potential <u>losses to firms</u> as a result of RJV participation may be the result of:

1. *Incompatibility with company interests*. The firm's expectations regarding the usefulness of the results of the cooperative R&D may remain unfulfilled.
2. *Delay of technological advance*. The RJV may actually delay technological advance due to: (i) different strategic interests of its partners; (ii) bureaucratic operating procedures; (iii) bad communication channels between partners.

3. *Loss of control to a vital technology* . By collaborating, a firm may lose control over a technology vital to its competitive strategy, thus creating add itional competition.

In addition, analysts have argued that benefits of RJVs to universities and other research institutes (also including government laboratories) may include:

1. Research better attuned to industry needs.
2. Promoting multi -disciplinary resear ch.
3. Enhancing areas of expertise.
4. Attracting external resources.

Potential losses to universities and other research institutes may include:

1. Incompatibility with vital interests of university researchers in terms of research themes and publication procedu res.
2. Problems with internal university management.
3. Incompatibility with the basic mission(s) of the laboratory.

3.2.2.2. Meso-economic level impact

Benefits may be the result of:

1. *Cross-levelling of knowledge. F* ormal and informal interactions generated by RJVs help create and disseminate knowledge sustaining the dynamics of a sector or a sub - system. Interaction encourages information flows and establishes common practices.
2. *Investment behaviour* . New investment options in technologies might change the "common sense" rules of agents' behaviour as well as inter -sectoral relationships and technological complementarities. The contemporary mobile telephone -internet market opportunity, dependent to a significant extent on inter -firm collaboration, provides a good example of investment behaviour changes in Europe.
3. *Increased industrial competitiveness* . This can be the result of increased overall R&D expenditure, faster rates of innovation, and enhanced linkages between industry and universities and government laboratories that facilitate knowledge transfer.

4. *Increased competition.* Diffusion of knowledge and learning practices can result to general upgrading of the technological capabilities in a sector and strengthening of competition.
5. *Standards*. In certain cases, the establishment of standards may lead to faster rates of technological innovation.

Losses may include:

Anti-competitive effects. A concern has been whether technology information sharing can be effectively separated from production collusion (Clarke, 1984). Especially in the case of large, diversified firms, "multimarket" contact can be compounded by "multiproject" contact through RJVs to raise the potential for anti-competitive behavior (Scott, 1993; Van Wegberg and Van Witteloostuijn, 1995; Vonortas, 2000). The results of increased levels of collusion can be higher prices, lower rates of technological advance, locking in less that the best technology standards and an overall loss of economic competitiveness.

Limiting parallel approaches to uncertain technological problems. By limiting research duplication, RJVs can actually restrict the time-honoured practice of using parallel research approaches to solve uncertain technological problems (Fusfeld, 1994; Nelson, 1961). This is the classic problem of "putting one's egg in one basket".

Leading industry to the wrong direction. Subsidisation of R&D that favours certain approaches in strictly defined areas may provide unnecessary incentives and lead to "dead-end" technical solutions.

3.2.2.3. Macro-economic level impact

Potential benefits can be distinguished into the following categories:

1. *Socio-economic benefits*. These can be the result of successful structural adjustment, increased competitiveness, and higher employment levels.
2. *Increased European cohesion*. RJVs are a mechanism of networking among partners in different European regions with different scientific and technological infrastructures and different industrial specializations, including peripheral and smaller EU countries.

Losses at this level basically reflec t misspent public resources. They may include:

1. *Dependencies on public resources* . Long-term subsidisation may create vicious circle of dependency on the public purse.
2. *Waste of taxpayers' money* . There is some scepticism over the extent to which multi - party collaboration can be compatible at all with individual firm interests. Incompatibility in this sense means that firms might delegate for cooperative efforts only the R&D that they consider peripheral to their operations. If so, the respective R&D projects are very low in the companies' priority list and the expected social returns equally poor. In addition, the presence of moral hazard when cooperative R&D is publicly subsidised raises doubts about whether companies will invest public money in the best interest of the taxpayer.

3.2.3 Issues Regarding EU Funding Policy for Cooperative R&D

It would be necessary, at this point, to consider important questions raised about the EU Research Funding Policy of cooperative R&D. The most important are the issues of competitiveness and cohesion and any emerging trade-off between these two. The competitiveness of European industry was the underlying concern for setting up the EU Framework Programmes for RTD in the 1980s and it has been extensively discussed in the relevant literature (Davignon, 1997, Pavitt, 1998 etc). More recently, the contribution of EU-funded R&D programmes to the cohesion between the countries and regions of he Community has been considered as a very important objective of these programmes. T he compatibility between the objectives of competitiveness and cohesion, however, has been debated (Peterson and Sharp, 1998).

Regarding competitiveness, it has been argued that altho ugh EU-funded cooperative R&D programmes can have a positive role , for instance, in strengthening the science base of Europe, it cannot be expected to contribute by themselves to a major shift to the direction and the rate of technical change in the EU. Regarding cohesion, two popular

claims have been made. On the one hand, assuming a trade-off between competitiveness and cohesion, it has been argued that the adherence to the principle of cohesion – implying preferential treatment for periphery countries – could have a negative impact on the quality of research with significant negative effects on long term European competitiveness. On the other hand, it is argued that the additional focus on cohesion may help dilute the emphasis of the EU Framework Programmes on European large multinationals (the "national champions") that currently seems somewhat misguided. It may also help divert attention from exclusively the interests of the richer, northern states and regions, to reflect the diversity of member states. There has been no extensive documentation to adequately support any of these two "extreme" arguments.

In fact, sizeable technological gaps continue to exist within the EU, despite the fact that "cohesion" countries and regions have indeed received relatively favourable treatment. Several factors may account for such performance, including:

a) The cohesion countries have not fully exploited the available opportunities because of a lack of the necessary complementary capabilities, skills, attitudes and institutions (Sharp, 1998);
b) The amount of the available EU funds fuelled to subsidised R&D remain low compared to the total resources dedicated to R&D in Europe (Pavitt, 1998).

In this context, Sharp (1998) argued that the necessary investments to build the complementary capabilities (physical plants, R&D facilities, and so forth) must come from domestic sources and the Structural Funds. The Framework Programmes do not provide the infrastructures but "new paths for institutional learning and institutional innovation". Furthermore, as "competitiveness" puts emphasis on the Union as a whole and "cohesion" is concerned with the catching-up of parts of the Union, the two need not be incompatible.

3.2.4. Issues for Exploration

The material in the preceding sections leads to long lists of hypotheses that can be explored in relation to RJVs.[6] Quite clearly, no single research project can deal with all relevant questions. This project dealt with issues falling in the following topical areas:

- Trends in RJV formation in Europe; characteristics of RJVs and participating organisations.

- Determinants of RJV formation.
- Performance of the RJV per se.
- Impact on firms participating in the RJV.
- Meso- and macro-economic level impacts for Europe , including competitiveness and cohesion.
- Development and comparison of policies promoting RJVs in Europe, the United States, and Japan.

These topical areas incorporate all basic questions raised listed in Section 2 of this report. They will define the exposition of the results in Section 3.4 below. The last item will be covered later in Section 4.

3.3. Research Methodology

3.3.1. Methodology

The research methodology involved three stages. The tasks of the first stage included:

(a) Bibliographic analysis of policies regarding RJVs at the EU level, the seven represented EU-member countries, the United States, and Ja pan.
(b) Extensive collection of data from diverse sources for this largely empirical project.
(c) A first look at the observed trends.

[6] See the "Conceptual Framework" working paper prepared early in this project by Y.Caloghirou, N.Vonortas, I.Kastelli, 1998.

The tasks of the second stage included:

(a) Statistical analysis of RJVs and RJV participants' characteristics, objectives and strategies.

(b) Econometric analysis of the determinants and impacts of RJVs.

(c) Case studies of a significant number of RJVs.

The tasks of the third stage included:

(a) Assessment of the overall effectiveness of policies regarding RJVs in Europe.

(b) Lessons learnt for future policies.

The partners agreed to engage in three kinds of empirical analysis: descriptive, statistical, and econometric. A first round of descriptive analysis would use the quantitative information in the EU-RJV, EUREKA-RJV and national RJV databases to indicate the basic characteristics of cooperative R&D with industrial participation at the European level and four represented EU-member countries.[7] This descriptive analysis and a simultaneous first round of statistical analysis would also try to identify the basic characteristics of business firm participants. It also aimed at identifying both RJV clusters and firm clusters in terms of technology areas, patterns of cooperation, firm nationality, and various firm characteristics such as business lines, size, investment, and so forth. The intent was to undertake this analysis at both the EU and the national levels.

Subsequently, a first round of econometric analysis would again use the quantitative information in the European and national databases in order to establish relationships between certain important variables according to specific hypotheses relating to the incentives for participating in and impact of the examined RJVs. This analysis was to be performed at the EU level and the national level for the countries that would have adequate quantitative information.

[7] The French, Irish, and Italian partners were unable to create RJV databases for their respective countries.

A second round of statistical and econometric analysis was agreed that would also utilise the qualitative information from the survey. While the surveys were intended to produce qualitative information, many of the questions will be formulated in a way that the responses were quantifiable (e.g., Likert scales). This analysis was also to be performed for the seven EU countries as a group and, depending on the quantity and quality of information, for individual countries as well.

Finally, each partner was responsible for three case studies of RJVs, resulting in detailed accounts of incentives and impacts of 21 RJVs in total.

3.3.2. Data

Perhaps the most formidable undertaking of this large ly empirical project involved a multi-faceted data collection exercise, which, arguably, also proved one of the project's most successful undertakings. Information on RJVs and their participants was compiled from four different sources: (a) the EU Framewor k Programmes; (b) the EUREKA programme; (c) national registries of the represented seven countries; and (d) a broad survey of firms that have participated in RJVs across these countries. The outcome has been the creation of the **STEP TO RJVs databank** which contains seven databases, one for each of (a), (b), and (d) above and four for (c). A fifth source of information, detailed case studies, is treated separately.

This section provides the rationale for collecting information from these diverse sources and explains the structure and basic content of the various databases in the STEP TO RJVS databank.

3.3.2.1. The EU-RJV Database

The RTD policy of the Community is implemented through shared -cost contractual research, concerted actions, and the Community' s own research. Shared -cost contractual

research is the major form of Community intervention in RTD and it is mainly carried out by transnational research joint ventures. These RJVs are made up of business firms, research centers, and universities and engage mainly in pre-competitive research. The Community usually covers 50% of the research cost.

A central node of the research in this project is the EU-RJV database containing information on transnational RJVs established in Europe. The ventures included in the EU-RJV database have been part of the joint research activities co-sponsored by the Framework Programmes for RTD and have at least one participant from the private sector. Included are projects initiated during 1984-1996. Thus, an extensive period covering the first four Framework Programmes is represented. [8]

The basic source of information for the construction of our database was the CORDIS CD-ROM (Edition III 97). We used the RTD-Projects database, containing details of individual activities, contracts and studies, and the RTD-Partners database, containing details of organisations participating in different projects.

Ten programmes from the 1st Framework Programme, twenty-four programmes from the 2nd, eighteen programmes from the 3rd, and twelve programmes from the 4th Framework Programme were ultimately chosen for inclusion in the current version of the EU-RJV database. To be included, a programme should satisfy the following criteria:

Central focus on Research and Technological Development.

Fund RJVs.

Must not mainly relate to or be characterised as: [9]

- Human capital and mobility;
- Co-operation with third (non-EU) countries and international organisations, or developing countries of the third world;
- Dissemination and exploitation of results;

[8] Only the first half of the 4th FWP is covered.

[9] This set of criteria aimed at excluding programmes whose main focus is not the creation of new technological knowledge. It was considered that inclusion of all programmes (i.e., without this kind of screening) would add to the difficulties in interpreting the final results of this project.

"Research and education" or "research and Training";

Promotion of energy technology;

Preparatory action (e.g., on renewable energies) or "exploratory action";

RTD for sciences and technologies for developing countries;

Socio-economic research;

Accompanying measure;

''Forecasting'', ''Evaluation'', ''Policies'', ''Mathematics and Statistics'', or ''Economic Aspects''.

All commonly known programmes (and many more) satisfied these criteria and are, thus, included in the database. In particular, the criteria resulted into a 71%, 69%, 62% and 46% programme inclusion rate for each of the first four Framework Programmes. Many of these are big, well-known programmes in information and communication technologies, telematics systems, industrial and materials technologies, and non-nuclear energy. But several other, less well-known programmes have been included as well. The complete list of the Programmes included in the current version of the EU-RJV database is shown in Appendix.

A total of 12,714 projects are recorded by CORDIS in all these programmes. However, a great number of these projects either were not cooperative (single-partner projects) or had a starting date after 1996. In addition, a good number of the remaining projects when screened for identifying at least one partner from the private sector failed the test: the type of the organisations participating simply was not available and could not be otherwise confirmed. This phenomenon was very commonly observed especially in the 1st and the 2nd Framework Programmes, where the quality of information was rather poor. Thus, the final usable number of projects (RJVs) – having at least one firm in the consortium – that are included in the current version of the EU-RJV database is 6,300. About 12,730 organisations (entities) from 42 countries are responsible for 43,406 participations in these RJVs.

The structure of the EU-RJV database is shown in Appendix. It incorporates 6 interlinked tables:

i. The RJV table, which contains information on the included 6,300 RJVs.

ii. The RJV-member table, which contains information on the participating organizations. The term "member" refers to participant, irrespective of its nature (e.g., a firm, a division of a firm, a lab, etc.). There are 43,406 memberships by all types of organizations.

iii. The third table is the entity table, which contains information on the participants at the entity level. The term "entity" refers to a self-standing organization (a firm, a university, etc.). [10] There are 12,730 entities accounting for the 43,406 memberships in the 6,300 recorded RJVs.

[10] An entity, then, can have more than one "memberships" in the examined RJVs.

iv. The fourth table is the financial data table, which contains detailed information on a large number of identified participating entities from the private sector. The source of this data is AMADEUS, a commercially available dat abase. The version used in this project (1998) contained longitudinal financial information for approximately 200,000 European firms, both traded and privately owned (1992 -1996). There are 2685 identified entities in AMADEUS with available financial da ta (40% identification).

v. The fifth table is the industry codes table, which contains sectoral information for the identified firms, obtained from AMADEUS. Three types of sectoral codification have been selected and have been included in the EU -RJV database: the British CSO (Central Statistical Office), the American SIC, and the NACE 1 codes (national codification).

vi. The sixth table is the R&D table, which contains data about R&D expenditures. The commercially available WORLDSCOPE database was used for this information. In all, 194 firms in the EU -RJV database had at least one yearly entry for R&D expenditures.

3.3.2.2. The EUREKA-RJV Database

The EUREKA initiative was launched in 1985 by 17 countries and the Commission of the European Communities. EUREKA is a network for industrial R&D through which industry and research institutes from 25 European countries and the European Commission develop and exploit technologies to strengthen European competitiveness by promoting 'market driven' collaborative RTD. [11] A project meets EUREKA criteria if it: i) is a hi-tech, market oriented R&D project, ii) involves partners from at least two EUREKA members, iii) aims to develop a cutting edge, civilian product, process or service, iv) is funded by the partners themselves , who receive public financing from their national governments.

EUREKA was purposively designed to complement the Framework Programmes for RTD rather than to substitute for them. Even though both the Framework Programmes and EUREKA focused on internationa l cooperative RTD among European organizations, the former were supposed to support research projects of a different nature than the projects of the latter. [12] The differences in focus can be summarized as follows:

[11] At the end of 1998, the EUREKA member countries were: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Netherla nds, Norway, Poland, Portugal, Romania, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, Russia, European Commission.

[12] Regarding Eureka's "raison d' etre" Peterson (1993) states: "Originally [EUREKA] viewed as a response to the American Str ategic Defence Initiative, Eureka's creation also was motivated by the reluctance of EC Member States to give up national R&D prerogatives to the Commission when huge increases in EC R&D spending were proposed in 1985. ….Finally it allowed governments to f und down-stream, product-oriented, "near market" collaborative projects without the restriction placed by EC competition law on the Framework Programme, which limit it to more upstream generic, "pre -competitive" R&D…..The "near market" focus of Eureka mean s that many of its projects attempt to develop products which combine discrete technologies in innovative ways".

- **The EU Framework Programmes are being set up through a largely "top-down" procedure, following extensive consultation between the Commission and the various stakeholders, including industry. In effect, this means that the Commission periodically announces "focused" competitions in specific techno logical areas. This is in contrast with EUREKA that leaves the technological area of concentration of the specific proposed projects totally to the partners.**
- **Projects funded through the Framework Programmes were intended to involve more pre-competitive (generic) research. EUREKA projects have involved more development research directly aiming at marketable products and services.**
- **The Framework Programmes involve subsidization (up to 50% of the total research cost) by a central source (Commission). Approval by EUREKA only means a label that improves chances for (decentralized) national funding; partners can only seek public financing from their governments.**
- **The results of the Framework Programme research projects are property of both the EU and the partners, whereas the results of EUREKA projects are the sole property of the partners.**
- **The European Commission oversees Framework Programme projects. In contrast, EUREKA projects are only supervised by the partners themselves according to the initial agreement.**

The rationale for creating a separate database for EUREKA RJVs was based on the expectation that the differences in the design of the two policy frameworks summarized above are also reflected somehow in the characteristics of the partnerships that have form ed under the auspices of each framework. The partners considered that, for certain purposes, comparisons across the EU-RJV and the EUREKA-RJV databases would be useful.

The EUREKA-RJV database includes all RJVs that have been chosen and promoted under the EUREKA label during 1985-1996. The basic source of information was the EUREKA Project database available at the EUREKA web site. RJVs with a member from the private sector have been included in the database. They amount to 1,031 RJVs.

The structure of the EUREKA-RJV database is identical to that of the EU-RJV database (see Appendix). It also consists of 6 interlinked tables.

i. The RJV table, which contains information on the included 1,031 RJVs.
ii. The RJV-member table, which contains information on the partic ipating organizations. There are 6,233 memberships by all types of organizations.
iii. The third table is the entity table, which contains information on the participants at the entity level. There are 4,261 entities from 36 countries accounting for the 6,233 m emberships in the 1,031 recorded RJVs.
iv. The fourth table is the financial data table, which contains detailed information on a large number of identified participating entities from the private sector. The source of this data is again AMADEUS, same version as before. There are 1,250 identified entities in AMADEUS with available financial data (40% representation).
v. The fifth table is the industry codes table, which contains sectoral information for the identified firms, obtained from AMADEUS. As before, three types of sectoral

codification have been selected: the British CSO (Central Statistical Office), the American SIC, and the NACE 1 codes (national codification).

vi. The sixth table is the R&D table, which contains data about R&D expenditures. The same version of the WORLDSCOPE database was used for this information. In all, 121 firms in the EUREKA - RJV database had at least one yearly entry for R&D expenditures.

3.3.2.3. The National RJV Databases

There are reasons to expect that transnational RJVs, of the kind selected by the EU Framework Programmes or EUREKA, usually differ from RJVs funded by national or sub-national (regional) governments. A clear indication of that are EU funds that are allocated to cooperative R&D projects indirectly, through national agencies. These funds are by and large part of the structural programmes of the community and their focus is broader than just cooperative research. An example is SPRINT.

In addition, national governments control their own R&D budgets – for most member states much larger than their allocation from the EU. Part of those funds has been spent for supporting cooperative research. Anecdotal evidence shows that, with some exceptions, the supported collaborative R&D is closer in terms of scope to the R&D funded under EUREKA than under the EU Framework Programmes. That is, the supported cooperative research projects are very market oriented. [13] Yet, differences with EUREKA projects are expected given that the membership of the RJVs comes from a single country in one case and from at least two in the other.

Seven national databases were projected to cover RJVs sponsored (fully or partially) by national sources in the countries represented by the seven partners to the consortium. The countries are France, Greece, Ireland, Italy, Spain, Sweden, and the United Kingdom. The methodology, characteristics and contents of the national RJV databases were agreed to be similar to those of the EU-RJV and EUREKA-RJV databases for comparison reasons. However, each of the national da tabases was expected to be much smaller than those two international databases in terms of numbers of covered RJVs.

[13] The fact that, if subsidized, the projects selected by EUREKA are funded from national sources concords to that view.

The outcome of this exercise was not as encouraging as originally thought. With the exception of Greece, there was no central registry of s ubsidised R&D projects in any country. In fact, the partners representing France, Ireland, and Italy failed completely to create a national database. The remaining four partners did create national databases for their respective countries. The coverage, ho wever, was not exhaustive and thus it was too difficult to compare across. In the end, the high volume of information resulting from the other sources, the relative delay in data collection, and the flaws introduced by selective data collection weighed aga inst the use of the four completed national databases (Greece, Spain, Sweden, UK). The four national databases can be considered however as a unique source for these countries, providing information on national funding of R&D cooperation. Below, a short de scription on the methodological specificities adopted for each national database is presented.

Importantly, the structure of all four national RJV databases is identical to the European RJV databases above (EU -RJV Database and EUREKA -RJV database). The pu rpose was to allow work across all databases in the **STEP TO RJVs Databank** .

Greek national database

The primary source for the construction of the Greek national RJV database was a large database of the National Documentation Centre (National Research Fo undation). It contains information for R&D partnership s funded by national sources. The information has been collected according to the following criteria:

- The selected project should include at least two partners , at least one of which should be a firm.
- Included projects should be supported by national sources (European Framework Programme projects are excluded).

The Greek national RJV database contain s 154 cooperative R&D projects corresponding to the period 1985 -1996. These projects correspond to 436 en tities (324 Greek and 106

foreign) and 875 memberships (762 Greek and 113 foreign). These cooperative R&D were funded by the following National Programmes:

- Programme for Development of Industrial Research (PAVE),
- Co-financing Programme (SYN),
- Business Programme for Research and Development I & II,
- STRIDE HELLAS,
- Programme Research Joint Ventures for Improvement of Competitiveness in the context of EPET II
- Programmes administered by the General Secretariat of Research and Technology but using European funds (i.e. LEONARDO, ALTENER, ADAPT, etc.) .

EPET I & II and STRIDE HELLAS were the most active programmes in terms of supporting RJVs. They directly targeted collaboration.

Spanish national database

The Spanish national database was based on an existing database of publicly sponsored RJVs from 1989 to 1997 of Memoria del Plan Nacional de I+D, Direccion General de la Ciencia y Technologia (DGCYT) .

The criteria of selection of the R&D projects were the same as in the Greek case. The database contains information for two types of projects funded by Spanish sources:

- Co-ordinated projects that promote R&D activities within firms by partially financing cooperative projects with public research institutes at zero interest.
- Co-operative projects that are similar to the co-ordinated projects other than cooperation now involves Technological Centres.

In total the Spanish database includes information on 892 projects and 718 participating entities.

Swedish national database

In Sweden the national research policy has a long history of decentralisation. As a result, there are no central public records or databases of research collaborations were private and public organisations interact. The Swedish national RJV database for this project was constructed on the basis of selected projects for which the Swedish team succeeded to get access to the organizations involved. Thus, although it consists a unique source for nationally funded R&D cooperative agreements, it is at the same time a very selective effort that cannot be considered as an exhaustive mapping of the Swedish activities.

The Swedish national database includes 82 RJVs and 219 participating entities. All projects involve public-private cooperation, including universities, research institutes, government agencies, private sector companies, and industry associations. The starting dates of the RJVs vary from 1984 to 1998, with most projects being initiated during 1996-1998. Twelve different technological areas are represented, with Material Science and Engineering being dominant, followed by Biotechnology. Additional financial information, obtained from AMADEUS, is available for 120 of the 178 firms in the database. There is R&D expenditure information on only 19 firms, obtained from the WORLDSCOPE database.

British national database

The UK national database has been adapted from an existing database of RJV projects supported under the LINK programme of the UK government. The database contains information on 812 RJVs involving 188 entities. Additional financial information for the larger of those companies has been obtained from AMADEUS.

3.3.2.4. The RJV-Survey Database

Publicly available data like that included in the EU-RJV, EUREKA-RJV, and national RJV databases do not cover all necessary information to study RJVs, the incentives of business participants to join, and the benefits from the cooperative activity. Several kinds of important information are missing. First, information on knowledge spillovers that are very important in determining the incentives of firms to collaborate in R&D. Second, information on strategic motives that lead firms to cooperate in R&D such as their effort to put together complementary resources, and exploit research synergies and economies of scope in research. Third, information on the factors that affect the choice of the specific partners for an RJV, including issues of reputation, trust, and so forth. Fourth, information concerning the type of new knowledge being created, learned, and transferred as well as the type of learning mechanisms between RJV partners. Fifth, information on the expected and fulfilled benefits by the participating firms from specific

RJVs. Sixth, information on the possibility of undertaking the same research effort without any external funding. Such missing information, of crucial importance for evaluating the effectiveness of policies towards RJVs, was collected through a wide-ranging survey of firms that have engaged in one or more RJVs (not necessarily subsidised).

Because of the different response rates that have been achieved, some countries may seem to be over represented in the dataset. However a wide range of statistical tests was performed in order to examine the country effect and also alternative sub samples were used in selected questions.

The results remain robust, indicating high reliability. Considering also the problems related to the translation of concepts and issues in 6 languages, the survey results were rather satisfactory. In the European area, there are not - at least to our knowledge - surveys achieving the specific number of completed questionnaires and also such coverage of 7 countries. Therefore, what at a first stage was considered too ambitious has finally concluded to a satisfactory outcome.

Following considerable deliberation among partners, it was decided to follow a two-pronged approach relating to the questionnaire (see Appendix). A "long" version of the questionnaire was drafted first containing three sections requesting:

(a) General information on the company, including type, size, various financial data for the most recent six years, and strategic orientation;
(b) Information on the specific RJV, including type of research, relation to core activities of the firm, intellectual property rights treatment, relation with partners, objectives and expected benefits from the specific RJV, and problems experienced in carrying out the activity; and,
(c) Information on the particular business unit that participated in the RJV in question, including business environment affecting the decision to collaborate, technology strategy, general attitude to and objectives for inter-firm collaboration, types of preferred partners, and problems frequently encountered while collaborating.

Subsequently, a “short” version of the questionnaire was drafted that abbreviated the general information section and omitted the section on the business unit but kept the section on the RJV unchanged.

Fielding two questionnaires rather than one was a compromise between some partners who felt strongly about the relation of corporate and business unit technology strategy and RJV participation and others who worried about low response rates to a long questionnaire. The target was to obtain 30 completed long questionnaires and 70 completed short questionnaires by team. Two teams (Greece , UK) chose to run only the long version of the questionnaire while maintaining the same overall target of 100 responses.

The survey sample was drawn from firms that have participated in a mixture of EU - funded, EUREKA, and nationally funded projects. Considering earlier experience with responses to questionnaires in the countries in question, it was considered prudent to allow some leeway to individual partners in selecting the final sample to be surveyed with a request for increased emphasis on RJVs funded by the EU Framework Programmes. The criteria given to the respondents to assist them in selecting collaborative R&D projects were: (i) The project should be completed or almost completed; (ii) If a firm had participated in more than one RJVs, then the projects considered in their response should be from different technological areas where possible or from different Programmes; (iii) a maximum number of 3 projects per company would be accepted; (iv) projects in which the firm was the prime contractor would be preferable. The respondent would be the R&D manager of the firm, at least for the first and the third sections of the long questionnaire. If necessary, he/she could forward the questionnaire to the scientist in charge of the activity related to the specific RJV for the second section of the questionnaire. Similarly for the short questionnaire.

The survey was conducted in the seven countries represented in this project – France, Greece, Ireland, Italy, Spain, Sweden, and the United Kingdom. The coverage and response rate by country are summarised in the Appendix. The response rate ranged from a low 7.25% for France to a high 57.89% for Greece. In all, completed responses were obtained from 504 firms relating to 636 RJVs. In addition, 317 business units from 312 firms also responded to the questionnaire – in other words, these firms and business units answered the long questionnaire.

The sectoral distribution of respondents is shown in the Appendix. A short profile of the respondent firms is as follows:

- Almost 1/5 of the respondents (94 firms) belong to sector 74 (NACE 1), other business activities (mostly technical consultancies). Another 12% (57 firms) is from sector 72: computer and related activities (hardware and software consultancies). Finally, chemicals (24), machinery and equipment (29), and research and development (73) represent 5% each of the responding firms.
- 40% of the respondents (145 firms) are small firms with less than 50 employees. 64% are SMEs, reporting up to 250 employees. Very large firms (>10,000 employees) account for only 7% of the sample (26 firms).
- 37% of the respondents (137) firms reported annual sales up to 5 million Euros. A good 9% of the sample (34 firms) reported annual sales topping 1 billion Euros.
- The majority of respondents, 56% (170 firms), have less than 10 employees fully employed in R&D. 7% (22 firms) reported more than 500 employees in the R&D department. More than half of the respondents have R&D to sales ratios up to 5%. About a quarter of the total reported R&D to sales ratios above 15%.
- 34% of the respondents reported profit to sales ratios between 0 and 5%, 8% (27 firms) reported more than 20%, and 20% reported a loss (3 year average).
- 90% of the respondents are private firms. 109 firms are traded and only 24 are family owned. 159 firms are members of a national group and 104 are subsidiaries of a multinational group.
- 90% of the firms reported professional management; the remaining 10% family-run firms are based in Greece.
- More than half the respondents think their main activity is in a mature phase. Up to 90% (267 firms) responded that their main activity is either in fast growth or in maturity stage. Only 2% responded that their main activity is in decline.
- Just 6% (20 firms) reported that they are following short term strategic planning primarily (less than a year).

3.3.2.5. Case Studies

Important as it is, even an elaborate survey cannot contribute certain kinds of information that necessary in understanding the decision of an organisation to engage in colla borative R&D. In particular, missing information relates to (a) the context of collaboration, and (b) the process and timing of events. Such information can be collected only through carefully conducted case studies of individual RJVs. As part of our multi ple research strategy, it was decided to undertake a number of such case studies to complement the empirical analysis based on the STEP TO RJV databank and the policy reports.

On the whole, 21 case studies were undertaken, three in each of the seven Europ ean countries represented in this project. The organisation of the research followed specific procedures that were developed early on collaboratively by the coordinating group and the British and Swedish partners. The main interest of these case studies wa s to shed light on how R&D cooperations are created, why are they formed, how the context influences their formation and what is the impact of the R&D cooperation particularly at the firm level.

Evidence from the on-going empirical analysis of the STEP TO RJVs databank and from the policy reports helped orienting interviews to the following basic topics:

- *origins and objectives of the RJV*
- *origins and objectives of the participant organisations*
- *position of the RJV in the firm 's strategy*
- *organisation of the R JV*
- *results and impacts of the RJV on participants, including the creation and accumulation of capabilities and new opportunities.*
- *impact at a sectoral or macroeconomic level*
- *commercial exploitation of the R&D results*
- *strategy of the firm towards RJVs*
- *the "politics" of the networ k (relationship among partners)*

The unit of analysis was the RJV. Only c ompleted projects were appraised, each covered by two interviews: one with the coordinating partner and one with one of the other

participant organizations. A common interview protocol for face-to-face semi-structured interviews with the representative of the organisation that was responsible for implementing the RJV (usually a technical manager or R&D manager). The case studies were chosen in a way to ensure a diverse portfolio of projects in terms of number of participants, technological area, involvement of public actors, type of relationship among the partners (vertical/competitive), involvement of SMEs . With minor variation, each partner has carried out case studies for one nationally funded project, one EU funded project, and one EUREKA project. [14]

[14] Case study reports are attached in the Annex.

3.4. Research Results

The research results are presented in accordance to the basic issues for investigation listed in Section 3.2.4. First, the basic trends in RJ V formation in Europe are presented, followed by the basic characteristics of both these ventures and the participants. Second, we appraise the determinants of RJV formation. Third, we address the performance of the RJVs and the impact on the collaboration on private sector participants. Fourth, we deal with the "big picture", that is relating to the impacts of R&D collaboration on industries and national/regional economies. The important question here relates to the economic cohesion of different European countries and the extent to which it may be affected by the examined collaborative R&D. Fifth, the qualitative results of a large number of cases studies of RJVs carried out by the seven partners of this consortium are summarised. These pertain to firm inc entives to participate, process of collaboration, and benefits from collaboration. Finally, the policies directly related to R&D cooperation are appraised comparatively, including science and technology policy, competition policy, and intellectual property protection policy. The consortium studied these policies at the level of the European Union as well as at the national level for the represented 7 countries, the United States, and Japan.

3.4.1. Trends

3.4.1.1. RJV Formation Patterns in Europe

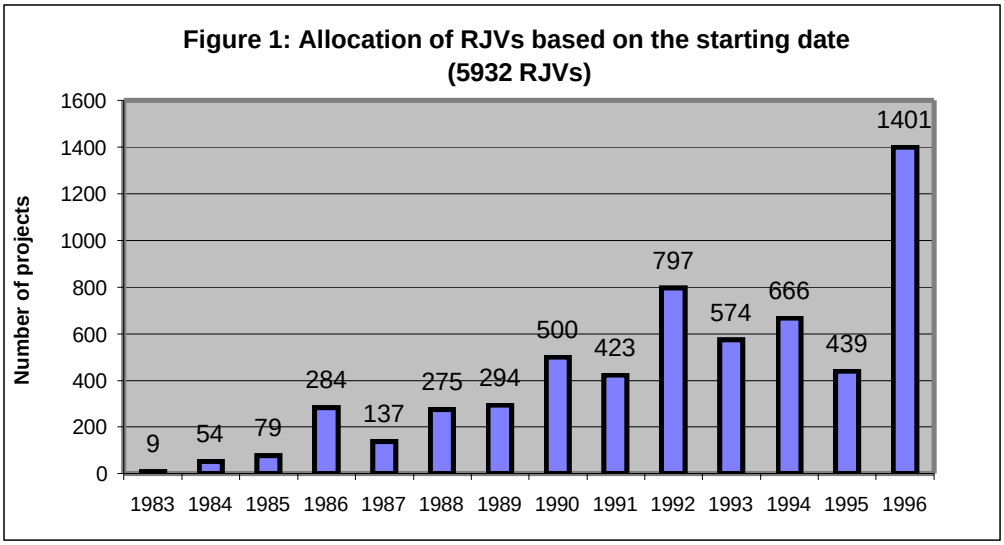
The diverse empirical information in the STEP TO RJVs databank enabled the drawing of a very rich picture of the patterns of formation of subsidized RJVs in Europe. This is presented from two angles below using the EU -RJV and the EUREKA -RJV databases [15]. It must be recalled from the section on data that the information below relates to RJVs with at least one identifiable partner from the private sector.

A. EU-RJV database

Figure 1 allocates the examined RJVs from the first four Framework Programmes for RTD by year of initiation. The launch of ESPRIT 1 with 9 RJVs in 1983 signals the commencement of the Framework Programmes. The observed peaks are related with the commencement of each Programme – with a 2-year delay because the majority of the RJVs have been usually fun ded two years after the official starting date of each Framework. Programme. [16] A large number of RJVs (representing more than 1/5 of the entries in the database) were initiated in 1996, the last year of data collection, reflecting activity in big programmes such as BRITE/EURAM 3 and ESPRIT 4.

[15] Y.Caloghirou, N.Vonortas, A.Tsakanikas: ''Descriptive Statistics Report: STEP TO RJVS DATABANK: The EU -RJV Database'', NTUA/LIEE, 2000 and Y.Caloghirou, N.Vonortas, A.Tsakanikas: ''Descriptive Statistics Report: STEP TO RJV S DATABANK: The EUREKA -RJV Database'', NTUA/LIEE, 1998

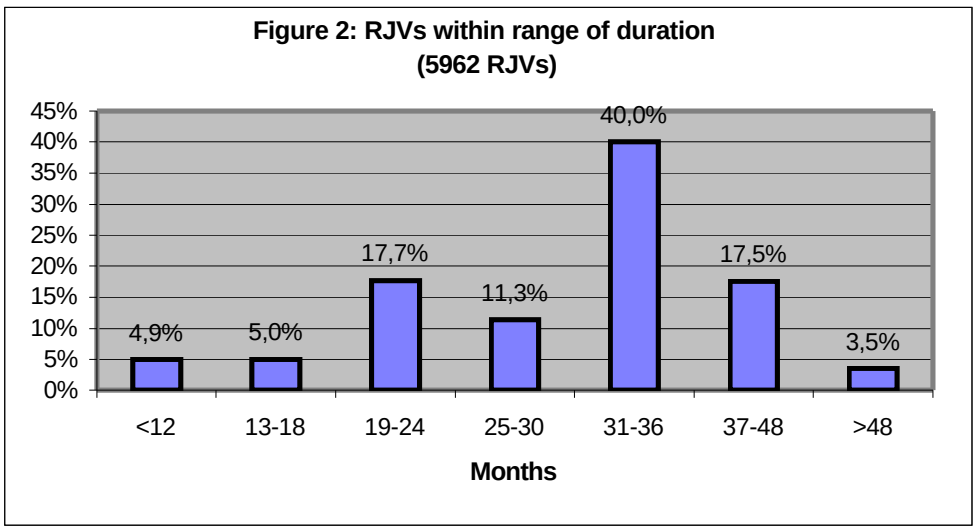
[16] The timing of the first four Framework Programmes for RTD was: 1984 -1987, 1987 -1990, 1990 -1994, 1994-1998.



Source: STEP TO RJVS DATABANK (EU -RJV database)

The dominant technical areas of concentration have been Information Processing and Information Systems with 15.2% and Electronics and Microel ectronics with 11,74% of the total number of recorded RJVs, followed by Materials, Industrial Manufacture, Aerospace technology, Telecommunications, and Renewable Energy Sources. [17]

The majority of the examined RJVs can be characterised as medium -term in terms of duration (Figure 2).



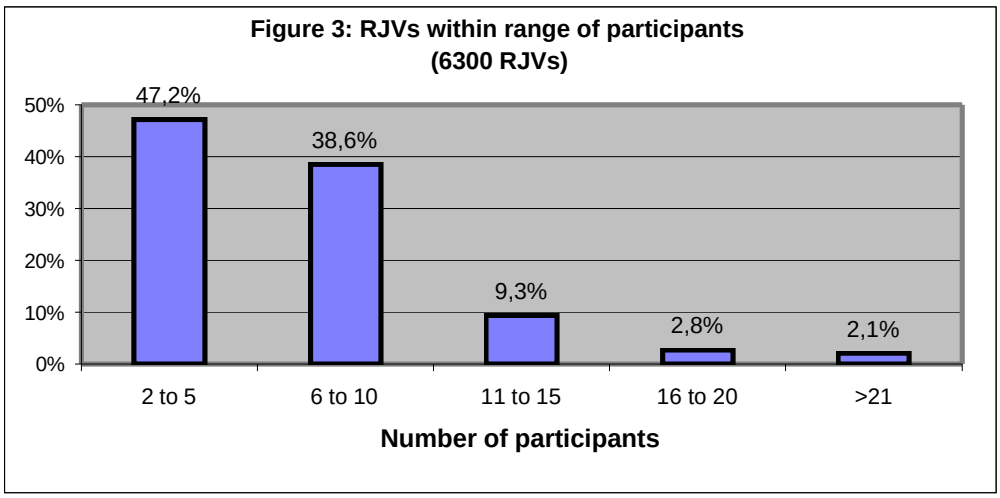
Source: STEP TO RJVS DATABANK (EU -RJV database)

Nonetheless, a significant number (almost 22%) extended to three years and beyond, which could reasonably be considered longer term, while only 5% la sted less than 1 year

[17] It should be stressed that almost all RJVs refer to two or three technical areas. These nu mbers then include double, and triple, counting.

(short term). It should be noted, however, that the project duration is often superimposed on the partners by the funding agency. Whole programs like TELEMATICS, for example, is on the shorter range in terms of project duration wherea s others like BRITE/EURAM are in the medium to higher range.

Almost half of the RJVs (47%) in the database had fewer than 5 participants; 86% of all RJVs have had up to 10 participants, leaving a significant number to be characterised as very large consor tia (Figure 3). The RJV with the highest participation has registered in the area of Biotechnology: it has 77 partners.



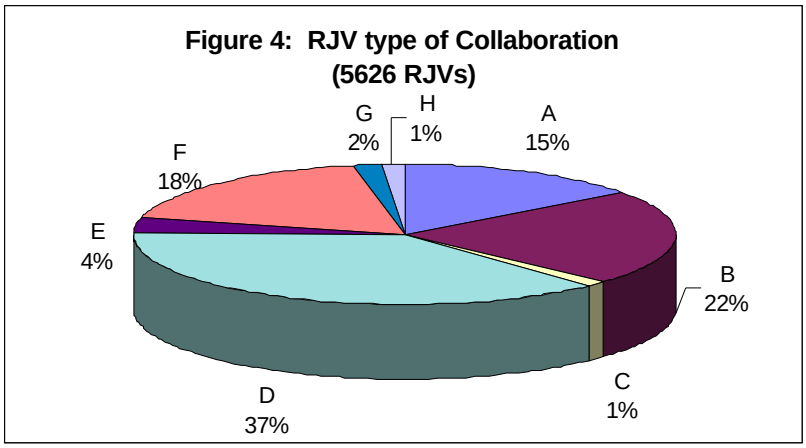
Source: STEP TO RJVS DATABANK (EU -RJV database)

CORDIS classifies participating organisations as: indu stry, consultancy, research institute, non -commercial, education, other. In the EU -RJV database, this arrangement was somewhat modified into: (i) "firm" (combining industry and consultancy); (ii) "university" (all educational institutions); (iii) "research centre" (combining research institutes and non -commercial foundations) and "other" (combining government, hospitals, libraries museums, city councils etc.). This arrangement resulted in eight possible types of RJVs as listed in Table 1.

Table 1. Types of RJVs in the EU -RJV Database

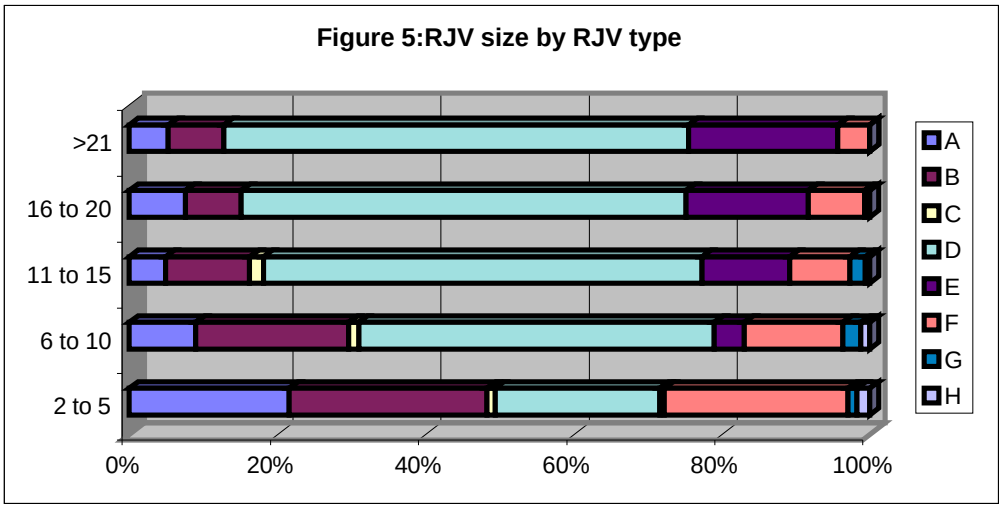
A	Firm – Firm	E	Firm – University – Research Center – Other
B	Firm – University	F	Firm – Research Center
C	Firm – University – Other	G	Firm - Research Center – Other
D	Firm – University – Research Center	H	Firm - Other

Figure 4 shows their distribution in the database. Collaboration exclusively between firms is in fourth place. The most frequent type of collaboration includes firms, universities and research centres. Industry -university collaboration has also been quite important.



Source: STEP TO RJVS DATABANK (EU -RJV database)

The relative allocation of projects between different kinds of participants indicates an emphasis on pre-competitive (generic) research. This contrasts the indication from the very short duration of projects in programmes like TELEMATICS. The discrepancy may be related to the type of participating organisations. Given the caveat that project length is determined administratively, it might be anticipated that RJVs with more than one participating firms tend to fall in the relatively shorter time ranges.



Source: STEP TO RJVS DATABANK (EU -RJV database)

Figure 5 blends two categories of RJVs: those reflecting participant organisational type (Figure 4) and those reflecting the number of participants (RJV size). RJVs combining firms, universities and research centers (category D) clearly dominate all RJV -size categories except the smaller size category, which is more evenly distributed between RJVs of several kinds. Information processing, information systems RJVs dominate every size group, followed by Materials and Industrial Manufacture which rank high in the lower size categories.

The situation is more or less the same with RJV types (based on participant organisation). Information processing, information systems and electronics, and microelectronics dominate almost every RJV type. Detailed observation reveals some interesting patterns. For example, agriculture RJVs tend to rank high in the E a nd D categories, highlighting the frequent participation of a non -private sector institution as a partner. RJVs in resources of the sea and fisheries rank high in the E and D category, indicating highly diversified RJVs. RJVs in the safety area rank high i n the G category, basically indicating the importance of government agents as participants.

Another interesting issue to examine is RJV coordination. There are at least two relevant questions here. First, how do the different types of participating organi sations rank in terms of numbers of RJVs in which they serve as coordinators? Second, which type of participating organisations usually ends up coordinating most RJVs in each of the RJV -type groups?

Table 2: RJV Coordination

Entities' type	**Number of RJVs**	**%**
Universities	903	15,67%
Firms	3517	61,03%
Research Centers	1248	21,65%
Other	95	1,65%
Total	5763	100,00%

Source: STEP TO RJVs DATABANK (EU -RJV database)

Tables 2 and 3 deal with these two questions. Business firms are responsible fo r the coordination of the majority of RJVs (61%), with Research Centers in second place (22%). Universities coordinated approximately 16% of the examined RJVs (Table 2). Business firms also dominate as coordinators across all different RJV type categories (Table 3). The only RJVs that are not coordinated mainly by firms are those in category E – the more diversified ones – where Research Centers outnumber the rest.

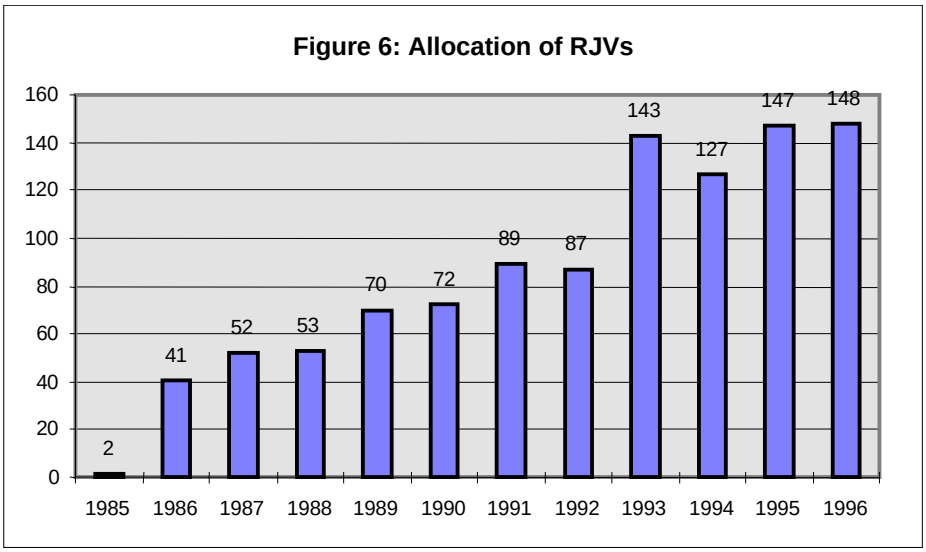
Table 3: RJV Coordinating Partners and RJV Type

Entities'type	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Firms	711	812	43	908	52	571	50	52
Universities	0	299	15	479	44	0	0	0
Research Centers	0	0	0	623	71	385	29	0
Other	0	0	7	0	30	0	14	16

Source: STEP TO RJVS DATABANK (EU -RJV database)

B. EUREKA-RJV Database

Figure 6 presents an allocation of the RJVs selected by EUREKA based on their officially reported starting date. A good part of the surge during the last four years can be explained by the fact that several countries from Eastern Europe joined EUREKA.



Source: STEP TO RJVS DATABANK (EUREKA -RJV database)

The majority of EUREKA RJVs have been in the Environment area, followed by Medical and Biotechnology, Information Technology, and Robotics/Production Automation. In more recent years, there was a slight decrease of registered RJVs in the Environmental and Medical areas.

The picture changes dramatically, however, if the "importance" of a technological area is determined on the basis of the total budget allocations in that area (Table 4). On this basis, Information Technology tops the list with a very large difference from the rest. The difference is largely the result of the irregularly high budgets of two major RJVs in this area, the 3,8 billion ECU budget of the Joint European Submicron Silicon Initiative (JESSI) and the 2 billion ECU budget of the recently launched MEDEA RJV which followed JESSI (concluded in 1996).

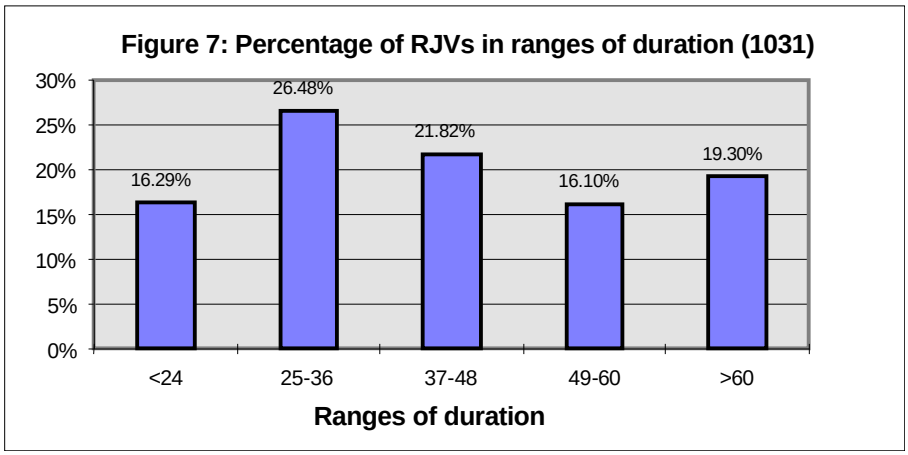
Table 4: Allocation of funding in different technological areas

Technological area	Budget (MECU)
Information Technology	8078.14
Communications	1935.4
Transport	1487.26
Robotics/Production automation	1115.19
Medical and Biotechnology	908.83

Environment	888.87
Energy Technology	550.92
New materials	421.34
Lasers	382.31

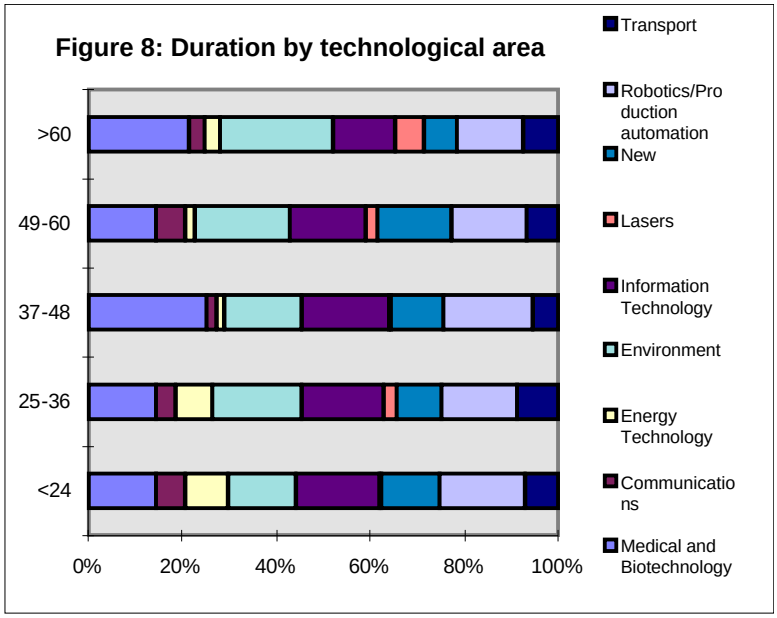
Source: STEP TO RJVS DATABANK (EUREKA -RJV database); calculated from reported budget for each RJV

Figure 7 classifies RJVs according to time duration. As in the case of Framework Programmes' RJVs, medium-term ranges are prominent. Moreover, a relatively high percentage of RJVs are in the over 60 months range (long-term). Interestingly, 12 RJVs have reported duration period over 10 years!



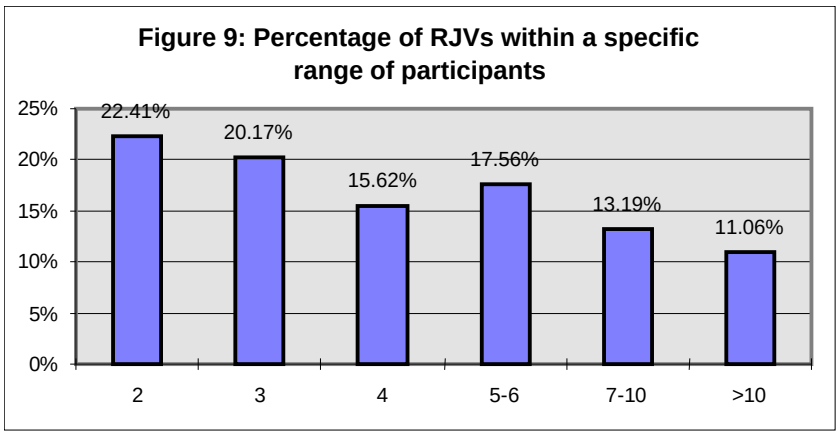
Source: STEP TO RJVS DATABANK (EUREKA -RJV database)

Figure 8 below combines RJV classification by technological area and by time duration. The over 60 months range is dominated by environmental RJVs followed by medical RJVs. Most of the medical RJVs are in the 37-48 month range. The majority of RJVs from Lasers have also operated for over 60 months.



Source: STEP TO RJVS DATABANK (EUREKA -RJV database)

Figure 9 allocates EUREKA RJVs on the basis of the number of participants. The majority of RJVs have had 4 or fewer members; EUREKA RJVs tend to be small -sized.



Source: STEP TO RJV S DATABANK (EUREKA -RJV database)

Medical and Biotechnology RJVs dominate the 2 to 4 member category. The 7 -10 size category features many RJVs in the Environment and Information Technology areas. RJVs in Robotics/Production Automation, Environment, and I nformation Technology have significant percentage in the higher member categories.

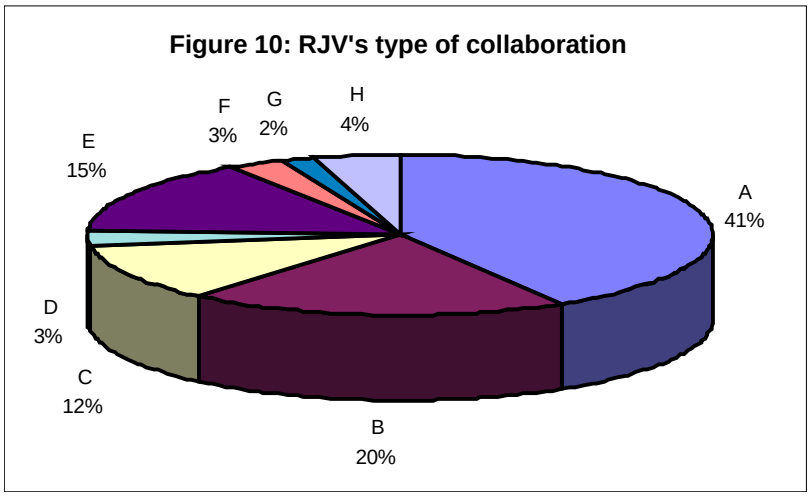
EUREKA RJVs were classified in the following categories in terms of type of participating organizations (Table 5). The largest group of RJVs (41%) involves cooperation betw een

firms only – which seems to agree with the objective of the Programme to pursue market oriented R&D (Figure 10).

Table 5: Types of RJVs in the EUREKA database

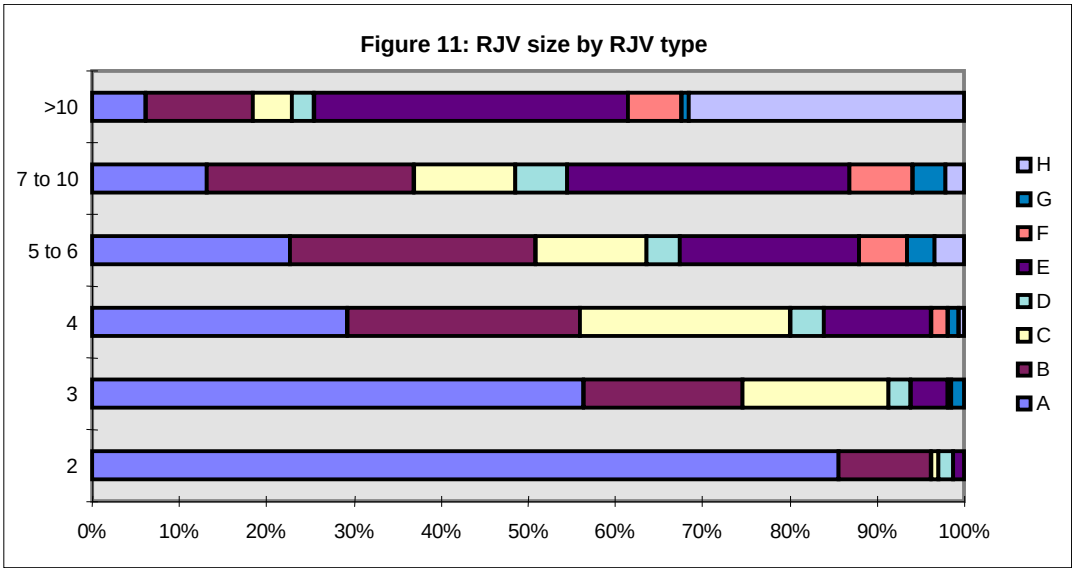
A	Firm – Firm	**E**	Firm – Research Institute – University
B	Firm – Research Institute	**F**	Firm - Research Institute – Government
C	Firm – University	**G**	Firm - University – Government
D	Firm – Government	**H**	Firm - University – Government - Research institute

Source: STEP TO RJVS DATABANK (EUREKA -RJV database)



Source: STEP TO RJVS DATABANK (EUREKA -RJV database)

Figure 11 blends two characteristics of RJVs: RJV type with the RJV size. Interestingly, the RJVs with 2 partners – which correspond to an important share of all EUREKA RJVs – overwhelmingly relate to firm to firm collaboration. The numbers of more diversified RJVs increase in the larger consortia categories, as expected.



Source: STEP TO RJVS DATABANK (EUREKA -RJV database)

Concerning the importance of different kinds of organizations in EUREKA RJVs as indicated by their role as coordinators, the general conclusion is that firms are the most frequent coordinators in all types of RJVs, with a low boundary share at 50% for H type, diversified RJVs and a high share of 81% for B type, firms /government institutions RJVs. It is noticeable that only firms are coordinators of G type RJVs. SMEs have been very active in EUREKA RJV coordination. Large companies are a close second in certain cases. In RJVs where only firms are involved (A type) – the largest RJV category in this database – there is a remarkable balance 50 -50%.

3.4.1.2. RJV Participant Characteristics

A. EU-RJV Database

Table 6 below summarises the overall participation by organisations (entities) based in various EU-member states and other countries. The Table also distinguishes between prime contractors (coordinators) and partners. German organisations ranked first in terms of total number of entities participating in the RJVs but they are slightly outnumbered by French organisations in terms of memberships in the examined RJVs. British and French organisations toped the list of most frequent prime contractors (coordinators).

Table 6. Participation in Framework Programme RJVs

Entities	% of entities	Country	Member-ships	% of memberships	Partner	Prime contractor	% of prime contractor
2205	17,33%	GERMANY	7420	17,09%	6349	1071	17,00%
2053	16,12%	FRANCE	7434	17,13%	6176	1258	19,97%
1809	14,21%	U.KINGDOM	6975	16,07%	5707	1268	20,13%
1347	10,58%	ITALY	4553	10,49%	3881	672	10,67%
998	7,84%	SPAIN	2866	6,60%	2541	325	5,16%
807	6,34%	NETHER'DS	3005	6,92%	2515	490	7,78%
654	5,14%	BELGIUM	2211	5,09%	1839	372	5,90%
475	3,75%	DENMARK	1530	3,52%	1288	242	3,84%
455	3,57%	GREECE	1797	4,14%	1609	188	2,98%
364	2,86%	PORTUGAL	1218	2,81%	1118	100	1,59%
354	2,78%	SWEDEN	1119	2,58%	1058	61	0,97%
266	2,09%	IRELAND	995	2,29%	874	121	1,92%
213	1,67%	FINLAND	637	1,47%	593	44	0,70%
200	1,57%	SWITZER'D	585	1,35%	579	6	0,10%
175	1,37%	AUSTRIA	364	0,84%	328	36	0,57%
171	1,34%	NORWAY	458	1,06%	432	26	0,41%
43	0,34%	LUXEMB'RG	65	0,15%	53	12	0,19%
22	0,17%	ICELAND	31	0,07%	29	2	0,03%
20	0,16%	Not Available	26	0,06%	20	6	0,10%
15	0,12%	POLAND	16	0,04%	16		
15	0,12%	RUSSIA	15	0,03%	15		
10	0,08%	ISRAEL	13	0,03%	13		
9	0,07%	HUNGARY	11	0,03%	11		
7	0,05%	ROMANIA	9	0,02%	9		
6	0,05%	CANADA	6	0,01%	6		
5	0,04%	CZECH REP.	5	0,01%	5		
5	0,04%	USA	6	0,01%	6		
4	0,03%	BULGARIA	4	0,01%	4		
3	0,02%	ESTONIA	3	0,01%	3		
3	0,02%	JAPAN	4	0,01%	4		
3	0,02%	SLOVENIA	11	0,03%	11		
2	0,02%	AUSTRALIA	2	0,00%	2		
2	0,02%	SLOVAKIA	2	0,00%	2		
2	0,02%	TUNISIA	2	0,00%	2		
1	0,01%	BRAZIL	1	0,00%	1		

1	0,01%	LIECHTEN'N	1	0,00%	1		
1	0,01%	Malta	1	0,00%	1		
1	0,01%	MONACO	1	0,00%	1		
1	0,01%	Morocco	1	0,00%	1		
1	0,01%	SINGAPORE	1	0,00%	1		
1	0,01%	South Africa	1	0,00%	1		
1	0,01%	UKRAINE	1	0,00%	1		
12730	100,00%		**43406**	100,00%		**6300**	100,00%

Source: STEP TO RJVS Databank (EU -RJV database)

More than 64 % of all identified entities in t he EU-RJV database have participated in only one RJV. A full 89% have participated in less than five RJVs. A few organisations, however, seem to have spread their participation over large numbers of RJVs (Table 7).

Table 7. Membership Frequency

Number of Memberships	Entities	%
1	8250	64,81%
2	1736	13,64%
3	756	5,94%
4	405	3,18%
5	278	2,18%

Number of Memberships	Entities	%
6 to 10	639	5,02%
11 to 20	352	2,77%
21 to 50	217	1,70%
51 to 100	64	0,50%
>100	33	0,26%

Source: STEP TO RJVS Databank (EU -RJV database)

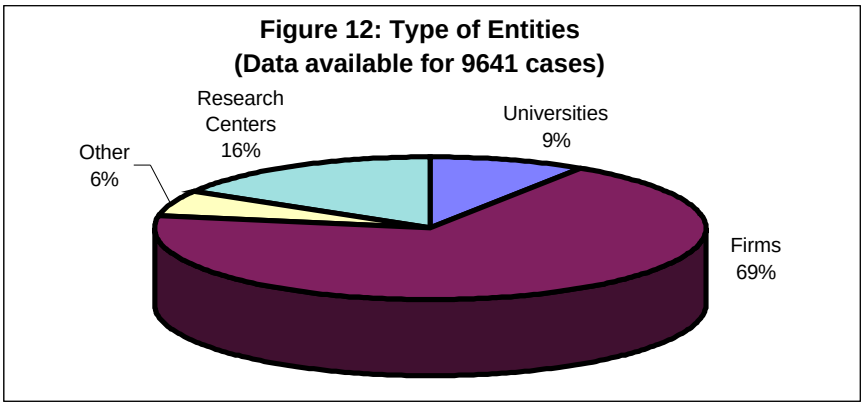
A significant number of firms, as well as universities and research centres, accounted for very high rates of participation. For example, 117 firms, 120 universities, and 70 research centres registered more than 20 participations each; 31 fi rms, 43 universities, and 22 research centres registered more than 51 participations each (Table 8).

Table 8. Membership Frequency by Type of Organisation

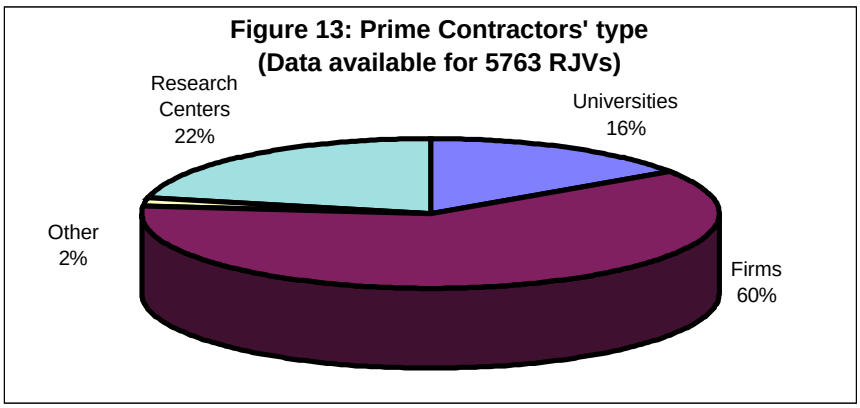
Number of memberships	Education	%	Industry	%	Research Centers	%	Other	%
1	331	37,40%	4268	64,44%	792	50,29%	418	75,18%
2	112	12,66%	958	14,46%	244	15,49%	74	13,31%
3	66	7,46%	406	6,13%	125	7,94%	22	3,96%
4	37	4,18%	222	3,35%	75	4,76%	16	2,88%
5	35	3,95%	148	2,23%	53	3,37%	9	1,62%
6 to 10	99	11,19%	345	5,21%	128	8,13%	10	1,80%
11 to 20	85	9,60%	159	2,40%	88	5,59%	6	1,08%
21 to 50	77	8,70%	86	1,30%	48	3,05%	1	0,18%
51 to 100	31	3,50%	22	0,33%	11	0,70%		
>100	12	1,36%	9	0,14%	11	0,70%		
	885	100,00%	6623	100,00%	1575	100,00%	556	100,00%

Source: STEP TO RJVS DATABANK (EU -RJV database)

A good 69% of the participating organisations comes from the private sector (firms) (Figure 12). Research Centres take 16% and Universities 9%. Firms serve as coordinators more frequently than any other kind of organisation (Figure 13). Universities and research centres have, however, an impressive presence. For example, 18 universities and 16 research centres are among the top 50 entities in terms of participations in EU RJVs.



Source: STEP TO RJVS DATABANK (EU -RJV database)



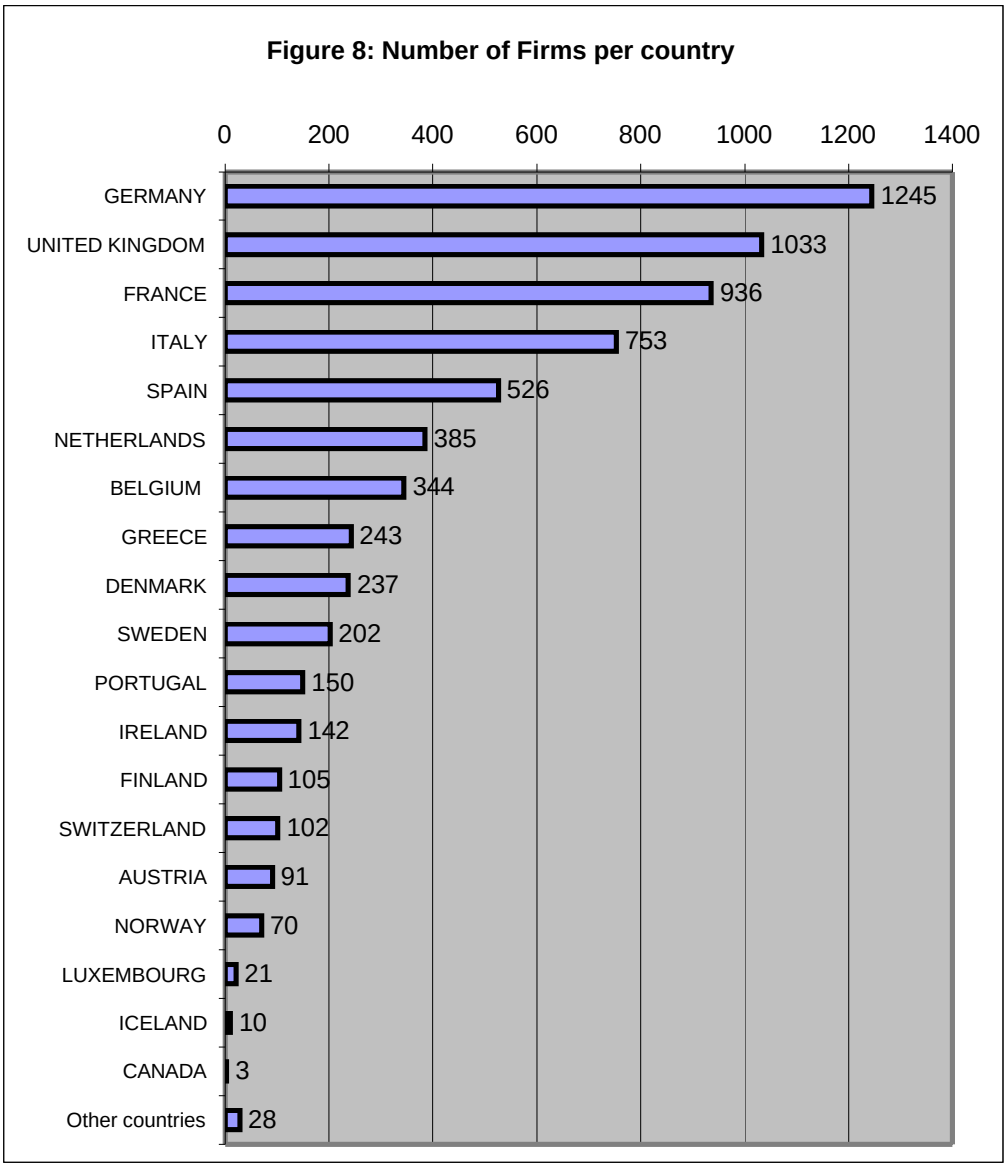
Source: STEP TO RJVS DATABANK (EU -RJV database)

The 50 most active firms, each with 40 or more participations in the examined Framework Programme RJVs, are listed in Table 9. They are large, well known multinational corporations with very significant research activity. Figure 8 shows the total number of identified firms in the examined Framework Programme RJVs by country of origin.

Table 9: Most Active firms in examined Framework Programme RJVs

Participations	Organization Name	Country
311	SIEMENS AG PUBLIC COMMUNICATION NETWORKS	GERMANY
168	THOMSON – CSF	FRANCE
154	NEDERLANDSE PHILIPS BEDRIJVEN B.V.	NETHERLANDS
146	BULL S.A.	FRANCE
133	AEROSPATIALE SOCIETE NATIONALE INDUSTRIELLE	FRANCE
130	INSTITUTO DE ENGENHARIA DE SISTEMAS E CO	PORTUGAL
127	DAIMLER BENZ AKTIENGESELLSCHAFT (DORNIER)	GERMANY
112	CENTRO STUDI E LABORATORI TELECOMICAZIONI S.p.A. – CSELT	ITALY
106	BRITISH TELECOMMUNICATION PLC	UK
87	CENTRO RICERCHE FIAT S.C.P.A. (CRF)	ITALY
82	ENEL SpA - SOCIETA PER AZIONI – CENTRO RICERCA DI AUTOMATICA	ITALY
82	ALCATEL SEL AG (STANDARD ELEKTRIK LORENZ A)	GERMANY
80	ROBERT BOSCH GMBH, GESCHAEFTSBEREICH KRAFTFAHRZEUGAUSRUESTUNG 3	GERMANY
79	GIE PSA PEUGEOT CITROEN	FRANCE
77	Siemens-Nixdorf Informations systems AG	GERMANY
76	INTRACOM S.A. - HELLENIC TELECOMMUNICATIONS AND ELECTRONICS INDUSTRY	GREECE
69	Alenia - Un'Azienda Finmeccanica S.p.A	ITALY
68	BMW Bayerische Motoren Werke AG	GERMANY
64	ROYAL PTT NEDERLAND N.V., PTT RESEARCH	NETHERLANDS
63	BERTIN & CIE SA	FRANCE
62	ALCATEL BELL MANUFACTURING COMPANY	BELGIUM
61	SGS-THOMSON MICROELECTRONICS SRL	ITALY
59	TELEFONICA DE ESPANA S A	SPAIN
58	BRGM - Bureau de Recherches Geologiques et Miniere	FRANCE
57	Alcatel Alsthom Recherche Subcontractor of Alcatel Cable	FRANCE
57	INTERNATIONAL COMPUTERS LTD (ICL)	UK
56	ROLLS ROYCE PLC	UK
55	CONSTRUCCIONES AERONAUTICAS SA	SPAIN
54	BRITISH AEROSPACE	UK
53	CENTRO DE ESTUDIO TELECOMUNICACOES (PORTUGAL TELECOM)	PORTUGAL
52	SGS THOMSON MICROELECTRONICS SA	FRANCE
49	ELECTRICITE DE FRANCE	FRANCE
47	DORNIER LUFTFAHRT GMBH	GERMANY
47	IMPERIAL CHEMICAL INDUSTRIES PLC (ICI)	UK
46	BRITISH GAS EXPLORATION AND PRODUCTION PLC	UK
46	GEC MARCONI MATERIALS TECHNOLOGY LTD	UK
45	Volkswagen AG	GERMANY
45	RENAULT SA	FRANCE
45	INTRASOFT S.A.	GREECE
43	Dassault Electronique S.A.	FRANCE
43	ING. C. OLIVETTI & C. S.P.A.	ITALY
43	ROVER GROUP LTD (PLC)	UK
43	CAP GEMINI INNOVATION	FRANCE
42	GEC-MARCONI LIMITED	UK
42	LABORATOIRE D ELECTRONIQUE PHILIPS SAS	FRANCE
42	VOLVO CAR CORPORATION	SWEDEN
41	CISE - Centro Informazioni Studi ed Esperienze SpA	ITALY

Source: STEP TO RJVS Databank (EU -RJV database)



Source: STEP TO RJVS DATABANK (EU -RJV database)

Table 10 provides a snapshot of the "concentration" of members hips by entities from each country: it shows the membership share accounted for by the 2, 4, 8, and 16 most active entities based in a country. The countries included are those, which had at least one RJV coordinator. One observes very large differences in terms of "membership concentration" among a few entities. Using the 8 -entity concentration ratio, for example, indicates the highest degree of concentration in Ireland (49%) and Finland (46%) and the lowest in the UK (11%). Country size seems to play a ro le. Other factors, such as the relative size and concentration of R&D expenditures, must also be important.

Table 10: Membership concentration ratios by country

Country	Top 2 entities		Top 4 entities		Top 8 entities		Top 16 entities	
	Memberships	% of total memberships	Memberships	% of total memberships	Memberships	% of total memberships	Memberships	% of total memberships
AUSTRIA	51	14,01%	83	22,80%	131	35,99%	175	48,08%
BELGIUM	378	17,10%	610	27,59%	831	37,58%	1001	45,27%
DENMARK	233	15,23%	320	20,92%	419	27,39%	562	36,73%
FINLAND	201	31,55%	257	40,35%	295	46,31%	354	55,57%
FRANCE	565	7,60%	897	12,07%	1395	18,77%	1924	25,88%
GERMANY	459	6,19%	726	9,78%	1116	15,04%	1602	21,59%
GREECE	289	16,08%	442	24,60%	671	37,34%	852	47,41%
ICELAND	9	29,03%	13	41,94%	17	54,84%	25	80,65%
IRELAND	262	26,33%	360	36,18%	483	48,54%	577	57,99%
ITALY	302	6,63%	487	10,70%	776	17,04%	1168	25,65%
LUXEMBOURG	10	15,38%	16	24,62%	27	41,54%	38	58,46%
NETHERLANDS	321	10,68%	540	17,97%	793	26,39%	1136	37,80%
NORWAY	54	11,79%	89	19,43%	138	30,13%	209	45,63%
PORTUGAL	261	21,43%	356	29,23%	496	40,72%	647	53,12%
SPAIN	307	10,71%	464	16,19%	625	21,81%	819	28,58%
SWEDEN	116	10,37%	197	17,61%	309	27,61%	451	40,30%
SWITZERLAND	125	21,37%	184	31,45%	249	42,56%	317	54,19%
UK	295	4,23%	473	6,78%	774	11,10%	1247	17,88%

Source: STEP TO RJVs DATABANK (EU -RJV database)

B. EUREKA – RJV Database

Table 11 shows the overall participation in EUREKA RJVs by country. French organisations have been dominant with most memberships and coordina tors. Germany and the UK are at the second and third position respectively in terms of participations. Dutch organizations have also been very active coordinators of RJVs. The vast majority of entities has participated only in one RJV (80%); an additional 12% have participated in 2 RJVs (Table 12).

Table 11: Representation of each country in the EUREKA -RJV database

Total Entities	% of Total Entities	Country	Number of participations	% of Total Participations	Partner	Coordinator	% of Coordinators
653	15.33%	FRANCE	1022	16.40%	829	193	18.87%
604	14.18%	GERMANY	924	14.82%	852	72	7.04%
448	10.51%	UK	624	10.01%	542	82	8.02%
366	8.59%	NETHERLANDS	501	8.04%	354	147	14.37%
279	6.55%	ITALY	431	6.91%	387	44	4.30%
261	6.13%	SWITZERLAND	420	6.74%	352	68	6.65%
307	7.20%	SPAIN	401	6.43%	303	98	9.58%

206	4.83%	SWEDEN	273	4.38%	234	39	3.81%
176	4.13%	NORWAY	263	4.22%	210	53	5.18%
160	3.75%	FINLAND	258	4.14%	209	49	4.79%
154	3.61%	AUSTRIA	219	3.51%	163	56	5.47%
128	3.00%	DENMARK	192	3.08%	147	45	4.40%
141	3.31%	BELGIUM	187	3.00%	162	25	2.44%
80	1.88%	PORTUGAL	122	1.96%	106	16	1.56%
38	0.89%	GREECE	58	0.93%	55	3	0.29%
41	0.96%	HUNGARY	56	0.90%	54	2	0.20%
39	0.92%	RUSSIAN FEDERATION	54	0.87%	52	2	0.20%
27	0.63%	CZECH REPUBLIC	38	0.61%	31	7	0.68%
23	0.54%	POLAND	28	0.45%	27	1	0.10%
24	0.56%	TURKEY	27	0.43%	25	2	0.20%
21	0.49%	SLOVENIA	26	0.42%	22	4	0.39%
19	0.45%	ICELAND	20	0.32%	15	5	0.49%
17	0.40%	IRELAND	19	0.30%	17	2	0.20%
3	0.07%	EUROPEAN UNION	17	0.27%	13	4	0.39%
8	0.19%	CANADA	11	0.18%	11		
10	0.23%	LUXEMBOURG	10	0.16%	6	4	0.39%
5	0.12%	LITHUANIA	5	0.08%	5		
2	0.05%	ESTONIA	4	0.06%	4		
4	0.09%	ISRAEL	4	0.06%	4		
4	0.09%	ROMANIA	4	0.06%	4		
2	0.05%	BRASIL	3	0.05%	3		
3	0.07%	USA	3	0.05%	3		
2	0.05%	CROATIA	2	0.03%	2		
2	0.05%	LATVIA	2	0.03%	2		
1	0.02%	SLOVAK REPUBLIC	2	0.03%	2		
1	0.02%	ARGENTINA	1	0.02%	1		
1	0.02%	F.Y.R.O.M.	1	0.02%	1		
1	0.02%	JAPAN	1	0.02%	1		
4261	**100.00%**		**6233**	**100.00%**	**5210**	**1023**	**100.00%**

Source: STEP TO RJVS DATABANK (EUREKA -RJV database)

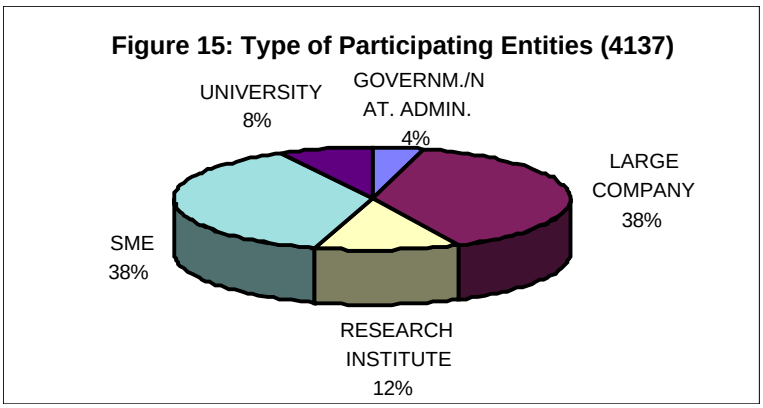
Table 12: Membership Frequency

Number of memberships	Entities	%
1	3384	79.42%
2	507	11.90%
3	165	3.87%
4 to 6	145	3.40%
7 to 10	37	0.87%
>11	23	0.54%
	4261	100.00%

Source: STEP TO RJVS DATABANK (EUREKA -RJV database)

Figure 15 shows an equal percentage of SMEs and large firms in the examined EUREKA RJVs, raising the total share of firms to 76% of all participating entities. The remaining are mainly Research Institutes (12%), Universities (8%), and government organizations. Firms also dominate as RJV co ordinators. Interestingly, SMEs outnumber large firms as coordinators in the examined EUREKA RJVs (43% versus 39% of cases).

Figure 15: Type of Participating Entities (4137)



Source: STEP TO RJVS DATABANK (EUREKA -RJV database)

Table 13 lists the most active organizations in EUREKA RJVs (more than 10 memberships each). Universities and research institutes occupy the first six places. The first SME firm is at the 32nd position with 9 memberships (not shown).

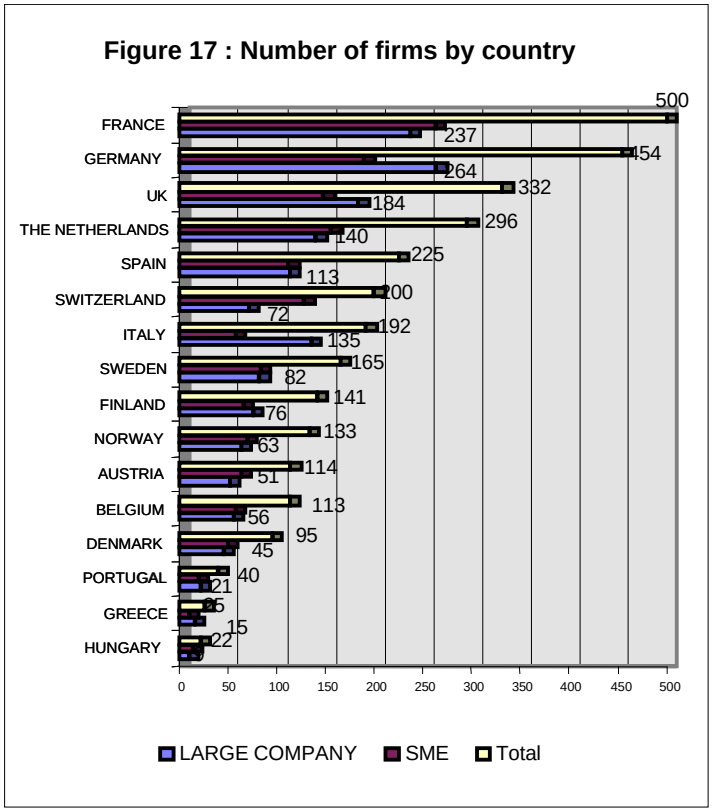
Table 13: Most active organizations in the examined EUREKA RJVs

	Organisation name	Organization type	Country	Number of memberships
1	FRAUNHOFER-INSTITUT	RESEARCH INSTITUTE	GERMANY	43
2	EPFL - ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE	UNIVERSITY	SWITZERLAND	32
3	SINTEF-SI	RESEARCH INSTITUTE	NORWAY	24
4	TECHNICAL RESEARCH CENTRE OF FINLAND (VTT)	RESEARCH INSTITUTE	FINLAND	22
5	ETHZ - TECHNISCHE HOCHSCHULE ZUERICH	UNIVERSITY	SWITZERLAND	19

6	TECHNICAL UNIVERSITY OF WIEN	UNIVERSITY	AUSTRIA	17
7	AEROSPATIALE S.N.I. S.A. - SIEGE	LARGE COMPANY	FRANCE	17
8	PSA - PEUGEOT CITROEN	LARGE COMPANY	FRANCE	16
9	CENTRE CIM DE SUISSE OCCIDENTALE	RESEARCH INSTITUTE	SWITZERLAND	15
10	BULL S.A.	LARGE COMPANY	FRANCE	14
11	KUL - KATHOLIEKE UNIVERSITEIT LEUVEN	UNIVERSITY	BELGIUM	12
12	HUT - HELSINKI UNIVERSITY OF TECHNOLOGY	UNIVERSITY	FINLAND	12
13	SAGEM SOC. D'APPLICATIONS GENERALES D'ELECTRICITE ET DE MECANIQUE	LARGE COMPANY	FRANCE	12
14	INSTITUTO DE SOLDADURA E QUALIDADE INVESTIGACAO E DESENVOLVIMENTO/DIVISAO ENGENHARIA SISTEMAS	RESEARCH INSTITUTE	PORTUGAL	12
15	KTH - ROYAL INSTITUTE OF TECHNOLOGY	RESEARCH INSTITUTE	SWEDEN	12
16	TWI - THE WELDING INSTITUTE	RESEARCH INSTITUTE	UK	12
17	UNIVERSIDAD POLITECNICA DE MADRID	UNIVERSITY	SPAIN	11
18	C.N.R.S.	RESEARCH INSTITUTE	FRANCE	11
19	ROBERT BOSCH GMBH (HEADQUARTERS)	LARGE COMPANY	GERMANY	11
20	ENEA - C. R. E. CASACCIA ENTE PER LE NUOVE TECNOLOGIE, L'ENERGIE, L'AMBIENTE	RESEARCH INSTITUTE	ITALY	11
21	UT - UNIVERSITEIT TWENTE	UNIVERSITY	NETHERLANDS	11
22	DSM N.V.	LARGE COMPANY	NETHERLANDS	11
23	IVF (LINKOEPING) SWEDISH INSTITUTE OF PRODUCTION ENGINEERING RESEARCH	RESEARCH INSTITUTE	SWEDEN	11
24	CSEM CENTRE SUISSE D'ELECTRONIQUE ET DE MICROTECHNIQUE S.A	RESEARCH INSTITUTE	SWITZERLAND	10
25	INRA - INSTITUT NATIONAL DES RECHERCHES AGRONOMIQUES	RESEARCH INSTITUTE	FRANCE	10
26	SGS-THOMSON MICROELECTRONIQUES S.A.	LARGE COMPANY	FRANCE	10
27	UNIV.STUTTGART	UNIVERSITY	GERMANY	10
28	CISE - CENTRO INFORMAZIONE STUDI ED ESPERIENZE S.P.A.	LARGE COMPANY	ITALY	10
29	AEA TECHNOLOGY	RESEARCH INSTITUTE	UK	10

Source: STEP TO RJ VS DATABANK (EUREKA -RJV database)

The total number of firms per country is presented in Figure 16, for the top 16 countries. The picture is proportional to the overall participations count. One notices significant variation between the relative shares of EUREKA RJV participation by large firms and SMEs across countries.



Source: STEP TO RJVS DATABANK (EUREKA -RJV database)

Membership "concentration" by country in shown on Table 14. The left two columns of the table present the share of memberships accounted for by the 10 most active firms based in a country. Considerable variation is observed here too. While concentration is relatively low for the countries at the top, it is very high for others like Greece where the 10 most act ive agents accounted for more than half of the overall participation from that country. The right two columns of the table show the number of the entities per country that are required for reaching a minimum 1/5 of the country's total memberships. UK featu res the most distributed membership. Greece and Ireland the most concentrated.

Table 14: Membership Concentration by Country

	Entities	Percentage of memberships	Entities	Percentage of memberships
GERMANY	10	12.77%	25	20.35%
FRANCE	10	11.45%	25	20.45%
UK	10	10.26%	28	20.19%
NETHERLANDS	10	13.17%	20	20.36%
ITALY	10	15.55%	15	20.65%
SWITZERLAND	10	25.95%	6	21.19%
SPAIN	10	12.97%	21	20.45%
SWEDEN	10	19.78%	11	20.51%
NORWAY	10	26.24%	5	20.15%

FINLAND	10	26.74%	5	20.93%
AUSTRIA	10	25.57%	7	21.00%
DENMARK	10	26.04%	8	21.88%
BELGIUM	10	24.60%	8	21.39%
PORTUGAL	10	35.25%	4	22.13%
GREECE	10	51.72%	2	22.41%
IRELAND	10	63.16%	2	21.05%

Source: STEP TO RJVS DATABANK (EUREKA -RJV database)

The analytical presentations of the two databases can be found in the Appendix, where each database is described in more detail.

Comparing Framework Programme and EUREKA RJVs [18]

The different design and governance of the two policy frameworks for collaborative R&D have resulted in different sets of RJVs. Important differences include:

- ***Technological areas*: Framework Programme RJVs have tended to concentrate relatively more on ICTs, whereas EUREKA RJVs have been more evenly distributed across several technical areas.**
- ***Duration:* Most of the examined EU-funded RJVs (66%) are medium-term. A larger percentage of EUREKA RJVs are longer term. However, it is worth noting that this "average" and "cumulative" picture hides an emerging trend: the gradual decrease in the duration of EUREKA RJVs. On average, EU and EUREKA RJVs initiated during the recent few years tend to last about the same time.**
- ***Size*: Most EU-RJVs are middle sized (6-10 partners), whereas the majority of EUREKA RJVs have been small-sized (2-3 partners).**
- ***Type*: EU-RJVs involve significant cooperation between firms, universities and research institutes; inter-firm cooperation is much more prevalent in EUREKA RJVs.**
- ***Coordinator:* Firms tend to be the coordinators in the majority of both EU and EUREKA RJVs. Other organizations such as universities and research institutes also tend to act as coordinators in a significant number of EU RJVs (38% of the total number of RJVs formed). Not so in EUREKA RJVs.**
- ***Business firm characteristics*: Large firms tend to participate more often, especially in the EU RJVs. On the other hand there is a large number of SMES firms that have a rather limited participation (1 to 3 times). Participation in EUREKA RJVs seems to have been more balanced between firms of different sizes.**
- **Participation by sector: In both types of RJVs firms active in the electrical and electronic engineering and business services sectors appear to be the more frequent participants than firms in other sectors. Firms active in the chemical**

[18] Y.Caloghirou, N.Vonortas, A.Tsakanikas: ''Funded R&D cooperation in Europe: Comparing EU Framework Programmes and Eureka Joint Ventures'',NTUA/LIEE, Working paper for the STEP TO RJVs project, 1999.

sector tend to have higher participation in EUREKA RJVs. Firms active in telecommunications appear to participate relatively more in EU RJVs compared to EUREKA RJVs.

3.4.2. Determinants of RJV Formation

3.4.2.1. Econometric Analysis

The econometric analysis of the incentives to form an RJV developed at two levels:

a) The first level addressed the question of why firms enter into an RJV [19].

b) The second level addressed the interaction between partners: why two or more firms decide to enter an RJV together [20].

a) The paper by Hernan, Marin, and Siotis (1999) addressed the first question. Their review of the theoretical economics literature showed that the mechanisms underlying RJV participation are complex. More specifically, strategic interactions in the product market affect the decision to participate in RJVs both directly and indirectly (e.g., when RJVs are simply used as a vehicle to enhance the feasibility of product market collusion). Second, RJVs involve internalization of technological spillovers, R&D cost sharing, and the gathering of information that may be of strategic importance. Third, the degree of asymmetry between participating firms influences the participation decisions. Surveying the empirical research, it was found that it has been hampered by two constraints: lack of micro data, and the unobservability of a number of key parameters in theoretical models such as the degree of knowledge spillovers and the differences in absorptive capacity across firms.

Data from the EU-RJV and the EUREKA-RJV databases were used in an attempt to bridge some of the gap between extant theoretical and empirical analyses. They estimated two logit regressions, focusing on the probability that a firm will join an RJV on the basis of characteristics of the firm itself and of its primary sector. The first regression attempts to identify the characteristics of firms that form RJVs out of the entire universe of firms (with available data). The results allow the authors to restrict the second estimation to a subset of firms that are known to be keen on RJV formation.

The variables included in the regressions are as follows:
- R&D intensity at the industry level, hypothesizing that cost reductions due to RJVs should be higher in R&D-intensive industries.
- "Spillover lag", a proxy of the speed at which innovations unwillingly diffuse within an industry.
- The Herfindal index of concentration for each industry, expecting the internalization of spillovers via RJV formation to be greater the smaller the number of rivals in an industry.

[19] R. Hernan, P. Marin, G. Siotis, "An empirical evaluation of the determinants of Research Joint Venture formation", Universidad Carlos III de Madrid, working paper for the STEP TO RJVs project, 1999.
[20] G.-B. Navaretti, P. Bussoli, G. von Graevenitz, D. Ulph, "Information Sharing, Research Co-ordination and Membership of Reasearch Joint Ventures", Fondazione Eni Enrico Mattei, working paper for the STEP TO RJVs project, 1999.

- Firm size, as a measure of asymmetry across firms. It is also hypothesized that size is related to absorptive capacity.
- Control variables, such as the country of the firm and the number of times it has participated in RJVs in the past.

The resulting expression is estimated twice for result robustness. The first was obtained by using the entire sample of firms. The second was limited to the firms whose characteristics make them likely to join an RJV. The final sample of RJV -active firms used in the estimations included 1,042 firms that had participated in RJVs during the period 1986-1996.

The first finding of this paper is that RJVs are found in R&D intensive industries. Second, spillovers are an important determinant, but their impact only emerges in R&D -intensive industries. Third, concentration has a positive effect on RJV formation, po ssibly because it facilitates spillover internalization and reduces the intensity of competition in the marketplace. Fourth, firm size is very significant, suggesting that RJV formation is primarily a large firm phenomenon.[21] Fifth, past experience in resea rch cooperation greatly enhances the probability of forming a cooperative venture. This indicates that firms appear satisfied on average with RJVs, as they show a clear willingness to repeat the experience. It also reflects that there are fixed costs and s trong learning effects associated with an RJV. Finally, little bias associated with the country of origin of the firm was detected. When such bias is detected, it works against firms originating in large and rich countries.

b) The paper by Navaretti, Buss oli, Graevenitz, and Ulph (1999) addressed the second question. The paper examined which firms from a heterogeneous pool are more likely to join together and form an RJV. This has been a question of rising importance among both business and policy experts. Rather than considering both firms that entered RJVs and others that did not, the analysis considered only the former. The basic idea is to test the probability that two firms join the same join venture against a set of variables related both to the interaction between the partners and to the RJV.

The theoretical paper of Roller, Tombak, and Siebert (1997) provided some of the background by combining a series of incentives of firms to collaborate, including:
- cost sharing through the reduction of duplicati on;
- internalizing spillovers
- exploitation of product complementarities;
- the possibility of exploiting market power.

Roller et al. (1997) concluded that the gains from RJV formation are highest when: (a) R&D spillovers create free rider problems; (b) duplic ative R&D creates opportunities for cost-sharing; (c) firms produce complementary products; and (d) firms are of fairly similar size.

[21] This argument needs to be qualified with the fact that only firms of certain size and kind (e.g., publicly traded) are usually represented in publicly available databases like Amadeus used here to draw financial data.

The paper by Navaretti et al. (1999). The theoretical part builds on recent work by Katsoulacos and Ulph (see theory sec tion) and introduces two significant features: (a) the opportunity that firms can also exchange information without entering an RJV (which it is hypothesized they will do if they produce complementary products) and (b) endogenous information sharing. The theoretical model, then, shows that, in contrast to Roller et al. (1997), the following take place:

(i) RJVs are more likely to form where there are significant gains to be had from research co-ordination.

(ii) Undertaking the R&D collectively or separately and exch anging information are strict alternatives. The gains from avoiding needless duplication arise when research paths are substitutes and are realized when the RJV operates a single lab. However the gains from exploiting complementarities through careful res earch design arise when research paths are complementary, and require the RJV to keep both labs open.

(iii) Another potential gain from RJV formation comes from increased information sharing. However this gain only arises when there is no information sharing in the non-cooperative equilibrium, and this will only be true when firms produce substitute products. Hence *ceteris paribus* RJVs are more likely to form when firms produce substitute rather than complementary products.

(iv) The effect of initial asymmetries o n RJV formation is ambiguous.

The empirical analysis used information from the EU-RJV and the EUREKA-RJV databases. In particular, the analysis focused on pairs of firms that entered EUREKA RJVs during the 1995-1996 period and Framework Programme RJVs during the 1996-1997 period. In all, there were 148 couples for EUREKA and 1219 couples for the Framework Programmes. The counterfactual consisted of all potential couples, which did not form between firms that have participated in these RJVs (thus firms s howing a positive propensity to form RJVs). Cross section probit analysis is utilized where the probability P_{ij} that firms i and j join the same RJV is a function of:

- the number of employees of the two firms;
- the sales of the firms;
- differences between the average return on total assets of the two firms;
- a product substitutability dummy variable;
- the GNP of the countries of origin of the firms; and
- the input-output relationship of the main industries of the firms.

Following the theoretical model, the author s test for the role of product substitutability and complementarity, asymmetries and subsidies.

The empirical analysis presents a picture that is consistent with the theoretical a-priori. The probability of forming a couple is found to be larger when fi rms are in the same industry and when their products are complementary. This result is robust and significant for both the EUREKA and the Framework Programme RJV samples. This result is said to be consistent with theory as far as substitute products are al so used as inputs by both firms. Gains from co-operation derive from sharing information and exploiting synergies under complementary research paths. But this case is more likely to arise if firms' products are also used as inputs, hence when substitutibil ity and complementarity arise

jointly. In the Framework Programme sample, it is found that the probability of forming an RJV is larger if firms produce substitute products using complementary inputs and follow complementary research paths.

This result is not as neat for the EUREKA sample. Here complementarity appears to be less important than substitutability, particularly if compared with the Framework Programme sample. RJVs are in this case less likely to be formed when firms are both in the same industry and follow complementary research paths.

The introduction of asymmetries into the picture sheds more light on this matter. It is found that for firms producing substitute products the probability of forming a couple is higher the lower the asymmetries between them. According to the authors, this is precisely what one would expect for firms in substitute industries with complementary research paths.

Results on asymmetry indicators are muddled for the EUREKA RJV sample. In contrast, for Framework Programme RJVs, the larger the asymmetries, the more likely RJVs to be formed. It is conjectured that this result is probably driven by policy design: a key objective of Framework Programmes is to favour research cooperation between small and large firms.

Finally, the paper examines the role of the countries of origin of the two partners. It confirms that EUREKA couples are more likely to take place between firms both based in Northern countries, but the relationship is not significant for Framework Programmes, again showing a policy bias in favour of firms based in Southern European countries. As the geographic location (North and South) reflects mildly the level of development, the authors also control for relative GNP. For both samples, couples are more likely to be formed the more similar the GNP of the countries of origin.

Summing up, the empirical results are consistent with theoretical predictions, but there are quite noticeable differences between the Framework Programme and the EUREKA samples. Framework RJV firms are more likely to be asymmetric and in complementary industries than EUREKA firms.

3.4.2.2. Survey

Both versions of the questionnaire (long and short) contained an identical section relating to a specific RJV the interviewed firm participated in.[22] Aggregating scores across questionnaires indicate the following major objectives of firms to join specific RJVs: [23]

§ Establishment of new relationships
(ranked high by 60% of respondents – Mean: 3.58)
§ Access to complementary resources and skills
(ranked high by 58% of respondents – Mean 3.54)

[22] The long questionnaire was completed by 312 firms that replied for 376 of their RJVs. The short questionnaire was complete d by an additional 226 firms that replied for 290 of their RJVs.
[23] The answers were based on a Likert scale 1 -5 where 5 is maximum points.

§ Technological learning
(ranked high by 55% of respondents – Mean 3.48)
§ Keeping up with major technological developments
(ranked high by 54% of respondents – Mean 3,39)

In contrast, the least important objectives we re:
§ Control future market operations
(ranked high by 24% of respondents – Mean 2,48)
§ Reduce loss of information to competitors
(ranked high by 10% of respondents – Mean 1.80)

Universities reportedly are the most desired partners of the surveyed firms
(ranked high by 57% of respondents – Mean 3.46)
Client firms and public research institutes followed with a high ranking by 39% and 37% of respondents respectively. Competitor firms were reported to be the least desired partners.

The long questionnaire also contained a section specific to the technology strategy of the surveyed business unit. The main objectives of the surveyed business units for collaborating in R&D were reported to be the following:
§ Access to complementary resources and skills
(ranked high by 66% of respondents – Mean 3.77)
§ Keeping up with major technological developments
(ranked high by 64% of respondents – Mean 3.62)
§ Technological learning
(ranked high by 62% of respondents – Mean 3.61)
§ R&D cost sharing
(ranked high by 62% or respondents – Mean 3.55)

Simple statistical analysis and cross-tabulation of the results of the survey dataset revealed several interesting relations concerning the determinants of RJV formation from the point of view of the participating firms. We report here the exam ined relationships between:
(a) The competitive strategy of the surveyed business unit and its most important general objectives when engaging in cooperative R&D; and
(b) The link of the cooperative R&D with existing firm activities and the reported importance of public subsidization of this R&D.

(a) Competitive strategy of business unit and general objectives for cooperative R&D

The survey provided information on the competitive strategy of the surveyed business units and on their general objectives for engaging in cooperative R&D.

Respondents were asked to evaluate (using a 5-point Likert scale) the extent to which the following statements correspond to their business unit competitive strategy:
(i) Achieving cost advantage in mass market

(ii) Achieving competitive advantage through differentiation in mass market in terms of (a) product characteristics and (b) marketing practices.
(iii) Achieving cost advantage by focusing on specific market segments
(iv) Achieving competitive advantage through differentiation in a specific market segment in terms of (a) product characteristics and (b) marketing practices.

Factor analysis of the responses allowed to clearly distinguish between two types of competitive strategy: advantage in mass market and advantage in market segments.

Respondents were also asked to evaluate (using a 5-point Likert scale) the importance of a long list of possible objectives of their business unit in cooperative R&D, including:
(i) R&D cost sharing.
(ii) Risk-sharing – uncertainty reduction.
(iii) Access to complementary resources and skills.
(iv) Research synergies.
(v) Technological learning.
(vi) Keeping up with major technological developments.
(vii) Improving speed to market.
(viii) Achieving critical R&D mass.
(ix) Creating and promoting technical standards.
(x) Obtaining external funding.
(xi) Promoting producer/user interaction.
(xii) Controlling future market developments.
(xiii) Creating new investment options.

We had 218 complete survey observations in seven EU member countries. Pearson r type tests between the two strategy factors and each of the thirteen objectives listed above showed that:

- The mass market-oriented strategy is positively correlated with objectives xiii, xii, and vi (in that order of importance).
- The market segment-oriented strategy is positively correlated with the same objectives. However the strongest correlation is now observed in relation to objective vii and the weakest in relation to objective vi.

All correlations are significant at the p<0,01 level.

The above (subjective) evidence seems to single out four objectives as very important for companies engaging in cooperative R&D, irrespective of whether their strategy orientation is towards mass markets or towards market niches. Firms will engage in RJVs to create new investment options, to control future market developments, to keep up with major technological developments, and to improve speed to market.

(b) Importance of Framework Programme funding

The question we wanted to answer here is whether firms prefer to involve in publicly-funded collaborative R&D projects that are related to their core or secondary business activities. The analysis focused on the correlation between the importance surveyed firms

attributed to public funding for a specific RJV and the closeness of the collaborative R&D in this RJV to the responding firm's core or peripheral activities.

The analysis used information from the second section of the questionnaire, which focused on a specific collaborative R&D project chosen by the surveyed business unit. Only Framework Programme RJVs were included in the analysis. We relied on simple cross-tabulation of responses. There were 456 usable responses.

The responding firms can be distributed into three groups Group1 includes firms reporting that they would not have undertaken the research at all if not funded by the Commission. Group 2 includes firms reporting that they would have undertaken the specific research with the same or different partners. Group 3 firms that would reportedly have undertaken the research project alone. The table below shows the cross-tabulations.

	Observations	**Core activity**	**%**
Group 1	287	186	64,81%
Group 2	78	62	79,49%
Group 3	91	66	72,53%

The majority of the firms would not have undertaken the research without Framework Programme funding. For over 60% of these firms the cooperative R&D related to their core business activity. The share of cases where the EU-supported cooperative R&D related to the firms' core activity was even higher for the other two groups – as would have been expected. Almost 80% of the firms that would reportedly have undertaken the specific R&D with the same or different partners and about 73% of firms that would have undertaken this R&D on their own were referring to EU-funded projects that related to their core business activity.

3.4.3. Performance

As shown earlier, a blossoming theoretical economics and business literature has offered a long list of useful concepts regarding the objectives and expected benefits of private sector firms for collaborating in R&D. Firms have been argued to join research partnerships in order to share R&D costs, pool risk, reduce R&D duplication, access complementary resources and skills, internalise R&D spillovers, exploit research synergies, diversify, create new investment options, and so forth. Unfortunately, the empirical literature has unfortunately struggled with thorny issues regarding both methodology and measurement of the outcome of collaboration (Geringer and Hebert, 1989; Glaister and Buckley, 1998). An example is the long-standing debate on whether financial or other objective measures of performance – such as partnership survival, duration, stability – should be preferred over subjective measures of performance. Another example is the debate over whether the appraisal of the performance of equity partnerships should (or could) be similar to the appraisal of the performance of non-equity partnerships. Yet a third example of disagreement is the debate on whose view on

performance counts given that different partners may have different objectives in the same partnership.

Much of the problem resides in the controversy concerning the measurement of organisational performance in general (Cameron, 1986; Eccles, 1991; Venkatraman and Ramanujam, 1990). As Glaister and Buckley (1998a) summarise it, one problem here has been the choice of the appropriate yardstick, another has been the extent to which the surrounding environment affects the performance of an organisation, and a third problem has been the differentiation between the indicators of performance and the determinants of performance.

Such difficulties get compounded in the case of hybrid organisational forms where, not surprisingly, there is no consensus concerning both the definition and measurement of performance (Geringer and Hebert, 1989, 1991; Glaister and Buckley, 1998a). The following have been important stumbling blocks. First, there is no clear definition of partnership success. There is disagreement on whether objective (e.g., financial) or subjective measures of success are more appropriate in appraising success. Objective measures are more widely available. Financial measures of performance such as profitability and growth as well as other objective measures such as partnership survival, duration, and stability have been used in several occasions (e.g., Franko, 1971; Gomes - Casseres, 1987; Harrigan, 1986; Kogut, 1988b; Killing, 1983; Lecraw, 1983; Stopford and Wells, 1972; Tomlinson, 1970). However, objective measures may not adequately reflect the extent to which a partnership achieved its short and long term objectives which are often diverse (Anderson, 1990; Contractor and Lorange, 1988; Killing 1983). For example, rather than profit generation, a partnership may be set up to improve the strategic positioning of the partners (Glaister and Buckley, 1996) or to enhance parent access to the intangible assets of the partner (….., 1991). Other subjective measures, including qualitative ones, must also be appraised for determining performance. Subjective measures are considered to be closer connected to partner objectives. Moreover, the available evidence concerning the correlation between objective and subjective measures of partnership performance is mixed (Geringer and Hebert, 1991; Geringer 1998; Glaister and Buckley, 1998a, 1998b).

Second, even when subjective measures can be constructed, there is difficulty in assigning values to individual measures of success for the partnership as a whole. Various partners usually have different expectations from the same partnership, thus making several authors argue against generalising from one partner's evaluation (Beamish, 1984; Beamish and Banks, 1987; Schaan, 1983). "Triangulation" of partner evaluations has thus been suggested (Geringer, 1998). Third, the availability of information concerning the explanatory variables, most of which are subjective, is fairly scattered (collected by occasional surveys) and discontinuous. Fourth, the literature providing the foundations for the various hypotheses is diverse, not necessarily sharing the same views concerning basic conceptual building blocks – such as, e.g., deciding what is the ultimate goal of a firm. This naturally complicates the interpretation of empirical results. For example, alliance volatility and short duration can be an indicator

of either failure or success depending on what the theoretical assumptions are concerning the operation of the parent firm.

It should be evident from the above that the appraisal of the performance of non-equity research partnerships – like those we are dealing with in this project – is not a straightforward exercise. The main problems include the following (Tucci, 1996). First, there is no central organisation as a stand-alone company, rendering most venture-level financial indicators meaningless. Second, a good number of research partnerships are designed to last for a limited time period, making the objective performance measures of survival, duration, and stability irrelevant. Third, partners often have different objectives regarding the venture, making venture-level subjective measures useless and cross-partner comparisons of firm level measures difficult to assess.

One can concentrate instead on the appraisal of the returns of the partnership to individual members of the partnership. Partnership success is, then, defined to be the degree to which partner objectives are met or surpassed (Brockhoff and Teichert, 1995). The achievement of firm-level strategic goals can be used as a measure of performance of partnerships (Yan and Gray, 1994; Tucci, 1996). This convention was adopted in this project.

Given the disagreement on whether objective (e.g., financial) or subjective measures of success are more appropriate in appraising success, on the one hand, and our fortunate position of having access to data allowing the construction of both, it was decided that we should follow both approaches. The data from the EU-RJV and EUREKA RJV databases were used to create "objective" measures of success from the point of view of the participating firms[24]. The data from the RJV survey database were used to create "subjective" measures of success, again from the point of view of the participating firms[25]. The results from these two approaches are not directly comparable, however, as the samples of RJVs and firms are based on overlap only partly.

3.4.3.1. Impact of collaboration on RJV participants

An "objective" measures approach

The paper by Benfratello and Sembenelli (1999) tests whether participation in EU-sponsored RJVs has a positive impact on participating firms' performance. This is compared to the impact of EUREKA RJVs on firm performance. The authors extract 1,339 manufacturing firms that participated in Framework RJVs initiated during 1992-1996. They also extract 750 manufacturing firms that were members of RJVs selected by EUREKA during 1985-1996. All these firms have financial data for the period 1992-1996 that were obtained from the database Amadeus. Their

[24] L. Benfratello, A. Sembenelli, "Research Joint Ventures and Firm Level Performance", Fondazione Eni Enrico Mattei, working paper prepared for the STEP TO RJVs project, 1999.
[25] Y. Caloghirou, G. Hondroyannis, N. Vonortas, "The performance of research partnerships", Laboratory of Industrial and Energy Economics / National Technical University of Athens, working paper prepared for the project STEP TO RJVs, April 2000.

final sample used in the estimations comprises 411 manufacturing firms, out of which 253 had joined at least one Framework Programme RJV, 101 had entered at least one EUREKA RJV, and 57 at least one RJV in both programmes. A control sample of 3,621 firms was also created from Amadeus according to the following criteria: i) similar cross-tabulation of firms by country and industry, ii) firms not involved in the RJVs covered in the two data sets; iii) firms with complete balance sheet data.

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

Labour productivity has been constructed as the ratio of the value added at constant prices to the average number of employees. The price cost margin variable is simply computed as the ratio of value added net of labour costs to sales. Finally, total factor productivity (TFP) is computed as the ratio of deflated value added to a weighted average of two input factors: labour and capital.

Descriptive statistics provide a preliminary, yet indicative, picture. Focusing on mean values, RJVs participating firms show higher TFP, labour productivity and price cost margin values than control sample firms. The ranking is confirmed for all variables but TFP if the median is used. Interestingly, by comparing Framework Programmes with EUREKA, firms the latter group is characterized by higher labour and total factor productivity but by lower price cost margins.

While suggestive, such descriptive statistics are inadequate as a statistical basis for testing for the impact of RJVs participation on firm performance. Firstly, it is at best naïve to assume that participation in an RJV has an instantaneous impact on performance, also bearing in mind that the average length of EUREKA (Framework) projects is three years and above. Furthermore, according to a survey conducted on EUREKA project leaders "project results were expected within two years by 8% of respondents and within 3-5 years by 49%" (Peterson, 1993). The bottom line is that joining a RJV in 1995 is very unlikely to have any impact whatsoever as soon as 1995 or even 1996. Secondly, if the impact of RJVs participation is additive also the number of RJVs a firm participates in is likely to matter. Thirdly, as already mentioned, the control sample is constructed in order to mimic the industry/country distribution of our sample of 411 firms. However, given a possibly different industry/country composition of the EUREKA and the Framework Programme samples of firms, comparisons do not take fully into account industry and/or country specific differences.

To circumvent the first problem, the authors split the sample period (1992-96) covered by their data in two sub-periods, labeled as "pre" (1992-94) and "post" (1995-96) respectively. The idea here is to focus only on firms participating to RJVs in the "pre" period and to test whether this participation has had an impact on performance in the "post" period. On average, this implies allowing a 2-year period between the RJVs start and the performance evaluation time. Data limitations precluded taking a longer time interval. In the 1992-1994 period, 242 firms (out of 411) have entered at least one RJV. Of those, 55 firms entered at least one RJV sponsored under the EUREKA framework, 199 one RJV financed under the Framework Programmes, and 12 at least one RJV in both programmes. About two thirds of the 242 firms have entered only one RJV during the examined time period. This figure is much higher if we restrict our analysis to EUREKA RJVs (78.2%), whereas it is slightly lower for RJVs under the Framework Programmes (65.8%).

The main result of this analysis is that firms participating EUREKA have experienced a significant improvement in their "adjusted" performance measures between the "pre" and the "post" period. Furthermore, for two of the variables (labour productivity and price cost margins) participating firms also show a lower than average in the pre-period but an higher than average performance in the post-period. On the contrary, firms participating in Framework Programme RJVs do not show any clear pattern.

Both parametric and non-parametric tests do not suggest any impact of Framework RJVs on firm performance. On the contrary, firms participating in EUREKA RJVs show a general increase in the values of the three performance variables. Also, for the labour productivity and price cost margin variables this increase is (rather comfortingly) significant in both the parametric and the non-parametric approach.

How should these results be interpreted? Does giving a causal interpretation to the statistical tests make sense? The authors argue that, on the one hand, empirical findings may be argued to be broadly consistent with the common wisdom on EUREKA and Framework Programme general objectives. EUREKA RJVs are commonly perceived to be relatively more "market" oriented. From this perspective, it is not unreasonable to assume that EUREKA RJVs are more likely to have a direct, or at least faster, impact on firm performance. A more radical explanation on the same venue is that Framework Programmes do not aim at all at improving firm level performance but have more general and indirect objectives such us promoting co-operation between firms, universities and research centres or stimulating the development of European networks.

A different, and perhaps competing, explanation is grounded instead on the institutional differences occurring between the two programs. Framework Programme RJVs broad objectives are defined by EU officials, which also directly finance accepted projects in exchange for the monopoly on property rights. On the contrary, within the EUREKA framework, RJVs objectives are defined by participating firms and projects are much more based on decentralized funding. Framework Programme institutional characteristics might then induce an adverse selection process, where firms carry out less profitable,

long term and very risky projects only if they can have access to public money through FPST funding. This in turn might explain these results.

A subjective measures approach

The paper by Caloghirou, Hondroyannis, and Vonortas (2000) also investigates the performance of RJVs from the point of view of individual industrial partners, this time using subjective information from the Survey-RJV database. Successful partnerships are defined to be those that meet or surpass partner objectives. The extent to which partner objectives are met (or surpassed) is hypothesised to depend on a long list of characteristics of the partnership, characteristics of the firm, and characteristics of the business unit directly involved in the partnership under question.

The paper investigates two sets of hypotheses. The first set of hypotheses examines the impact of a number of behavioural and situational characteristics of the partnership and of the partner on the success of the partnership in meeting (and surpassing) the set of objectives of the responding partner as a whole. The second set of hypotheses examines the relationship between each of several objectives of the responding firm and each of these behavioural and situational characteristics of the partnership and of the partners. The paper uses the full set of completed survey questionnaires. The analysis of the first set of hypotheses is based on 471 observations. The analysis of the second set is based on 496 observations. The variation is due to differences in the number of completed answers in the specific questions.

Only preliminary econometric results were available at the time of this writing. Nevertheless, some conclusions were already clear enough to be reported. First, it was found that the success of government subsidised RJVs in meeting or surpassing the overall objectives of individual industry partners, as perceived by each partner, increases:
(a) the more related the cooperative research is to the existing activities of the firm;
(b) the lesser the problems of knowledge appropriation between the partners;
(c) the higher the effort of the specific business unit involved in the RJV to learn from it through various channels.

In contrast, success in meeting or surpassing overall objectives appeared unaffected (no statistical significance) by:
(a) the complementarity of resources and capabilities of the partners;
(b) the coordination and communication problems between partners.

Second, it was found that the incentive of a firm to join an RJV in order to share risks and decrease market and technological uncertainty is positively correlated with cooperation with supplier and buyer firms as well as with competitors. This incentive is negatively correlated with cooperation with universities and public research institutes and with the degree of appropriability of the cooperative R&D.

Finally, the motivation of a firm to join an RJV in order to create new investment options was found to be positively correlated with cooperation with competitor firms and

negatively correlated with cooperation with universities and public research institutes and with the degree of appropriability of the cooperative R&D.

In addition to the econometric analysis reported above, cross-tabulations and simple statistical analysis of survey responses (Survey-RJV database) resulted in important insights regarding the benefits of RJVs as perceived by individual member firms.

A section of both the long and the short questionnaires asked firms a series of questions regarding a single RJV in which they had participated in. Respondents reported the following as the most important expected benefits from these RJVs:

§ Acquisition/creation of new knowledge
(ranked high by 71% of respondents – Mean 3.90)
§ Development of new products
(ranked high by 55% of respondents – Mean 3.30)
§ Improving the technological and organizational capabilities of the participating unit
(ranked high by 47% of respondents – Mean 3.21)

The least important expected benefits reportedly were:

§ Improvement of existing products
(ranked high by 32% or respondents – Mean 2.62)
§ Exploit complementary resources
(ranked high by 31% of respondents – Mean 2.64)
§ Increase profitability
(ranked high by 30% of respondent – Mean 2.59)

Expectations were fulfilled for:

§ Acquisition/creation of new knowledge
(ranked high by 69% of respondents – Mean 3.81)
§ Improving the technological and organizational capabilities of the participating unit
(ranked high by 44% of respondents – Mean 3.10)
§ Continuation or acceleration of existing research
(ranked high by 43% of respondents – Mean 2.86)

In addition, a section of the long questionnaire asked a series of questions on the strategy of the identified business unit of a firm. [26] Respondents reported the following as the most important incentives to collaborate in R&D:

§ Acquisition/creation of new knowledge
(ranked high by 72% of respondents – Mean 3.91)
§ Improving the technological and organizational capabilities of the participating unit
(ranked high by 54% of respondents – Mean 3.40)
§ Continuation or acceleration of existing research
(ranked high by 53% of respondents – Mean 3.28)
§ Development of new products
(ranked high by 52% of respondents – Mean 3.31)

[26] For small firms, the business unit is the firm itself.

In contrast, the least important expected benefits were:

§ Increase market share

(ranked high by 31% o f respondents – Mean 2,67)

§ Increase profitability

(ranked high by 21% of respondent – Mean 2.65)

The literature has postulated a positive relationship between the technological capabilities of the firm and the degree to which it can benefit from publicly available knowledge. Extended to RJVs, this implies that the benefits a partner obtains are positively related to the innovation effort this partner undertakes outside the specific RJV. In this context, we used survey information to correlate:

(a) the mechanis ms for acquiring and creating new knowledge used by the surveyed business units and the reported benefits from cooperati ve R&D;

(b) the frequency of the practice of partners to undertake independently R&D similar to that of RJVs they participate in and the obt ained benefits from these RJVs.

(a) Mechanisms for acquiring or creating new knowledge and benefits from R JVs

The analysis used information from the third section of the survey questionnaire that focused on the responding business unit. Respondents were requested to evaluate (using a 5-point Likert scale) the importance of the following twelve mechanisms for creating and/or acquiring new knowledge for their business unit:

(i) Undertaking basic research internally.
(ii) Undertaking applied research internally.
(iii) Undertaking development research internally.
(iv) Undertaking design engineering internally.
(v) Developing formal relationships with users and/or suppliers.
(vi) Developing informal relatiosnhips with users and/or suppliers.
(vii) Observing and imitating processes of other firms .
(viii) Learning from patents.
(ix) Learning from codified scientific and technical information (databases etc.)
(x) Using employee training and education.
(xi) Engaging in long -term forecasting and product planning.
(xii) Institutionalising procedures for exploiting ideas and init iatives from individual employees.

Factor analysis did not produce satisfactory groups of mechanisms of knowledge creation and acquisition..

Respondents were also requested to evaluate (using a 5 -point Likert scale) the importance of ten possible benefits from cooperative R&D for their respective business unit. The listed benefits were the following:

(i) Development of new products.
(ii) Development of new processes.
(iii) Improvement of existing products.
(iv) Improvement of existing processes.
(v) Continuation and acceleration of existing research.
(vi) Exploitation of complementary resources.

(vii) Acquisition/creation of new knowledge.
(viii) Increased profitability.
(ix) Increased market share.
(x) Improvement of unit's technological and organisational capabilities.

Factor analysis proved very reliable in grouping benefits into three distinct factors. The most important factor (explaining almost 40% of the variance) describes the direct product development and profitability benefit. It is made of the listed benefits i, iii, viii, and ix above. A second factor captures the process development benefit. It is made of the listed benefits ii and iv. A third factor captures a more multifaceted dimension of the firm related to the benefit on the firm's knowledge base. It is made of the listed benefits v, vi, vii, and x.

We had 271 complete survey observations in seven EU member countries. Pearson r type tests between the three benefit factors and each of the twelve mechanisms for creating and acquiring new knowledge listed above showed that:

- The benefit on the firm's knowledge base is positively correlated (at $p<0,01$) with all mechanisms for creating and acquiring knowledge. The strongest relationship is observed with the process of conducting development internally and the weakest (but statistically significant) with employee education and training.
- The process development benefit is positively correlated (at $p<0,01$) with observation and imitation of processes of other firms. Significant correlation is also observed with undertaking applied research and development internally.
- The product development benefit is also correlated with most of the processes (except for employee education and training). The stronger positive relationships are with developing informal relationships with users and/or suppliers, undertaking development research internally, and developing formal relationships with users and/or suppliers.

(b) Independent similar R&D and benefits from a specific RJV

Do firms that undertake internally R&D similar to that they undertake cooperatively in RJVs benefit more from cooperative R&D? This is the specific question we ventured to analyse here using information from the second section of the survey questionnaire which focused on a specific collaborative R&D project chosen by the surveyed business unit .

Respondents were asked to indicate (using a 5-point Likert scale) the extent to which their business unit undertook internally similar (parallel) R&D to that of the RJV in question. This allowed a categorization of the sample of firms into two groups: those that did very much utilize this learning mechanism (Group 1) and those that didn't (Group 2).

Respondents were also requested to evaluate (using a 5-point Likert scale) the extent to which ten possible benefits from cooperative R&D in the specific RJV were actually fulfilled as far as their respective business unit was concerned. The listed benefits were the following:

(i) Development of new products.
(ii) Development of new processes.
(iii) Improvement of existing products.
(iv) Improvement of existing processes.
(v) Continuation and acceleration of existing research.
(vi) Exploitation of complementary resources.
(vii) Acquisition/creation of new knowledge.
(viii) Increased profitability.
(ix) Increased market share.
(x) Improvement of unit's technological and organisational capabilities.

A sample of 488 usable survey observations from seven EU member countries were available. Pearson r type tests between the two groups of firms and each of the ten potential benefits from the RJV listed above showed that:

- Undertaking similar R&D internally is positively correlated (at $p<0,01$) with the benefits of acquisition /creation of new knowledge, improvement of unit's technological and organizational capabilities, increase market share and exploitation of complementary resources (listed here by diminishing strength of the relationship).
- Group 1 (firms that did take parallel internal R&D) have had a consistently higher rate of benefit fulfilment that group 2 (firms that did not undertake parallel internal R&D).

Additional ANOVA analysis shows that the two groups of firms differ significantly in all obtained benefits (except i and iii).[27]

(c) Business unit strategy and benefits from cooperative R&D

What is the relation between business strategy and benefits from R&D cooperation? We addressed the question with information from the third section of the survey questionnaire, focusing on the responding business unit. As shown in earlier sections, factor analysis of the responses allowed to clearly distinguish between two types of competitive strategy of business units: creating advantage in mass market and creating advantage in market segments. Also as shown in earlier sections, the benefits from cooperative R&D to responding business units can be reduced into three distinct factors: product development and profitability benefit; process development benefit; and benefit to the firm's knowledge base.

A sample of 218 usable responses was available. Pearson r correlation tests between the two types of competitive strategy and three benefit factors revealed that:

[27] More broadly, these results confirm the expectation in the literature that internal R&D is important not only for developing new technological knowledge but for maintaining the necessary capabilities of firms to learn from knowledge in the public domain (Cohen and Levinthal, 1989).

- The competitive strategy of mass market is positively correlated with process development benefits.
- The competitive strategy of market segment is positively correlated with product development benefits.

In other words, mass market-oriented strategies are more compatible with process development benefits from collaborative R&D while market niche-oriented strategies are more compatible with product development benefits from collaborative R&D. [28]

3.4.4. Impact of RJVs on Industries and Regional Economies

Empirical analysis in this project considered the effects of international cooperative R&D on short-term productivity gains among European manufacturing firms and the role of spillovers in technological diffusion [29]. More specifically, the paper by Bussoli (1999) assesses whether a short-term technological convergence process has been taking place among manufacturing firms in the seven EU member countries represented in this consortium. It uses a data set of 4,171 firms with detailed information about balance sheets that allows to measure technological change at the level of the firm by calculating TFP and to examine technological convergence for both the whole sample of firms and within the sub-sample of firms that participate in the examined RJVs.

The empirical analysis proceeds in three steps. First, the paper assesses the presence of countrywide and sectorial technological convergence among all firms in the sample. Second, after short-term convergence is established, the paper studies the role of the characteristics of international RJVs in this process. It concentrates on a sub-sample of firms participating in RJVs to better understand the process of convergence and technological diffusion within the group of firms that join RJVs. Finally, the paper investigates the extent to which the presence of RJVs in the different manufacturing sectors affects the technological gap between a given firm and the best performing firm in the sector. Thus, the final step of the analysis is to construct the productivity gap (dispersion, distance), which is comparable across sectors, and to explain the distance measure in terms of firm and RJV characteristics. The idea here is that, if new technological knowledge developed in RJVs is transmitted to firms outside RJVs, then the productivity of firms should be relatively higher in sectors with larger presence of RJVs.

The data set supporting the conclusions of this paper was drawn from the EU-RJV and the EUREKA-RJV databases. It consists of a group of 434 firms that participated in RJVs and had complete financial information for the 1992-1996 time period. For 40 of them there are data on R&D investment for the whole period. The data set also includes a counterfactual 3,700 firms that did not join the examine RJVs. The countries involved in

[28] Such a result is widely expected. It validates the value of the information in the business survey.
[29] P. Bussoli, "An empirical Analysis of Technological Convergence Process and RJVs in Europe at the Firm Level", Fondazione Eni Enrico Mattei, working paper prepared for the STEP TO RJVs project, September 1999.

the analysis are Belgium, France, Germany, Italy, Netherlands, Portugal, and the UK. The counterfactual sample was randomly drawn from the Amadeus database, which was the most representative of European firms at the country and sectoral level. The selected 21 sectors are at the 3-digit level (NACE 91) and represent manufacturing.

The analysis across countries and across different manufacturing sectors in Europe supports the hypothesis that RJVs favour technological convergence at the country level – this effect is not statistically significant for Germany and the UK – and at the sectoral level for 14 of the examined 21 sectors – excepting clothing, ferrous products except machinery, office machinery and computer, radio, TV and telecommunication, medical equipment, measuring instruments and watches, and furniture and other manufacturing.

Regarding the second question – do international RJVs increase technological convergence among firms that participate in them – the analysis concentrated on firms from 6 countries (Belgium, France, Germany, Italy, the Netherlands, and the UK) and 18 sectors (tobacco, wood products, furniture and other manufacturing industries were excluded). The results support the hypothesis of convergence among all countries except Germany and the UK. The convergence effect is found to be stronger the high the degree of asymmetry among firms joining the same RJVs. [30]

Both for the sectoral analysis of the sample comparing all firms and for the sample of firms participating in RJVs the paper finds an inverse relationship between the growth rate of capital and the growth rate of technology (TFP): the higher the growth rate of capital and lower the growth rate of technology. This result might suggest the presence of important adjustment cost factors in the adoption of new innovations that affect negatively the short-term technological growth process.

The third question concerned whether the level of firm TFP is affected by international R&D cooperation. Here the paper appraises the determinants of a dispersion term measuring the gap between a given firm and the sector's best performing firm. The results show that such cooperation has a positive impact on the technological productivity distance. Larger firms are found to have a greater distance from the best performing firm in their sector – they are less likely to achieve higher levels of technological productivity.

On the whole, the paper finds:
(a) substantial evidence of short term convergence across firms in Europe,
(b) the overall convergence process is positively influenced by the presence of international R&D cooperation,
(c) symmetric RJVs increase productivity to a greater extent than RJVs between asymmetric firms.

These results should be considered with the caveat that the Bussoli (1999) paper does not measure all other factors that may be important to convergence.

[30] Firm asymmetries are defined in terms of efficiency as measured by profit margins or return on total assets.

Finally, a preliminary analysis by NTUA/LIEE on a subset of 3874 Framework Programme RJVs during 1992-1996 attempted to map established networks in the European area between participating firms. It can be argued that network formation is an an effective mechanism for transforming the European knowledge and for promoting economic cohesion. Even in such a short time period, multiple links have been created between pairs of firms, reaching a maximum of 32. In the exercise reported here, a link between two firms was considered only if it was based on seven or more RJV contacts between the two firms. Three major networks in European industry thus emerged:

1. **Auto industry network, including close links between very large and well-known firms from the sector of automobile industry such as Fiat, BMW, Volkswagen, Renault, Peugeot-Citroen, Volvo, and Rover.**
2. **Aerospace industry network, including firms such as Construcciones Aeronauticas, Aerospatiale, Alenia, Dassault, and Dornier.**
3. **Electronics/Telecommunications industry network, including almost all large players in the IST industry across Europe (including the "cohesion" countries like Greece or Portugal). Thomson, Siemens, Alcatel, Bull, British Telecom, Telenor, and Telefonica are some of the most active members of this network.**

Furthermore, these three networks are also connected with each other through certain important members of each network. For example, network 1 is connected with network 2 through ten links between Fiat and Aerospatiale, while network 2 is connected with network 3 through seven links between Aerospatiale and Thomson. Network 1 and network 3 are connected through several links between Daimler Benz and Siemens.

One implication of dense networking is that the European Framework Programmes on RTD have established an important mechanism for transferring knowledge and experience across traditional sectoral boundaries as well as across national/regional boundaries.[31]

3.4.5. Cumulative Evidence Through Case Studies

The preceding sections of this report have discussed a wide array of results based on analysis of data from the different databases in the STEP TO RJVs databank. In addition to analysing aggregated data across firms and RJVs, several case studies of individual research joint ventures have been carried out. The empirical evidence of the case studies has been organised according to the main questions of this project. The summary of the most important results is reported here. The topics include:

[31] Another implication of dense networking may be the use of the European programmes by large corporations for anticompetitive reasons (Mytelka, 1995; Van Wegberg and Van Witteloostuijn, 1995; Vonortas, 2000). The potential for collusion through publicly supported RJVs is a subject that would deserve further study – anticimpetitive behaviour would, of course, run counter the objectives of the European Commission.

- Initiation of the idea for the RJV
- Relationship among partners
- Context of RJV formation
- Objectives of the participants
- Benefits from R&D collaboration
- Limitations and problems in the collaboration
- Exploitation of the R&D results
- Information sharing among the partners
- Importance of external funding (subsidies)

♦ ***Initiation of the idea for the RJV***

Previous relationships among partners played a critical role in several cases. The type of these relationships was either personal (e.g. between a supervisor and his/her doctoral student) or professional resulting from previous informal or formal collaboration.

A "research entrepreneur" often played an important role in the initiation phase of RJVs by both giving birth to the idea and by having an active presence in the implementation phase. The role of this type of "research entrepreneur" becomes more important in the presence of institutional inadequacies or when the strategies of the economic actors are not clear. For example, personal initiatives seem to be more decisive in undertaking R&D in Greece, where such conditions often prevail.

♦ ***Relationship among partners***

Trust appeared to be a major issue for collaboration. Initiating a partnership was reported to be made easier by experience from previous collaborations. Trust building seemed to be a dynamic process that enables new collaborations.

Firms with complementary business appeared to collaborate more often. When collaboration involves competitors either there is no major market challenge or there is need for establishment of technical standards that is difficult (very costly) to be established without the earlier consensus of the main actors in the field.

Firms and universities seem to share more easily knowledge and experiences than firms with firms. There were some cases where academics shared same laboratories with firms.

Competitors collaborate at a pre-competitive level. When the object of the project is closer to the market competitors either do not collaborate or, if they do, they do not share crucial information.

♦ ***Context of RJV formation***

The institutional set-up and regulations are a motive for new collaborations. Often, collaborations appear as a response to institutional changes such as environmental regulations or technical standards in specific technologies.

Subsidised RJVs have occasionally been created as a response to international competition. In such cases, collaboration has been viewed as the most efficient way to offer more competitive prices or to capture market share.

Rapid technological change in many fields creates uncertainty and burdens firms with higher R&D cost, while the lifecycle of many products tends to shorten. Many R&D collaborations are formed under this pressure.

Occasionally, changes in institutions or in the features of competition may alter partners' expectations from the project and may modify their interest in the project thus critically affecting the chances of success. Competition between different types of technologies may also change the rules of the game for the actors undertaking a collaborative R&D project.

Very often the complexity of the product under development requires complementary capabilities. Cooperation among firms operating in different, but related, sectors (such as telecommunications services and semiconductors) with different strategies and corporate cultures ensures the intercourse of various assets, skills and experiences, which are not easily integrated in a single corporation.

- ***Objectives of the participants***

Two main objectives for R&D cooperation were observed in the case studies:

- Collaborate in areas of high uncertainty, where the research outcome is not close to the market but may open new market opportunities in the future, after further development by each partner. In this group we find actors that have their own technological and organisational capabilities, are already well recognised in their field of activity, and have a clear strategy regarding their business plans.
- Collaborate to learn or to create the necessary technological and organisational capabilities that will enable the firm to compete internationally. In this second group we find small sized firms with few resources for R&D that participate in subsidised RJVs in the expectation of creating a critical mass of R&D or learning from their more experience partners. In this group are also participants that consider cooperation a very constructive process from which they acquire experience in research in specific fields.

In countries where the national funds for R&D are low, participating in subsidised RJVs is a way of overcoming the lack of financial resources for doing R&D, both for firms and Universities / research centres.

Cooperation with Universities / Research centres allows firms to access experienced academic researchers.

Small firms that cannot afford extensive R&D investment occasionally choose to subcontract or to collaborate with Universities or research centres that have the people

and infrastructure for specific research activities. In general, firms seem to profit fr om sharing experiences and expertise with the academic sector.

Generally speaking, there are differences between firms in terms of objectives to collaborate in R&D. Perhaps not unexpectedly, large firms behave differently from the SMEs. Large firms seemed to participate in RJVs primarily to access complementary skills and knowledge and cope with technological and market uncertainty. The examined RJVs do not seem to be the first priority in their R&D activities. Many enter these projects aiming at imposing their own standards and thus influence the context in which they operate. On the other hand there are small firms that seem to depend more on funding for doing R&D. Public programmes subsidising collaborative R&D play a role of indirect support for them.

- ***Benefits from R&D collaboration***

In most examined cases, it was difficult to determine the outcome of the collaborative R&D in terms of introduction of a final product or production process. Various explanations may account for that, including RJV focus on pre-competitive R&D, early stage of the research effort, time lag between research and product introduction to the market, or unsuccessful collaboration. In some cases, individual partners succeeded to introduce new or improved products or processes on th eir own, after the completion of the collaborative R&D project.

Reportedly, a major benefit from participating in the examined RJVs has been the acquisition of new knowledge in fields in which either they were not willing/able to invest their own resource s or they didn't possess the necessary capabilities to tackle on their own.

Cooperation often provided the possibility to access the complementary assets of partners, including technological knowledge, human capital, financing, and so forth.

RJV particip ation also opened new market opportunities for firms and gave opportunities to the academic sector to make their research efforts more visible.

The benefits from the cooperation should, of course, be measured against what would have happened in the absenc e of the RJV. The counterfactual is almost impossible to obtain within reasonable confidence levels.

- ***Limitations and problems in the collaboration***

The reported problems can be grouped into two main categories:

Problems due to the funding programmes. In many cases the participants of subsidised RJVs reported problems resulting from the rigidity of the programmes, more specifically relating to budget allocation changes and partner changes. Especially for the latter, it was

pointed out that although the responsibility of the prime contractor is clearly defined, the flexibility of dealing with problems with the partners is low.

The number of reports required from the Commission, in the case of the EU funded projects, and was often considered too high.

The budget cuts from the Commission were often thought not to take into consideration the integrity of the project, thus, resulting in the reduction of the implemented tasks with occasionally negative results upon the quality of the outcome.

Reported bureaucratic rigidities were more serious in the case of nationally funded projects.

Problems related to the cooperative scheme . The opportunities for commercialisation of the R&D results are one main concern of RJV participants from the private sector.

In some cases, the absence of a manufacturer appeared to have deprived the RJV of the ability to design a prototype according to production specifications. The presence of a manufacturer may increase the chances of commercialisation mainly through: i) the strategic interest of the specific partner for commercial exploitation of the R&D outcome, ii) the distribution channels that the specific partner may already possess, iii) the linkage of the R&D content to the production process.

The cost of patenting may prove to be a strong disincentive for bringing the research outcome closer to the market, particularly for smaller firms.

- ***Exploitation of the R&D results***

RJVs subsidised by EU and national sources tend to follow specific guidelines for IPR arrangements.

In most of the examined cases the rights over the research output were kept separate and there was no joint exploitation. The partners could differentiate their products by further developing a variety of applications.

Commercial agreements were signed in some cases among part of the partners for the exploitation after the end of the project. Small firms often appeared reluctant to sign separate collaboration agreements within the consortium fearing opportunistic behaviour by their larger partners.

- ***Information sharing among the partners***

The most frequently used channel for information exchange was meetings of personnel. However, it was obvious in many cases that, when trust and understanding had been established between partners, informal channels of communication were developed that sustained very active interaction.

♦ ***Importance of external funding (subsidies)***

Not surprisingly, the importance of government subsidies has been pointed out in all examined cases. There were differences, nevertheless, in the reasons that made subsidies important:

(i) Cases where funding was decisive for supporting the specific R&D activity.

(ii) Cases where projects aimed at strengthening European competitiveness. Public underwriting has created a mechanism for bringing together important economic agents that needed an institutional framework for doing business together. Public funds as such were of secondary importance.

Some interviewees saw the value of spreading funding over more projects in future Framework Programmes. This would reportedly result in participation incentives resting more on higher visibility and networking than access to funds. Some projects could arguably proceed without funding beyond administration expenditures.

3.4.6. Policies for Cooperative R&D Across Europe

This research project studied cooperative R&D in the European Union, including R&D at the European level – mainly supported by the Framework Programmes on RTD but also EUREKA – and R&D at the national level – supported by national government S&T budgets. As a first necessary step, the partners appraised the policy climate supporting the formation of research joint ventures at both the European Union and the national levels. The represented EU-member countries includes: (i) three of the four largest R&D-spending member states (France, Italy, UK); (ii) one of the six developed, smaller countries (Sweden); and (iii) three of the cohesion-4 member states (Greece, Ireland, Spain). In addition, it was decided to appraise the relevant policies of Japan and of the United States for comparison purposes. Japan was chosen because it has been a pioneer in the past few decades in cooperative industrial RTD; its apparent success in the late 1970s and early 1980s with cooperative RTD created the impetus for European and US governments to move in similar directions. The US was chosen because it has gone through very significant policy changes since the early 1980s in support of cooperative R&D.

The seven partners in this consortium prepared ten "policy position" papers in total, nine for the countries indicated above and one for the European Union as a whole. The papers were written under instructions by the coordinator to summarize the S&T policies related to RJVs since the early 1980s. [32] **In addition to S&T policies the authors were requested to investigate and report on the competition policies and the intellectual property rights (IPR) policies in these countries. Competition and IPR policies significantly affect both the incentives of economic agents to participate in RJVs and the returns from the cooperative RTD activity.**

[32] In the absence of explicit S&T policy, the authors were instructed to cover industrial policy.

The papers indicated extensive differences between the policies of individual EU member states. Policies have ranged from the almost complete indifference to the issue of R&D cooperation until recently (Ireland), to rapidly decreasing attention (UK), to lukewarm policies in anticipation (Greece, Italy), to well established, specialised network systems (Sweden), to highly determined programmes to assist cooperative industrial R&D (France, Spain). The level and type of support has varied widely as have the specific programmes, their technological focus, and the numbers and kinds of economic agents that have participated.

Amidst this variability, the European Commission's policies have played a boosting and cohesive role. The visibility (and funding) of European programs has increased to the extent that member state governments see them as complements to their own S&T policies.

As expected, the policies of Japan and the US have also been quite different from those in Europe. In Japan, the emphasis on cooperative RTD continues. Government-sponsored RJVs, however, seem to have made the transition in the 1980s from mechanisms for assisting whole sectors to catch up with world best practice to mechanisms for creating a broader technological superstructure to assist a large group of high technology sectors.

The US has followed a rational approach to increasing attention to cooperative R&D. During the 1980s, it changed its institutional structure and relevant legal system. During the first half of the 1990s, it tried to put in place specific programmes to actively promote cooperative R&D. Political developments and the decreasing pressure from the "competitiveness camp" due to particularly favourable economic conditions for the American industry in the second half of the previous decade lessened the attention of policy makers to research partnering. Cooperative R&D is still considered a potent S&T policy mechanism, however, surely to surface again as soon as the currently relentless pace of economic growth slows down. Policy experts are currently focusing their attention on the value of RJVs in assisting industry decrease the high levels of uncertainty associated with opening up new emerging product markets.

The EU approach seems to have been the reverse of the US approach, but equally rational.[33] Faced with a wide collection of nationally-based S&T policies, the Commission tried first to put in place its own supra-national programmes for cooperative RTD before harmonising policies across its member states. Harmonisation efforts and "cohesion" efforts have continued, of course, but the process has naturally been a slow one due to path dependencies and vastly different S&T capabilities among the European core and the periphery. The Commission apparently hoped that a series of well-established and funded Framework Programmes for RTD would increase the chances of success for these efforts. It may well have been so. What comes out clearly in this collection of papers is that

[33] See also Vonortas (forthcoming) for a comparison between the EU and US S&T policies, in general, and collaborative R&D policies, in particular.

the EU policies have become a force well reckoned by member state governments. The latter have increasingly influenced policies at the national level if not shaped them to the degree of straightforward translation.

Below, we present short summaries of the ten "policy position" papers, starting with EU policies, moving to seven member state policies, and ending up with policies in Japan and the United States.

- **European Union**[34]

The Community's involvement in R&D can be traced as far back as the Treaty of Rome – establishing the European Atomic Energy Community, and other multi-annual research programmes to be carried out either through the Joint Research Centre (JRC) or through research funding to organisations in member countries.

However, the catalytic events establishing a central role for the Commission in European R&D tok place in the 1980s, first with the pilot ESPRIT programme in 1981, followed by the successive 4-year Framework Programmes on RTD officially implemented for the first time in 1984. ESPRIT lended many of its features to the Framework Programmes. One such feature was the support of RJVs. Another was the public support of "pre-competitive" or "pre-normative" research that was sufficiently far from the market.

The legal basis for the Framework Programmes came with the Single European Act in 1987 that defined the overall objective of the EU S&T policy to be the strengthening of the scientific and technological basis of industry, thus strengthening its international competitiveness.[35] **The basic tenet of the policy is the promotion of cooperation both among the S&T policies of the country members and the EU and among individual agents including firms, universities and other research institutes.**

Four Framework Programmes have already been completed and the fifth is currently under way (1998-2002). The main RTD policy instrument of the Framework Programmes has been the "shared cost" research projects, referring to the support by the Commission of up to 50% of total costs of joint research by agents of various kinds based in different EU member countries. These joint research projects are the focus of this study.

Similarly to S&T policy, the roots of competition policy in the Community can be traced to the Treaty of Rome which gave competition law a constitutional character. Article 3 of the Treaty of Rome required the institution of system to ensure undistorted competition. Articles 85 and 86 dealt more specifically with

[34] "European Union Science and Technology Policy and Research Joint Venture Collaboration", working paper prepared by PREST, January 2000.

[35] From 1993 onwards, the Maastricht Treaty has provided the legal basis of the Framework Programmes. The first one to be affected was the fourth Framework Programme.

competition, the former directed to any sort of agreements to restrict or dis tort competition and the latter directed to the abuse of dominant market positions.

Inter-firm agreements to cooperate in RTD could be open to charges of anti -competitive behaviour. The need to safeguard the Framework Programmes from such charges has nec essitated the provision of specific exemptions for agreements involving RTD. The basic ground for exemptions from the anti -competitive behaviour of Article 85(1) (above) has been provided by Article 85(3). It exempts agreements that contribute to improvi ng the production and distribution of goods or to promoting technical or ec onomic progress while allowing consumers a fair share of the benefit. Only the Commi ssion may grant exemptions after formal notification. The exemptions are clarified in Regulatio n 17 for RTD agreements, particularly Article 4(2). Moreover, given that Framework Programme RJVs are always aimed at improving the competitive advantage of enterprises – thus possibly creating dominant positions that are checked by Article 86 – they have had an ambiguous status within Europe. Special exemptions have been required. An important type of exemption to the competition rules is block exemptions u nder which the firms are not required to notify the Commission of agreements. The first important block exemption in the field of RTD came in 1985.

Relevant areas that have been covered by block exemptions include RTD agreements, patent licensing agreements, and know -how agreements. In particular, the conditions for exemption qualification of joint R TD and exploitation projects include (a) transparency of the addressed field and (b) accessibility of the results by all partners and ability to exploit the results independently if the agreement provides only for RTD. Horizontal agreements (between direc t competitors) are exempt if combined production does not exceed 20% of the market. Exemption covers only RTD in this case and not joint exploitation of the results, unless competitive factors outside the EU prompt the Commission to award individual exemptions. Vertical agreements (parties are not co mpetitors) are exempted for the duration of the project plus five years from first market i ntroduction. The period can be extended as long as combined production does not exceed 20% of the total market for the product(s) involved.

- **France**[36]

The French S&T system is arguably one of the most centralised in Europe and has traditionally been characterised by significant government intervention. Moreover, the French system has also been characterised by a centralis ed system of organising and funding fundamental research (CNRS) and by a dual higher education sector where the "Grand Ecoles" produce an elite of technical e xpert engineers also doubling as expert industrial managers and high -level political pe rsonnel. This elite has made possible to stitch together this overall centralised science, technology and innovation system.

[36] O. Dartois, "Science and Technology Policy in France", working paper, December 1999.

During most of the post-War period, policy was aimed primarily at the creation of a strong technological base (and the technology itself) to support a state-of-the-art economy, at least in priority areas such as electrical power, telecommunications, space, weapons, electronics, oil, railroads, civil engineering, and medicine.

During the past couple of decades, significant attention has been paid to SMEs and the broader and deeper diffusion of technological knowledge in the economy.

French policies have been successful in creating a powerful network of public research institutions. They have been less successful in creating an equally good system of intermediation between research and the rest of the economy (beyond the select mainly large firms in select sectors). Hence, the more recent emphasis on technological knowledge diffusion mechanisms. Sensing the difficulties, public authorities have redoubled efforts to promote all kinds of linkages including firms to firms, firms to universities, and firms to public research institutes. Rather than distinctly sector-based plans (like the Calcul programme in electronics in the 1980s), bringing public and private R&D together across industry has become a priority. Focus areas have been expanding to include, for example, chemicals, biotechnology and microbiology. Universities have had a larger role than other public bodies in promoting links with SMEs.

Like other EU member countries, France has strengthened internal competition legislation. The legal base of antitrust policies has been harmonised with the relevant articles of the Treaty of Rome. However, implementation has been fairly difficult as it has come head to head with a long history of interventionist industrial policy that favoured "champions" and oligopolies. There is no reason to believe that cooperative R&D agreements are more extensively scrutinised for anti-competitive reasons in France than in the EU as a whole.

- **Italy**[37]

The Italian paradox in S&T reflects, on the one hand, a large industrialized country with relatively low expenditures in R&D, significant specialisation in traditional sectors with low R&D intensity, and extensive dependence on SMEs and, on the other, strong international patent performance, significantly positive technological balance of payments, and successful performance in terms of industrial competitiveness and market penetration. Italian S&T policies have tended to be broad. They have also been poorly implemented, being subject to delays and discontinuities.

The state has a dominant role in research. Industrial R&D is dominated by a few large firms. Then there is a relatively small number of small firms in high technology sectors and a much larger number of SMEs in more traditional sectors.

[37] M.-R. Battaggion, P. Bussoli, "Italian Policy Towards Cooperation in R&D", working paper, December 1999.

Historically, subsidization of R&D through non-discriminatory financial incentives has been the preferred mode of government intervention, thus avoiding targeting specific lines of research. The first attempt for more selective government intervention was the Law 46 of 1982 that created two funds: the FRA fund for the support of applied research and the dissemination of the results, and the FRT fund to sustain technical advances in the last stages of applied research. While research consortia are eligible for funding, no specific incentives for the formation of cooperative R&D are foreseen by this legislation.

A number of other efforts to promote R&D cooperation between firms, universities and public institutions are in place, including:

(i) A program of the National Research Council (CNR) to fund specific cooperative projects involving public and private laboratories and research centers, in particular involving universities and companies.

(ii) The National Programmes of Research which address high risk, multidisciplinary research projects of use to the private sector.

(iii) Some regions (notably Lombardy) provide financial incentives for SMEs to collaborate in R&D with research centers and universities.

(iv) A significant proportion of Italian industrial R&D activity is tied to international cooperative programmes, often under public subsidy.

The Italian competition policy (based on Law 287/90) reflects very closely articles 85 (restriction of competition) and 86 (abuse of dominant position) of the Treaty of Rome. While RJVs are generally considered exempt, special agreements between partners that may limit the R&D activity, access to pre-existing knowledge or the use of the results by one or more partners may be placed under scrutiny. The law has some special provisions for protecting the international competitiveness of Italian firms.

Concerning the IPR system, the first patent law dates back to 1939. This was modified with Law 338/1979 that conformed the national regulations to European patent standards. An interesting difference between the Italian and the European patent systems is that in Italy a patent is given without a formal examination of originality, novelty and overall patentability. The law recognizes team invention that may be of interest to RJVs, using the standard rules for joint ownership. These rules also determine sharing of the returns from a joint patent: the benefits are equally shared by all owners, unless explicitly specified otherwise.

- **United Kingdom**[38]

The interest of British governments in cooperative R&D for high tech industries has been relatively recent and always reluctant. The first, and most well known, such cooperative RTD programme in the UK was the Alvey Programme of research in advanced information technologies that began in 1983 and lasted for five years.

[38] K. Barker, L. Georgiou, C. Mac Kinlay, "United Kingdom Public Policies and Collaboration in Research and Development", working paper, January 2000.

Even though various evaluations of the Alvey programme have indicated positive outcomes in terms of new research results in enabling technologies, there was no direct continuation. Instead the government opted for a combination of (moderate) Advanced Technology Programmes to cater primarily for inter-firm cooperation and LINK, an initiative for university-industry collaboration.

All this changed once again in 1993 with the announcement of a refocusing of S&T policy on technology transfer and access to technology and services. The ATP programmes were abandoned altogether. LINK has been continued, albeit with lesser support. It is now the principal mechanism for supporting cooperative RTD. The emphasis of S&T policy has, however, shifted to the Foresight Programme aiming at identifying priorities for public support for science, stimulating partnership between the science base and industry, and promoting a foresight culture in UK industry. There is a limited number of Foresight LINK awards every year.

Legislation relevant to competition policy was first introduced in 1948 and has since gone through several changes (the latest being the introduction of the Competition Act of 1980) without, however, changing the main objective of avoiding restrictive trade practices. Until now, none of this legislation specifically affects the formation, or operation, of RJVs. At the time of the writing of the British paper, a new Competition Bill was expected which is intended to harmonise the domestic competition regime with that of the European Treaty, particularly Articles 85 and 86. As in the Treaty, exemptions for agreements with potential benefits to consumers and producers will be provided. These exemptions will also benefit cooperative RTD agreements.

The UK has been at the forefront of activities aiming at regulating IPRs and enforcing regulation. The country has one of the oldest IPR systems in the world. The Patents Act of 1977 is the main legislation for the "first-to-file" system in place. It has no special provisions for IP collectively owned by, e.g., the members of an RJV. The UK has also ratified the Community Patent Convention that aimed at fully harmonising the European patent system.

- **Sweden**[39]

The Swedish national innovation system is idiosyncratic, characterised by:
(a) Extensive decentralisation;
(b) Emphasis on university research and education;
(c) Very high share of industry R&D in overall R&D expenditures;
(d) High concentration of industrial R&D in very few large groups;
(e) High importance of defence RTD.

[39] D. Ioannidis, E. Wikstrand, "Independent actors in a complex network. The Swedish Science and Technology System", working paper, October 1999.

Every three years, a government research bill defines the general directions of S&T policy. Different agencies and authorities can decide about their internal organisation, the S&T areas they give priority to, and the way they distribute government funds. The government thus decides about the basic directions of long-term RTD policy and allocates funding to the ministries accordingly. The relatively small ministries, in turn, distribute funds to sector agencies and research councils attached to them. Sector agencies undertake their own RTD and finance basic and applied RTD to universities and public research institutes. Research councils distribute funds mainly to basic research projects (thus, universities) but also involve in transferring knowledge and services to industry.

Industry is the largest source and performer of RTD in Sweden. Industry covers about 90% of its RTD needs from its own funds. It per forms close to 70% of the total RTD in Sweden, the rest being shared between universities and the public sector. In the late 1980s, almost 10% of industry RTD expenditures went to universities but this percentage has declined considerably more recently. Industrial RTD is heavily concentrated in the hands of large corporations: 75% of total company-financed RTD originates in companies with more than 1,000 employees with almost 50% being contributed by the largest ten companies. Larger companies have also benefited significantly from defence-related RTD.

A lot of attention has been paid more recently on two issues. The first involves the assistance to smaller firms, following a widespread recognition that they play a significant role in economic growth and, yet, they are very underrepresented in the R&D system of the country. Given small firm heterogeneity, different policy tools have been used to support them. One involves regional RTD support to SMEs and regional universities in the hope that the result will be increasing collaboration between the two.

The second issue involves widespread efforts to bring universities and industry closer together for expediting knowledge exchanges. The law defining university tasks has been extended to include, in addition to education and research, the responsibility for initiating and developing relationships with their surrounding environments, thus increasing and broadening the relationship between universities and industry for creating and diffusing technological knowledge.

Competition law was introduced in 1993, following some lessons from the industrial crisis of the 1970s and the preparation of the country for integrating with the European Community. This law explicitly prohibits agreements to limit competition. RJVs are seen as positive developments, however, when no harmful effects to third parties exist.

IPR legislation dated from 1949 gives to employees the rights to their patentable inventions, unless there is a different agreement between employer and employee. The employer, however, has the right to exploit the invention in exchange of economic compensation. University personnel are excepted from this law, retaining

automatically the right to own and exploit their inventions. Increasing collaboration between universities and industry is expected to create some problems in that front, as researchers may be "forced" to pass on their rights to companies. Anticipating such problems, during the past few years researcher patent companies have been formed in association with universities to explore the patentable possibilities and advise researchers in legal, patent and marketing matters. They also participate in the commercial proceeds.

- **Greece**[40]

Until the early 1980s, relatively little attention had been paid to domestic technological development in Greece. Industrial policy offered the only policy tools available for technological upgrade. Technology was mainly transferred from abroad through a liberal foreign direct investment regime and a liberal licensing policy. Around the end of that era, a set of important changes materialised mainly through the creation of new institutions, including: the National Organisation of Small and Medium Sized enterprises and Manufacture; the National Organisation of Standardisation; and special education institutions for forming a middle management class. Importantly, responsibility for S&T matters passed on to the Ministry of Coordination. The Law 706 of 1977 finally established third-party (non-government) funding of basic and applied research in universities.

Many of the protectionist industrial policies of this earlier period have either been abandoned altogether or weakened since the country's accession to the EC in 1981. During the 1980s, the first attempts to set more precise objectives for a technology policy were observed. A number of important events marked the increasing interest of policy makers in the S&T system at that time:

(i) The Ministry of Research and Technology was created in 1982; it was later downgraded to the General Secretariat of Research and Technology, housed in the Ministry of Industry, Energy and Natural Resources, and currently of the Ministry of Development.

(ii) A series of laws were passed to create financial incentives for R&D, innovation and exports and to establish applied industrial research laboratories, and streamline technology transfer.

(iii) Calls for tender for national programmes promoting innovation and new product design started to be announced on a regular basis, notable examples of which are the two Programmes for the Development of Industrial Research.

(iv) Intermediate organisations for Industrial Research and Technological Development were created to support firms in several sectors, including textiles, food, metals, etc.

(v) Increasing participation of Greek organisations in the European Framework Programmes for RTD.

[40] I. Kastelli, "Science and Technology Policy in Greece. Policy initiatives for R&D cooperation", working paper, October 1999.

(vi) The Organisation for Industrial (Intellectual) Property was established in 1987 which is the Greek equivalent to a patent office.
(vii) Venture capital firms were institutionalised in 198 8.
(viii) There were efforts to better link education to production and create various training programmes.

During the 1990s, the Greek policy decision -making machinery galvanised regarding the importance of technological development and industrial u pgrading. Even more, the objectives of Greek S&T policy have been largely tailored around those of the European Union. The national legal framework offers explicit support to cooperative R&D in the context of the European programmes and of some national programmes who se objectives derive from the basic orientations of the EU S&T policy.

Competition policy had not been a policy concern in Greece until very recently. On the contrary, industrial policies of the past promoted the preserved monopolistic positions in the internal market. Various pieces of legislation since the late 1970s trying to harmonise with the Treaty of Rome had been generally ineffective until 1995 when Law 2296 introduced the legal framework for systematic control of anti - competitive practices. The Competition Commission can now move in a preve ntive fashion to scrutinise mergers, joint ventures and other forms of market concentration where the participants control more than 25% of the market or have a turnover above 50m. Euros. RJVs have generally r eceived favourable treatment.

The Greek system of IPR protection was rudimentary until 1988 when the Organisation for Industrial (Intellectual) Property became functional. While it is considered that the current legal framework regarding IPRs and tec hnology transfer is consistent with the European Patent Convention and the Treaty of Rome, national law still dominates regarding the patent annulment. RJVs are e xplicitly treated in this legislation in the case they involve a patent license; they are then declared invalid if they constrain competition in the sense of Article 85 of the Treaty of Rome. The claims and benefits from any patent resulting from cooperative R&D are equally distributed among partners unless it is differently defined in the patent application form.

Special provisions exist for the results of R&D subs idised by the national government. For some programs, the provisions are specific to cases where the R&D result is not being exploited commercially by the proprietor or where the initial proprietor assigns the rights to a third party. For other programmes, the public sector owns the inte llectual property and takes part in the proceeds from it.

- **Ireland**[41]

[41] K. Benetatou, A. Christoforou, Y. Katsoulacos, "Science and Technology Policy and Linkages with Competition and Intellectual Property Rights (IPR) Policy in Ireland: Featuring RJVs", working paper, December 1999.

Ireland is a latecomer in S&T policy. Moreover, the newly instituted Irish S&T policy has been intimately linked with industrial policy, industrial competitiveness, and economic growth. The S&T policy, then, must be understood as a recent "extension" of industrial policy.

Probably the most influential document underlying current S&T poli cy in Ireland, "Making Knowledge Work for Us" (Tierney Report), was produced in 1995 by the Science, Technology and Innovation Council. This report created the basis for the 1996 White Paper on Science and Technology Policy that has given the S&T policy "roadmap" currently in effect in Ireland. The White Paper placed the promotion of innovation activities in Ireland within the conceptual framework of the national innovation system. It concentrated on eight areas:

- **(i) National S&T strategies and structures, a iming at creating a coherent national framework (for the first time in this case) and at determining long - term national R&D prior ities;**
- **(ii) Innovation in business enterprises, aiming primarily at measures to assist private sector firms undertaking R&D in Irela nd;**
- **(iii) Technical services for enterprises, aiming at the provision of such services that cannot be provided more effectively by other means;**
- **(iv) Support for natural resource -based sectors, aiming at developing the full potential of these sectors (which include mo st of the indigenous firms undertaking R&D);**
- **(v) Programmes in advanced technology, aiming primarily at technology transfer in key -technologies with a significant impact on economic and industrial develo pment;**
- **(vi) Third level research and the role of colleges, aim ing at the research activities of third -level educational institutions other than universities;**
- **(vii) Education and training, aiming at their improvement;**
- **(viii) Awareness of science, technology, and innovation, aiming at increasing public awareness of the "technical e nterprise".**

This White Paper underlines the importance of a government programme to encourage inter -firm cooperation and networking (area (ii) above). Various surveys administered by Forfas have indicated relatively low inter -firm cooperative R&D activity in Ireland. Cooperation involving universities and public institutes is at fairly similar le vels to those of other European countries.

The major development in terms of competition policy in Ireland was the Compe tition Act of 1991 that reshaped an arguab ly weak (and unevenly enforced) Irish comp etition law to conform to Articles 85 and 86 of the Treaty of Rome. The block exemptions of Community law have also been accepted. There is no explicit mention in the law for more favourable treatment of RJVs. Pr esumably, however, they will be treated at least as leniently as at the EU level. [42] Finally, there are no special provisions of the IPR systems for the outcome of cooperative R&D a ctivities.

[42] And perhaps a little bit more given a history of both relatively weak competition laws until recently and extensive support of targeted industries for economic development.

♦ **Spain**[43]

Spanish S&T policy emerged in the 1980s when relevant legislation was adopted and five-year national S&T plans were put in place. The Spanish S&T policy can be characterized as diffusion-oriented, focusing primarily on the diffusion and adoption of existing technology. There has been a move away from fundamental research and a push towards applied and market-oriented research. Emphasis has been placed on building the technology infrastructure and on intensifying the links between public research institutes and universities with industry. The contribution of the public sector in S&T has been very important in this time period not least because of the pro-active role it chose to play in this field. Such a role was deemed necessary first in view of the country's accession to the EC and then in view of the needs of Spanish industry to improve its competitiveness in a much more open economic environment.

The ten years prior to EU accession were the turning point for Spanish S&T policy. In 1977 the Industrial Technological Research Centre was created to assist the technological activities of firms. Besides financial incentives, the Centre managed Technological Development Projects (create or improve products and processes) and Technological Innovation Projects (introduce new technologies). In 1983, the University Reform Act established mechanisms to promote university-industry cooperation in R&D. In 1986, the Scientific and Technological Research Promotion and Coordination Act reorganized the institutional framework for Spanish S&T policy. It introduced the 5-year National Plans for Scientific Research and Technological Development. An inter-ministerial Commission for Science and Technology was also created to oversee implementation and monitor the results. This Commission coordinates both domestic and international R&D activities.

The National Plans set the objectives and priorities of domestic S&T policy and allocate resources between different activities. They are funded by the National Fund and are all encompassing. Three National Plans have been implemented until now, 1986-1991, 1991-1996, 1996-1999. The first two Plans were on similar lines. Among others, they created two main Programmes for supporting R&D: PACTI (Programme for the Promotion of the Scientific and Technological-Industrial System) and PETRI (Programme to encourage the Transfer of Scientific and Research Results). PETRI finances complementary applied research to facilitate the adoption of new technology by industry.

The 3rd National Plan introduced several novelties. It is more clearly oriented towards applied research. It aims at improving the transfer of knowledge from the science sector to the productive sectors. It emphasizes the diffusion of existing technological knowledge across the economy. Finally, it aims at coordinating R&D activities at the national and international levels. The PACTI Programme has been

[43] P. Marin, G. Siotis, "Science and Technology Policy in Spain, 1980-1998", working paper, December 1999.

charged with identifying and developing actio0ns to maximize interactions between the different communities involved in R&D. This has been pursued through: (i) the development of interfaces among the scientific, technological and enterprise sectors; (ii) the stimulation of cooperative R&D; the growth of human resources with adequate technological training in companies.

In addition to the National Plans, the Ministry of Industry and Energy has developed an incentive system for industrial R&D activities framed in two PATI programmes from 1990 onwards (Industrial and Technological Action Plan) and in ATYCA since 1997 (Supporting Actions for Industrial Technology, Safety and Quality). The PATIs aimed at improving competitiveness through the generation and implementation of advanced technologies. ATYCA integrates PATI with existing quality and safety programmes. Competitiveness growth is now combined with increased living standards as objectives. Finally, several of the Spanish Autonomous Communities have developed their own S&T programmes and developed Regional Research Plans.

Prior to EC entry in 1986, Spain had no antitrust legislation relevant to RJVs. The current legal framework for RJVs in Spain has been introduced wholesale from the EU. Competition policy consists of the translated Articles 85 and 86 of the Treaty of Rome and the relevant EC regulations (also translated and turned into Spanish law). The Antitrust Commission is responsible for overseeing the system. A similar situation exists for IPRs. A 1929 law regulating IPRs was deemed inadequate and was replaced by the Patent Act of 1986. This Act basically translates the 1973 Munich Convention on European Patents and the 1975 Luxembourg agreement on European Community patents. The EU regulations on block exemptions related to both unfair competition and patent agreements are also applicable in Spain. Overall, then, the legal framework applicable to RJVs in Spain boils down to European legislation.

- **Japan**[44]

Japan has been a pioneer in the post-War period in supporting cooperative R&D. Like its industrial and general S&T policy, however, the objectives and organisation of cooperative R&D organisations have changed significantly in Japan during this time period. The idea of research associations was basically imported from the UK but, in classic Japanese fashion, adapted from an instrument for assisting declining industries and firms to an instrument for gathering, adapting (and progressing), and distributing technological information more efficiently in high technology industries.[45] **The Japanese Engineering Research Associations (ERAs) were the outcome of the Mining and Manufacturing Industry Technology Research Association of 1961. Sakakibara (1997) has counted 237 government promoted**

[44] K. Benetatou, A. Christoforou, Y. Katsoulacos, "Science and Technology Policy and Linkages with Competition and Intellectual Property Rights (IPR) Policy in Japan: Featuring RJVs", working paper, January 2000.

[45] See Vonortas (1991) for a summary of the evolution of Japanese ERAs.

ERAs set up between 1961 and 1992 but it is hard to know how many exactly due to the lack of a unified source of information.

Around the mid-1970s, ERA focus changed significantly from generating/adapting specific technologies to assist whole sectors catch up with world practice to the creation of more generic knowledge, thus creating a broader technological superstructure for a large group of high technology sectors (Oshima and Kodama, 1986). Some ERAs were met with considerable success but seemingly nothing close to what was at the time imagined in western countries. Government funds were small, measurable technology outputs fairly modest, and collaboration often meaning an agreement to share the work but work independently (no common labs). Recent research has shown that the most important incentive for firms to participate is to access complementary (technology) resources rather than the traditionally viewed cost-sharing incentive.

ERAs represent only one form of collaborative R&D in Japan. Such cooperation also includes trade associations, joint research institutes, collaboration within large keiretsus, and more informal agreements. The basic difference of ERAs is that they are formed under the auspices and guidance of the government and often include a significant proportion of the large players in a technological area. While technically they are bound by the collusion statutes of the Antimonopoly Law, the Japanese Fair Trade Commission (that enforces the Law) apparently does not consider this type of cooperative R&D to pose a real threat to competition. In some sense, it does seem that Japanese cooperative R&D agreements promote competition. E.g., patents that have resulted from conditional loans – a frequent mechanism of government support – must be held jointly. In these cases, the ERA will typically set the conditions for licensing agreements and fees. In cases where MITI has provided direct grants for the R&D the resulting patents are controlled by the government. Recent versions of the White Paper on Science and Technology have anticipated cooperative R&D to continue playing a role in the development of Japan.

The Japanese competition law is based primarily on the Antimonopoly Act of 1947. The Act has been subsequently amended in 1977, 1991, 1992, and 1996. It covers unreasonable restraint to Trade (cartels), monopoly and oligopoly, mergers and acquisitions, unfair trade practices, activities of trade associations, and restrictive international contracts. As a result of the amendments, both the original Act and the enforcing agency – Fair Trade Commission – have been strengthened. The last three amending steps reflected attempts of harmonization with foreign practice.

The basic document to work on the competition implications of IPRs in Japan is the "Guidelines for the Regulation of Unfair Trade Practices with Respect to Patent and Know-how Licensing Agreements" released by the FTC in 1989. According to these, the actual influence of the imposed restrictions in IPR transactions on competition must be analysed on a case-by-case basis in order to determine whether a specific transaction constitutes an unfair trade practice. Specifically for RJVs, the

FTC released the "Antimonopoly Act Guidelines Concerning Joint Research and Development" in 1993. Again, the determination of whether an RJV substantially restraints trade in the relevant product or technology market is to be made on a case-by-case, rule-of-reason basis.

- **United States**[46]

The federal government has acted on RJVs under mounting pressure during the early 1980s that an increasing number of firms in high technology sectors has been choosing cooperative R&D agreements routinely to carry out technological activities. In addition, the belief of policy decision-makers in the merits of cooperative R&D fed on fears concerning the relative loss of international economic competitiveness. It also fed on the past experience of fast-follower countries that promoted cooperative R&D to access, assimilate, and diffuse technology quickly in their efforts to catch up.

The first Reagan Administration set the stage for a radical shift in market environment affecting business strategy and behavior, including the undertaking of R&D. This shift was encapsulated in extensive changes in antitrust regulation enforcement and intellectual property rights enforcement. Starting in 1982, the Merger Guidelines issued by the Department of Justice (DoJ) and the Federal Trade Commission (FTC) have promoted a new approach to examining the competitive effects of "partial mergers" (joint ventures). They should be judged on a "rule-of-reason" basis – that is, on a case-by-case basis where the static anticompetitive effects would be juxtaposed to their potential for beneficial effects over time. If anything, more recent versions of the Merger Guidelines (1992) have pushed even harder in the same direction. In the case of RJVs, dynamic effects imply the enhanced ability of firms to create new technological knowledge as a result of the collaboration. This opened the door for the National Cooperative Research Act (NCRA) of 1984 to promote RJVs undertaking research of generic interest, a clear signal that cooperative research was now becoming a desirable activity. Its follow-up, the National Cooperative Research and Production Act (NCRPA) of 1993, welcome any type of inter-firm collaboration as long as it is based on cooperative R&D.

On the other hand, the initiation of the brand new 11th Circuit Court especially for IPR issues that clearly leaned towards a much stricter approach to infringement gave a clear signal of the increased status of private intellectual property. This provided further incentives for collaboration by diffusing the fears of prospective RJV participants for involuntary loss of knowledge to their partners in the joint venture and others outside it. In addition, a series of legislative actions, starting with the Baye-Dole Act in 1980, created the legal framework for permitting the private sector and universities to benefit financially from the results of the research undertaken with or for the government (excepting national defense items). This legislation opened the door for collaborative agreements between industry, universities and government laboratories. It created the background for setting up Cooperative Research and Development Agreements (CRADAs), the number of which has increased very much during the past ten years or so.

[46] N. Vonortas, "US Policy Towards Research Joint Ventures", working paper, November 1999.

Following the creation of the appropriate leg al background, Congress moved towards establishing selective programs to also fund RJVs. The turning point was the Omnibus Trade and Competitiveness Act of 1988 that redefined (largely extended) the role of the National Institute of Standards and Technolo gy (NIST) and tasked it with the management of the Advanced Technology Program (ATP).

Democratic Administrations that took office early in the 1990s built on this sy stem. In addition to further reinforcing the legal environment favoring the establishment of RJVs, they pushed forward a series of Programs actively promoting collaboration in R&D through subsidies or other incentives. The objective was now to use government resources to "channel" private sector R&D activity in certain technological areas wit h significant potential for widespread economic returns. Government resources were limited; RJVs were used as a mechanism to leverage these resources with the resources of industry.

A host of programs promoting cooperative R&D were either put in place or largely expanded in the first half of this decade. These, for example, include: (i) the ATP that focuses on very risky, longer term, and yet applicable R&D for civilian technologies; (ii) the Technology Reinvestment Program (TRP) promoting dual -use (military-civilian) technologies; (iii) the Partnership for a New Generation of Vehicles (PNGV) involving a large number of government agencies and the major US -based motor vehicle manufacturers for accelerating the introduction of new, less fuel consuming power plants in automobiles; (iv) the Environmental Technology Initiative (ETI) in the Environmental Protection Agency (EPA) to assist industry generate more efficient and environmentally benign manufacturing processes; and so forth. Meanwhile, various state g overnments have also initiated cooperative R&D programs within their territory. Finally, government agencies such as the National Science Foundation have been influential in enhancing university-industry collaboration through various programs since the ea rly 1980s. Perhaps the most well known such program involved the establishment of a number of Engineering Research Centers with both university and industry participation.

Unfortunately for such efforts, the new Republican majority voted in to Congress i n 1994 made very clear that it viewed all these programs to be "corporate welfare" and, thus, considered their elimination a priority. The first clear signal came with the elimination of the Office of Technology Assessment (OTA) – serving Congress itself – in 1995. Then TRP was unraveled. ATP barely escaped elimination, but since 1995 has been a shadow of its prior self. PNGV has also lost its initial determination, largely due to the lack of focused government support. The recent buy -out of one of its three industrial partners by a foreign firm has more or less paralyzed it. A well -publicized report of the Congressional Committee on Science two years ago did not provide major hope either for a turnaround in terms of sympathizing with the current Admini stration's wish to involve more in the T part of S&T po licy (US Congress, 1998).

The above has coincided with very impressive rates of growth of the American economy, which have also lessened pressures from the international competitiveness camp. Currently in an election period, the federal government is not attempting any risky moves

– no new programmes have been announced recently or are being planned.

4. CONCLUSIONS AND POLICY IMPLICATIONS

Since the early 1980s, most industrial country governments have promoted cooperative industrial R&D aggressively. The European Union has been a front-runner, turning cooperative R&D into a cornerstone of the Framework Programmes in RTD since day one. The direct or indirect support of cooperative R&D has also gained a lot of ground in member states, including both those with significant experience in science, technology, and industrial innovation policy and those without.

The economic, business, and policy literature on cooperative R&D has also proliferated during the same time period. It has provided the conceptual rationale for active government policy under a serious handicap: the lack of systematic and extensive evidence to validate its theoretical underpinnings. This is not to say that evidence on motives for and outcomes of collaboration has been missing altogether. Quite the contrary. It can be strongly argued, however, that available evidence has been fragmented because of the lack of extensive data collection on the subject by statistical agencies. Empirical analysis has depended on either multiple case studies on a small number of well-known RJVs, on one hand, and on (often limited) databases created by academic researchers and private sector companies, on the other. Some well known examples of widely utilized academic databases of this sort include CATI, covering technical strategic alliances announced globally since the late 1970s, and the NCRA-RJV and CORE databases, covering RJVs registered with the US Department of Justice since 1985. [47] **Unfortunately, such data have not necessarily been compiled for the same purpose, overlap only partially in terms of coverage, and use different primary sources of information. Even so, research has hitherto reached important conclusions and has provided useful insights in to business strategy and technology policy.** [45]

A major, if not the most important, contribution of this project has been the creation of a new source of information on cooperative R&D, focusing exclusively on Europe. This is the STEP TO RJVs databank, made up of four separate databases. First, the EU-RJV database contains information on all RJVs with at least one business participant that were funded through the European Union's Framework Programs for RTD since 1984. It currently also contains selected financial information for the period 1992-1996 on a large number of identified business participants. Second, the EUREKA-RJV database contains similar information on all RJVs selected by the EUREKA programme since 1985. Third, four national databases contain information on RJVs funded by the governments of four EU member states: Greece, Spain,

[47] CATI is maintained by John Hagedootn and his colleagues at the University of Maatricht. NCRA-RJV is maintained by Nick Vonortas at the George Washington University. CORE is maintained by Al Link at the University of North Carolina.

Sweden, and the United Kingdom. Finally, the RJV Survey database contains detailed information from an extensive survey of European firms participating in RJVs. The latter is really one of the most extensive databases of its kind containing detailed information on the characteristics, strategies, and incentives and benefits from cooperative R&D for several hundreds of business respondents. The STEP TO RJVs Databank is currently maintained by Yannis Caloghirou and his colleagues at the National Technical University of Athens.

The link across all the databases in the STEP TO RJVs databank is the private sector – covered partnerships include at least one member organization from the private sector. They have all been constructed under the objective of allowing the study of the incentives for and impacts of cooperation on the private sector. The distinguishing feature of the STEP TO RJVs databank as a whole is that it focuses solely on government supported RJVs, with the partial exception of the RJV Survey database that also includes non-subsidized RJVs. In addition, the databank combines diverse kinds of information – subjective (quantitative) and objective (qualitative and quantitative) – on diverse kinds of RJVs (in terms of sources of funding). It thus allows the most direct undertaking of analyses matching the objectives for and impacts of policies supporting cooperation in the creation and dissemination of new technological knowledge.

This research project used a multi-faceted analytical approach, the different databases in the STEP TO RJVs databank, and a large number of RJV case studies, to address several issues in the following broad topical areas:

1. Trends in RJV formation in Europe and their characteristics.
2. Determinants of RJV formation.
3. RJV performance and impact on participating firms.
4. Impact on European industries and regions.
5. Policies supporting RJVs in Europe, the United States, and Japan.

4.1. Trends in RJV Formation

The study showed in considerable detail the formation of RJVs funded through the first four Framework Programmes on RTD during 1984-1996.[48]

- Starting with ESPRIT in 1983, RJV numbers have increased considerably into the 1990s. Formation seems to follow a cycle that peaks about two years into a Framework Programme, no doubt as a result of available funding.

- Information Processing and Information Systems, and Electronics and Microelectronics have taken more than a quarter of all RJVs. Other important areas have been Materials, Industrial Manufacture, Aerospace, telecommunications, and renewable energy sources.

- More than three quarters of the RJVs extended up to three years, with half of that around the three-year range.

[48] Time limitations allowed coverage of only the first part of the 4th Framework Programme.

- Various organizations participate. The largest single category of RJVs has firms, universities and research institutes as members. The next three largest involve firms collaborating again with non-private sector organizations in various combinations.

- RJV size, duration, and combination of members indicates concentration on pre-competitive research.

- Firms are by far the most frequent coordinators of the examined RJVs.

The EUREKA data was compiled in order to have a point of reference. EUREKA and the Framework Programmes are, of course, very different. The EU Framework Programmes largely reflect a top-down procedure, following extensive consultations with stakeholders, that is implemented through "focused" competition in specific technological areas. This contrasts EUREKA practice. On the other hand, unlike the Framework Programmes, EUREKA has always focused on applied research aiming at the development of marketable products and processes. In addition, whereas Framework Programmes involve subsidization, approval by EUREKA only means a label that improves chances for national funding of individual partners. Finally, whereas the Commission overseas Framework Programme projects whose results are the property of both the Commission and the partners, nobody else but the partners oversee EUREKA projects or own their results.

The different design and governance of the two policy frameworks for collaborative R&D have resulted in different sets of RJVs. Important differences include:

- ***Technological areas*: Framework Programme RJVs have tended to concentrate relatively more on ICTs, whereas EUREKA RJVs have been more evenly distributed across several technical areas.**

- ***Duration:* Most of the examined EU-funded RJVs (66%) are medium-term. A larger percentage of EUREKA RJVs are longer term. However, it is worth noting that this "average" and "cumulative" picture hides an emerging trend: the gradual decrease in the duration of EUREKA RJVs. On average, EU and EUREKA RJVs initiated during the recent few years tend to last about the same time.**

- ***Size*: Most EU-RJVs are middle sized (6-10 partners), whereas the majority of EUREKA RJVs have been small-sized (2-3 partners).**

- ***Type*: EU-RJVs involve significant cooperation between firms, universities and research institutes; inter-firm cooperation is much more prevalent in EUREKA RJVs.**

- ***Coordinator:* Firms tend to be the coordinators in the majority of both EU and EUREKA RJVs. Other organizations such as universities and research**

institutes also tend to act as coordinators in a significant number of EU RJVs (38% of the total number of RJVs formed). Not so in EUREKA RJVs.

Ø ***Business firm characteristics*: Large firms tend to participate more often, especially in the EU RJVs. On the other hand there is a large number of SMES firms that have a rather limited participation (1 to 3 times). Participation in EUREKA RJVs seems to have been more balanced between firms of different sizes.**

Ø ***Sectoral representation*: In both types of RJVs firms active in the electrical and electronic engineering and business services sectors appear to be the more frequent participants than firms in other sectors. Firms active in the chemical sector tend to have higher participation in EUREKA RJVs. Firms active in telecommunications appear to participate relatively more in EU RJVs compared to EUREKA RJVs.**

4.2. Determinants of RJV Formation

4.2.1. EU-RJV and EUREKA-RJV Databases

The first question for this empirical analysis was why firms enter RJVs. The analysis addressed important questions in the theoretical economic literature. Main findings include the following:

Ø Knowledge spillovers are an important determinant of RJV formation, but their impact only emerges in R&D-intensive industries.

Ø Industry concentration is positively related to the rate of RJV formation. One reason may be that concentration may facilitate the internalization of spillovers. It also reduces the intensity of competition in the marketplace.

Ø **Firm size is a very significant determinant of participation in RJVs. This finding may be qualified by the fact that only firms of certain size and kind (e.g., publicly traded) are usually represented in publicly available databases like Amadeus used here to draw financial data.**

Ø Past experience in research cooperation greatly enhances the probability of forming new cooperative ventures. This may indicate several things. First, it may indicate that firms appear satisfied on average with RJVs, as they show a clear willingness to repeat the experience. Second, it may indicate that there are fixed costs and strong learning effects associated with an RJV.

The second question for this empirical analysis was what determines the exact pairs of firms that collaborate. In other words, why the observed couples of firms and not others? Main findings included the following.

- The probability of forming a couple is larger when firms are in the same industry and when their products are complementary.

- For firms producing substitute products the probability of forming a couple is higher the lower the asymmetries between them.

- In the Framework Programme, the larger the asymmetries between firms, the more likely RJVs to be formed. This result should, however, be taken with caution as it may simply reflect the design of these Programmes.

- EUREKA couples are more likely to form between firms both based in Northern European countries. This relationship is not significant for Framework Programmes, showing a policy bias (cohesion) in favour of firms based in Southern European countries.

4.2.2. RJV Survey Database

4.2.2.1. Cross-tabulations of survey responses

Tabulations of subjective information from the survey revealed the importance of the following objectives of firms to join specific RJVs (listed by order of importance):
- Establishment of new relationships.
- Access to complementary resources and skills.
- Technological learning.
- Keeping up with major technological developments.

Concerning the objectives of firms to generally collaborate in R&D, they were reported as follows (by order of importance):
- Access to complementary resources and skills.
- Keeping up with major technological developments
- Technological learning.
- R&D cost sharing.

4.2.2.2. Statistical analysis

It was possible to aggregate the competitive strategy of surveyed firms into two broad categories – focusing on either existing large markets (mass markets) or smaller market segments (niches). Both kinds of strategies correlated with the same four objectives of companies for engaging in cooperative R&D:
- Create new investment options;
- Control future market developments;
- Keep up with major technological developments;
- **Improve speed to market.**

The mass market oriented strategy was highly correlated with creating new investment options – apparently reflecting the use of RJVs as a mechanism for differentiation in new markets – and with controlling future market developments – probably reflecting the size of the respondents, their invested interests in existing large markets, and their fear of losing control as a result of new technologies. Such firms may be using RJVs for casting their nets wide – be present when something exiting happens. In contrast, the market segment oriented strategy was highly correlated with improving speed to market, and least correlated with keeping up with major technological developments. Such firms would seem to have identified the technologies they are interested in and to be using RJVs in order to access the necessary complementary resources to bring their products to market quicker.

An important question to policy decision makers is the difference that public funding makes in forming the RJV. Almost two thirds of the responding firms (total 456) said that they would not have undertaken the specific research (cooperatively or otherwise) without government funding. The rest one third would have gone forward even without such funding. Importantly, for between two thirds and three quarters of the respondents, this information related to cooperative research that falls within their core business activity.

4.2.3. RJV Case Studies

RJV case studies offered particularly valuable insights into the question of RJV formation. More specifically:

- Previous relationships among partners (personal or institutional) played a critical role in several of the examined cases.

- The importance of the role of a "research entrepreneur" cannot be over estimated. Such people often are responsible for the original idea for the specific R&D and its implementation through the RJV.

- Successful collaboration depends on trust. Initiating a partnership is always easier by experience from previous collaborations. Trust building is an important dynamic process.

- Firms in complementary business collaborate frequently. An important reason tends to be the complexity of the product under development that requires complementary capabilities. Cooperation among firms operating in different, but related, sectors (such as telecommunications services and semiconductors) with different strategies and corporate cultures allows the necessary interchange of assets, skills, and experiences.

- Competitors will collaborate either when there is no major market challenge or to establish technical standards. Otherwise, competitors will limit their collaboration to pre-competitive research.

- Ø Firms and universities share knowledge and experiences more easily than firms with firms.

- Ø The institutional set-up and regulations (environmental, technical standards, etc.) often provide the motive for new collaborations.

- Ø Government-subsidised RJVs are often set up in response to international competition.

- Ø Many RJVs are formed under the pressure of high uncertainty and rising R&D expenditures due to rapid technological change.

- Ø Another way to slice the observed objectives to collaborate in R&D is between large, established firms and small, less resource-rich firms. The former tend to collaborate in areas of high uncertainty, where the research outcome is not close to the market but may open new market opportunities in the future, after further development by each partner. The latter firms collaborate to learn or to create the necessary technological and organisational capabilities that will enable the firm to compete internationally and to leverage their own limited R&D resources.

- Ø Small firms that cannot afford extensive R&D investment occasionally choose to subcontract or to collaborate with Universities or research centres that have the people and infrastructure for specific research activities.

4.3. Performance

The literature has identified a number of problems in analyzing the performance of alliances. The most important involve:
. Differences in the definitions of RJV success among individual member organizations;
. Lack of appropriate empirical measures of performance;
. Disagreements over the relative appropriateness of objective versus subjective measures of performance; and,
. The fact that some of the most important indicators can only be expressed through subjective evaluations.

By design, this project allowed access to data suitable for the construction of both objective (e.g., financial) and subjective (survey) measures of RJV success . It could thus support a two-pronged econometric and statistical approach to the question of performance. The data from the EU-RJV and EUREKA RJV databases were used to support an objective-measure approach while the data from the RJV survey database were used to support a subjective-measure approach. Even though the results from these

two approaches are not directly comparable due to partly different RJV and firm samples, they are both informative and relatively rare for combining both methodological venu es.

4.3.1. EU-RJV and EUREKA-RJV Databases – Objective Measures Approach

This analysis focused on the impact of participation in either Framework Programme or EUREKA RJVs on firm performance.

- Descriptive statistics indicate higher productivity (on avera ge) for RJV participating firms than for nonparticipants. Firms in EUREKA RJVs were shown relatively more productive than firms in Framework Programme RJVs.

- Econometric analysis was able to establish a positive impact of EUREKA RJVs on the examined firms but no clear trend for Framework Programme RJVs.

The downside is that these results depend on relatively small samples and with short time lags between the initiation of the research and the measurement of performance. This may be important given the gene ral orientation of Framework Programme RJVs for more pre-competitive R&D that is expected to affect performance in longer time period than the development research which is the primary focus of EUREKA RJVs.

4.3.2. RJV Survey Database - Subjective Measures Approach

4.3.2.1. Econometric analysis

Successful partnerships were considered in this analysis to be those that met or surpassed the objectives of partner firms.

- The success of the examined RJVs in meeting or surpassing the overall objectives of individual industry partners was found to increase:
  - (i) the more related the cooperative research is to the existing activities of the firm;
  - (ii) the lesser the problems of knowledge appropriation between the partners;
  - (iii) the higher the effort of the specific business unit involved in the RJV to learn from it through various channels.

- The incentive of a firm to join an RJV in order to share risks and decrease market and technological uncertainty:

(i) is positively correlated with cooperation with supplier and buyer firms, and cooperation with competitors;
(ii) is negatively correlated with cooperation with universities and public research institutes and with the degree of appropriability of the cooperative R&D.

Ø The motivation of a firm to join an RJV in order to create new investme nt options:
(i) is positively correlated with cooperation with competitor firms;
(ii) is negatively correlated with cooperation with universities and public research institutes and with the degree of appropriability of the cooperative R&D.

4.3.2.2. Statistical ana lysis

A persistent question in the literature relates to the apparent asymmetric benefit of various partners in an RJV. In other words, what accounts for the apparently disproportionate benefits of some partners over others from the same RJV?

Each of a long list of learning mechanisms – i.e., mechanisms for creating and acquiring new knowledge – was correlated to three broad categories of benefits from RJVs: direct product development and profitability benefit, process development benefit, and benefit on the firm's knowledge base.

Ø The strongest relationships were found with respect to the knowledge base benefit which was correlated with all learning mechanisms, including:
(xiii) Undertaking basic research internally;
(xiv) Undertaking applied research internally;
(xv) Undertaking development research internally;
(xvi) Undertaking design engineering internally;
(xvii) Developing formal relationships with users and/or suppliers;
(xviii) Developing informal relatiosnhips with users and/or suppliers;
(xix) Observing and imitating processes of other firms ;
(xx) Learning from patents;

(xxi) Learning from codified scientific and technical information (databases etc.);

(xxii) Using employee training and education;

(xxiii) Engaging in long-term forecasting and product planning;

(xxiv) Institutionalising procedures for exploiting ideas and initiatives from individual employees.

Undertaking of internal (independent) development R&D proved the best facilitator of benefits to the knowledge base of the firm.

- Product development benefit also correlated positively with all learning mechanisms (except xii), particularly so with developing formal and informal relationships with users and/or suppliers, and undertaking development research internally.

- Process development benefit was positively correlated with imitation of other firms, and undertaking internal applied and development research.

- Undertaking independent, similar R&D to that of the RJV was found strongly correlated with the ability of firms to maximise their benefits from the RJVs they participate in. Such R&D especially helps them to acquire/create new knowledge, improve their technological and organisational capabilities, increase market share, and exploit complementary resources.

- Mass-market oriented strategy is correlated with process development benefits from RJVs. Market segment (niche) oriented strategy is correlated with product development benefits from RJVs.

Such results confirm earlier findings in the literature that independent research effort in the firm enhances considerably its ability to benefit from RJVs and, more broadly, from knowledge in the public domain. They also strongly indicate more general benefits from RJVs (knowledge base) than those tied to specific products and production processes.

4.3.2.3. Cross-tabulation of survey responses

Respondents reported the following as the most important expected benefits from specific RJVs they had participated in (listed by order of importance):

- Acquisition/creation of new knowledge
- Development of new products
- Improving the technological and organizational capabilities of the participating unit

Expectations were fulfilled for the following expected benefits (listed in order of importance):

- Acquisition/creation of new knowledge
- Improving the technological and organizational capabilities of the participating unit
- Continuation or acceleration of existing research

4.3.3. RJV Case Studies

RJV case studies also offered valuable insights into the question of RJV performance. More specifically, it was found with respect to benefits: [49]

- In most examined cases, it was difficult to determine the outcome of the collaborative R&D in terms of introduction of a final product or production process. While various explanations exist, outright failure to reach the RJV's objectives should not be excluded from the list of possible reasons for this disappointing finding.

- A major reported benefit from participating in the examined RJVs has been the acquisition of new knowledge in fields in which either responding firms were not willing/able to invest their own resources or they didn't possess the necessary capabilities to tackle on their own.

- Cooperation often provided the possibility to access the complementary assets of partners, including technological knowledge, human capital, financing, and so forth.

- RJV participation also opened new market opportunities for firms and gave opportunities to the academic sector to make their research efforts more visible.

Reported problems in the RJV can be grouped into two main categories:

- *Problems due to the funding programmes.* In many cases the participants of subsidised RJVs reported problems resulting from the rigidity of the programmes, more specifically relating to budget allocation changes and partner changes. Especially for the latter, it was pointed out that although the responsibility of the prime contractor is clearly defined, the flexibility of dealing with problems with the partners is low. Moreover, reporting requirements, budget changes, and bureaucratic rigidities were mentioned as impediments.

[49] The benefits from the cooperation should, of course, be measured against what would have happened in the absence of the RJV. The counterfactual is almost impossible to obtain within reasonable confidence levels.

Ø *Problems related to the cooperative scheme* . The opportunities for commercialisation of the R&D results are one main concern of RJV participants from the private sector. Lack of appropriate consideration concerning how to bring the results of R&D to market was a frequently reported problem.

Not surprisingly, the importance of government subsidies has been pointed out in all examined cases. There were differences, nevertheless, in the reasons that made subsidies important:

(iii) Cases where funding was decisive for supporting the specific R&D activity.

(iv) Cases where projects aimed at strengthening European competitiveness. Public underwriting has created a mechanism for bringing together important economic agents that needed an institutional framework for doing business together. Public funds as such were of secondary importance.

Some interviewees commented on the potential value of spreading funding over more projects in future Framework Programmes. This would reportedly result in participation incentives resting more on higher visibility and networking than access to funds. Some of the subsidised projects could arguably proceed without funding beyond administration expenditures.

4.4. Impact on Industries and Regional Economies

Has collaborative R&D supported by the Framework Programmes on RTD and EUREKA contributed to the convergence of firms based in different regions of the European Union? Has such R&D contributed in narrowing the technological gap between participating firms? Has it contributed to narrowing the technological gap between firms in manufacturing?

Based on a sample of RJVs drawn from the STEP TO RJVs databank, econometric analysis in this project has found (a) substantial evidence of short term convergence across firms in Europe and (b) positive effect of international R&D cooperation on the overall convergence process.

More specifically, regarding the first question, the analysis across countries and across different manufacturing sectors in Europe supports the hypothesis that RJVs favour technological convergence both at the country level – this effect is not statistically significant for Germany and the UK – and at the sector level for 14 out of the examined 21 sectors.

Regarding the second question, the results support the hypothesis of convergence among all countries except Germany and the UK.

Regarding the third question, the results show that cooperative R&D has a positive impact on closing the technological productivity distance between firms in a sector. The

highest the number of RJVs in which a firm participates, the smaller the deviation from the highest productivity firm in its sector.

A different analytical approach was also used to map the networks formed in a subset of 3874 Framework Programme RJVs during 1992-1996. Network formation can reasonably be expected to contribute to technological and economic convergence. Considering a "link" between two firms to exist if they cooperated at a minimum in seven RJVs during this time period, researchers were able to three major networks in the automobile, aerospace, and electronics/telecommunications industries. In all three cases, large, well-known corporations based in the core countries of the European Union have central positions.

The three networks are also connected with each other through links between certain important members of each network.

One implication of dense networking is that the European Framework Programmes on RTD have established an important mechanism for transferring knowledge and experience across traditional sector boundaries as well as across national/regional boundaries. Another implication may be the use of the European programmes by large corporations for anticompetitive reasons (Mytelka, 1995; Van Wegberg and Van Witteloostuijn, 1995; Vonortas, 2000). The potential for collusion through publicly supported RJVs is a subject that would deserve further study – anticompetitive behaviour would, of course, run counter the objectives of the European Commission in the Framework Programmes.

4.5. Policies for Cooperative R&D

There are extensive policy differences between individual EU member states. Although potentially oversimplified, the broad picture painted by a series of papers prepared by the members of this consortium defines a policy range from the relative indifference to the issue of R&D cooperation until recently (Ireland), to rapidly decreasing attention (UK), to lukewarm policies in anticipation (Greece, Italy), to well established, specialized network systems (Sweden), to highly focused programmes to assist cooperative industrial R&D (France, Spain). The level and type of support has varied widely as have the specific programmes, their technological focus, and the numbers and kinds of economic agents that have participated.

Amidst this variability, the European Commission's policies have played a boosting and cohesive role. The visibility (and funding) of European programs has increased to the extent that member state governments see them as complements to their own S&T policies.

As expected, the policies of Japan and the US have also been quite different from those in Europe. In Japan, the emphasis on cooperative RTD continues.

Government-sponsored RJVs, however, seem to have made the transition in the 1980s from mechanisms for assisting whole sectors to catch up with world best practice to mechanisms for cr eating a broader technological superstructure to assist a large group of high technology se ctors.

During the 1980s, the United States changed the regulatory and relevant legal system to promote cooperative R&D. During the first half of the 1990s, the US government put in place specific programmes to actively promote cooperative R&D. Political developments and the decreasing visibility of the "competitiveness camp" due to particularly favourable economic conditions for American industry during the past dec ade lessened the attention of policy makers to research partnering. Cooperative R&D is still considered a potent S&T policy mechanism, however, surely to surface again as soon as the currently relentless pace of economic growth slows down. Policy experts a re currently focusing their attention on the value of RJVs in assisting industry decrease the high levels of uncertainty associated with opening up new emerging product markets.

The European Union went even further, making cooperative R&D the cornerstone of its S&T policy as reflected through the Framework Programmes on RTD. Particular features of the region, however, necessitated an EU approach that was almost the reverse of that of the US.[50] Faced with a wide collection of nationally-based S&T policies, the Commission tried first to put in place its own supra-national programmes for cooperative RTD before harmonizing policies across its member states. Harmonization efforts and "c ohesion" efforts have continued, of course, but the process has naturally bee n a slow one due to path dependencies and vastly different S&T capabilities among the European core and the periphery. The Commission apparently hoped that a series of well-established and funded Framework Programmes for RTD would increase the chances of s uccess for these efforts. It may well have been so. What comes out clearly in this collection of papers is that the EU policies have become a force well reckoned by member state governments. The latter have i ncreasingly influenced policies at the nation al level if not shaped them to the degree of straightforward translation.

The policy papers also point at the apparently increasing convergence of key policy areas in Europe during the past 10-15 years that directly affect the incentives of firms to engag e in cooperative R&D. Such convergence has been reflected in science, technology, and innovation policies, competition policies, and intellectual property rights policies. Important tendencies in this direction across the continent include:

- Increasing awar eness of the competitiveness issue and its relation to innovation.
- Increasing awareness of innovation as a process involving both a technology producing and a technology-using side.
- Increasing awareness of systems of innovation, firmly based on interconnec tions and interaction between economic agents of different kinds.

[50] See also Vonortas (forthc oming) for a comparison between the EU and US S&T policies, in general, and collaborative R&D policies, in particular.

- Greater attention to the potential of R&D cooperation to serve as a mechanism that promotes such interaction and contributes to increasing the technological prowess of firms and regions.
- Emphasis on university-industry and public research institute-industry cooperation.
- Assistance to small and medium sized enterprises (SMEs), placing special emphasis on small entrants into emerging high technology markets.
- Awareness of the importance of the institutional, physical, regulatory, and financial infrastructure to support emerging technologies. Increasing realization of the importance of adequate competition and IPR policies to promote cooperative R&D.

The latter should not be underestimated given that it became most clear in the case studies conducted in this project that a good part of the incentive for collaborative research is to be found in the environmental conditions confronting a firm. The EU influence in these areas has been quite visible. A process of policy harmonization can only help firms interested in setting up RJVs as it decreases uncertainty and variability within the European Union.

Interestingly, widespread policy support for industrial cooperative R&D has primarily been based on theoretical developments, anecdotal evidence, and business case studies pointing to the potential of considerable benefits to RJV participants. There has been much less systematic evidence of widespread (social) socio-economic benefits from extensive R&D collaboration. Adding to such evidence was one of the basic objectives of this research project. The other was to highlight policy implications.

4.6. Policy Implications

7. It is time to take stock of the widespread cooperative R&D in Europe.

Support for cooperative R&D in high-technology industrial activities is widespread in Europe. This compounds the already widespread practice of strategic technical alliances under private initiative. The process has created high expectations for increased competitiveness that has proven very difficult to show quantitatively until now. New policy expectations for cooperative R&D have also been introduced in the form of achieving social and economic cohesion among the EU's many different member countries and regions. This study took a first, bold step in the direction of empirical appraisal by employing a multi-faceted methodology to create and systematically analyze large amounts of empirical information. More needs and can be done.

8. Policy analysts need to consider long lists of benefits and costs to cooperative R&D.

Cooperative R&D creates private and social benefits (and costs). Private benefits (and costs) accrue to participating organizations. Potential private benefits include:
- R&D cost sharing;

- Reduction of R&D duplication;
- Risk sharing, uncertainty reduction;
- Spillover internalisation;
- Continuity of R&D effort, access to finance;
- Access of complementary resources and skills;
- Research synergies;
- Effective deployment of extant resources, further development of resource base;
- Strategic flexibility, market access, and the creation of investment "options";
- Promotion of technical standards;
- Market power, co-opting competition;
- University and research institute research better attuned with private sector interests.

Examples of private costs are the actual cost of the activity, loss of control over a technology, transaction costs to ensure compliance and smooth collaboration, etc.

Cooperative R&D also creates social benefits (and costs) that accrue to non-participating organizations and the rest of society. Social benefits may be the result of:
Knowledge spillovers to non-participants;
Increased competitiveness;
Increased levels of competition;
Favourable changes in investment behaviour;
Technology standards;
Economic convergence.
Social costs may be the result of collusion and anti-competitive behaviour, lessened innovative effort, waste of taxpayers' money, creating dependencies on public funds, etc.

There is also direct and indirect benefits and costs from R&D cooperation. Direct benefits and costs are those linked directly to a cooperative R&D activity – e.g., the introduction of a new innovation, or the transaction costs involved in this activity. Indirect benefits and costs are the unintended by-products that often turn out to be very significant. For example, engaging in an RJV may not only result in the introduction of a new product but also the maintenance of certain capabilities internally that will allow the firm's presence in that technological area for time to come. Or, increased competitiveness in a particular industry segment may also boost the chances of client industries. It may also have other socio-economic benefits like employment and regional upgrading. The latter might be an interesting issue for future investigation.

Policy analysts should try to account for as many as possible of these in cost-benefit appraisals. Unfortunately, it is the private, and direct, benefits and costs that are relatively easier to determine within some acceptable range of accuracy. Social, and indirect,

benefits and costs are much harder. It is, of course, the latter that policy makers are interested in.

9. The recently introduced European approach of appraising the socio-economic effects of policy seems appropriate in the case of RJVs.

As a result of the fact that RJVs create direct and indirect, private and social benefits and costs, the analysis of the incentives of firms and other organizations to participate and the impacts of these RJVs necessitates multi-faceted and interdisciplinary approach. A strong case can be made for both objective and subjective measures of performance. Essentially, this means that socio-economic appraisal of incentives and impacts is the most reasonable way to proceed.

10. Benefits (and costs) of cooperative R&D cannot be appraised solely on the basis of objective measures of performance – such as financial data for firms. Subjective measures of performance are at least as necessary.

Experts have struggled with thorny issues regarding both methodology and measurement of the outcomes of collaboration. The long-standing debate on whether financial or other objective measures of performance – such as partnership survival, duration, stability – should be preferred over subjective measures of performance has been at the forefront of attention. Much of the problem resides in the controversy concerning the measurement of organisational performance in general. Difficulties get compounded in the case of hybrid organisational forms where, not surprisingly, there is no consensus concerning both the definition and measurement of performance. There is no clear definition of partnership success. There is disagreement on whether objective (e.g., profitability, growth, duration) or subjective measures of success are more appropriate in appraising success. Objective measures are more widely available. However, objective measures may not adequately reflect the extent to which a partnership achieved its short and long term objectives which are often diverse. Even when subjective measures can be constructed, there is difficulty in assigning values to individual measures of success for the partnership as a whole. Various partners usually have different expectations from the same partnership, thus making several authors argue against generalising from one partner's evaluation. "Triangulation" of partner evaluations has thus been suggested.

When queried, firms often tend to rank their objectives to participate in collaborative R&D quite differently than standard theory would anticipate. In fact, they rank "soft"

objectives pretty highly, of the kind that economic theory has had problems to appraise them. For example, highly ranked objectives by firms in this study include: (a) establishment of new relationships; (b) access to com plementary resources and skills; (c) technological learning; (d) keeping up with major technological developments. Such objectives are difficult to quantify accurately.

All in all, problems in combining objective and subjective measures of partnership performance abound. It is beyond doubt, however, that the use of subjective measures of performance is unavoidable if we are to reasonably approximate the true extent of the diverse benefits and costs involved in cooperative R&D agreements (and strategic alliances more generally).

5. As it occurred from the analysis of the project results, the most frequent participants in RJVs are large firms although the majority of participating firms are basically SMEs. It was also evident from the survey results that firms participating in RJVs tend to operate in a business environment characterised by technology and product-features based competition.
6. There is a fixed cost involved in collaboration. Government programmes can assist create the preconditions for new comers – especially smaller firms – to be successfully integrated into RJVs.

The parties willing to enter a transaction must be able to create a mechanism to provide the necessary incentives to perform to expected standards. The way RJVs may achieve such a mechanism is by creating a "mutual hostage" situation through the commitment of resources by all partners. To the extent that the agreement is one of a kind for the specific partners, the RJV will require significant commitments of specialized resources by each and every one of them. Smaller firms, often lacking reputation and market credibility when trying to enter their first RJV, will need to compensate with a significant resource commitment. On the contrary, the presence of multimarket and multiproject contact between partners (firms "meeting" each other in many markets and many partnerships) may easily create the necessary preconditions for mutual forbearance between partners, freeing them from the burden of significant resource commitment. Such conditions require diversified and larger firms with presence in various present and future markets. The implication is that firms that lack significant resources need them the most in order to be accepted in RJVs. Cooperative R&D programmes could be tailored to assist SMEs create the necessary "capital" in their first steps to collaboration.
There is also a fixed cost involved in R&D activity. This is especially important for the "cohesion" countries that often lack significant resources for initiating research activities. Funded cooperative agreements offer the possibility for achieving a critical mass of R&D, not only because of subsidizing this fixed cost but also because actors from Southern Europe become networked with other organizations and establish channels for knowledge transfer and for keeping up with technological developments.

8. Benefits obtained from collaborative R&D increase with the internal (independent) capabilities and research activities of firms.

Evidence in this study strongly confirms earlier resu lts indicating that knowledge in the public domain does not benefit everyone equally. Two conditions are required: (a) a willingness to learn; and (b) an ability to learn. Earlier work has shown that, in addition to creating new knowledge, R&D is useful fo r maintaining/increasing the ability to learn from others. Translated in the context of RJVs, internal R&D, perhaps even parallel R&D projects, increase the benefits from R&D undertaken cooperatively. Active monitoring (willingness to learn) also works in the same direction.

By offering the possibility to the different organizations to achieve a critical mass of R&D resources, funded cooperations help them to improve the ir capabilities, at least in doing R&D. Considering the positive correlation between c apabilities of the firm and benefits obtained from the R&D undertaken through cooperation, it might be correct to argue that the participation for the first time in a subsidized RJV may become a positive factor for continuation in successful R&D cooperatio ns.

11. Learning capabilities and objectives of R&D cooperation.

In an effort to account for the apparently differential benefits that some partners in RJVs are able to obtain compared to others, this study related each of three broad categories of benefits (product development, process, knowledge base) to a long list of learning mechanisms. The mechanism of undertaking internal, independent, and related R&D was strongly correlated with all three types of benefits. Benefits to the knowledge base correlated with all other learning mechanisms.[51] Similarly for product development benefits (with only one exception), particularly so with developing formal and informal relationships with users and/or suppliers. Process development benefit was positively correlated with learning by imitating other firms. In all cases, ability to learn was important for reaping benefits from cooperative R&D. The lesson for public policy is that innovation involves complex processes that require attention not only to "technology push" factors – the traditional focus of technology policy – but also to "technology pull" factors (technology user).

12. Trust is a major factor in inter-organizational collaboration. Mutual trust among prospective partners lowers transaction costs and increases the desirability of an RJV. Tailoring government programmes to "underwrite" trust can prove a real booster for R&D cooperation, particularly for firms with lesser amounts of market reputation and goodwill (such as new technology-based firms (NTBFs)).

[51] Thus, confirming from a different angle the argument for direct and indirect benefits, requiring both objective and subjective measures of performance to be properly accounted for.

Trust between partners plays a crucial role in cooperation. By lowering transaction costs, trust makes partnerships more desirable. Trust-building, however, is a process dependent on reputation and prior interaction. It is not accidental that this and other studies have found a strong, positive relationship between prior engagements in collaborative R&D activities and tendency to do it again. The reason is that frequent RJV participants use their reputation as good, trustworthy for lowering their direct resource commitment in later deals and in enticing new partners. It is also not accidental that firm size has a strong, positive relationship with RJV participation – the effect comes through reputation. Governments may have a critical role to play in assisting newcomers (especially SMEs) create the necessary "reputation capital" and obtain the necessary resources in order to be accepted to the club.

13. **There is a great need to better understand the factors that determine pairs of cooperating firms. While studies like this one are all about this subject, we still lack standardized indicators of prospective pairs of collaborators forming in particular technological areas. Such indicators would greatly help in designing public programmes.**

This project pointed out some of the variables that could be used to create standardised indicators of likely pairs of collaborators. Such essentially variables match the characteristics of pairs of firms that have ended up collaborating in the past trying to extrapolate future collaboration patterns. They include the sector(s) of the firms in the pair, the relationship between their products, and the extent to which the firms are symmetric. Several other characteristics could also be tested. A particularly useful exercise may be to test the extent to which the defined relationships between characteristics hold as firms tie up more and more often within individual technological areas. Being able to anticipate more accurately the likely participants to RJVs should promote better delivery of public programmes to the targeted populations.

14. The design and governance of government programmes supporting cooperative R&D is important in determining the effects on industry.

The different design and governance of Framework Programmes and EUREKA have resulted in different sets of RJVs and differential effects on industry. While the evidence in this project cannot be considered conclusive, there was evidence nonetheless of: (a) relatively different features between the two sets of RJVs, (b) pairs of collaborating firms with differential objectives, and (c) confirming expectations, more short term productivity effects for EUREKA RJVs than Framework Programme RJVs. National programmes also seemed to owe their relative success to their particular institutional set-up and clear delineation of objectives. Such findings underline the importance of the design and governance of a programme for achieving its objectives. Indirectly, it also underlines the importance of using differential approaches to appraise programmes with different objectives.

15. Is public funding necessary? This perennial question of government policy was answered positively in this study with respect to the formation of RJVs.

A total 456 firms answered the question in the survey relating to alternatives, had public funding for the specific RJV not materialised. Almost two thirds reported that they would not have undertaken the specific research without government funding. For between two thirds and three quarters of the respondents, the spec ific cooperative R&D related to their core business activity.

Standing on its bottom, this information may be significantly discounted because it is based on the subjective evaluations of the respondents to the survey. It gets additional weight when combi ned with the discussion on points 4 and 5 above. Public funding may be more important for some kinds of firms than others. The finding also receives additional credibility when there is evidence that the R&D supported by public funds has latent public good characteristics. Public funding is more important for some kinds of research than others. Attention to SMEs and focus on pre-competitive research would seem to fit the bill.

Government funding is not only important for its resource aspect, however. Confi rming earlier work in the United States, case studies showed that larger, more sophisticated firms frequently participate in publicly underwritten cooperative R&D programmes not for the money as such but for the ability to reach partners considered valuabl e. In other words, public programmes may create the institutional framework that makes collaboration possible. One way this can happen is through the implicit guarantee of acceptable behavior by all partners in the presence of the public authority as an ar bitrator. Such a guarantee could, for example, allay the fears of smaller firms that may feel intimidated to collaborate with much larger counterparts, being afraid of losing control of critical knowledge to them. Another way this can happen is by making a vailable the minimum necessary resources for enticing smaller, valued partners to participate in the RJV.

13. **Established networks have been observed in the European area between participating firms. It can be argued that network formation is an effective mechanism for transforming the European knowledge and for promoting economic cohesion. Three major networks in European industry thus emerged in the auto industry, the aerospace industry and the electronics/telecommunications industry.**

14. Improving research li nks between universities and public research institutes and industry has become a policy priority in Europe. RJVs are an appropriate vehicle for such interaction.

When it comes to research, there is a difficult trade-off in the relationship between industry and universities. On the one hand, they do not usually see each other as direct competitors and consider that they have complementary capabilities and resources. On the other hand, the extensive differences in the incentive systems of the two kinds of

organizations make collaboration difficult. Complementarities induce cooperation: knowledge and experiences are exchanged more easily among non-competing organizations. While there is never going to be a perfect match for as long as the incentive systems remain so different, industry and universities already collaborate extensively on R&D and more of it is expected in the future.

15. Firms often react to the opportunities (constraints) provided (imposed) by the institutional set-up and regulations (environmental, technical standards, etc.). Policy affecting these is also expected to indirectly affect R&D cooperation.

Firms try to adapt to their environment. One mechanism of adaptation is cooperation – indeed, strategic alliances are said to increase the flexibility of the private sector. Earlier research in the United States has shown that, in fields like environmental technologies, RJVs are formed in reaction to (or anticipation of) regulatory changes. The case studies conducted in this project also found evidence to that effect.

16. Firms realize the value of complementary resources, strengths, and needs for reaping benefits from cooperative R&D.

The frequency of collaboration between firms with complementary resources, strengths and needs was underlined in this study as it has been before. An important reason tends to be the complexity of the product under development that requires complementary capabilities. Cooperation among firms operating in different, but related, sectors (such as telecommunications services and semiconductors) with different strategies and corporate cultures also facilitates the exchange of assets, skills, and experiences. In addition, it has long been understood that interaction between technology users and producers increases innovation efficiency. Moreover, firms that are not direct competitors will exchange information much more willingly than if they were. And so forth. The lesson for policy analysts is that they should look for such complementarities in designing and implementing cooperative R&D programmes as they are a major determinant of the success of collaboration.

That is not to say that competitors do not ever cooperate. Rather, it is to say that they will tend to cooperate in the limited set of circumstances that economic theory has predicted, including the establishment of technical standards and the undertaking of research that is subject to severe problems of appropriability. Standards and knowledge appropriability problems would, then, provide more appropriate foci for programmes aiming at horizontal cooperation between firms.

17. Firms do not appreciate cumbersome reporting requirements to public authorities and frequent policy changes.

Not surprisingly, several case studies showed complicated proposal submission procedures, cumbersome reporting requirements, and frequent policy changes to discourage collaboration (under government auspices).

18. Widespread collaboration in R&D can also have a downside in that it may promote anti-competitive behaviour. Competition policy authorities must be vigilant.

Several results in this study indicated that the examined RJVs are largely the domain of large firms. While this may partially reflect exogenous preferences and/or capture, the finding is robust enough to suggest that absolute size facilitates RJV formation. The reasons may be many but they certainly include the existence of high fixed costs, learning (how to cooperate) costs, and transaction costs in setting up collaborative agreements. RJVs were also found to take place in more concentrated industries. While cooperative R&D agreements enjoy block exemption from antitrust consideration in the European Union, we feel that competition authorities would do well to actively monitor them.

A potential source of anti-competitive behaviour, which this study did not explore systematically but some recent literature has called attention to, is the combination of multimarket and multiproject contact. The idea is straightforward. Multimarket contact – referring to the fact that large, diversified firms often "meet" (compete) in many markets – increases the possibilities of anti-competitive behaviour as both the benefits from collusion and the ability to enforce collusion increase with the number of markets in which two firms "meet". Multiproject contact – referring to firms "meeting" (collaborating with) each other multiple times through RJVs and other technical alliances – could also raise the chances for anti-competitive behaviour. The argument is similar: both the benefits from collusion and the ability to enforce collusion increase with the number of future markets in which two firms expect to "meet". Importantly, however, whereas multimarket contact refers to existing markets multiproject contact refers to future markets (those to be opened as a result of current R&D). Compounded, multimarket and multiproject contact can have deleterious effects on competition.

It is our understanding that the possibilities of multimarket and multiproject contact have not been picked up by competition authorities around the world. This is partly a matter of availability of adequate information given that the analysis necessitates having the picture of the whole nexus of collaborative agreements of individual firms. Such a picture is what the STEP TO RJVs Databank may help provide.

5. Dissemination of Results and Publication Strategy

The coordinators are committed to the widest dissemination of the results of this project. A long list of working papers has been already produced (see Annex) and will be available at the special web site <http://www -liee.chemeng.ntua.gr>. Other ways of dissemination have also been used (discussions, workshops, teaching etc.). In addition, several collective publications have been planned.

1. "Industrial Collaboration in Research and Development: A Comparative Analysis of Public Policy": edited volume by Yannis Caloghirou and Nick Vonortas, on public policies promoting cooperative R&D in France, Greece, Ireland, Italy, Spain, Sweden, UK, European Union, Japan, USA. The boo k will be published by Edward Elgar editions .

2. 2. “Research Joint Ventures. A critical survey of theoretical and empirical literature”, paper prepared by Y. Caloghirou, S. Ioannides and N. Vonortas, to be submitted to the Cambridge Journal of Economics, May 2000.

3. The coordinating team has presented the conceptual foundations of the RJVs and the empirical evidence that came out from the project to the TECHNOSCOPE training seminars for managers, 1999 and 2000 at NTUA.

4. The Greek case studies are used from the coordinating team for teaching in MBA courses.

5. FEEM’s Note di Lavoro / Working Paper Series: FEEM is disseminating a number of working papers of this project through its website and working paper series.

6. A working paper prepared by Universidad Carlos III de Madrid on the determinants of the RJV formation was presented in:
- Universidad Carlos III de Madrid
- Pompeu Fabra (Barcelona)
- Jornadas de economia industrial (Madrid)
- Université de Lausanne
- EARIE conference (To rino, autumn 1999)
- Universidad Complutense (Madrid)

The paper has been submitted to the Journal of Industrial Economics in january 2000, and the authors are waiting for the referee reports.

7. Three working papers prepared by FEEM, namely on the charac teristics of research cooperation and information sharing, on the impact of R&D cooperation to technological convergence in Europe and on the impact of RJV participation to firm’s performance, have been presented to the EARIE conference in autumn 1999.

8. The coordinating team has submitted three abstracts with intention to present the respective papers in International Conferences: a) on University -Industry cooperation in research and development, to the Purdue Conference (9 -11 June 2000), b) on inter-country relationships, to the EAPE 2000 Conference (2-4 November 2000), c) on R&D cooperations as a mean for knowledge creation, to the EAPE 2000 Conference (2 -4 November 2000)

9. "On the growing collaboration between firms in kn owledge production", Y. Caloghirou, paper presented in the European Socio -Economic Research Conference, Brussels 28-30 April 1999.

10. SIRN is working on the issue of technology policy and cooperative R&D.

11. The Swedish team has made contacts with the publishing division of the Swedish Center for Business and Policy studies and the Norwegian Institute for Studies in Research and Higher Education. The latter institute has a quarterly journal, Forskningspolitikk.
Results and analysis of the project has been utilized in a course on the entrepreneurship of SMEs.

The research teams of the STEP TO RJVs consortium reported the following intentions regarding the dissemination of the project's results:

Universidad Carlos III de Madrid plans to keep on doing rese arch using the various databases. They also plan to exploit the Spanish national database.
Another issue on which they plan to work on is how the presence of a public sector institute influences the type of firms that join a RJV.

PREST is preparing certain case studies for publication. They are willing to help integrate case studies for a collective publication. If, for some reason the collective publications do not succeed then they will think of publishing elsewhere.
They will probably use the case studies in their MSc teaching.

The Stockholm School of Economics is planning to circulate the Swedish results of the survey study and the databases in the working paper series of the Economic Research institute of the Stockholm School of Economics.
The Swedish research team has initiated a new project on the basis of insights of the STEP TO RJVs project: "control, safety and monitoring - a hidden entrepreneurial development block?"

The National Technical University of Athens / Laboratory of Industrial and Energy Economics intends to extend the STEP TO RJVs Databank and the Greek – survey database.

The Laboratory also intends to prepare a collective publication based on the case studies of the STEP TO RJVs project.

The Greek team will also work on the following topics :

- The emergence and sustainability of R&D networks in specific industries
- The measures of RJV performance
- The financial characteristics of firms participating in European RJVs
- The role of individuals in the establishment and implemen tation of cooperative R&D
- The collaboration between public research institutes and industry

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