1. General introduction

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At the start of a new millennium, Europe finds itself at a crossroads. At Europe's core, the European Union (EU) has provided the continent with stable democratic institutions and is fulfilling long-held dreams of integration of the continent, divided for centuries by wars and languages but united by shared common cultures and traditions. With no fewer than ten new countries to add to its existing 15 member states and with an on-going debate on broadening versus deepening, the EU has launched unprecedented efforts to achieve monetary union among member states, to proceed with an orderly expansion to the east and south that may double membership in just a few years, and to reconsider its budgets, institutional organization and constitutional statutes.

In the midst of all this upheaval, the Union has embarked on a major reorganization of its famed Framework Programmes for Research and Technological Development (FWP). Officially initiated in 1984, the first five FWPs have been basic pillars of European scientific and technological development, integration and cohesion during the past couple of decades. They have supported all kinds of research and development (R&D) in high technology sectors, have forced European organizations to work together in cross-border partnerships, and have created a sense of European 'togetherness' in science and technology (S&T). The time of this writing coincides with the launch by the European Commission of the Sixth Framework Programme (FWP6).

The Sixth Framework Programme for Research and Technological Development (FWP6) has been touted as a new start and a major break on the previous five FWPs. Whereas they had imposed an R&D structure living and breathing in parallel with national S&T programmes and policies, FWP6 is the first expected to tackle yet another European dream: the creation of the European Research Area (ERA). The ERA is an institutional superstructure that will increasingly weave EU S&T programmes administered by the European Commission, EU-subsidized S&T programmes administered by national and regional governments, and national/regional

S&T programmes into a seamless web of a European-centered technical enterprise. In its abstraction, the ERA concept fits well with all other efforts for greater socio-economic integration.

On the eve of the introduction of FWP6, the European Union is taking stock of past S&T policies that have contributed to the Union's current levels of economic development, international competitiveness, and social cohesion. The success of FWP6 in spearheading a new era of scientific and technological achievement in Europe will critically depend on the clear understanding of the successes and shortcomings of past S&T policies both at the EU and member state levels.

A STUDY OF COOPERATIVE R&D IN EUROPE

This is the context of the present book. A single book cannot, of course, tackle all the important developments currently unfolding in Europe. It focuses on a small part of these developments, primarily relating to co-operative industrial research in the European Union in the last two decades. The book is itself a product of cooperative research, more specifically of research funded by the Targeted Socio-Economic Research Programme of FWP4.¹ The material presented herein builds on the collaborative work of seven capable European research teams, including senior researchers from:

- Laboratory of Industrial and Energy Economics (LIEE), National Technical University of Athens (coordinator) – Greece;
- Strategic Industrial Research Networks (SIRN) – United Kingdom;
- Fondazione Eni Enrico Mattei (FEEM) – Italy;
- Institut de l' Audiovisuel et des Telecommunications (IDATE) – France;
- Stockholm School of Economics (SSE) – Sweden;
- Universidad Carlos III de Madrid (U:Carlos III) – Spain;
- Policy Research in Engineering, Science and Technology, Victoria University of Manchester (PREST) – United Kingdom.

During a two-year period (1998 to 2000), this consortium undertook an in-depth theoretical, empirical, and policy analysis of cooperative R&D in Europe. This book recounts some of their important findings while paying particular attention to policy-related questions.

The research project dealt with various forms of cooperative research activity:

1. EU-funded cooperative R&D, primarily of a precompetitive nature, generated by a top-down procedure, activated by the Commission, and implemented through the FWP.
2. Cooperative R&D for the development of marketable products and services, generated by a bottom-up procedure, selected by EUREKA, and usually subsidized by national governments. Getting the 'Eureka label' for a project and granting public funding for its implementation differs between EU countries.
3. 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 at least one partner is an industrial firm. A significant number of these partnerships also include academic institutions and other public research organizations.

A very extensive data-collection enterprise was launched to support the multi-faceted 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 subsidized R&D collaboration in Europe?
- Why do firms and other organizations collaborate?
- How do firms and other organizations 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 the research project dealt with include:

- 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 organization 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?

RESEARCH PARTNERSHIPS: SOME STYLIZED FACTS²

Inter-firm cooperation in R&D is neither a new phenomenon nor an exclusively European one. In fact, during the past couple of decades the number of cooperative agreements has increased dramatically world-wide, while their nature has changed from, primarily, agreements involving equity (formal equity joint ventures) to, primarily, non-equity agreements.

Research on the MERIT-CATI database has revealed a number of worldwide trends in technology partnerships (strategic technical alliances) during the last quarter century.³ As announced in major technology and trade magazines and the popular press, the number of new partnerships set up annually has gradually increased from about 30–40 in the early 1970s, to 100–200 in the late 1970s, and then again to around 600 or more later in the 1980s and 1990s. During the early 1970s about 80 per cent of the announced research partnerships were equity joint ventures. Gradually this distribution changed. By the mid-1990s more than 85 per cent of technology partnerships did not involve equity investments.

The share of domestic inter-firm collaboration recorded in CATI as occurring during the 1970s and 1980s was only about 35 per cent of the total. The share of domestic partnerships has gradually risen to about 45 per cent during the 1990s. This change has largely been caused by the role of intra-US collaboration in two major fields, information technology and biotechnology, reflecting the very important role that United States firms have played in leading edge research in these two fields. That role not only makes them attractive partners for international collaboration, but also raises the probability of intra-US joint research at the scientific and technological frontier.

During most of the 1970s (when some current high-technology activities such as biotechnology and advanced materials research were almost non-

existent), the share of high-technology sectors (OECD classification) was on average about 40 per cent of the total number of inter-firm partnerships. During the late 1970s and early 1980s, this share increased to between 50 per cent and 60 per cent. From the mid-1980s to the mid-1990s this share increased even further. According to the most recent data, about 80 per cent of the inter-firm research relationships are established in high-technology areas. Information technology has by far been the dominant technology area in partnerships, followed at some distance by biotechnology and new materials.

The majority of technology relationships have been established within the Triad – North America, the European Union and Japan. During the 1970s and 1980s the share of the Triad in all these partnerships was over 95 per cent. In the 1990s this dominance became less strong as the share of other combinations rose to about 20 per cent. The growth of inter-firm partnerships with partners from outside the Triad reflects the growth of the share of alliances with companies from South East Asian countries, such as South Korea, Taiwan, Singapore and Hong Kong (Freeman and Hagedoorn, 1994; Hagedoorn, Link and Vonortas, 2000).

The information on countries beyond the Triad is fragmented. Most of it shows an increase in the activity. Focusing on information technologies, Vonortas and Safioleas (1997) reported a number of interesting trends for alliances involving at least one participant from developing countries (including economies in transition) between 1984 and 1994. They found that the number of such alliances grew impressively during that period – faster in fact than alliances with participants from industrialized countries only. Transitional economies and NICs have dominated alliance activity. The vast majority of alliances have involved the creation, exchange, or transfer of technological knowledge. Telecommunications was found to have passed ahead of computers to dominate these alliances in the early 1990s. Contractual agreements tended to dominate alliances by developing country firms. Agreements involving R&D have been increasing.

There were clear indications that certain developing country firms have been able to extract significant benefits from alliances, not only in terms of accessing superior technology but also acquiring the capability to develop new technology on their own. The most active partners from industrialized countries have been large multinational enterprises in telecommunications, computers, electronic components and consumer electronics, reflecting their world-wide reach, indisputable technological strengths and significant financial resources.

These developments have been mirrored by a dramatic change in the way policy analysts and decision-makers perceive the advantages and disadvantages of inter-firm cooperation. Rather than organizational mechanisms to

assist declining industries and weakened firms, inter-firm cooperative agreements to create and disseminate technological knowledge are now viewed as veritable competitive mechanisms, right at the strategy core of most companies in high technology industries (Vonortas, 1997). A voluminous economic and business literature has supported these views (see following sections).

Prompted by concerns over the lagging international competitiveness of high technology industries, both the United States and the European Union mobilized in the early 1980s to establish policies that both provided the necessary legal environment and actively promoted R&D cooperation. In a radical shift away from its earlier orientation, the US government made major policy steps in the past couple of decades to accommodate and actively promote government-university-industry partnerships (Vonortas, 2000). This system was further strengthened in the 1990s by a series of programmes actively promoting government-industry-university partnerships and efforts to 'channel' private sector R&D activity in technological areas with potentially widespread economic returns. Similar concerns over the international competitiveness of industry have also underlined the establishment of a formal science and technology policy in the European Union during the 1980s, very much based on the support of collaborative R&D through the FWP.

Such policy developments condoned collaboration in R&D and gave clear signals of the new policy orientation of the American and European leaderships. Industry has never looked back. The result has been a frenzy of 'deals', ranging from simple, long-term contractual agreements to share products, technologies and markets, all the way to complex mega mergers and acquisitions. The vast majority of these deals reflects the vision of corporate strategists of the shape of future business in an environment of rapid technological advance and increased technological and market uncertainty.

POLICY DEVELOPMENT BACKGROUND

In the 1980s, 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 leading to specific products and process, is largely the responsibility of the private sector. Where there was (and still is) disagreement is in the grey area between the two, a murky space that some say is small, some say is large, and many believe is of variable proportions that change with the characteristics of the industry and the technology. This area is sometimes called precompetitive, or generic, research (Nelson, 1989, 1990). This research was considered imperative for competitiveness but subject to serious market failures.

The debate was 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 FWPs. 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 this time the D was emphasised much more than the R. In contrast to the FWPs, EUREKA did not subsidize R&D. EUREKA selected worthy collaborative R&D projects – thus, raising their chances for getting funded at the national level 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 increased 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 co-operation that, even though somewhat suspect at present, alluded to greater innovation efficiency and better ‘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 political and

economic events during the intervening time period, however, have affected the *raison d'être* of these policies. On the one hand, the European Union already has five additional members and is currently (in 2003) preparing to accept several more. Economic cohesion between the 'centre' 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, strong economic growth in its history, achieving full employment for the largest part of the 1990s.⁴ Meanwhile Japan, projecting the major competitive threat for both European and American industry in the late 1970s and throughout the 1980s, has reeled under prolonged 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 cooperative research. This has created some uneasiness among policy analysts who have argued that there may be a trade-off between competitiveness and cohesion, which may decrease the effectiveness of the FWP. Only the market failure rationale remains in the United States. Japan, a staunch supporter 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.

This is actually a good time for taking stock. The study underlying the material in this book 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 research hypotheses, the consortium partners took into consideration the main policy concerns above and the important questions raised in the economics and business literature.

ANALYTICAL APPROACH

We focus here on one kind of strategic technical alliance that we describe as Research Joint Ventures (RJVs). RJVs are defined as (temporary) organiza-

tions, 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 organizations.

The study only dealt with RJVs involving at least one participant from the private sector. When more than one firm is 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-subsidized cooperative R&D agreements, in practice our data sets include RJVs subsidized by government funds, at least in part.

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 information on subsidized 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 the 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 draw lessons for future policies.

One of the most formidable undertakings in this study 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 data-bank, which contains seven databases, three international and a set of four national databases.

EU RJV Database

This contains information on transnational RJVs established under the first four FWP's up to the end of 1996. It contains information 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 database includes 6,300 usable RJVs with 12,730 participating organizations 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 between 1985 and 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 organizations 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 as a unique source of information on 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 includes 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.

An additional rich source of information used in this project came from 21 case studies of RJVs led by firms based in the seven countries represented in the 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 organizations, RJV organization and relationship to member firm strategy, working relationship among partners, RJV results and impact on participants, and commercial exploitation of cooperative R&D outcomes.

ORGANIZATION OF THE BOOK

The book is divided into two parts: an analytical part and a policy part. The chapters forming the analytical part deal with the theory on cooperative R&D and the empirical analysis of European RJVs. Chapter 2 concentrates on the theory of RJVs as it appears in the economics and business management literature. Chapter 3 recounts the main trends of European RJVs on the basis of the EU RJV and EUREKA RJV databases. Chapter 4 utilizes the responses of more than 500 companies in seven EU country members to illustrate the strategic considerations of European firms when forming RJVs and the expected tangible and intangible returns from this activity. Chapter 5 focuses on the qualitative evidence from the case studies of more than twenty RJVs exploring the factors that enable or constrain the formation and evolution of R&D cooperation, the effects of cooperation and the role of subsidies. Chapter 6 summarizes the results of empirical work undertaken by consortium partners on the determinants of RJV formation, RJV performance, and on the impact of RJVs on industries and regional economies.

Seven chapters form the policy part of the book. These chapters deal with the policies towards R&D cooperation of individual countries and one region. Three kinds of policy are discussed: science and technology policy, competition policy and intellectual property protection. Chapters seven to twelve, then, appraise the relevant policies of the European Union, the United Kingdom, France, Italy, Spain and the United States of America respectively. Policy chapters have been contributed by the consortium partners, with the exception of that on France, which has been prepared by an expert outside the consortium. Chapter 13 closes this part by tracing the common policy threads across countries.

Finally, Chapter 14 concludes the book by delineating the main policy lessons for Europe and by pointing out important avenues for future work.

NOTES

1. Y. Caloghirou and N. S. Vonortas, *Science and Technology Policy Towards Research Joint Ventures*, Final Report of the STEP-TO-RJVs Project SOE1-CT97-1075, Targeted

- Socio-Economic Research Programme (TSER), European Commission, DG Research, March 2000.
2. This section draws extensively on Hagedoorn, Link and Vonortas (2000).
 3. See Hagedoorn (1996, 2001), Hagedoorn and Schakenraad (1990, 1992), and Hagedoorn, Link and Vonortas (2000). Global alliance trends during the 1990s, including both technology-intensive and non-technology based agreements, have been described in Kang and Sakai (2000).
 4. This remarkable achievement has been followed by a significant economic slowdown which, at the time of this writing, had yet to raise the competitiveness concerns of the 1980s.

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