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The impact of publicly funded research on innovation

An analysis of European Framework Programmes for Research and Development

European Commission
Enterprise and Industry

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The **impact** of publicly funded research on **innovation**:

An analysis of European Framework Programmes for Research and Development

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THE IMPACT OF PUBLICLY FUNDED RESEARCH ON INNOVATION

INDEX OF TABLES AND FIGURES

Executive Summary

The Innovation Impact (INNO IMPACT) study[1] has assessed the impact of publicly funded research on innovation. The study has focused on the interface between research, technological advancement and innovation. Special emphasis is placed on the role of the collaborative R&D projects funded by the 5th and 6th European Framework Programmes for Research, Technological Development and Demonstration in promoting innovation and the innovation output of the FPs.

The study focused exclusively on collaborative R&D schemes as vehicles through which two or more organizations join forces to develop new knowledge and competencies that can be applied to innovative products/services and processes. The analytical concentration has been two-pronged, assessing the impact of research project management, on the one hand, and of firm, industry, technology and market characteristics, on the other, on the effective utilization of research results for innovation.

The background theoretical approach of the study emphasized the resources, capabilities, and organizational needs for the exploration and exploitation of new technical ideas. Building from a solid theoretical background, the study has deployed a mix of methodologies for data collection and analysis as well as a variety of data sources, to cover all areas and all types of participants in both FP5 and FP6. The study used several data collection routes, including (1) desk research that supported descriptive and empirical work, (2) an extensive survey among FP participants (over 8000 responses, representative across FP's, thematic areas and instruments), (3) the Community Innovation Survey, and (4) some seventy five case studies of organizations participating in the 5th and/or 6th Framework Programme.

A combination of quantitative and qualitative analytical techniques has been used to address the research questions of this study. The results of this analysis are presented in four core sections of this report under the headings of (a) (FP participating) organization characteristics, (b) (collaborative) project characteristics, (c) market, firm and project-level effects on the innovation impact of FP R&D projects, and (d) additionality of FP R&D projects. The balance of analytical techniques has varied in reflection of the type of question to be answered and the type of available information. Four types of analytical approaches were pursued:

- Descriptive statistical analyses on the information gathered in an extensive survey of FP participating organizations,
- Empirical (econometric) analysis of the data obtained from the survey,
- Empirical analysis of the Community Innovation Survey,
- Qualitative analysis of a large number of case studies among FP participants.

Main findings: Characteristics of participants and participation

An important finding from our analysis of the Community Innovation Survey (CIS 3 and 4) is that the Framework Programme attracts the highly innovative companies and research institutions in Europe. We find that FP participants are characterized by:

- R&D intensities that are above the average of their sector of principal activity;
- They are significantly more networked with clients and universities than average;

[1] This report is a shortened version of the extensive final report that has been published and can be downloaded from www.innovationimpact.org.

- They are significantly more orientated towards international markets than average; and
- Their patenting activity is significantly higher than average.

Participation in the FPs has an added value on the innovative sales of participating organizations. Moreover, the empirical analysis of CIS micro-data for three countries has shown substantial input additionality among smaller firms. Participation in FP4 and/or FP5 resulted in a significant increase of R&D intensity between 2000 and 2004 among firms of up to 100 employees (R&D intensity is roughly doubled!). This however does not hold for larger firms.

Technology and knowledge-related objectives dominate the other objectives for participating in the FP, including network, market, and cost-risk sharing related objectives. We consider it a very important observation that this ranking is highly stable not only over the different categories of participants, it also holds across FP5 and FP6 projects, with some (but rather small) differences among FP instruments (NoE and CA, for instance, stand apart in FP6). The differences are more pronounced with respect to thematic areas (e.g., between IST and life science projects).

Participants that do not have commercial/innovation goals at the start of the project are very unlikely to achieve any commercialisation (even if there are commercialisable results). SMEs demonstrate more economically driven objectives (innovation, commercialisation and market related) than large companies.

In terms of research and innovation strategy, the new instruments NoEs and IPs appear to be used for projects of a slightly more exploratory nature whereas exploitation of R&D is more to be found in self-funded cooperative R&D projects. Larger companies have clearer strategies for diverse contexts of collaborative R&D than SMEs and smaller organisations.

Regarding protection strategy, the surveyed organizations were not very keen in maintaining knowledge private with traditional intellectual property protection mechanisms such as patents in general as well as in the specific context of the FP projects. Firms do not change their IP protection strategies radically in FP projects, although some of them – such as those with no previous experience in FP projects – tend to use secrecy and technological complexity slightly more often in this specific context. While FP5 and FP6 seem to be approximately the same in this respect, there are differences between instruments and – especially – thematic areas.

Project roles are almost evenly split between R&D performers, technology producers and users. The roles of specific organizations change across projects. Research organizations tend to collaborate more often with partners with whom they had worked before and to collaborate less with industry. To some extent this is the same for the service organisations. In contrast, manufacturing participants are engaged with relatively fewer partners with whom they had worked before and more with other industry participants. Interestingly, newcomers are involved in projects with a significantly lower proportion of partners with which they had worked before than old timers.

Main findings: characteristics of FP projects

The origin of the idea on which the FP projects are based seems to have gradually shifted in successive FPs towards a more important role of research or education partners in FP6. It should be noticed that this is likely to have an influence on the probability of creating innovation output from an FP project, because enterprises are more prone to produce such outputs. In this development, there are of course differences between programmes with the IST programme remaining largely industry-driven.

One of the most remarkable results of this study is the absence of sharp differences between the different collaborative R&D portfolios and the average EU project characteristics in terms of costs, risks, flexibility, and distance from the core activity of the firm, etc.

We do find though, in the case of firms, that NoE and IP projects in FP6 and other FP5 and FP6 projects exhibit similar characteristics that set them apart from cooperative projects exclusively funded via internal R&D budgets. FP projects are, on average, characterised by:

- Lower commercial risk
- Longer term R&D horizon
- More interest in 'peripheral' technologies outside the core technologies of participants
- Focus on exploration (rather than exploitation) strategies
- Lower degree of flexibility
- Higher administrative burden

All these results are remarkably stable over most of the classifications of participants. This picture is the same across companies of different type and size. What is most striking is the fact that these project characteristics do not change substantially between the FPs despite that fact that FP5 and FP6 have seen presumably major changes with the introduction of new instruments.

It is also important to stress that FP projects are not and should not be assessed as stand-alone R&D activities, but rather form part of a wider portfolio of R&D projects: in more than half the examined cases, in-house R&D projects in a specific topic had preceded FP projects of the organization in question on a similar (or same) topic. In a third of the cases, FP projects opened a new area for the participants. This result is stable across all types of participants. In FP5 and FP6, the proportion of past FP project cited as a source for a subsequent FP specific project is about one third of the total. This proportion is significantly higher in Sustainable Development (FP6) and IST (FP6) and lower in SME (FP6). From this observation it is obvious that innovation output very often cannot be attributed either to the individual FP project or to the in-house R&D project alone.

Main findings: Market, organisation, and project-level impacts on innovation

Econometric analysis could not support the proposition that market conditions strongly influence the various aspects of project success (product-process innovation, technical knowledge creation). A plausible explanation is that the projects undertaken in the Framework Programme are of the "technology-push" variety rather than "market-pull". In other words, it may be that the typical project is driven by a promising emerging technology, usually in its early stage of development, and for which market opportunities for exploiting it are not yet clear. As such, the partners are driven by a motive to explore rather than to commercially exploit a mature technology. In such circumstances the current or anticipated demand conditions may not have a strong influence.[2]

[2] Differences between sectors or broad thematic areas can be observed, of course. For example, R&D projects in the IST programme are often considered to be closer to the market than, for instance, life sciences. Still, the variation within the IST programme is quite significant, with many projects looking at novel technologies or standards which are not directly applicable to the market.

Another plausible explanation is that the measures used to capture market conditions in the survey were specified at an aggregate level not allowing for fine, yet important, differences between and across sectors and technological trajectories. The analysis of case studies, for instance, indicated differences in behaviour among enterprises in four types of markets:

Companies operating in competitive markets with high technology/innovation intensity tended to make better and more direct use of FP projects in their commercialization plans. Many of enterprises in this category show a strong involvement in Framework Programmes and a strategic role of EU funds in R&D process. For those companies, the FP R&D funding is well integrated with the company research activity. FP projects are mainly carried out to do applied research and to exploit the innovative results coming from it.

For enterprises in monopolistic/oligopolistic sectors with high technology/innovation intensity examples of direct and consistent commercial exploitation of FP project results are fairly rare even though these companies tend to be well experienced with FP projects. They report a generally low degree of novelty of the technical results. Exploitation, when it happened, was in niche markets. For enterprises in monopolistic/oligopolistic sectors with low technology/innovation intensity FP-funded R&D projects seemingly have a minor role in the overall company strategy, largely due to the marginal relevance of innovation in these sectors. For most such companies FP projects have offered at least indirect gains such as networking opportunities and development of standards, creation of databases. Direct commercial exploitation is fairly unlikely.

Finally, for enterprises in competitive sectors with low technology/innovation intensity, the answers vary. In the case of the small part of enterprises that base their activity on R&D and have long experience in FP projects the European projects have become a structural instrument of financing the company development, technological development through networking, acquiring qualified competences. For the remaining enterprises of this class the FP projects funds are not part of an integrated research activity.

SMEs reported a generally strong strategic alignment with FP projects and explicit goals related to innovation outputs such as developing a prototype, developing a patentable technology, or developing a complementary technology that will enhance competitiveness.

Medium-sized companies seem to have reaped the largest innovation benefits from FP project participation. Apparently, these organizations can achieve critical mass for R&D in a focused area and often have explicit strategy and goals for innovation. They often take a leading role in projects, and are most frequently found as coordinators, in parallel with research organizations.

Small-sized firms (with fewer than 50 employees), on the other hand, often remain too focused on a core technology and too centred on research (compared to on development) in order to be able to sustain market driven development and commercialisation in their own right.

In contrast, large firms appeared much less inclined to commercialize right out of the project compared to a number of highly committed-to-commercialization SMEs. Because of the often more marginal role of FP projects, larger companies frequently reported weaker strategic alignment a nd less explicit goals. When goals were clear, they typically focused on project dimensions such as developing new knowledge, building partnerships, or exploring a new technology area. Only exceptionally interviewees in larger companies referred to the external dimension of market related goals. Thus, with respect to large-sized firms, our case study sample presents the least successful project participation from a product or process innovation point of view.

An intriguing finding of the econometric analysis pertains to the positive effect of first-time participation in FP projects on both product and process innovation. One would be tempted to attribute this to greater motivation of "newcomers", as there is no reason to believe that they are systematically more capable to drive FP projects to success than repeat participants.

Another strong empirical result is that prior experience of an organization with R&D, both intramural and extramural, positively and significantly affects the likelihood of obtaining product innovation from FP projects. Extramural R&D, past innovation experience and past innovation performance all positively influence process innovation. On the flip-side, firms that have a focus on imitative strategy (i.e., introduction of new-to-the-firm products, as opposed to new-to-the-market innovations) are relatively less likely to report process innovation. Overall, the results concerning the "innovation history" of both firms and research organizations largely confirm the hypothesis of a positive association between prior innovation experience and project success in terms of innovation. Case analysis corroborated this result by showing that building up a broader innovation culture was an important underpinning factor behind product and process innovation success. Firms with an explicit R&D / innovation structure and model proved more successful in producing innovation results.

The nature of the project appears to be a very important determinant of project success. Strong empirical evidence was obtained that projects that are commercially driven, risky, complex, and new area (for process innovation) tend to be more successful:

- Projects that are driven by commercial objectives from the outset are found more likely to result in product innovation and to lead to technical knowledge creation. In contrast, projects aiming at networking seem less successful in terms of generating new knowledge;
- The nature of a project, in terms of being risky, exploring a new technological area, or being scientifically complex, influences project success in important ways. The degree of risk affects positively both product innovation and knowledge creation, but in both cases the degree of project risk exhibits an inverse U-shaped relationship to the dependent variables: excessive risk appears to lead to diminishing returns as regards the likelihood for product innovation and knowledge creation;
- Exploring a new technological area has a positive effect on process and negative effect on product innovation. The degree of technical complexity has a positive effect on process innovation;
- The extent to which the technology resulting from a project is expected to have a relatively short life cycle and the extent to which it is distant (or unrelated) to the firm's existing stock of competencies decreases the likelihood of process innovation;
- When the project idea is generated by industrial partners this has a positive effect on knowledge creation;
- Projects that build on past R&D activities are more likely to result in process innovation and technical knowledge creation.

While both the empirical and the qualitative analysis showed a strong relationship between explicit intention to commercialize from the outset of the R&D project and project success, the extent to which commercialization is an issue and an explicit goal within the FP RTD projects seems to be seriously questioned by a significant number of the interviewed organizations. Dissemination of the results was also seen with mixed feelings. Opinions about dissemination ranged from "a core activity" or "very important for image building" or still "an opportunity to make ourselves known", to "an activity without substance" or "a half-hearted and insufficient effort to reach a market" (firms irrespective of size). When the results are commercialized, the channel is very project and situation-specific.

Case study interviewees emphasized the importance of management during the implementation of the R&D projects. They referred to the continuous support and follow-up on the part of the coordinator with respect to the scientific and administrative obligations contracted between the project consortium and the EU. Successful projects shared a positive assessment of the capabilities of the coordinator, both as an R&D performer and as an administrator. Such capabilities apparently seem necessary but not sufficient conditions for success, as there were cases where even such well-managed projects failed at the level of innovation outcomes, due to for example, insufficiency of R&D results, rights conflicts between partners beyond the control of the coordinator or the frameworks of the instruments, or changing market conditions rendering project outcomes obsolete.

Main findings: Innovation output and additionality

A great majority of FP participants reported at least one form of commercializable output (new or improved processes, products, services, standards) stemming from their FP project; a large number even recorded more than one of such outputs. This finding is even more remarkable as the hierarchy of project goals had not changed over the years and goals related to 'direct commercialisation' still are not the most important aspects for participants.

We found that several factors increase the chance of producing innovation output successfully from an FP project, like firm size, experience with partners and track record in innovation. What we could not find was that this innovation output would have occurred to a significant extent only with the help of the FP project. Thus, we conclude that there was relatively little output additionality in terms of direct innovation. We could find output additionality in this vein, though, with respect to some project (higher risk), combination of partners (newcomers as part of the consortium) and technology (novelty of technology area) characteristics. This gives some hints for policy and programme management.

Recommendations for policy and programme management

It is important to stress at the outset that this study should not be seen as another evaluation of the Framework Programmes. The study has had a much narrower scope, concentrating on the impact of FP projects on innovation and, accordingly, on the managerial, project, firm, and market-related factors that influence the extent and speed of the commercial exploitation of the results of cooperative R&D funded by the 5th and 6th Programmes. Recommendations must be viewed in this context.

1. *Directly commercialisable output has not been a core objective of Framework Programmes. Yet we find significant impact on innovation. Caution should be exercised in extensively modifying the Programme to further enhance direct innovation impact.*
2. *Keep funding instruments simple. Maintain instrument continuity. Deep changes increase the cost of Programme administration without demonstrably significant benefits.*
3. *ather than differences among instruments applied horizontally across all thematic areas, pay closer attention to the needs of the thematic areas at different levels and their associated markets, as well as to the needs of participating organizations.*
4. *The current setup of the Framework Programmes carries the risk of occasionally being dominated by large companies in oligopolistic sectors – whether technology and innovation-intensive, or not. Enhance the role of SMEs in the strategic development of the Programmes.*

5. *The role of the traditional IP protection mechanisms (patents) as a general instrument to promote innovation per se is generally low and highly depending on the thematic area and the specific market. Industry effects should be taken into account*
6. *Perceive the individual FP R&D project for what it really is: a single research instance among many for a participating organization. Do not expect huge impacts from individual projects either on innovation or on the 'behaviour' of the participating organizations.*
7. *Small and medium-sized enterprises indicate more positive results in terms of innovation in FP projects and seem more susceptible to the Framework Programmes as a policy instrument than their larger counterparts. They may deserve more attention on that basis.*
8. *For successful innovation, collaborative research consortia should include one or more of the following types of partners:*
   a. one or more partners with strong research and innovation experience;
   b. highly motivated partners who may either be smaller companies that depend on the specific project very much and/or new participants;
   c. experienced, motivated coordinators who manage to align the diverse interests of the various partners with the needs of the collaborative research project.
9. *Encourage commercialisation thinking at the proposal stage. Possibly provide the opportunity to innovators for a follow-up stage – or a follow-up project – where the commercialization of the research results is the core priority.*
10. *Promote projects that are risky, technically complex, and in new areas.*

1 Introduction

1.1 Study Focus

The Innovation Impact (INNO IMPACT) study has assessed the impact of publicly funded research on innovation. More specifically, the study has focused on the interface between research, technological advancement and innovation, placing special emphasis on the role of the collaborative RTD projects funded by the 5th and 6th European Framework Programmes for Research and Development in promoting innovation.

This interface has two main attributes:

- ***The impact of research management on the propensity to innovate:*** the effect of the different ways in which RTD projects are managed through their life-cycle on the rate of commercial exploitation of the knowledge created.
- ***The impact of firm, industry, technology, and market characteristics on the effective utilization of research results for innovation:*** the effect of critical micro-economic factors, other than R&D project management, on the likelihood that research will lead to the introduction of new/improved products, services, or production processes. These factors include the set of organization-specific, market, technology, and industry characteristics pertinent to innovation.

The study was based on four lines of inquiry that allowed the project team to identify, explore and evaluate the interactions between research, technological advancement and innovation. The four lines of inquiry included:

- *Characteristics and strategies of organizations in the Framework Programme*
  - Which organizations have participated in the Framework Programme and h ow can they be differentiated from the rest, including both those which have tried and failed and those which have never tried? (RQ1)
  - Why did these organizations take part in the Framework Programme and what benefits did they actually receive from their participation? (RQ2)
  - What role do the Framework Programme projects play in the overall innovation strategy of the organization? How do companies manage their research and development portfolios inclusive of Framework Programme projects? (RQ3)
- *Research project characteristics, project management and innovation*
  - What kinds of projects did the participating organizations undertake in the Framework

Programme and how do these projects compare, or relate to, others that they undertook, either independently or in collaboration with others but with no subsidy? (RQ4)
  - Management practices for collaborative R&D projects at all stages (design, application, implementation, post project monitoring and exploitation of results) (RQ5)
  - How do project-level characteristics, including consortium characteristics, type of prime contractor, managerial practices, and project-team dynamics affect the chances for research success and the chances for research result uptake for innovation and commercialization? (RQ6)

- *Critical micro-economic determinants of the impact of research on innovation*
  - How do firm-level characteristics, including resources/capabilities, internal organization and management, influence the likelihood of research result uptake for innovation and commercialization? (RQ7)
  - How do industry and market characteristics affect the likelihood of research result uptake for innovation and commercialization? (RQ8)

- *Lessons for programmes targeting innovation*
  - What types of additionality with specific emphasis on innovation can be observed in FP5 and FP6? How can additionality be improved? (RQ9)
  - What are the lessons for improving the R&D projects funded by the Community Research and Innovation Programmes (FP, CIP)? (RQ10)

INNOIMPACT has concentrated on the impact on innovation of one of the pillars of the European system of innovation: publicly-funded research programmes. The study specifically focused on an important slice of such public programmes: the Framework Programmes for Research. Although relatively small in terms of share in the overall European expenditure on R&D, the Framework Programmes play a fundamental role in shaping the European Research Area (ERA). The study was, thus, intended not as an appraisal of the overall innovation system in Europe, but rather as a treatise on the impact of a relatively small part of public R&D expenditure, even though a perceived core part, on this system.

It is generally agreed that the EU Research Framework Programmes have played an important role in developing the European knowledge base and that they have demonstrated a significant level of additionality and European added value. Despite that very significant contribution, the achievement of the Framework Programmes has arguably been more modest in terms of *direct contribution to innovation*. This is related to the so-called “European Paradox”, a term connoting a strong research performance but comparatively weak innovation and economic performance. Even though it should be stressed from the outset that *the production of specific commercialised innovation has never been the core focus of the Framework Programmes*,[3] the fact remains that a closer connection between EU-funded R&D activity and commercialized innovation needs to be set as a high priority if Europe is to achieve the Lisbon objectives for improvement in job and wealth creation, enhanced competitiveness, social cohesion and inclusion, and environmental quality in the European Union.

Even though R&D is a core activity and a starting point (albeit not the only one[4]) for innovation, the link between the two is not straightforward. The commercial exploitation of research results stemming from an R&D project is a complex process governed by a multitude of factors, including the internal dynamics of the project per se, the motives and the innovation-related capabilities of the participants in the project, and the characteristics of the market environment towards which the prospective innovation is to be directed. In this study we seek to explore those complex links by examining the factors underlying the success of collaborative Research & Development (R&D) projects under the 5th and 6th Framework Programme for Research and Development.

This report is a shortened version of the extensive final report that has been published and can be downloaded from www.innovationimpact.org.

[3] The core objective of the Research Framework Programmes has been the strengthening of the European research system as a whole.

[4] Innovation can be the result of a scientific invention, but it can also involve imitating an idea from a distant market, or reconfiguring an old product in a new way, among others. In this sense, innovation is not *necessarily* related to science and research, or put differently, innovation does not stem exclusively from scientific research.

2 Methodology and **chosen approach**

A unified methodological approach was delineated in the early stages of the study. This methodology has focused primarily on the managerial and microeconomic literatures dealing with the incentives for technological advancement and innovation, organizational aspects with emphasis on collaborative R&D, and impacts of technological innovation. It emphasized the resources, capabilities, and organizational needs for the exploration and exploitation of new technical ideas and underlined the definitions of innovation and expected results of collaborative R&D used in this project. The Section below summarizes the core argument.

2.1 Theoretical Framework

Innovation is a complex and multifaced phenomenon that, to be properly understood, requires in depth examination of a large variety of phenomena spanning from the inception of the original innovative idea, to the research activities to turn this idea into new knowledge that can be potentially applied, to the process of embodiment of this knowledge into a product/service or process to be commercialized.

These phenomena operate at the micro-organizational level (group), micro level (firm), meso level (industry), and macro level (economy) of analysis. A partial list of these phenomena would include the dynamics of groups working on innovative projects, the characterization of the process through which innovation is generated and implemented, the organizational factors that induce/inhibit the innovative performance of firms, R&D collaboration and networks, the dynamics of innovation dissemination within and across industries, the workings of the national/regional innovation systems and the institutional environment.

2.1.1 EXPLORATION-EXPLOITATION AND ABSORPTIVE CAPACITY AS FRAMEWORKS FOR THE STUDY OF THE INNOVATIVE PERFORMANCE OF R&D CONSORTIA

It is widely acknowledged that intangible assets, in general, and knowledge, in particular, are key drivers of innovation. The entire new product development process can be viewed as a process of creating and embodying new knowledge in a product or technology artefact. It is thus imperative to consider the type of learning and knowledge-based practices utilized during the various stages of the innovation development process (Nooteboom, 2000). Our conceptual framework takes this into account by concentrating on how the different stages of the R&D process motivate different types of exploration and exploitation activities for organizations collaborating in the development and commercial success of R&D results.

The capacity to exploit new knowledge depends upon prior exploration of this new knowledge. During the early stages of the R&D process, an R&D consortium is prospecting for new wealth-creating opportunities. During this discovery period, the consortium pursues an exploratory search, acquires and assimilates information and knowledge engaging in more basic, risky research and building new capabilities with the goal of transforming and developing new knowledge (R&D output) which it can be subsequently exploited to create commercial value. Once potentially valuable knowledge and skills have been acquired during exploration, the commercializing organization then turns to exploitation activities. Thus, the exploration-exploitation distinction implies some sort of a logical sequence – although the two occasionally overlap and are linked by feedback loops. Exploitation activities cannot take place without prior exploration by the same or other organization.

The accumulation of knowledge *per se* is not, however, a sufficient condition for increased R&D performance. It is the effective management and use of the available information and knowledge stocks that determines differences in R&D performance, a perception that provides the basic rationale of absorptive capacity.

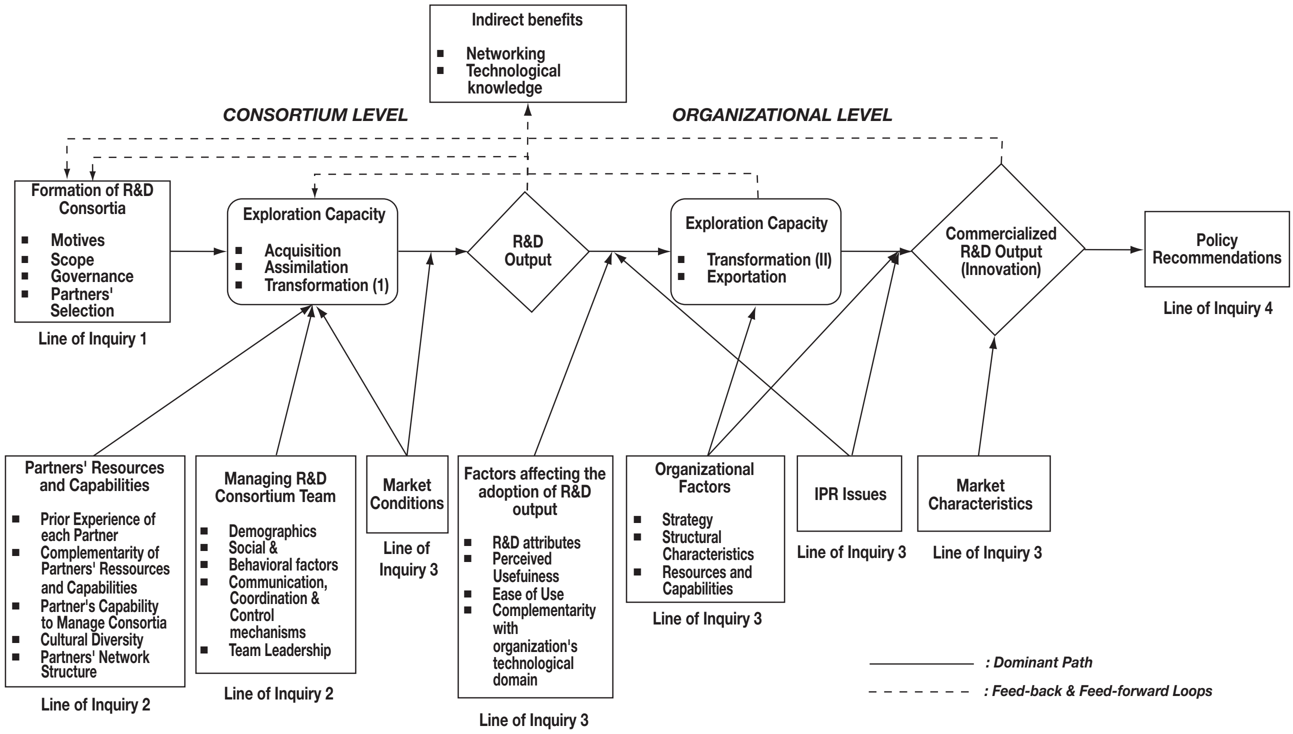
Absorptive capacity is central to R&D performance and innovation. Cohen and Levinthal (1990), for example, relate absorptive capacity to innovative capabilities and innovative performance in terms of R&D spending. Numerous other scholars have found absorptive capacity to influence research productivity, environmental adaptation, capability building, new product development, technological distinctiveness, sales cost efficiency, alliance payoffs and long-term competitive position, strategic flexibility, and entrepreneurial wealth creation. Absorptive capacity has been linked to effective knowledge flows and transfer of best practice within the boundaries of the firm as well as the levels of overall R&D expenditure, use of alliances, and effective communication with alliance partners (Veugelers and Kesteloot, 1996; Lane and Lubatkin, 1998; Lane et al., 2001).

Our general theoretical framework synthesizes the concepts of exploration–exploitation and the absorptive capacity concept to apply them to R&D consortia. Figure 2.1 illustrates the general model assuming the whole spectrum of activities from early stage R&D to commercialization. The performance of the R&D consortium is portrayed as a development path with three main phases (formation, exploration, and exploitation activities) and two key results (initial R&D output and final innovation introduced to the market). Although many feed-back and feed-forward loops exist in the R&D and innovation process (dotted lines in Figure 2.1), the dominant path is shown as one of linear progression, which enables us to conceptualize the different ways through which diverse groups of factors influence these phases and outputs. Six major categories of factors are hypothesized:[5]

- Partners' resources and capabilities (i.e., prior experience, complementarity of assets, capability to manage consortia, cultural diversity, and partners' network structure),
- Managing aspects of the R&D consortium team (i.e., demographic characteristics, social and behavioural features, communication, coordination and control mechanisms, and team leadership roles),
- Perceived characteristics of the R&D output (i.e., complexity, trialability, relative advantage, usefulness and ease of use),
- organizational factors (i.e., firm strategy, structure, resources and capabilities),
- R&D protection mechanisms (i.e., appropriability regimes), and
- Market conditions (i.e., technological shifts, government regulations, market structure, size and uncertainty).

[5] For an extensive description of this framework see the original background document "Critical Literature Review" (Spanos et al., 2006).

Figure 2.1: Exploration, Exploitation, Absorptive Capacity and R&D Consortia



2.1.2 RESEARCH "NOVELTY" AND THE INNOVATIVE PERFORMANCE OF R&D CONSORTIA

There is a widespread perception among the general public that exploration and rapid innovation are incompatible. While the fact that exploration includes "blue sky" research that might lead to radical innovation cannot be disputed, the identification of exploratory research with "blue sky" only certainly can. It is as if the original research that led to the basic concepts of nanotechnology is placed in the same category with vast follow-up research in that broad field which explores the possibilities of applications of new scientific principles in new product areas well beyond what was originally envisioned. We would claim that both of these are exploratory research, alas of a very different kind. They require different antecedents, different capabilities and, thus, mostly depend on different organizational structures for effective management of the research. The exploitation of the research outcome is also different in each. "Blue sky" research aims at establishing scientific principles. It is carried out more efficiently in universities and other specialized public research laboratories whose reputation does not depend on near term profitability.

The second kind of exploratory research aims much more directly at commercial exploitation and, as such, it tends to be positioned much closer to the market. For-profit organizations, including business firms and other research laboratories are better attuned to it.

Research in the Framework Programmes has traditionally been described as "precompetitive". Such research supports development and applications and is very much informed by them but it does not purport to develop specific products and processes on its own. In other words, precompetitive research can be perceived as the second type of exploratory research discussed above and which is depicted to interact with exploitation activities in Figure 2.1.

Such exploratory research, we would argue, is fully compatible with rapid innovation. It may well pay to venture into new technological areas, to have newcomers on board who will bring energy and fresh ideas, to change the composition of consortia from time to time, to tackle areas of research that are somewhat distant from the core business, to take additional risks. If well managed and connected to applications, such novelty-seeking exploratory behaviour can be compatible with rapid rates of commercialization.

2.1.3 PARTICIPANT SIZE, CONCENTRATION AND THE INNOVATIVE PERFORMANCE OF R&D CONSORTIA

One of the earliest foci in the economics and business literature on technological change and innovation has been the relationship between firm size and innovation and, between market concentration and innovation.[6] The basic idea behind the debate has been that the advantages of size and market concentration for innovation in complex technological fields (economies of scale and scope in R&D, "critical mass" in organizational capabilities, people, finance) may be balanced against inferior incentives vis-à-vis smaller firms and competitive markets.

The dichotomy between large and small has turned out to be important for inter-organizational collaboration in R&D as well. Such collaboration is pursued for various reasons. The basic underlying incentives include those mentioned in the previous paragraph: to create economies of scale and scope by combining resources, capabilities and synergies; and to create "critical mass" in organizational capabilities, people, and finance.[7] Other important incentives to collaborate are to share risk, access information, and access markets. Another important incentive is to collaborate in order to pre-empt competition. Different partners will join the same R&D consortium for different reasons. Smaller partners will typically join for the first set of reasons (economies of scale and scope, critical mass), plus access to markets and finance. They will tend to look for the complementary resources to achieve a specific objective that will typically be a new or improved product/service or process. Larger partners will typically join for the second set of reasons (risk, information), plus shaping the competitive game in the market by influencing standards and technology platforms. They will look for the less direct returns, using the consortia primarily as "listening posts", as vehicles for building their networks, as instruments for placing bets in early-stage risky research fields, and as platforms for influencing the competitive market game.

2.1.4 COGNITIVE DISTANCE, ABSORPTIVE CAPACITY AND THE INNOVATIVE PERFORMANCE OF R&D CONSORTIA[8]

Resource heterogeneity between partners provides potential for learning and innovation. It can be perceived in terms of the cognitive distance between the partners that hold these resources. There are two opposing forces at work: a novelty effect that increases with larger cognitive distance and an absorption effect that decreases with larger cognitive distance. The novelty effect originates from making new combinations, and whether these combinations are potentially valuable is largely determined by the industry context. The absorption effect is more of an endogenous phenomenon to the firm. Furthermore, one may anticipate a differential effect of cognitive distance on innovation performance, depending on the R&D context and, in particular, the extent of exploration versus exploitation. The positive effect of cognitive distance (novelty value) could be higher when an innovation is more radical as is the case in exploration. The positive effect of cognitive distance could be low(er) in collaboration processes that are geared towards exploitation.

Consequently, an important issue in R&D collaboration has been the optimal combination of the heterogeneous resources and capabilities that different partners bring to the plate for optimizing innovative performance. Nooteboom (1999) has argued for an inverted-U shaped relationship between cognitive distance among partners and innovation: sufficient cognitive distance to tell something new must be balanced against too large distance that precludes mutual understanding.

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[6] For excellent surveys of the so-called neo-Schumpeterian hypotheses see, for example, Wesley M. Cohen and Richard C. Levin (1989) "Empirical Studies of Innovation and Market Structure," in Richard Schmalensee and Robert D. Willig (eds.) Handbook of Industrial Organization, North-Holland; Chris Freeman and Luc Soete (1997) The Economics of Industrial Innovation, 3rd ed., The MIT Press; Gerhard Rosegger (1996) The Economics of Production and Innovation, 3rd ed., Butterworth-Heinemann; and Jan Fagerberg, David C. Mowery and Richard R. Nelson (eds.) (2005) The Oxford Handbook of Innovation, Oxford University Press.

[7] See Nicholas Vonortas "Economies of Scale and Scope in Research", in Luc Soete, Ugur Muldur, and Henri Delanghe (eds), The European Research Area, Edward Elgar, forthcoming 2009.

[8] The argument in this Section is based on Bart Nooteboom, Wim Vanhaverbeke, Geert Duysters, Victor Gilsing, Ad van den Oord (2006) "Optimal Cognitive Distance and Absorptive Capacity," Discussion Paper 2006-33, CentER, Tilburg University, the Netherlands; and Bart Nooteboom (1999) Inter-firm Alliances: Analysis and Design, London: Routledge.

2.2 Methodology

We have chosen a variety of analytical techniques, both quantitative and qualitative, to address each research question (Section 1.1). The balance of analytical techniques has varied in reflection of the type of question to be answered and the type of available information. Three types of analytical approaches were pursued:

- Empirical analysis based on (a) the information obtained from the extensive survey of FP participating organizations and on (b) Community Innovation Survey (CIS) data for three EU member states,
- Tabulations of the answers to the survey,
- Qualitative analysis of a large number of case studies of FP participants.

2.3 Data

2.3.1 CIS

The Community Innovation Survey (CIS) is a survey conducted every four years by EU member states that allows the monitoring of Europe's progress in the area of innovation. For the purpose of this project we were able to access the CIS3 and CIS4 data for the Netherlands, Germany and France.

As defined by the CIS, innovations have three characteristics. The innovation should:

- be based on technological new knowledge,
- be new or significantly improved to the corresponding firm, and
- be implemented successfully, either in the form of new (or significantly improved) products or services (product innovations) or new processes (process innovations).

The harmonised questionnaire refers to a three-year period such that a firm is designated as an innovator if it has introduced an innovation in the current or one of the two preceding years (Hempell et al, 2004)[9]. To allow for a sufficient time lag between the period a firm employed inputs into its innovation process (e.g., received funding under a Framework Programme) and the eventual outputs of its innovation process, we have used the two most recent consecutive waves of the CIS: CIS3 (1998-2000) and CIS4 (2002-2004).

Analysing innovative output necessitates using a time lag. In general this means using independent variables measured in the CIS3 data and a dependent variable from the CIS4 data. As a result, the analysis on 'Innovation impact' has been restricted to firms that:

- Are present in both surveys: CIS3 and CIS4
- Are innovators in the sense that they report:
  - Product innovation, or
  - Process innovation, or
  - Other innovation (these three are the 'filter questions' on innovation)

When we want to incorporate a lagged dependent variable (e.g., innovative output), we also restrict our sample to firms with a positive innovative output in CIS3.

2.3.2 Survey

The database used for the survey is CORDIS (Community Research & Development Information Service), which holds the information on all FP funded projects and the organisations participating in those projects. From CORDIS the relevant project information (including type of instrument, thematic area, project acronym and title, etc.) on all FP5 and FP6 projects was extracted. In addition the project data was related to the relevant participating organisation data (organisation name, type, size, address, contact details, etc.).

From the CORDIS data we made a sample selection of the organizations to be invited to participate in the survey. The total population of organizations in

[9] Hempell, Thomas, George van Leeuwen und Henry van der Wiel (2004), ICT, Innovation and Business performance in Services: Evidence for Germany and the Netherlands, ZEW Discussion Paper No. 04-06, Mannheim., erschienen in: OECD (ed.): The Economic Impact of ICT, Measurement, Evidence and Implications, Paris, pp. 131-152

our disposal was 121660. This is split in 80397 for FP5 (66.08%) and 41263 for FP6 (33.92%).

The following principles were used in the selection of the sample from the CORDIS database:

- Have a representative sample of the main instruments,
- The primary focus of the selected projects was collaborative R&D,
- An organisation can participate in the survey up to four times per Framework Programme.[10]

A sample of 54492 organisations was thus selected. Of these, 38375 (70.42%) were selected for FP5 and 16117 for FP6 (29.58%).[11] These organisations received the invitation to participate in the survey by post.

2.3.2.1 RESPONSE AND REPRESENTATIVENESS PER COUNTRY AND FP

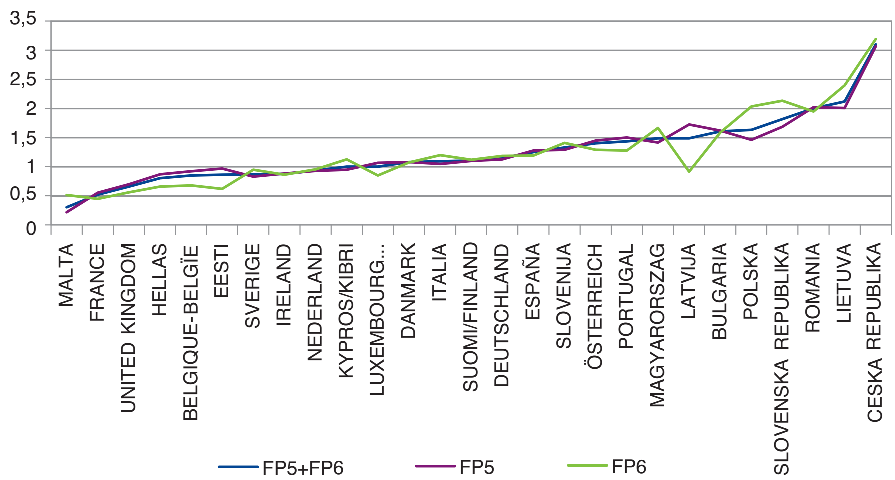
The response per country and per Framework Programme holds few surprises: larger countries have submitted the highest number of responses; the number of responses for FP5 is higher than FP6.

More interesting however than the absolute numbers is the representativeness of the response. Our analysis shows that the majority of countries fall within the 0.75-1.25 bracket of responses compared to the sample (1 is an optimal representation), which is very satisfactory and shows there is little to no bias in the response in terms of geography.

Table 2.1: Representativeness total sample per FP

	Total Population		Sample		Survey results	
FP 5	80397	66.08%	38375	70.42%	4985	70.23%
FP 6	41263	33.92%	16117	29.58%	2113	29.77%
Total	121660		54492		7098	

Figure 2.2: Representativeness Member States Response / Sample



[10] This was done in order to decrease the possibility that large organizations dominated the survey and thus bias the results.

[11] The relatively larger proportion of FP5 projects in our survey sample can be explained by the fact that in FP6 more recurring participation took place, which had an impact on the sampling.

2.3.2.2 REPRESENTATIVENESS OF SAMPLE AND RESPONSES FPS, INSTRUMENTS AND THEMATIC AREAS

Of the 54492 organisations that received the invitation to participate in the survey, 7098 completed questionnaires were returned (13.03% response rate). The participation in the survey was voluntary and furthermore the respondents were guaranteed that their individual replies would be treated confidentially and for research purposes only. The 7098 completed questionnaires can be split up to 4985 for FP5 (70.23%) and 2113 for FP6 (29.77%). This is almost identical to the sample we selected and thus underpins the importance of our sample selection

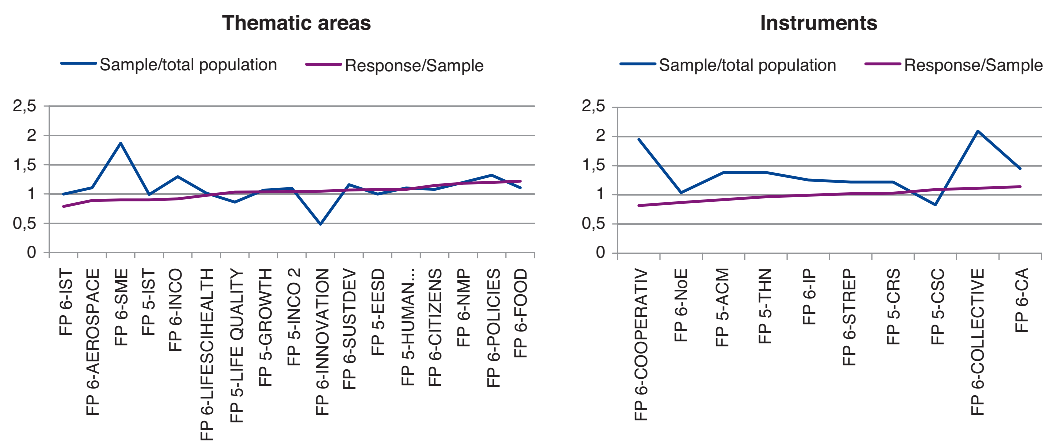
The overall representativeness per Thematic Area and per theme is high across the board, especially for the main areas and instruments. As the charts below show the representativeness of the response to the sample is very high, there is a larger discrepancy between the sample and the total population which is largely due to the sampling procedure applied[12] (described above).

2.3.3 NON RESPONSE ANALYSIS

A thorough analysis of the "structural" features of non-respondents was carried out. During the telephone follow up at the time of the survey, non respondents (at that stage) were asked why they had not yet responded. After the closure of the survey another 288 enterprises (manufacturing and services firms) that did not respond in the survey were contacted with the same question.

Our non response survey and related analysis provides two main results. First, there appears to be no sign that non response in the original survey was a result of "project failure". That is, those who did not respond did so mainly because they did not in fact receive a call to participate in the survey or, simply, declined to respond due to lack of time and not because the project in which they participated was a failure. (Needless to say, lack of time and failure to reach the targeted population are very common causes of non response.) Second, there exists some evidence suggesting that the analysis sample contains a larger proportion of projects that produced no innovative results compared to the non-response survey sample. Taken together, these results deliver confidence that our reported findings are reasonably robust and that non response should not be considered a major problem in our study.

Figure 2.3: Representativeness FP 5 and FP 6 Thematic areas and Instruments



[12] In order to avoid high numbers of repetitive participation the maximum number of participations of a single organisation in the survey sample was limited to four per Framework Programme

3 Organisation **characteristics**[13]

3.1 Introduction

This chapter analyses the characteristics of the organisations participating in the Framework Programmes. In essence it aims to provide answers for three questions: who participates, why do organisations participate, and how do they participate.

3.2 Framework Programme participants versus non participants

3.2.1 INTRODUCTION

In this Section we use data from the *Community Innovation Survey* (*CIS*). The CIS asks firms whether, during the past three years, they developed and introduced technologically new products that were either 'new to the firm' (i.e., already known in their market) or even 'new to the market'. While the former is an indicator of imitation, the latter covers what we might consider 'true' innovations, defining an innovation as the market introduction of a product. For the purpose of this study, we were interested in products new to the market. By dividing a firm's innovative sales by a firm's employees, we obtain a measure of the output side of the innovative process. Relating a firm's innovative inputs (R&D) to its innovative 'output' (sales of products new to the market), we can investigate factors that influence the efficiency of the innovative process. A number of factors can influence the more or less efficient use of inputs with respect to the production of innovative output. Typical factors are the size of the firm, technological opportunities in the firm's sector of principal activity or possibilities for appropriation of innovation benefits. Below, we shall discuss such factors in more detail.

In order to test whether the FPs have a positive impact on innovation, it is not sufficient to show that firms participating in the programme innovate more than firms that do not. It might be that a Framework Programme attracts firms that are 'better' innovators than non-participants. In other words, there may be the well-known Heckman self-selection bias for which we must correct. Therefore, we first estimate a "selection equation" that informs us about typical properties of firms which participate in FPs. Subsequently, we use the

[13] This chapter is based on contributions from TUD: Alfred Kleinknecht and Ronald Dekker, Intrasoft: Robbert Fisher, Anders Gjoen and Babis Ipektsidis, and Beta: Mireille Matt and Laurent Bach

information from the selection equation for correction of our estimates that explain the innovativeness of firms.

Besides testing whether participants (after correction for self-selection and after controlling for other influential factors) do or do not have higher innovative output, we can apply some refinements. By means of so-called 'cross-terms', we can evaluate whether certain types of participants (e.g., smaller or larger firms; more or less R&D intensive firms) do or do not achieve more innovative output if they participate in an FP. Here again, we apply a Heckman correction for self-selection into the FPs.

3.2.2 PROPERTIES OF FIRMS THAT PARTICIPATE IN FRAMEWORK PROGRAMMES

A priori, we expect that FP participants should belong to the 'elite' of innovating firms in Europe. Firms without innovation activities, or those that have only very modest or occasional innovation activities would probably not pass through the tough selection procedures of the EU. The results for France are consistent with our expectations: FP participants generally have above-average probabilities of engaging in all four types of R&D collaboration distinguished: collaboration with clients, suppliers, competitors and universities. In the Netherlands and Germany, however, FP participants do have higher probabilities of collaborating with clients, but not with suppliers. In Germany, FP participants also have higher probabilities of collaborating with competitors but this does not hold for the Netherlands. It comes as no surprise that FP participants do collaborate more often with universities and public research institutes in all three countries, as many Framework Programmes involve (and almost require) such collaboration.

As expected, larger firms have higher probabilities of being involved in Framework Programmes. FP participants also have R&D intensities above the level of the R&D intensities in their sector of principal activity. Moreover, FP participants have a stronger international orientation.

In all the three countries we find that FP participants are also more likely to hold patents. This supports the impression that they belong to the 'elite' of innovators, although one should note that patents are not necessarily a reliable indicator of innovation.

3.2.3 DO PF PARTICIPANTS HAVE HIGHER SALES OF INNOVATIVE PRODUCTS?

It is not sufficient to check whether FP participants have higher than average sales of innovative products. FP participants tend to have R&D intensities above the average of their sector; they are large and export-oriented, etc. When analyzing the sales of innovative products of FP participants, we must consider this self-selection effect explicitly. We must consider the possibility that they are not 'good' because they participate in an FP, but they may be participating in FPs because they are 'good'. We therefore estimate a selection equation and use the information from this selection equation for correction of our estimates on sales of innovative products.

Moreover, we also control for a number of other factors that contribute to larger sales of innovative products. Inclusion of these other factors implies that we test a number of hypotheses. Among these are the following:

- Firms that collaborate on R&D should produce higher innovative output, ceteris paribus, than those that do it alone. First, they can share costs and risks. Second, they can exploit complementary knowledge, which should save costs and shorten the time-to-market. Third, firms that collaborate can 'internalize' positive externalities. Finally, firms that collaborate should have a higher chance of determining a dominant standard;
- By the reasons just mentioned, we would expect FP participants also to show higher sales, although much of the R&D in a Framework Programme is pre-competitive. On the other hand, considering the time distance between FP4 (1994-98) and FP5 (1998-2002) and the new product introduction period (2002-2004), we would expect that

advantages derived from FP participation should be discernible in sales of innovative products in the year 2004. Perhaps this holds less for FP5, but it should certainly hold for FP4;

- Many people who use the output indicators from the CIS ignore one important limitation of these indicators: They are **not** suitable for comparisons across industries. Various industries have characteristic differences in the typical lengths of the life cycles of new products. As a correction factor, we include the average sales of innovative products in a firm's sector of principal activity. Inclusion of this latter variable implies that we actually explain whether a firm's sales of innovative products deviate from the average of the firm's sector of principal activity;
- As we are interested in a possible **increase** of innovative sales in 2004 (compared to 2000), we also include a firm's sales of innovative products in 2000 as an explanatory variable. We assume that participation in FPs during 1994-98 and 1998-2002 will have effects on innovative sales in 2004, but not yet in 2000;
- As R&D intensities can differ tremendously across sectors, we use the deviation of an individual firm's R&D intensity from the average of its sector of principal activity;
- We control for firm size. We have no a priori expectations about the sign of the coefficient of firm size. Typical advantages of smaller firms (notably flexibility) might be offset by typical disadvantages (e.g., lack of resources);
- Following evidence for 'demand-pulled' innovations,[14] we include growth in a firm's total sales during 2002-4 as a control variable;
- Finally, we include control variables for two more types of firms. First, for firms which belong to a foreign conglomerate. Such firms may introduce new products from the mother company. Second, we control for firms that underwent a major organizational change due to a merger or acquisition (data quality).

Two findings merit closer discussion. First, firms that collaborate on R&D with clients, suppliers, competitors or public institutions do **not** perform better or worse than firms that do it alone. Second, participants in FP4 and/or FP5 do **not** have more innovative sales than non-participants.

Of course, participation in collaborative R&D or in FPs also has obvious disadvantages. First, the management and coordination of the collaborative projects absorb time and effort. Second, notably in inter-country collaboration, cultural mismatch and physical (travel) distance between partners can have a negative role on efficiency. Third, collaboration partners often need to undertake extra efforts for the protection of their intellectual property, for example by acquiring patents or copyrights, as they want to be protected against opportunistic behaviour of their partners. Such factors lead to a loss of time and money and this will compensate some of the obvious advantages from collaboration.

Another possible explanation could relate to the type of projects that is undertaken in collaboration. In principle, the Framework Projects are 'pre-competitive'. The commercial exploitation of results can therefore be expected to follow the projects with considerable time lags. As we measured participation in FP4 (1994-98) and FP 5 (1998-2002), we would expect that at least participation in FP 4 should have some results during the period covered in CIS 4 (innovations introduced during 2002-4).

Another question relates to why firms collaborate. Suppose, you have an idea for an innovative project that looks like a gold mine. Why should you invite collaboration partners with whom you have to share the gold mine? Two possible answers to this question could be: (1) The firm has not enough readily available knowledge for doing it alone; or (2) the project looks promising, but is also surrounded with uncertainties and therefore you feel a need to share costs and risks.

It is reasonable to expect that firms will do the least risky and most profitable projects themselves, independently of whether they receive some funding from

[14] The 'demand-pull' hypothesis goes back to the seminal work by J. Schmookler: *Invention and economic growth*, Cambridge: HUP, 1969. For a recent survey of research on demand-pull see Brouwer, E. & A. Kleinknecht: 'Keynes-plus? Effective demand and changes in firm-level R&D'. *Cambridge Journal of Economics*, Vol. 23 (1999), p. 385-391.

the EU. Successful application for participation in an EU-funded project may lead them to doing perhaps also the more risky projects. There is some evidence in the case studies that this may hold.

From the considerations above, one would expect that EU-FP projects are, in one or the other way, more 'difficult'. Our survey among FP participants covers some information about the nature of the FP projects when compared to 'normal' projects. In our survey among FP participants, we included question 19: "How would you describe [a] specific FP project along the following dimensions in comparison to an average project?"

Compared to 'normal' R&D projects, FP 5/6 projects differ only little in terms of costs and commercial risks. On the other hand, they do differ in the following respects:

- They have higher scientific and technological risks,
- They have a higher scientific and technical complexity,
- They are more long-term oriented, and
- They belong more often to the firm's core technological area.

These results suggest a **positive** interpretation of our **in**significant outcomes reported above: In spite of FP participants undertaking more difficult pre-competitive projects (more risky, more complex, more long-term), they do **not** differ from others in terms of sales of innovative products. In other words, in spite of doing more 'difficult' projects, futures sales are not less than the sales from 'easier' projects. This is an indication that participation in FPs has some value-added with respect to producing innovative output.

3.2.4 DOES PUBLIC EU R&D FUNDING LEAD TO INCREASED R&D EFFORTS?

Ideally, one would like to have an answer to the following question: *How many Euro of R&D will a firm spend, on average, for each Euro of R&D subsidies received?* Answering this question would require firm-level data on R&D budgets prior to and after subsidization **and** on amounts of subsidies received. The latter data are not available in the Community Innovation Survey. Fortunately, there is still a second-best solution. The CIS data allow answering the following question: *Does participation in FP 4 (1994-98) and/or FP5 (1998-2002) have an effect on the **change** in a firm's R&D intensity between 2000 and 2004?*

We estimate an equation that explains **changes** in a firm's R&D intensity between 2000 and 2004, including, besides some control variables, a dummy variable on whether the firm participated in FP4 and/or FP5.

Our estimates show that, not surprisingly, firms having high R&D intensities in 2000 again have high R&D intensities in 2004. Moreover, in the Netherlands, firms that are more internationally oriented and firms that hold patents have significantly higher R&D intensities in 2004 compared to locally oriented firms or firms having no patents. This observation does not hold for Germany and France. As expected, distinction by firm size makes an important difference in all three countries. After control for other influential factors, a firm with less than a hundred employees will, on average, increase its R&D budget between the year 2000 and year 2004 by roughly a 100% if it participates in FP4 and/or FP5. In interpreting these estimates we need to take into account that the confidence intervals around these estimates are rather wide. Therefore, the point estimates need to be read with caution. We nonetheless trust that there is a significant increase in R&D efforts if smaller firms participate in a Framework Program.

3.2.5 PARTICIPANTS IN FP5 AND FP6 - A CLOSER LOOK

Following the conclusions from the CIS, we have used the survey data to further define the characteristics of the participants.

The survey data confirm the high innovator participation from industry (manufacturing and services). As high innovators we have defined those who have introduced a new product or service into the market in the past three years. Medium innovators are those who have introduced products or services new to the firm or new processes in the past three years, but nothing new to the market. Finally low innovators are defined as those participants who have not introduced any new product, service or process in the past period. More than 70% of the respondents stated that they have introduced a new service or product into their markets in the past three years.

The universities and research institutions were asked if they had contributed to the design of new or significantly improved products and services that was brought to the market (by any organisation), whether they had been involved in a spin off company based on the technological/scientific work of the organisation or whether they had awarded licences on patent to businesses all in the past 3 years.

The innovation levels of participants do no differ significantly between the Framework Programmes although FP6 seems to have attracted marginally more high innovators than FP5.

The different types of instruments and thematic areas show more diversity in terms of participation of the different levels of innovators (Figure 3.1). The specific SME instruments (Collective and Cooperative research projects) attract relatively high numbers of high innovators, as do CRS and IPs, whereas the network-oriented projects rank significantly lower. It is interesting to note that the Thematic Networks attracted more high innovators than the NoEs. The differences between the instruments in general are explained by the nature of the different instruments and the requirements for varying roles of the partners in the projects.

We also see major discrepancies between the different thematic areas (Figure 3.2). FP6-IST, FP6-SME, and IST score highest and have fairly similar patterns; FP6-NMP has a very low participation of low innovators. Particularly low in attracting high innovators was the Life Quality Programme and to a lesser extent EESD and LifeSciencesHealth, which also contains the highest number of no or low innovators.

3.3 Motivation for participation

It is to be expected that the objectives will differ per type of organisation, type of project and thematic area. This Section therefore looks at these aspects in order to analyse whether there are differences, whether these differences can be explained, or play a role in the ultimate question of this study: what is the impact on innovation.

For this purpose, we use the objectives/motives for participation in a specific project as expressed by the respondents. Table 3.1 below details the specific objectives in the following categories:

3.3.1 GENERAL OBJECTIVES OF ALL PARTICIPANTS

In principle all objectives in all categories indicated above are considered relevant in themselves. The technology/knowledge related objectives are clearly dominant, however. On the other side of spectrum,

Figure 3.1: Innovation levels by type of instrument

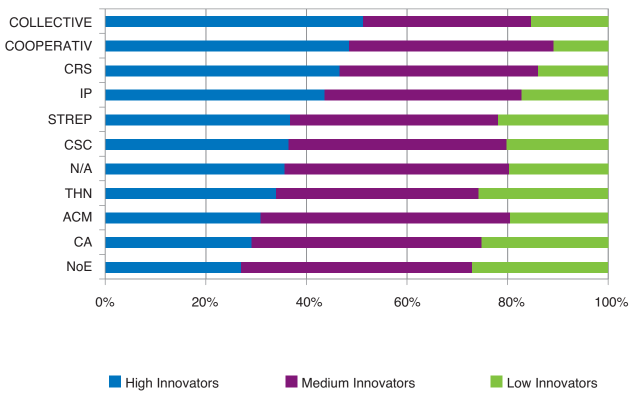


Figure 3.2: Innovation levels by thematic area

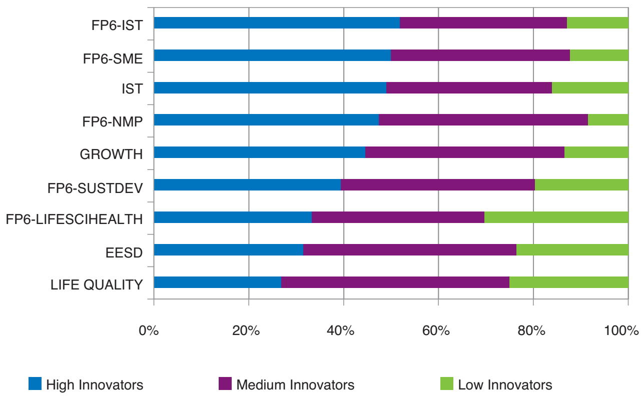


Table 3.1: Specific objectives/motives for participation per category

Technological/knowledge	• Accessing complementary resources and skills • Allowing your organization to reach a critical mass of resources and skills in a given technological field • Keeping up with state-of-the-art technological developments • Exploring different technological opportunities
Network	• Highlight technological competences • Networking / finding new partners • Promoting user/producer interaction • Joint creation and promotion of technical standards
Cost and risk	• R&D cost sharing • Risk sharing- reduce uncertainty • Obtaining funding
Market and commercial	• Creating a commercialisable innovation output • Improving speed of bringing innovation to market • Allowing entry into a new market • Controlling future market developments

"Joint creation of technical standards" and "market control" are described as least important. The responses clearly indicate that market-related factors and cost/risk reduction and/or sharing are not the main reasons why organisations are entering the projects. This seems to indicate that the Framework Programmes are not generally considered to be a primary means to develop directly commercialisable outputs: innovation per se (in the narrow sense of the word) is not considered as a key objective of a project as such.

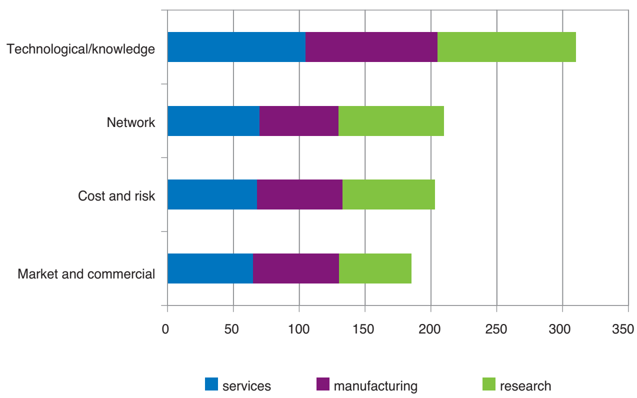
3.3.2 ORGANIZATION CHARACTERISTICS AND OBJECTIVES

The results described in the previous paragraph are fully confirmed by the results when distinguishing between type and size of organisations with regards to the most and least relevant objectives. When analysing the different categories of objectives per type of organisation, the Technology and Knowledge related objectives clearly stand out as being most relevant for all types of organisations, whereas market-related objectives feature low for research organisations. The other categories seem to be fairly evenly distributed across the different types of organisations as well as between themselves (Figure 3.3).

The case study interviews give a more nuanced picture on the specific objective of obtaining funding. Funding appears to be more significant as an objective for manufacturers and services than the result of the online survey would suggest. In the case studies a number of manufacturing and service companies have explicitly stated that funding was one of the main objectives for participation. In other cases where funding was not referred to as the main objective, funding from the EU's FP programmes was said to be one of the main sources of R&D financing, indicating that funding has played a role in the firm's decision to join EU-funded research projects.

There is a clear distinction between SMEs and larger companies when it comes to 'creating a commercial innovation output', 'allow entry into a new market' and 'obtain funding' as objectives for participation in the Framework Programmes. Smaller companies are more likely to look for projects where the funding element is sufficient, where the envisaged result of project participation is a commercialisable innovation output and projects that would allow entry into new markets. What these three objectives have in common is the economic element or the direct economic reward from participation, either during the course of project in terms of funding from the EU, or from the market immediately after the project has ended.

Figure 3.3: Clustered objectives by type of organisation



Other objectives do not vary significantly depending on the size of the firm, according to the survey. Also being a newcomer or having previous experience in FP does not lead to any differences regarding the objectives to participate.

3.3.3 MARKET AND TECHNOLOGICAL ENVIRONMENT

There does not seem to be any relation between the stability of the market and the technological environment and the motives for being involved in projects. In fast growing markets, networking is relatively more important, while in declining markets issues of cost-risk control and market share become more critical and technology is less important.

3.3.4 OBJECTIVES AND STATED ACHIEVEMENTS

In general participants manage to achieve their specific (and highly ranked) objectives to a reasonable extent especially with regards to the technology and knowledge oriented objectives. The exception to this overall assessment is that market related objectives do not score high, but market related achievements are major outcomes.

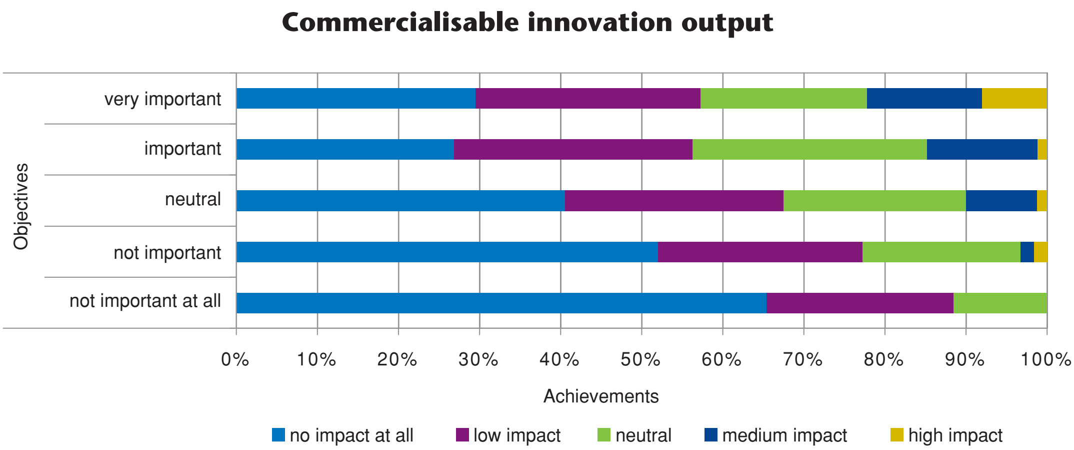
The knowledge and technology related objectives are ranked highest amongst the objectives in general and the achievements are considerable. Keeping up with the state-of-the-art technology is considered a key objective as seen in the previous sections. Close to 80% of the respondents that give a high importance to this objective achieve the set goals. Equally the networking objectives are generally well matched with achievements. Of the cost and risk related objectives around 40% of the respondents who consider risk sharing a very important objective manage to achieve a medium to high impact on risk sharing and reduced uncertainty. 60% of those who consider this objective to be unimportant have no achievement, which was to be expected.

The market-related objectives show a clear picture. If the market related objectives were not seen as important at the start of a project, in general no market-related achievements are reported, not even as a side effect.

An important message is that the likelihood that they will commercialise aspects of the project is almost negligible for organisations that do not have commercial objectives at the start of a project (Figure 3.4). This strongly supports the hypothesis that if organisations have no commercialisation vision when defining and entering a project, no direct result will be brought to the market, even if there would be marketable product or service.

In summary one can say that most objectives are fairly well matched with the achievement of project partners, whereby especially the key knowledge/technology and networking related objectives are generally achieved, whereas the more difficult commercial objectives are rather problematic.

Figure 3.4: Creating a Commercialisable Output: Objectives versus Achievement



3.4 Strategic considerations

3.4.1 TECHNOLOGICAL STRATEGY: EXPLORATION VS. EXPLOITATION

For this question we have made a direct comparison between the new instruments IPs and NoEs, the traditional instruments (STREPS, CSC, etc.) and not publicly supported (self-funded) collaborative projects.

The ranking between the three types of projects is quite clear: the new instruments are more often used for projects that are a bit more exploratory of nature than the traditional funding instruments, whereas the self-funded project are used for more exploration oriented projects.

For most of the categories of participants (except the low innovators, the very small firms and the those who participate for the first time), the ranking is the same as for the whole sample.

3.4.2 MEANS OF PROTECTION OF INNOVATION ADOPTED IN GENERAL

Enterprises give a very clear picture on how they prefer to protect their innovation: "Keeping staff" is the most important means of protection. "Patent" and "other IPR" are the least important. This fully confirms the numerous studies this subject. Other means of protection are not clearly separated.

Manufacturing companies put equally high value on "secrecy", "lead time advantage" and "technological complexity". Service companies highlight "complementary services" and to a lesser extent "lead time advantage". Secrecy, other IPR and patent (not surprisingly) are also less used by those firms. There are some significant differences between firms according to size (except for "complementary services"): the larger the company, the higher importance is given across all means of protection. The large firms put a relatively higher value on "patent" (and to a lesser extent on "secrecy") than SMEs.

The more innovative firms rank all protection means high across the board. Medium and Low or non innovators only rank "Complementary services" and "Technological complexity" higher than the high innovators.

3.4.3 PROTECTION STRATEGY ADOPTED IN FP PROJECTS

The means of protection most often used in the context of the surveyed projects are "technological complexity", "secrecy", "complementary services" and "lead time advantage". Similar to the general protection strategy, "patents" and "other IPR" are ranked last.

Overall there are only small differences between participants of different size: all categories exhibit more or less the same profile, apart from the very small firms who put the highest emphasis on "complementary services" and less on "secrecy".

High innovators tend to use all types of protection more intensively than the others, apart from "complementary services" and "secrecy", which is also used by all participants on the research side. The importance of "patents" among research participants is mainly due to high innovators. The higher the ratio R&D/turnover, the more often IPR (including patent) and technological complexity are being reported.

There is a significant difference between firms with and those without previous experience (newcomers): the ones that enter for the first time in FP tend to put more emphasis on "secrecy" and less on "complementary services".

Those participants applying patents generally report more outputs across the board than those applying secrecy. When publications and PhDs (and also models and simulations) are produced, secrecy no longer is relevant. The other types of output are not related to the strategy of secrecy. For enterprises, the relation between the type of commercial exploitation output confirms the low use of patents (less than 30% of those commercially exploit the output have used patents).

FP5 and FP6 show a very similar profile for the preferred ways to protect innovation (Figure 3.5). FP6 project "patents" and "other IPR" are reported slightly more often. The use of patents and other IPRs can largely be attributed to research participants, while companies seem to use more frequently "lead time advantage" and "technological complexity" in FP6.

The instruments show fairly similar profiles all along (with a notable similarity between IPs and STREPs). CRS scores relatively high on secrecy, whereas patenting across all instruments is not deemed very important.

Importantly, projects that apply protection, are generally more costly, more risky, more complex and (a little) more long term oriented than the "average R&D projects", than those that do not apply protection to the project results. Closeness to the core activity however does not seem to be related to any of the means of protection.

The proportion of industrial partners in a project is positively correlated to the use of all means of protection, except with "other IPR" (negatively correlated) and "technological complexity" (no correlation).

Figure 3.7 compares protection strategies for the whole sample of responding organizations. "Secrecy", "lead time advantage" and "technological complexity" appear to be the most important strategies.

Figure 3.5: Means of protection by FP

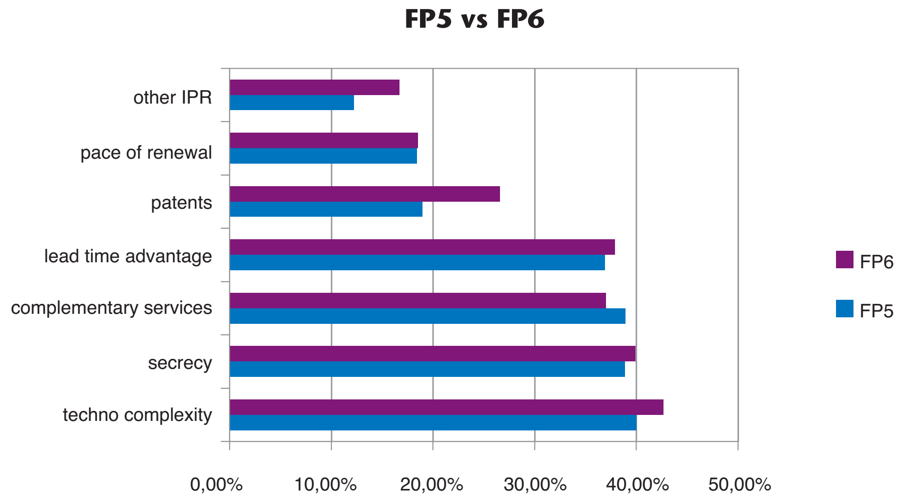
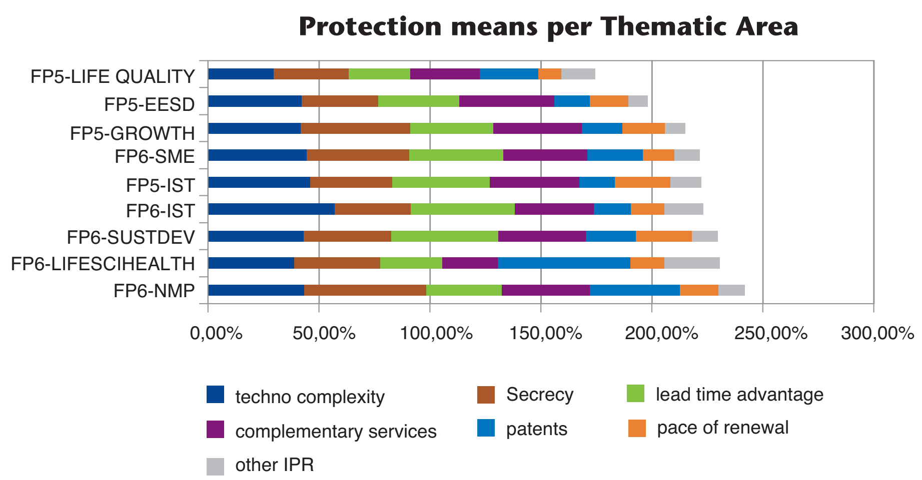


Figure 3.6: Means of protection by FP areas



3.5 Summary conclusions - Organisation Characteristics

The participants in the Framework Programmes are the 'elite' of innovators, meaning:

- their R&D intensities are above the average of their sector of principal activity;
- they are significantly more networked with clients and universities;
- they are significantly more orientated towards international markets;
- exhibit significantly stronger patenting behaviour.

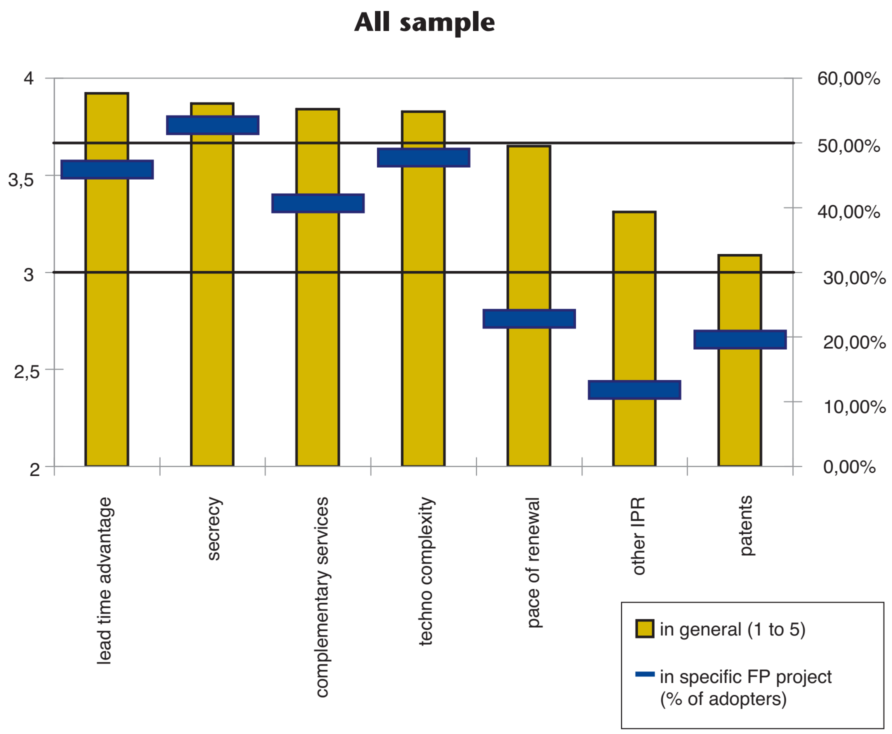
There is substantial input additionality among smaller firms. Participation in FP4 and/or FP5 results in a significant increase of R&D intensity between 2000 and 2004 among firms of up to 100 employees (R&D intensity roughly doubled!). This does not hold for larger firms.

When choosing to participate in an FP project, technology-related objectives dominate other types of objectives, including market, cost-risk sharing and network-related. This ranking is highly stable over the different categories of participants: even when looking at more detailed classification of motives, the two to three top ranked objectives and the last ones are always the same. These results are similar in FP5 and FP6 projects, however some differences appear among FP areas and among instruments (e.g., NoE and CA showing differences in FP6).

With regard to technological strategy, NoE and IP are used for projects which are slightly more exploratory than the other FPs, and self-funded cooperative RD projects are used for projects more of the exploitation type. The larger a firm participating in an FP project, the more clear its technological strategy pursued in different contexts of collaborative R&D.

In general, "Keeping staff" is the most important means of protection used by participants. Formal IPR (incl. patent) are the less important. In general, firms do not change their favourite means of protection in FP projects. Innovations from FP5 and from FP6 are protected roughly in the same way, but some differences appear within FPs according to areas and instruments. Means of protection are quite aligned with the type of innovation usually produced by companies and with the type of outputs from the projects.

Figure 3.7: Comparison of protection strategies



4 Project Characteristics[15]

4.1 Key characteristics

4.1.1 OBJECTIVES AND PROJECT CHARACTERISTICS: THEMATIC AREA AND TYPE OF INSTRUMENT

There are no extensive differences in motivations between FP 5 and FP 6 projects.

Table 4.1: Objectives by thematic area

	FP5				FP6				
	GROWTH	IST	LQ	EESD	IST	LSH	NMP	SME	SUSTDEV
Access to complementary resources and skills	++	++	++	++	++	++	++	++	++
Keeping up with state-of-the-art technological developments	++	++	++	++	++	++	++	++	++
Show up scientific/technological competences	++	++	++	++	++	+	++	++	++
Networking / find new partners	+	+	++	+	+	++	++	+	+
Explore different technological opportunities	+	+	+	+	++	+	++	+	+
Gain a window into state of the art	+	+	+	+	-	+	+	+	+
Create a commercialisable innovation output	+	+	-	+	-	+	+	+	-
Access to application fields for testing/validating theories	+	+	+	-	+	-	-	-	+
Obtain funding	-	-	+	+	+	+	-	-	+
Allow your organization to reach a critical mass of resources and skills in a given technological field	-	-	+	-	+	+	-	+	-
R&D cost sharing	-	+	+	-	+	+	-	-	-
Signal up technological competences	+	-	-	-	+	-	-	+	-
Promote user/producer interactions	-	-	--	-	--	-	-	-	-
Allow entry into a new market	-	-	--	-	-	--	-	-	--
Improve speed of bringing innovation to market	--	-	--	-	-	-	-	-	--
Joint creation and promotion of technical standards	--	--	-	-	--	-	--	--	-
Risk sharing- reduce uncertainty	-	--	--	--	--	--	--	--	--
Control future market developments	--	--	--	--	--	--	--	--	--

[15] This chapter is based on contributions from Beta: Laurent Bach and Mireille Matt, Joanneum Research: Wolfgang Polt and Gerhard Streicher and Intrasoft: Robbert Fisher and Babis Ipektsidis.

Overall the different instruments show a fairly consistent picture, with the notable exception of the Collaborative research projects that seem to focus more on cost and risk, as well as technology and knowledge-oriented objectives (Table 4.2).

Table 4.2: Objectives by type of instrument

	FP5				FP6					
	CSC	ACM	CRS	THN	IP	NoE	STREP	CA	COOP	COLL
Access to complementary resources and skills	++	++	++	++	++	++	++	++	++	++
Show up scientific/technological competences	++	++	++	++	++	++	++	++	++	++
Keeping up with state-of-the-art technological developments	++	++	+	++	++	++	++	++	+	++
Networking / find new partners	+	++	+	++	+	++	+	++	+	+
Gain a window into state of the art	+	++	+	++	+	+	+	++	+	+
Explore different technological opportunities	+	+	+	+	++	++	+	+	++	+
Access to application fields for testing/validating theories	+	+	+	+	+	+	+	-	-	-
Allow your organization to reach a critical mass of resources and skills in a given technological field	+	+	-	-	-	+	-	+	+	+
Create a commercialisable innovation output	+	-	+	-	+	--	+	--	++	-
Signal up technological competences	-	+	-	+	+	-	-	-	+	+
R&D cost sharing	+	-	+	--	-	-	+	--	-	+
Obtain funding	+	-	-	-	+	+	+	-	-	--
Allow entry into a new market	--	-	-	-	--	-	-	-	+	-
Promote user/producer interactions	--	-	-	-	-	-	--	-	-	--
Joint creation and promotion of technical standards	--	--	--	-	--	-	--	-	--	-
Improve speed of bringing innovation to market	--	-	--	-	-	--	-	-	-	-
Risk sharing- reduce uncertainty	--	--	-	--	--	--	--	--	--	-
Control future market developments	--	--	--	--	--	--	--	-	--	-

4.1.2 OBJECTIVES AND OTHER PROJECT CHARACTERISTICS

Other characteristics of the project and of the activity of project participants are also taken into account. Objectives are regrouped in four categories here: market, technology, cost-risk, and networking. A "dominant" type of objectives is associated to each project.

Project characteristics – cost, risk, time horizon, distance to the core R&D field of the participants – re quite clearly related to the motives for being involved in the FP projects; this is especially the case for manufacturing companies and to a lesser extent for services companies (and again the relation is weaker in the case of research participants). This can be interpreted as an evidence of the coherence of strategic choices made by firms when entering Framework Programmes. In particular, risks related to the projects seem to be quite critical to the motives that drive involvement in projects. For instance, when cost-risk sharing is stated as an objective, projects are indeed more costly and more risky; when networking is the main objective however, projects are less risky and closer to the core activities of the participants.

The fact the project comprised a new R&D area for the participant is significantly related to the nature of the objectives of the participant: partners with market-related objectives are involved in new areas, while those with dominant network-related objectives are not involved in new areas.

There is no relation between the types of objectives and the proportion of partners with which the participants had worked prior to the project.

The percentage of industrial partners is higher in projects carried where market-related objectives are dominant, then in projects with technology, cost-risk-sharing and network objectives, respectively.

4.1.3 ORIGIN OF THE PROJECT[16]

The origin of the idea on which the projects are based seems to have somewhat evolved from one FP to the next (and those differences are statistically significant) (Figure 4.1).

When looking at the thematic areas covered by FPs, one could see that in FP5 only the Life Quality was characterized by a larger share of projects where the idea was coming from research/education side (Growth and IST projects being much more inspired by industry). This situation is slightly different in FP6 where only IST projects seem to remain highly company driven (with SMEs also being quite balanced). In both FPs, the origin of Life Science projects is to be traced to research/education organizations in more than 80% of the cases, which could reflect the low level of implication of Big Pharma and high-tech bio companies in FPs[17].

4.1.4 MARKET CONDITIONS

In their majority, FP projects are reportedly focused on markets at an emerging stage or an early stage of development. The partition of projects according to the stage of market development is almost the same in FP5 and FP6, with a very light (but statistically significant) downstream shift in FP6 (Figure 4.2).

Figure 4.1: Origin of the Project

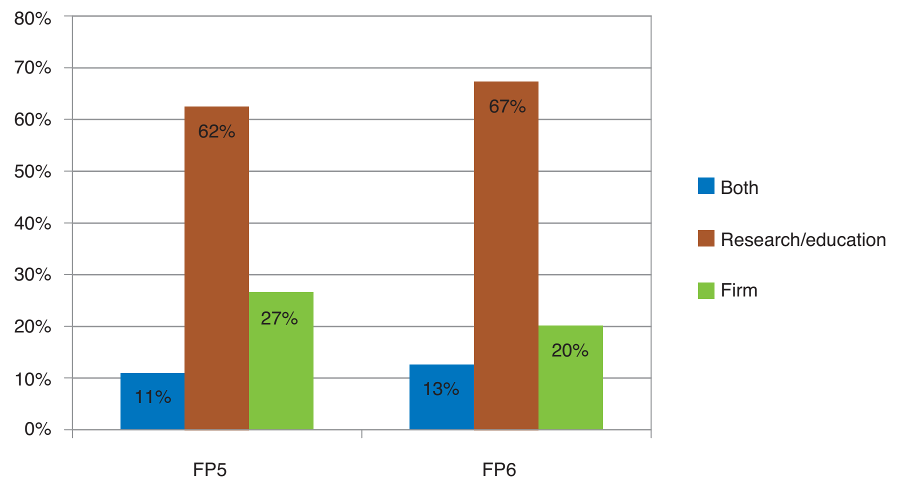
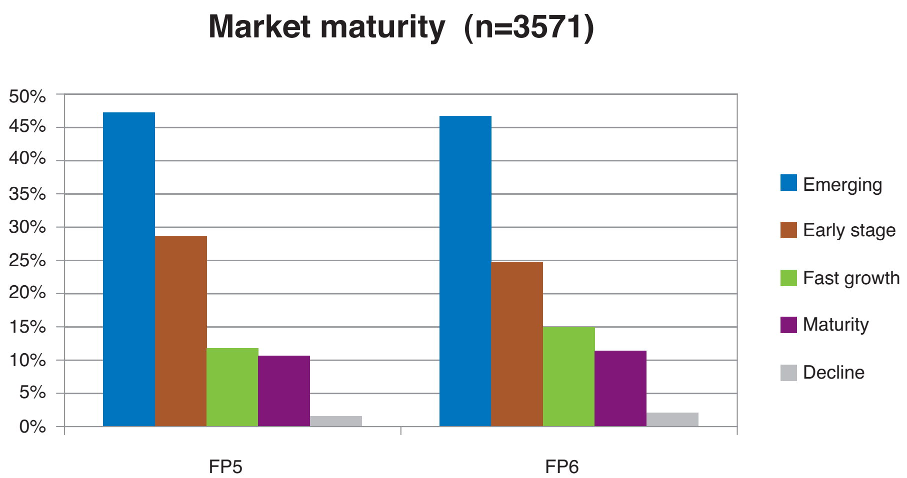


Figure 4.2: Market conditions



[16] This analysis is based on the answers to question Q12 of the survey (reflecting the opinion of one partner only) and on the simplified classification of participants provided by CORDIS, the two classification being slightly different.

[17] Again, according to companies the shift from Industry to Research origin can be traced over all areas, except in IST which remains company-driven.

This result is very stable across the different areas in FP5 and in FP6 (with only a higher proportion of projects related to the more mature market in FP5-Growth and FP6-NMP). But some differences appear across instruments (Figure 4.3).

4.1.5 THE INVOLVEMENT OF PARTICIPANTS IN PROJECTS

Forty percent of manufacturing participants are R&D performers, which is similar for both technology producers and users (note that a given participant could play different roles in the same project). This indicates a balance of roles in projects.

The role of manufacturing companies is more balanced than the role of participants from the whole sample. Not surprisingly, research organisations – and to a lesser extent service companies – are more concentrated on performing R&D. Manufacturing companies are proportionally more involved as producers of technology and, similar to services companies, users of technology (Figure 4.4).

Very small firms are more frequently R&D performers (nearly 50% of them), whereas large companies are more often technology users (over 50%).

The average total number of partners in projects is just over 12, and on average 19% of the partners are from industry. Participants reported to have worked with 26% of the participants they had collaborated with prior to the specific FP project for which the questionnaire was completed.

There are significant differences among organizations regarding their preferred partners. Research organizations are more often associated with partners they have worked with before, and less with industry,

Figure 4.3: Market conditions by instrument

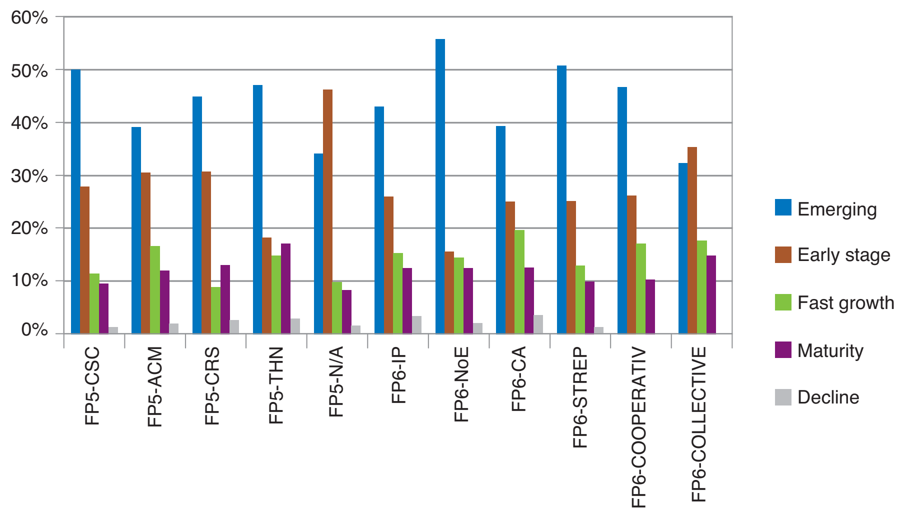
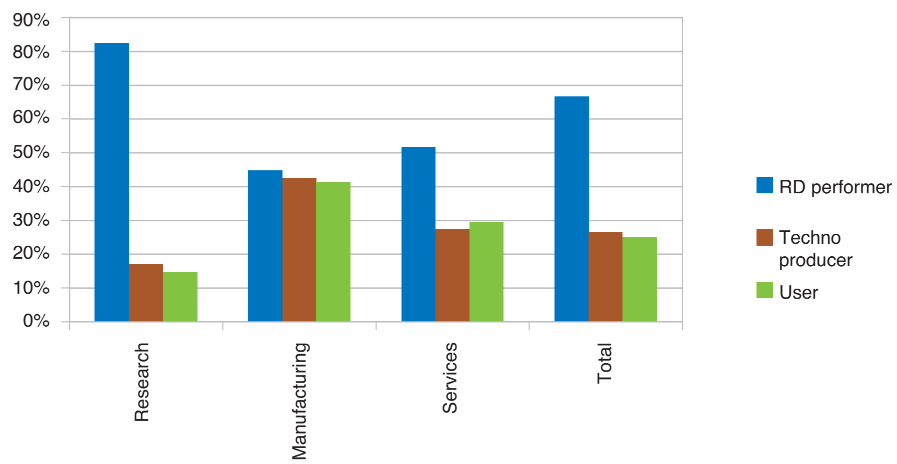


Figure 4.4: Role of participants in FP projects



which is to some extent the same for the participants from the services sector. In contrast, manufacturing participants are engaged less with partners they had worked with before and more with other industry participants.

Very small firms are engaged in projects with fewer industry partners and they had previously worked with less partners; large firms in projects with more partners and they had previously worked with more partners.

High innovators are engaged in projects with fewer partners and with a higher proportion of industrial partners. There is no link, however, between the innovativeness of participants and the proportion of partners with whom they had already worked before FP projects.

4.2 How do FP projects compare to other projects

4.2.1 FP PROJECT AS COMPARED TO THE "AVERAGE R&D PROJECT"

The characteristics of the specific projects compared to an "average R&D project" of the company clearly show that FP projects mainly differ from others on three points: they are more complex, more long-term oriented, and (to a lesser extent) closer to the core technological area of participants. But FP projects are closer to "average R&D projects" regarding risk (a bit higher for scientific and technological risk, a bit lower for commercial risk) and project cost.

On average, FP5 and FP6 projects show similar characteristics (Figure 4.6). Generally speaking, the same profile of characteristics can be found across all FP5 thematic areas, with minor differences related to risk. EESD projects (and to a lesser extent Life Quality projects) seem to be less risky (especially from a commercial point of view) and slightly closer to the core. Characteristics of projects in FP6 areas are more diverse. The main difference can be found in Life Sciences and Health and Sustainable Development (less commercially risky and very close to the core), while SME projects are less complex and less long-term oriented.

Important differences appear when looking at FP instruments (Figure 4.7). In FP5, while CSC and CRS show more or less the same standard profile of characteristics already described, ACM and THN projects clearly differ to the extent that they are well below the "average R&D project" in terms of cost and of both types of risk. In FP6, the diversity of profiles is higher. STREP projects follow more or less the standard profile. IP projects are largely above the "average R&D project" in term of cost. NoE projects show interesting characteristics: they are more long-term oriented and less risky especially as regards commercial risk. CA projects are well below the "average R&D project" in terms of cost and both types of risk.

There is evidently a close connection between the market and technological conditions on the one hand and the project characteristics on the other. This is true both with regard to the general environment in which participants are working, and with regard to the specific market conditions related to the specific project.

When the environment is highly unpredictable and risky because of different factors on the demand and supply side, FP projects are more risky and more complex; participants then seem to use FP projects as a way to cope with the characteristics of their environment. Projects with high technological risk and high level of complexity are associated with an environment of technological uncertainty. In stable environments, participants work closer to their core field in the FP than in their average R&D project. The only characteristic which does not seem to be linked to the environment is the time horizon.

The relation between environment and project characteristics is more intense when looking at the specificity of the market related to the FP project. Again, various "classical" results seem to be confirmed by the results. Notably, in emerging markets, projects are more scientifically and technologically risky and more complex. In declining markets, projects are less risky and less complex.

Figure 4.5: Projects as compared to an "average R&D project"

Project cost, Degree of scientific and technical risk, Degree of commercial risk, Scientific and technical complexity: (1) low to (5) high

Short / long term R&D (1) short to (5) long

Distance from core technological area (1) core to (5) peripheral

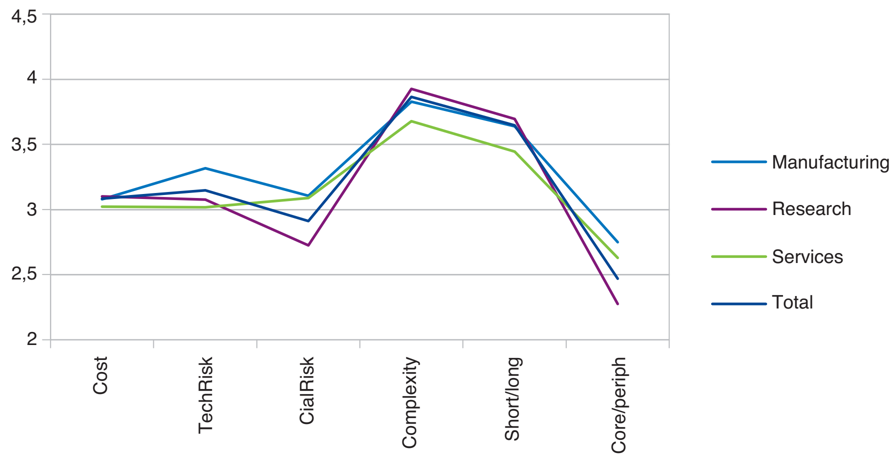


Figure 4.6: Relations between characteristics of FP projects and EU project classification

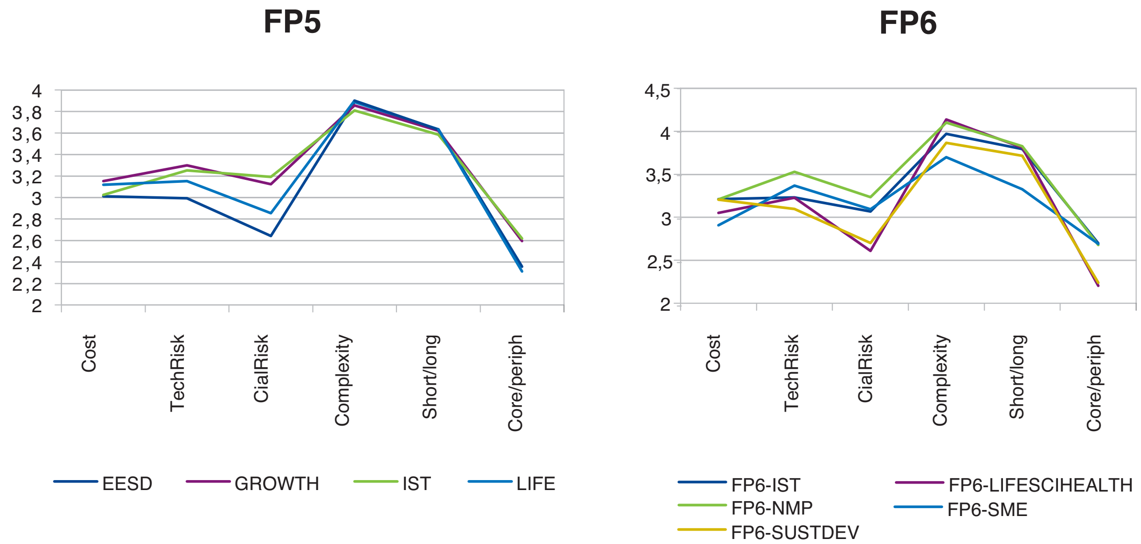
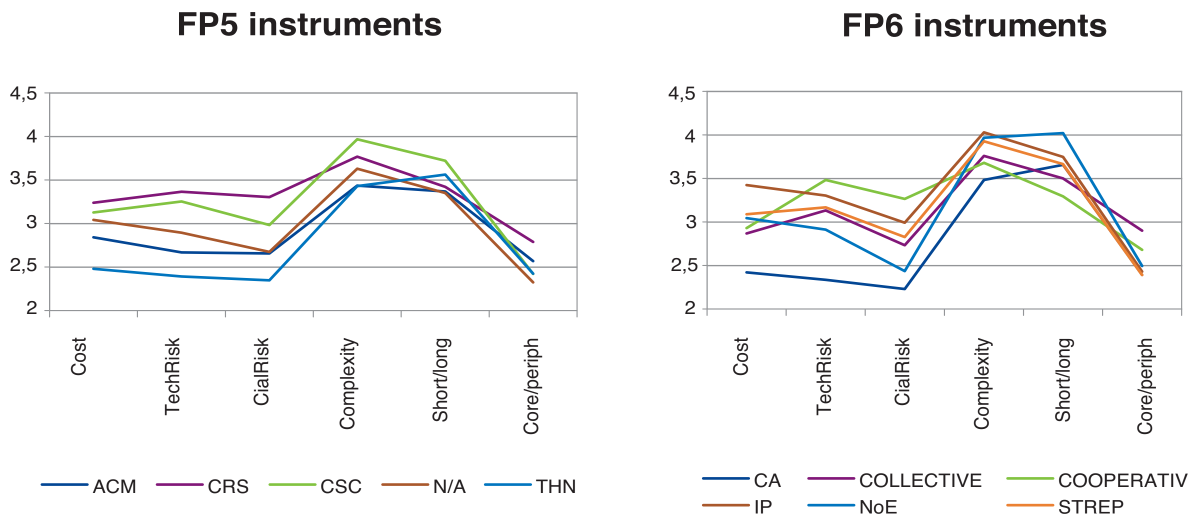


Figure 4.7: Relation between characteristics of FP projects and EU project classification



The type of the originator of the project idea is positively correlated with the level of cost, of scientific and technological risk, the complexity, as well as the closeness to the core R&D field. In the case of firms only, the link is mainly with cost, commercial risk and closeness to the core field. This seems to confirm the results previously obtained when comparing the motives for being involved in FP and the origin of the project idea. Participants are more driven by standard market/cost oriented factors when they are the originators of the project idea. When they follow in some manner an initiative of other partners, they are more sensitive to technology or network related arguments. They are also keener to work closer to their core field of competence when they are the originators of the idea; another interpretation could be that, when they have an idea on which a FP project could be launched, they take part only when this idea is close to their core field.

Taking the opportunity of a FP project to enter a new area of research is associated with risky projects and peripheral activities, which again is what one could reasonably expect.

The higher the proportion of partners with whom common work had taken place prior to the specific FP project, the closer the project to the core technological area of the company. This result can probably be linked to the necessary level of trust and complementarity between partners.

A higher proportion of industrial partners in projects makes them more risky and more peripheral.

4.2.2 COMPARISON BETWEEN THE SPECIFIC FP PROJECT SURVEYED AND THE OVERALL FP PROJECTS OF PARTICIPANTS

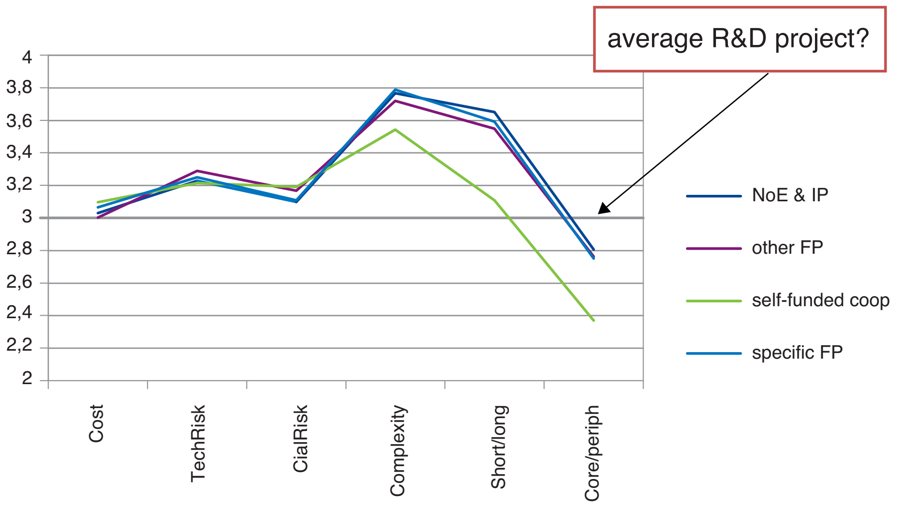
Some of the dimensions of FP projects compared to "the average R&D project" of the participant were also used to compare different contexts in which cooperative R&D work can be carried out. This second comparison, only possible regarding companies, leads to two main conclusions:

1. there is not much difference between NoE and IP, and other types of FP projects;

2. the main differences between the three types of projects are related to complexity, (which is slightly higher in FP projects), time perspective (clearly more longer term in FP projects), and closeness to core technologies (the self-funded projects being closer to the core field) (Figure 4.8).

Overall, the profiles of the FP projects are very similar. FP projects are partly different than other self-funded cooperative projects and the average R&D project of the responding organization.

Figure 4.8: Comparison of characteristics of the specific FP to the overall FP projects of the participants



4.3 How do FP projects relate to other projects

In more than 58% of the cases, in-house R&D projects preceded the referenced FP projects. Self-funded cooperative programmes were the origin in 14% of cases.

This result slightly differs over the type of organisations. While in-house R&D is always the most cited related past R&D activity, another FP project (for Services companies and Research participants), national programme (for Research participants), and new area (for all firms) are highlighted significantly. The ranking of past R&D contexts is the same whatever the size of the partners (Figure 4.10).

Previous FP experience obviously has an impact on the importance of FP as a source: organisations without previous FP experience are less frequently citing other FPs. New area is less often cited by the insiders to FP projects than by the newcomers.

Another insight can be provided by looking at the correlation between previous FP projects and national programmes, and the specific FP project. The proportion of past FP projects cited as a source for the specific FP project is about one-third in both FP6 and FP5 (33% against 30%). This proportion is significantly higher in Sustainable Development (FP6) and in IST (FP6). With regards to instruments, the proportion is significantly higher in NoE projects (F65) and lower in CRS (FP5) and Cooperative and Collective projects (FP6).

The proportion of projects that have a national programme as an origin is slightly higher in FP6 than FP5 (31% against 26%). This is particularly true

Figure 4.9: Past R&D projects in relation with FP projects and participant types

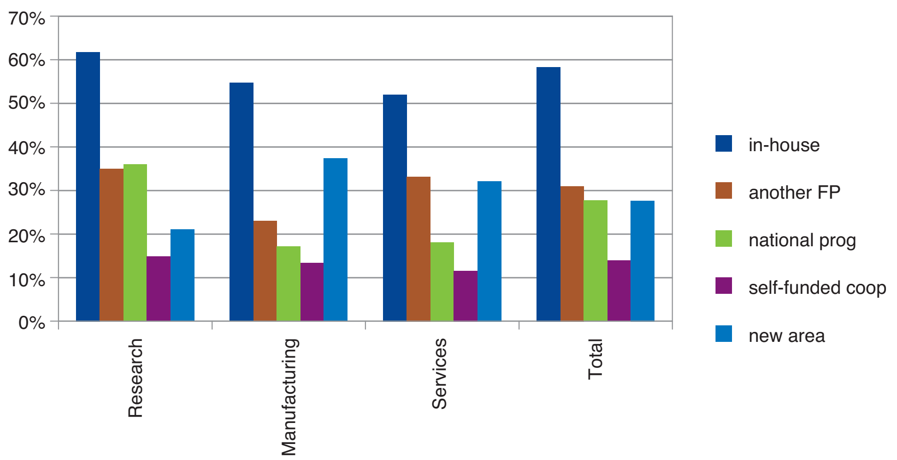
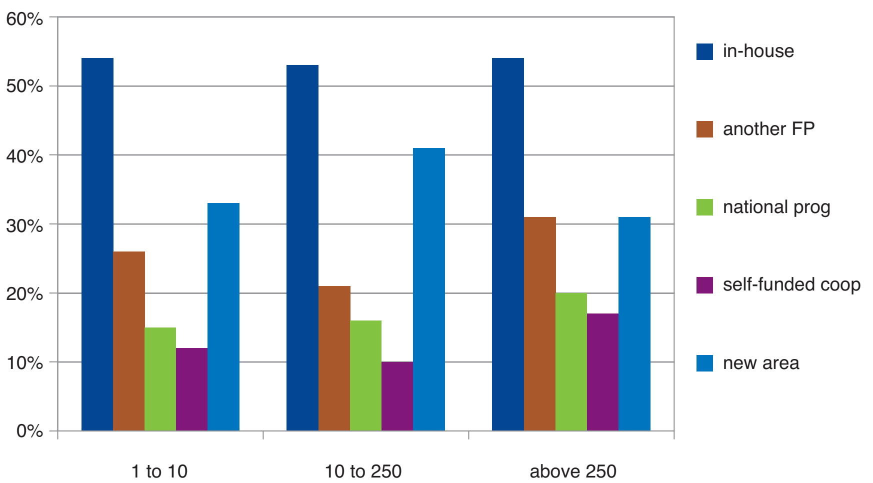


Figure 4.10: Past R&D projects in relation with FP projects by organization size



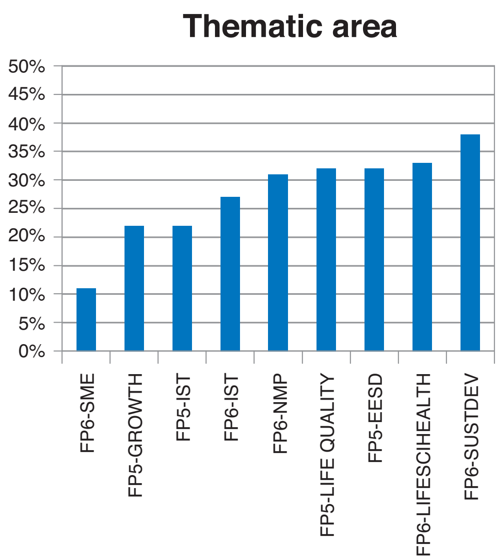
for Sustainable Development and for the instruments IP and NoE. Conversely, SME (FP6), CRS (FP5), and Cooperative and Collaborative (FP6) are lower than average in that respect.

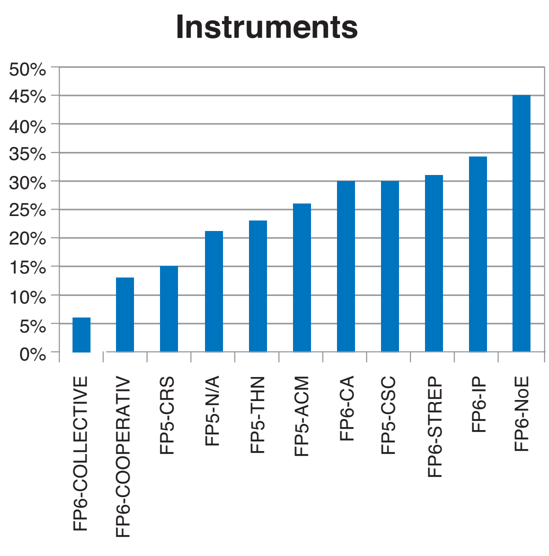
These results point to non-trivial, but somewhat different, degrees of interaction and complementarity between national and European programmes, to be found in technology areas and funding instruments.

Most likely R&D performers are those who reported past R&D conducted in-house as the basis of their involvement in the specific FP project (more than 60%), whereas this share is only about 35% for those for whom the FP project constituted a new area of research.

For a majority, follow-up R&D projects constituted a significant output of the specific FP project: their respective share is typically above 55% or even 60%; only for respondents for which the specific FP project constituted a new area of research, this share is below 55%. Past work in another FP project and in national programme seem to be more favourable to the generation of new R&D projects. As to the different roles, managers and R&D performers are slightly more likely to report follow-up projects than respondents with other roles, especially when they have been involved in previous FP projects in the same area (for managers) and in national programmes (for R&D performers). The role of user, service providers and testers (all in "other"), probably more marginal in the projects, is less conducive to follow-up R&D projects.

Figure 4.11: Past R&D projects in relation with national projects per Instrument and Programme





5 Market, Firm, and Project-level effects on the **innovation impact** of FP R&D projects[18]

This Section concentrates on the determinants of the innovation impacts of publicly funded R&D projects along three broad dimensions, namely project-, firm- and market-related factors. In addition to these, we also examine the effects of two other classes of factors, including aspects of the commercialization process of a research result and the attributes of the research result *per se*. The basic proposition explored is as follows:

Proposition: *(a) the ways a project is managed; (b) the resources, experience and capabilities of partners; (c) market conditions; (d) the character of the commercialization effort and problems confronted during the process; and (e) the nature of the technology resulting from the project significantly affect the innovation impacts of FP-funded R&D projects.*

Two sections below present the setup and results of the empirical and qualitative analyses respectively relating to this proposition.

5.1 Econometric Analysis (Survey)

5.1.1 INNOVATION IMPACTS DEFINED

For present purposes innovation impact is conceived to comprise of *commercially exploited outputs* (products, services, production processes) and of the *technical knowledge* obtained by the responding organization as a result of its involvement in a specific cooperative R&D project. Taken together, product/process innovation and/or the creation of new technical knowledge will be considered to constitute *project success*. We examine the determinants of project success along the dimensions of market, firm, and project-related factors. We also examine the effects on project success of aspects of the commercialization process of a research result and the attributes of the research result *per se*.

[18] This chapter is based on contributions from AUEB: Nick Vonortas, Yiannis Spanos and Eric Söderquist, and Formit: Luca Remotti

Project-related factors refer to "structural" features, such as the thematic area of a given project, the size of the consortium that has undertaken the research work, and management aspects of the project. The latter include social and behavioural features in the management of the project team, such as communication, coordination mechanisms, and team learning. Moreover, in this category we include management rules and practices imposed by the Commission to govern the setup and workings of research consortia. Firm-related factors pertain to the resources, experience, and innovation-related competencies of the partners involved in the project. Included are factors such as firm size and age, previous experience in innovation activities, resources and skills for innovation, etc.[19] Market-related factors involve the characteristics of the industry and market to which the partners in a research consortium belong. To the extent that market conditions are dynamic and highly competitive, a firm will be motivated to engage seriously in innovation activities as a way to confront market pressures, and therefore is more likely to commit resources in the implementation of the joint R&D efforts and be strongly interested to project success. Finally, the likelihood that a project results into product or process innovation is also influenced by the character of the commercialization process and the ensuing difficulties and by the attributes of the research result per se.

In contrast, the character of the commercialization process and the attributes of the research result do not affect technical knowledge which is "causally prior" to them.

The next figure depicts schematically the aggregate relations underlying the econometric analysis.

5.1.2 DATA

Two separate questionnaires were developed for business enterprises and research organizations (ROs) (universities, research institutes, etc.). We only discuss analytically the results from the enterprise questionnaire here. Both sets of data have been analysed with similar methodologies, however, and occasionally we may refer to the results from the RO sample.

Survey data were collected from business enterprises from the EU and beyond. The techni-calities of data collection as well as descriptive statistics have been detailed in Chapter 2.

5.1.3 VARIABLES

As already noted, project success is conceptualized to comprise two dimensions: product or process innovation and technical knowledge creation. We measured innovation with two dummy variables, indicating whether the project resulted in product and process innovation. Technical knowledge creation was measured with a three-item Likert-type scale, measuring the significance of knowledge-oriented outcomes, such as development of tools and techniques, and prototypes. These outcomes embody knowledge of a technical nature that can provide the basis for further development leading (eventually) to commercialization.

The use of a single instrument (participant survey) to collect all variables poses the threat of common method bias. To test for this possibility we used Harman's single factor test.

5.1.4 RESULTS

We examine the effects of five sets of factors, namely: market related, firm related, project related, commercialization related, and "nature of research results" factors on project success. We conceptualize project success to comprise of two dimensions: tangible commercialized results, that is, new product or process innovation, and intangible "technical knowledge" as an intermediate output that may or may not get commercialized. The impact of the five sets of factors on product/process innovation was assessed using *logistic* regression analysis, whereas their impact on the production of technical knowledge was assessed using ordinary regression

[19] Our data are single responses per project. As a result, the effects of these firm-related factors reflect their influence on the likelihood that the responding organization indicates that it has been able to obtain results under the specific project.

(OLS). The results are presented in the order: (a) product innovation, (b) process innovation, and (c) technical knowledge.

NEW PRODUCT INNOVATION

The most significant contributors, statistically, to product innovation are basic firm characteristics (marginally significant), the innovation history of the organization, the nature of the project, the role of the respondent in the project (i.e., manager or producer or user of the technology), and the factors related to the commercialization of the research result. Among these, the nature of the project appears to be the one with the most visible contribution. The lack of significant contribution of firm resources and capabilities and project management (as *sets* of variables) is notable.

Turning to the individual coefficients, we find the following statistically significant effects:

"Market effects": No significant coefficient in this class of explanatory variables.

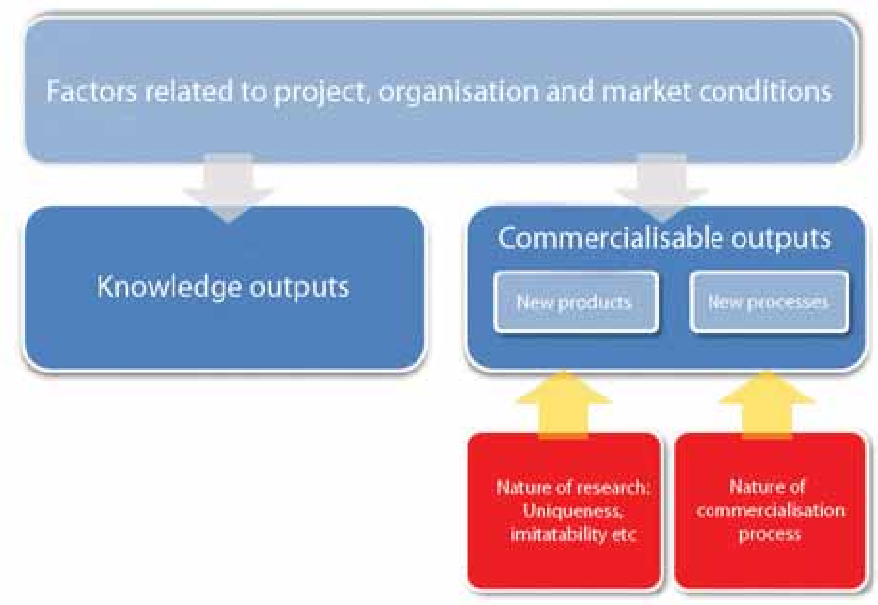
"Basic firm effects": Again, no significant coefficients are found. Manufacturing firms in the sample are slightly more likely to report product innovation in comparison to services firms.

"Firm resources and capabilities": A history of innovation *protection* through "complex" technologies positively and significantly affects the odds of the project resulting in product innovation for the participant. It appears therefore that the more a firm is using "complexity of technology" and by keeping qualified people in the firm as a general means to protect its innovations the more likely it is to come up with product innovation as a result of its involvement in an FP project.

"Innovation History": The next two significant coefficients concern intramural and extramural R&D. These two variables reflect a firm's history of research activities, and the significant positive effects confirm the hypothesis that the more experienced a firm in R&D is the more likely its project to prove successful. Firms that have engaged in past intramural R&D are about 10 times more likely than the rest to produce product innovation in FP-financed R&D projects. This is a very strong result; in fact it is the strongest coefficient found with respect to product innovation. It suggests that *firm history in R&D activity, particularly in-house research, plays a key role in the development of product innovation.*

"Basic project characteristics": The next significant coefficient suggests a rather intriguing result. Firms for which participation in the focal project was their

Figure 5.1 Conceptual Framework



first-time involvement in FP programmes are more than twice as likely to report project success, in terms of product innovation, in comparison to "old-timers".

"EU rules": With regards to management practice, the extent to which the set-up and rules imposed by the EC regarding partners' selection and negotiations are perceived as facilitating project success appears to exert a positive influence on the likelihood for product innovation. This finding should not be interpreted as implying a *causal* relationship between EU rules and product innovation, but rather that firms experienced with the provisions and rules set by the Commission find no difficulty *in this particular regard* to achieve innovation.

"Nature of the project": The next three significant coefficients relate to the nature of the project. More specifically, projects characterized as having *commercial* objectives and that are considered *risky* are also more likely to result in product innovation. In contrast, those projects that are considered to be involved in the exploration of "new" technological areas are significantly less likely to produce innovative products. We find support for the possibility of an inverted U-shaped relationship between innovation and the extent to which a project is risky or exploring "new areas". Our *results suggest that projects driven and motivated by clear commercial objectives, which are also mildly risky, are more likely to result in success in terms of product innovation.*

"Project Management effects": We find no support of a significant relationship among any of the variables reflecting project management and product innovation.

"Commercialization-related effects": In this set of independent variables, the results show two significant coefficients. Specifically, the "Problems in commercialization 1: no plan/no intention" variable quite naturally has a negative effect in the odds for producing product innovation. In contrast, Problems in commercialization 2: IPR issues (i.e., "IPR-related problems during commercialization") appears to exert a significant positive influence. This is a counterintuitive finding, as one would logically expect that a situation of IPR-related conflict among partners would reduce the odds of finally commercializing the innovation. This finding may simply imply that despite such problems, should an opportunity arise the partners in a project will overcome IPR conflict in view of the prospect for commercial exploitation.

"Nature of research results": In this final set of explanatory variables, we find two significant effects. The coefficients of "Nature of research result 4: dynamic" and "Nature of research result 5: "distance" from key technological area" are estimated negative and significant. The former reflects a technology with a relatively *short life cycle*. In this context, the prospects of commercialization are not so promising, hence the negative effect. The latter variable reflects the case where the technology is relatively *distant from the core technological competence* of the responding organization. The negative coefficient, therefore, suggests that the further away from the firm's existing technological resources and capabilities the less likely it is that the project results in product innovation.

NEW PROCESS INNOVATION

The statistically most significant contributors to process innovation include: industry effects (which were found insignificant for product innovation), firms' innovation history (as was found also for product innovation), the role of the respondent in the project (again as was the case for product innovation), project management, and the factors related to the commercialization of the research result. Among these, the nature of the project appears to be the one with the most visible contribution, a result that coincides with the one found for product innovation. As in the case of product innovation, the contribution of firm resources and capabilities on process innovation is not significant.

"Market effects": Even though the variables comprising market effects are, *collectively* as a set, statistically significant, individually we find no significant coefficient in this class of explanatory variables.

"Basic firm effects": Size is found positive and significant. Larger firms appear somewhat more likely to report process innovation. The Manufacturing dummy is positive but insignificant.

"Firm resources and capabilities": A firm's capacity to "introduce new products speedily" is found to be *negatively* associated with process innovation. In contrast, the coefficient for "integration capabilities" is found positive and significant. In the extant literature on innovation it is consistently argued that the capacity for integrating internal and external to the firm activities and functions is a critical prerequisite for implementing innovation. Our finding is clearly in line with this argument. Finally, in this set of independent variables, we also find a significant negative coefficient for "innovation protection through legal means". This variable refers to the use of patents and other IPR-related means for protecting the firm's innovative position. A possible explanation here is that patenting mostly refers to products that can be imitated by rival firms; in contrast, process innovation, which usually reflects tacit knowledge, is more difficult to be imitated and hence there is less need to be protected by a patent. Process innovation is also more difficult to be patented.

"Innovation History": *As with the case of product innovation, the set of variables reflecting a firm's "innovation history" is clearly the most important in explaining variation in process innovation.* Specifically, we find that a firm that has engaged in "extramural R&D" is about twice as likely to report process innovation as a result from its participation in the FP project. Similarly, we find strong positive coefficients for the "introduction of process innovation in the past three years", and for the "percentage of turnover from new/improved products introduced in the past three years". *It is therefore reasonable to argue that firms experienced in innovation activities, both process and product innovations, are more likely to report process innovation as an outcome of the FP project.* Interestingly, those firms that engage in innovation activities by *imitating* others are found less likely to report process innovation. The final significant coefficient in this set is the positive effect of "first participation in FP". This is consistent with the result obtained for product innovation; there is strong evidence that "newcomers" in FP programmes are more likely to engage in projects that ultimately prove successful.

"Basic project characteristics": The only significant coefficient in this set is the strong positive effect of "FP6 vs. FP5". It suggests that FP6 projects compared to those of FP5 are more likely to result in process innovation. This may be taken as evidence of improvement through time in the set up and management, and perhaps the "quality" of participants in FP programmes.

"EU rules": In contrast to product innovation, no significant coefficients were found for this set of effects.

"Nature of the project": The next three significant coefficients relate to the nature of the project. More specifically, projects "building on past R&D activities" and that are characterized as "new area" and "complex" are more likely to result in process innovation. Recall that with respect to product innovation we have found that "risky" projects are more successful whereas "new area" projects are less likely to be successful. Testing for possible inverted-U effects between project characteristics such as "risky", "new area", and "complex" and process innovation reveals no such relationship.

"Project Management effects": We have noted with respect to product innovation that we have found no relationship with any of the variables reflecting project management. As far as process innovation is concerned, our results show only one significant effect, and this is counterintuitive: "intuition in team-learning", that is, the extent to which project team-members offer new ideas, are capable of combining and synthesizing new ideas and can improvise, is negatively associated with process innovation.

"Commercialization-related effects": The only significant coefficient found is "Exploitation was made through collaboration". This dummy variable indicates whether the output of the project has been "exploited" by means of collaboration or not. The significant positive effect found suggests that exploitation is seven times more likely to take place through collaboration than without.

"Nature of research results": No significant effects were found in this final set of explanatory variables.

TECHNICAL KNOWLEDGE

Technical knowledge is the third dimension of project success examined in this study. It represents an intangible output of an FP project, one that is indirect in the sense that its immediate consequence is not directly manifested in the market place. Nevertheless, such intangible knowledge can be very significant as it contributes to the participating firms' capacity for *future* innovation. We seek the antecedents of technical knowledge on the same sets of factors used in product and process innovations. For obvious reasons, this time we do not model the effects of commercialization-related variables and of factors concerning the nature of research results.

"Firm basic characteristics", "innovation history", and "project basic characteristics" do not contribute significantly in technical knowledge creation as a project output. The remaining classes of effects contribute significantly, the most important being "firm resources and capabilities" and the "nature of the project".

"Market effects": In contrast to the cases of product and process innovation, we find a significant coefficient from the market effects set on technical knowledge. "Dynamism" in customer preferences has a positive effect in knowledge creation: volatility in customer preferences seemingly induces the development of new technological knowledge.

"Firm resources and capabilities": "Firms' resources and capabilities" as a set accounts for a relatively large proportion of explained variance (together with the "project nature" set). However, of the individual coefficients only "legal means as a means for innovation protection" is found positive and significant.

"Nature of the project": Together with "firm resources & capabilities" this set of explanatory variables accounts for the largest part of the variability of technical knowledge. We find a number of statistically significant coefficients. IDEA, a dummy variable indicating whether the project idea has been generated by *industrial* partners was found positive. This is in line with the previous result of a positive effect for FRACTION. Active involvement from the part of industry (in terms of numbers of partners in the consortium, and idea generation) positively influences knowledge creation. Moreover, projects "building on past R&D activities", having clear "commercial objectives", and characterized as "risky" are more likely to result in knowledge creation.

As before, we have examined more closely the effects of "risky", "new area" and "complex" to test the possibility of an inverted U-shaped relationship between these variables and technical knowledge creation. We find that for all but excessively high levels of risk, knowledge creation strengthens as project risk increases. In other words, knowledge performance is increasing until a certain level beyond which excessive degrees of risk are associated with worsening technical knowledge creation.

"Project Management effects": The coefficient of "clear project objectives" is found negative and significant. New knowledge creation is a complex process of exploration and discovery, where clear objectives set out from the beginning do not always prove valid or productive. Another significant coefficient in this set of explanatory variables concerns the positive effect on knowledge creation of "cohesion and trust" and "learning" within the project team.

Table 5.1 summarizes the econometric results before turning to their discussion in the next Section. The first three columns summarize the results for enterprises that were discussed above. For completeness, the last two columns summarize the obtained results for ROs.

Table 5.1: Summary of Econometric Results

Ind. Variables	ENTREPRISES			RESEARCH ORGANIZATIONS	
	Product	Process	Technical Knowledge	Product	Process
MARKET-RELATED					
Market environment: dynamism in customer preferences			+		
Emerging prospective field				-	-
FIRM-RELATED					
"Basic"					
Size class		+			
EU(27)				+	
"Firm's resources and capabilities"					
Capacity for "speed"		-			
Integration capability		+			
Innovation protection: legal means		-	+		
Innovation protection: "complex" technology	+				
"Firm's innovation history"					
Intramural R&D in the past 3 years	+				
Extramural R&D in the past 3 years	+	+			
Development of new or improved goods and services introduced in the past 3 years: (ROs sample only)					+
Creation of spin-off introduced in the past 3 years: (ROs sample only)					+
Product Innov (New-To-The-Market) introduced in the past 3 years: Industry / Patents introduced in the past 3 years: (ROs sample only)					-
Product Innov (New-To-The–Firm) introduced in the past 3 years: Industry / IPR introduced in the past 3 years: (ROs sample only)		-		-	
New Process Innovation introduced in the past 3 years: Industry / Award licenses to firms introduced in the past 3 years: (ROs sample only)		+			
Innovation performance (% turnover from new/improved products)		+			
First participation in FP? (yes/no)	+	+			
PROJECT-RELATED					
"Basic"					
FP – FP6 (vs.FP5)		+			
Proj_type					
Fraction – % of partners from industry			+		
"Eu rules"					
Practices in line with EU rules					+
EU rules' impact on: partner selection/negotiations	+		+		
"Nature" of the project					
IDEA – The project's idea comes from industrial partners (yes/no)			+		
PAST-RD – The project builds on past R&D activities (yes/no)		+	+		
Project objectives: commercial	+		+		
Project objectives: funding & reduce risk					+
Project objectives: "technological"				+	+
Project objectives: "networking"			-		
Nature of project: "risky"	+		+		
Nature of project: "new area"	-	+			-
Nature of project: "complex"		+			
Role – Respondent is manager/ or user/ or technology producer (yes/no)	+	+			

	ENTREPRISES			RESEARCH ORGANIZATIONS	
Ind. Variables	Product	Process	Technical Knowledge	Product	Process
"Project management"					
# of partners having worked with				+	
# of partners having not worked with				-	
Clear project objectives			-		+
Communication (within team)					-
Cohesion/Trust			+		
Learning within team: Intuition		-			
Learning within team: Interpretation			+		+
Learning within team: Integration					
COMMERCIALIZATION-RELATED					
EXPL_COLLAB – Exploitation was made through collaboration (yes/no)		+			
Time to market (months)					
Problems in commercialization: no plan/no intention	-				
Problems in commercialization: IPR issues	+			+	
Problems in commercialization: technology-related				-	
Problems in commercialization: consortium-related					-
"Nature" of research result					
"Nature" of research result: inimitable					+
"Nature" of research result: dynamic	-				
"Nature" of research result: "distance" from key technological area	-				

DISCUSSION AND CONCLUSIONS FROM THE EMPIRICAL ANALYSIS

We hypothesized that *market conditions*, specifically the intensity of competition and velocity of customer preferences, and the stage of the life-cycle of the relevant market at the time the project would be significantly related to project success. We find limited support for these hypotheses. A plausible explanation is that the very nature of the projects undertaken in the Framework Programme is of the "technology-push" variety rather than "technology-pull". In other words, it may be that the typical project is driven by a promising emerging technology, usually in its very early stage of development, and for which there is no clear market opportunity for exploiting it, at least in the short to medium term. As such, the partners are driven by a motive to explore rather than exploit a technology, which presumably is not mature enough for prospective commercialization. In such circumstances market conditions may be largely "irrelevant".

With respect to *basic firm characteristics*, particularly in regards to age and size of the responding organization, we do find a significant and positive coefficient for firm size with respect to process innovation. The result may indicate that larger firms are more inclined to pursue process innovation, presumably as they have more pressing needs to optimize their large-scale productive operations.

We hypothesized that the extent to which a firm is endowed with innovation-related capabilities will be positively associated with the likelihood of reporting project success. Specifically, we hypothesized that capabilities connected with marketing, the ability to develop and introduce new products speedily, the capacity to integrate internal and external technological developments to the firm activities, and the firm's ability to protect its innovative position (through legal or competitive means, or by the very complexity of its technology) will positively influence the likelihood that the project does indeed result in success. We have not found statistically significant support for this hypothesis.

Regarding the coefficient of legal means of innovation protection, we find a negative coefficient with respect to process innovation and a positive one with respect to technical knowledge. The negative effect is perhaps explained by recognizing that process innovation as highly idiosyncratic and tacit to the firm does not need protection through legal means. In contrast, the positive coefficient is in line with expectations: firms having the resources and experience to protect their innovations through patents and other IPR-related legal means have the motive to pursue the development of technical knowledge, which they can subsequently protect from possible imitation in the hope they can develop it into a concrete product or process innovation. Finally, we find a significant positive coefficient for the effect of the capability to protect innovation through complex technology on product innovation. Being able to keep qualified people in-house and developing complex technologies that competitors find it difficult to imitate implies that the firm has valuable technological capabilities that would allow it to pick promising R&D projects to participate and contribute substantively towards their success.

We also hypothesized that a firm's experience with R&D and innovation-related activities (*innovation history*) will be positively associated to project success. We find support for this hypothesis. First, we observe that experience in both intramural and extramural R&D positively affects product innovation. Extramural R&D also positively influences process innovation. Past innovation performance, as manifested in the percentage of turnover attributed to new products introduced in "the past three years" also has a positive effect on *process* innovation (a positive effect on product innovation would be more likely, however). In addition, we observe that firms that have a history of imitation (i.e., introduction of new-to-the-firm products, as opposed to new-to-the-market innovations) are *less* likely to report process innovation. This implies that a "history" of imitation in fact inhibits the likelihood for project success.

A rather intriguing finding pertains to the positive effect of first-time participation in FP projects on both product and process innovation. One would be tempted to consider this to imply that "newcomers" are more motivated to drive FP projects to success. Whether the indirect implication that "getting too comfortable" with FP funding inversely affects the chances of project success is reasonable to consider as an empirical question that needs to be balanced against the positive effects of past experience reported herein.

Regarding the effects of *EU rules*, we argued that their principal value is to allow the efficient and effective management and monitoring of a vast portfolio of projects by the EU authorities. At the level of the individual project, their value is to create an administrative platform, within which internal activities are developed, implemented, and monitored. These rules serve as the official mechanisms by which the project manager is made accountable to the sponsor. Accordingly, the positive coefficients found with respect to EU rules' impact on partner selection and negotiation on product innovation and on technical knowledge suggests that those partners that are comfortable with those kinds of rules are able to select the best possible partners, hence increasing the odds of success.

The *nature of the project* appears to be a very important determinant of project success. First, projects that are driven by commercial objectives from the outset are found more likely to result in product innovation and to lead to technical knowledge creation. In contrast, projects aiming at networking seem less successful in terms of generating new knowledge. The nature of a project, in terms of being risky, exploring a new technological area, or being scientifically complex, influences project success in important ways. First, the degree of risk affects positively both product innovation and knowledge creation, but in both cases the degree of project risk is exhibiting an inverse U-shaped relationship to the dependent variables: excessive risk appears to lead to diminishing returns as regards the likelihood for product innovation and knowledge creation.

Taken as a whole, our results provide support to the notion that the nature of a project affects, to an important extent, its subsequent success. We obtain strong evidence that projects that are commercially driven, risky, complex, and in new areas (for process innovation) tend to be more successful. Projects that build on past R&D activities are more likely to result in process innovation and to technical knowledge creation.

In contrast, the *management aspects of project implementation* appear to be less decisive to project success. This is somewhat puzzling and is very much moderated in the next Section by our qualitative analysis results. More specifically, clear and agreed upon objectives are found to have a negative impact on technical knowledge. This may suggest that clear objectives from the very beginning of a project could leave little room for creative exploration and experimentation, thus limiting opportunities for novel results. In contrast we estimate positive effects for cohesion and trust and interpretative learning on technical knowledge creation.

Limited support was also found for the effect of aspects of the commercialization process on project success, including issues of intellectual property protection. Similarly for *basic project characteristics*.

Finally, in relation to *attributes of the technology* resulting from a project, we find that the extent to which the technology resulting from a project is expected to have a relatively short life cycle and the extent to which it is distant (or unrelated) to the firm's existing stock of competencies decreases the likelihood of process innovation.

5.2 Qualitative Analysis (Case Studies)

5.2.1 PROJECT-LEVEL CHARACTERISTICS FOR RESEARCH SUCCESS AND COMMERCIAL EXPLOITATION

MAIN MANAGERIAL ACTIVITIES DURING PROJECT *PLANNING AND SET UP*

The case studies could distinguish between three types of participants. *Ad-hoc project participants* are organizations where the strategic role of the EU funded RTD projects was rather insignificant. *Focused project exploiters* evaluate carefully opportunities in Framework Programmes and are characterized by a strong reputation in their technology field. Third, *coordinators* quite naturally show a strong strategic alignment of their activities with the core subject of the project. They initiate a project idea, formulate a coherent proposal outline, and identify and contact appropriate partners with the objective of "setting a research agenda", "exploiting a new technology field" or "bringing a science-based innovation to the market".

Data from interviews with both coordinators and non-coordinators indicate the existence of two related phenomena that could be labelled *coordinator power* and *coordinator strength*. *Coordinator power* refers to the opportunity to shape and implement projects with high degree of control and ownership. *Coordinator strength* refers to the extent to which the coordinator is able to mobilize resources in order to bring the project to success in spite of various difficulties that might arise. Both phenomena seem to exert a positive influence on the innovation output of the projects, irrespective of type of innovation or type of organization.

It is difficult to relate innovation impact to the three groups of *ad-hoc participants*, *focused project exploiters*, and *project coordinators*. There were examples of successful as well as failed innovation in all cases. The distinguishing factor seems to be the strategic criticality of the RTD project. For the first group of companies it is low, for the second and third it is high.

Interviewed coordinators strongly emphasized the importance of the project planning and set up, so as to ensure a strong team committed to the common goals of the project. In spite of this fact, at the end of projects, almost all interviewees referred to some partners that were perceived as not having contributed relevantly and "seemed to have come along by accident". Successful projects shared a positive assessment of the capabilities of the coordinator both as R&D performer and as administrator. Each of these capabilities thus seems necessary but not sufficient for success, as there were cases where even such 'well-managed' projects failed at the level of innovation outcomes, due to e.g., insufficiency of the R&D results, rights conflicts between partners beyond the control of the coordinator or the project frameworks, or changing market conditions rendering project outcomes obsolete.

IMPLEMENTATION

During the implementation of the RTD projects, the importance of project management can not be underestimated. It refers to the continuous support and follow-up on the part of the coordinator with respect to the scientific and administrative obligations contracted between the project consortium and the EU. Particularly important factors, in a cross section of all case studies were immediate follow up on delays, pressure on partners not delivering, decisive exclusion of non-responding or dormant partners and efficient reallocation of resources, consistent and well anticipated preparation of all meetings and interactions, and operating with internal project quality managers with an exclusive role of monitoring quality and progress. A perceived problem is the balancing act between performing R&D and simultaneously catering to the management obligations. The latter are not always a top priority, let alone a core competence of an R&D performer coordinator. Hence, project management was many times referred to as "weak" by the non coordinator participants, leading to delays jeopardizing the intended return from the project.

PROJECT DISSEMINATION, EVALUATION AND CLOSURE

Dissemination is seen with mixed feelings among the interviewees; from "a core activity" (research organizations) or "very important for image building" (among larger companies) or still "an opportunity to make ourselves known" (among SMEs), to "an activity without substance" or "a half-hearted and insufficient effort to reach a market" (firms irrespective of size). In parallel, very little information came out regarding evaluation and closure procedures. If at all referred to, interviewees declared that there is no real evaluation, no such thing as a formalized post-project evaluation to recount the pros and cons of the project.

Experience also varies widely with what actually happens after the project ends. Some partners decide to couple for exploiting some of the results further. In other cases, partners seem to roll the ball between them, expecting that the other party will take the next step towards some kind of follow on of the project efforts. In other cases still, the outcome of a project is exploited by one partner together with some other organization who was not part of the initial project (Box 5.1). Hence, as it seems, one can indeed as well talk about a 'fuzzy back-end' of the EU RTD projects, as of the more established 'fuzzy

Box 5.1: Spinning Out Innovation through Extra-Consortium Collaboration of an SME

One way of pursuing the results of projects consisted of some companies bring knowledge, prototypes or other outcomes into a process of commercial development together with a relevant and reliable partner that, however, was not part of the consortium. Seen a little bit as a 'failure' from the perspective of the project consortium, e.g., the other partners were not interested or competent enough to take the step towards commercialisation, it could in fact be an even greater success due to a dissemination of the results outside the consortium.

In this SME of 70 people, characterized by a serial participation in EU-funded RTD projects, the internal project manager of an FP6 CRAFT project saw the opportunity and felt the need to pursue the results of the project despite the weak interest of the other partners. While those seemed satisfied with the "important new knowledge gained", the pressure in our SME of "getting something more than usual" out of the project was great. Hence, in consensus with the other partners, the company decided to launch a full blown product development of an application building on the results the project, albeit much simplified with a third party and in a third country. At the moment of the study, the set up of this collaboration was progressing. At is clear that in such cases, the project would have lost momentum and most probably never been introduced on the market wasn't it for these partners that stuck to their goal of producing an innovation on the market, even if it meant to capitalize only partly on the project and build up another external collaboration.

front-end' of R&D[20]. Only that the back-end fuzz is about confusion concerning the exploitation of the results and not about a breeding ground for creativity as in the front-end. In some instances, interviewees blamed the rules of the funding instruments for allowing for too much free interpretation about what a successful end of project phase means, and for allowing legal problems to surface too easily. The back-end fuzz is also the major reason behind the fact that even well-managed projects might 'stumble' towards the end and therefore result in no significant innovation impact (Box 5.2).

The solution for many company interviewees would be to assist the research institutions in creating spin-offs for exploiting project findings. On the other hand, research organizations roll the ball back to the companies, saying that exploitation is not their role. Hence, there is an apparent gap between an inability of companies to commercialise the project output due to a lack of full R&D chain control, and an incapacity or even strategic misalignment from the side of the research organizations to enter into spin-off or spin-out activities. A potentially relevant bridge over this gap (Box 5.5) might be the SME.

ENABLING AND INHIBITING FACTORS FOR PROJECT SUCCESS

Regarding project level enablers for effectively running the project and achieving the technical and commercial outcomes, the case analysis informed a number of issues, including:

- Strong customer involvement;
- Complementarity among partners;
- Core (or driving) partners: This refers to what many interviewees characterised as the backbone or the catalysts of the RTD projects. Successful exploitation of results often materialize from the continued individual or collaborative action between such core partners;

Inhibitors: Factors Identified in Projects Blocking Product or Process Innovation

To a large extent the inhibiting factors are the antipodes to the enablers. There are, however, a few stand-alone issues identified from the case data. In several of the less successful cases, managers emphasized the *lack of market focus and market understanding* as a dominant failure factor. Compared to research organizations,

Box 5.2: The Impact-Stopping Stumbling Block

We encountered cases where, in spite of clear goals, efficient and smooth communication and project management processes, different 'Stumbling Blocks', fatal for innovation impact, intervened towards the very end of the project.

Legal stumbling blocks refer to last minute conflicts about exploitation rights, where the rules of the instrument and the agreed procedures prove insufficient when, at the bottom line, the question is about who will make a profit from the project output.

Market related stumbling blocks refer to changing needs on the demand side that were not understood or anticipated during the unfolding of the project. In one case, in spite of a clear goal for commercialisation from the very beginning (under the responsibility of a large-sized producer partner) and satisfactory technology and knowledge results, including product prototype, the product remained on the shelf due to a market collapse, which, in turn, had a regulatory underpinning (the technology field was car emissions control).

User system stumbling blocks refer to a situation where a product innovation fails because when commercialisation is engaged, partners realize that other supporting technology or system components needed as complements for the use of the innovation produced are not present in the targeted market. Development of the wider technology system might have been slower than anticipated during the project, process technology might not yet be reliable and economically viable for sustaining larger scale production, or the product is targeted to a market where user conditions are different for, e.g., regulatory or competitive reasons.

[20] Notion coined by Smith, P.G. & Reinertsen, D.G. (1991), *Developing Products in Half the Time.* New York: Van Nostrand Reinhold. See also, e.g., Susan E. Reid, S.E. & de Brentani, U. (2004), "The Fuzzy Front End of New Product Development for Discontinuous Innovations: A Theoretical Model", *Journal of Product Innovation Management,* 21 (3), 170–184.

Box 5.3: The Power of Mission, Strategy and Goals in a SME

This seven-people company, dedicated to developing advanced bio-economy and carbon recycling technologies, has carved out a successful niche and presents a successful process innovation from an FP5 EESD project. Building on its mission "Science to Achieve Results", bridging the gap between research and innovation is actually an integral part of this company's mission, and a main explanatory factor behind its strong innovation focus within the FP-funded projects it participates in. Strategically speaking, the company selects projects only if they fit 100% with its mission and technology development directions, and systematically integrates customers in the projects.

Positioned in a high growth but still immature market, the strategy in terms of 'where to go' –sustainable lead in environmental technologies- and in terms of 'how to get there' -be an innovative solutions provider- reinforce the technology-based innovation focus maintained in project activities. As the entrepreneurs summarized the approach "On our narrow road, we want to be the best, the most concentrated and focused to collect and exploit all the available knowledge in the field".

The project subject of the case study, for which this SME was also coordinator, concerned a clean energy process and enabled to exploit important knowledge that had been built up in the partner organizations. The outcome was a full-blown industrial application of the clean process, a scale up of the technology and initiation of a licensing process.

firm interviewees strongly emphasized the need for enhancing the exploitation part in the FP-funded RTD projects. This enhanced exploitation focus did not necessarily mean to emphasize commercialisation of a new product or process coming directly out of the project. Rather it meant to, firstly, indeed be able to follow through and fulfil all those tests and applications that are contracted in the projects without making time and budget concessions, and, secondly, to integrate more of market building activities in the projects. An R&D Director, in a large-sized company with a long and successful track record of innovation, suggested that if indeed commercialisation of the outcomes and 'innovation impact' is the objective in a future foreseeable from the time perspective of the projects, then market scanning, market planning and market build-up activities must be fully recognized and integrated in parallel to the R&D process.

Project Management and the EU Rules

The EU rules certainly impose a specific structure on all analysed project cases. The qualitative findings related to project management and the EU rules were:

- The rules are generally seen as complex and not easily integrated with "normal" project management processes;
- Companies mention that the rules are more adapted to the situation of a research organization;
- There is an important learning effect in that after one or two "rounds" the conformance to the rules is much easier;
- Rules are perceived as changing frequently without understanding the rationale for these changes. In this case the learning effect mentioned above is lost;
- Consultants who offer assistance in proposal writing and project management are met with suspicion;
- Organizations that seek to justify project failures might use the rules as an explanatory factor;
- Rules are perceived as weak when it comes to support rights and protection issues.

It was also more generally perceived that the EU rules put the projects in a kind of straight jacket that in some cases acts unfavourably with respect to achieving the most relevant and significant results, especially from an innovation perspective. This problem often related to a perceived difficulty of adapting the project to changing circumstances beyond the control or reach of the original set up and rationale for the project.

5.2.2 FIRM-LEVEL CHARACTERISTICS FOR RESEARCH SUCCESS AND COMMERCIAL EXPLOITATION

Planning & Set-up: Factors Related to Mission, Strategy and Goals

Successful projects were strongly characterized by *clarity of mission* for R&D in general, *strategic alignment* of the project in particular (although not necessarily high strategic importance) and *explicit goals* of what the studied organizations *expected* from these projects.

In terms of mission, we find firms, especially SMEs, that have developed and adhere to innovation-related missions. Most SMEs reported generally a strong strategic alignment with the project and explicit goals related to innovation outputs (Box 5.3). In larger companies, mission was rarely referred to in the context of the EU FP projects. Generally speaking, and because of the often more marginal role of the projects, larger companies often reported weaker strategic alignment and less explicit goals. If goals were clear, they would typically be limited to the internal dimension of the projects, e.g., developing new knowledge or building partnerships. The role of missions in Research Organizations is much less apparent. Strength of leadership was a distinguishing factor between ROs, although it is very difficult to relate it to innovation impact. ROs with strong leadership indeed produced some successful projects in our sample, but so did ROs where this dimension was less apparent. What stood out was that some ROs operate with close-to-firm type of leadership with strong mission statements, clear strategies, tangible and measurable goals, participative management, and gave importance to marketing and image building activities beyond the purely scientific dimension.

Implementation: Factors Related to Age, Size, and Resource Base

Analysts have typically grouped together the factors age, size and resource base, the conceptual correlation being that older means larger, which means richer in resources relevant for conducting R&D. However, at least when it comes to companies, there was no perfect fit identified between this equation and the success of the EU-funded RTD projects. In particular, this concerns the size dimension.

Small-sized firms (<50 employees) often remain too focused on a core technology and too centred on research (compared to on development) in order to be able to sustain market-driven development and commercialisation in their own right. Medium-sized firms (between 50 and 500 employees) seemed to be best positioned to reap innovation benefits from the projects. On the one hand, these organizations can have a critical mass in themselves for conducting both Research and Development in a focused area. On the other, they are often either established players in their industry or quickly growing ones that have overcome the threshold of successful commercialisation of a first generation of innovation-based products or process technology. Generally speaking, these companies also have explicit strategy and goals for innovation; here are found most of the "focused project exploiters". Hence, these firms often take a leading role in projects, and are most frequently found as coordinators, in parallel with the Research Organizations.

When it comes to large-sized firms, it seems that our case study sample presents the least successful project participation from the point of view of product or process innovation. For reasons already mentioned, such as weaker strategic alignment, larger distance from core activity, objective of exploration and not exploitation, or lack of overview and internalised control, large firms either scope intangible outcomes or reported plain failure of the projects. The intangible outcomes might concern learning / knowledge / networking / pre-competitive control outcomes. Project failures seemed then to relate to a combination of lack of strategy for the EU-funded projects, poor internal integration, and poor engagement and commitment to the management procedures in the consortium (Box 5.4).

There were of course successful innovation cases among large case study companies too. When a large multinational R&D driven organization mobilizes its resources and capabilities and engages whole-

Box 5.4: Problems Accumulated: The Creeping Effect of a Variety of Failure Factors

In this case of a large internationalised and divisionalized corporation, the FP5 GROWTH project under study was considered as unsuccessful both in terms of innovation and knowledge outcomes. Although both industry conditions (a defined institutional regulation framework) and organizational resources and competencies seemed to play in favour of the project, a series of factors led to this disappointing outcome. Despite its size and innovation-based history, the company lacked policy for integrating EU projects in its operations. Moreover, the project provoked internal conflicts as the company had several roles in it, including R&D performer, producer of technology and service provider. These unclear roles led to conflicts about priorities and hampered the advancement of the project. The goals were also somewhat contradictory and lacked any reference to producing an innovation output.

Concerning the inter-partner collaboration, this quickly turned out difficult as the consortium involved players that are direct competitors in other areas than that of the project. This led to a context characterized by weak trust and insufficient sharing of information. The project management structure and the administrative follow up was also weak. There were not enough meetings and those that were held were irregular and inefficient in terms of advancing the technical issues of the project. As a result of the many difficulties the participation in this particular project gave no added value to the company. The problems were fundamentally internal and of collaborative nature, the EU rules cannot be blamed, except for the issue of too strong intervention in terms of selection of partners.

heartedly in an EU-funded RTD project, the result has a good chance of becoming a success.

The issue of *building up a broader innovation culture* came out as an important underpinning factor behind product and process innovation success in some of the case studies. It can be characterised as a set of shared values, beliefs and behaviour that guide the way that activities and process should function in order to gain competitive advantage from innovation at a moment 't', and that are reinforced and readapted dynamically in order to provide this advantage over time (moment t+1, t+2, …). Several of the older companies indeed showed a long path of innovation-based growth and development.

Social capital refers to "the goodwill that is engendered by the fabric of social relations and that can be mobilized to facilitate action"[21]. The importance of social capital for innovation performance has been documented in many instances already[22].

In many of the case studies, the reputation of coordinators and/or partners as reliable, knowledgeable, cooperative and efficient managers and/or R&D partners was frequently advanced as a factor influencing positively project success. Either self-estimated by the interviewees, or attributed to other partners, this goodwill, once it has been achieved and as long as it can be sustained, provides a number of advantages to its possessors that also spill over to the collaborating partners and the project itself. These advantages include high probability of being granted relevant projects over time, strong bargaining power vis-à-vis the EU, relative ease in attracting excellent partners to new consortia, relative ease of making partners adhere and align to project objectives and management structures, and relatively strong dissemination impact of results due to the presence and the weight of a prestigious-built-on-merit organization.

With very few exceptions, the organizations emphasized access to knowledge as a central reason for joining projects in the first place. Most of them were also quite satisfied with the knowledge output from the projects. However, it was not really possible to extract and conceptualise a learning capability adapted to the context of the EU-funded RTD projects. Good practice include mainstream knowledge management activities such as rotation of personnel between the project and the normal duties in order to maximize the learning effect, setting and deploying explicit objectives of extracting knowledge from the projects, and activating resources and processes of technology scanning and watch in these projects as well. Rather, when learning from the

[21] Adler, P.S. & Kwon, S-W. (2002), "Social Capital: Prospects for a New Concept", *Academy of Management Review*, 27: 17-40, quote p. 17.

[22] E.g., Haragon, A. & Sutton, R.I (1997), "Technology Brokering and Innovation in a Product Development Firm", *Adm. Science Quarterly,* 42: 716-749; Tsai, W. & Ghoshal, S. (1998), "Social Capital and Value Creation: The Role of Intrafirm Networks", *Academy of Management Journal.,* 41: 464-478.

projects was discussed, many interviewees referred to the importance of learning how to participate in the FP projects and adapt to the different rules and regulations. Although not directly related to the development of technical knowledge for enhancing innovation, it might have an indirect effect, as those organizations in the case sample that reported a greater satisfaction with the EU framework were also more successful innovators.

DISSEMINATION, EVALUATION AND CLOSURE: FIRM FACTORS RELATED TO COMMERCIALISATION

As already discussed, the extent to which commercialisation is an issue and goal within the FP RTD projects, from an institutional viewpoint, seems to be seriously questioned in the studied organizations. An intriguing finding from the case studies is that the organizations that are best positioned to commercialise an innovation, i.e., large firms with a full blown marketing and sales organization, were much less inclined to do so compared to a number of highly committed-to-commercialization SMEs (Box 5.5). Hence, the benefit that the projects could have from the participation of big companies is not fully tapped into and the commercialisation process can turn out to be somewhat sub-optimised and progress (or not) with resources that are not at the height of the innovation to be commercialised. It was also striking that few interviewees referred to combining the outcome of the EU project with some other institutional, national or regional incentive for commercialisation, such as seed

Box 5.5: Highly Committed-to-Commercialisation SMEs

Four SMEs among the case studies stood out in terms of having achieved a significant commercialisation output from the investigated projects.

The first company, active in the IT and Management Consulting business, succeeded in commercialising the output - a trading platform for the banking sector- from an FP6 IST STREP through the creation of a spin-off company. Besides being coordinator of the project, thus able to set up and structure the project to best fit its objectives, the role of the company in the project was that of developing specific features of the product. The project level factor identified as decisive for commercialisation success was that all partners had interest in seeing commercialisation take place, but that simultaneously these interests were not conflicting due to different focus on product, process and supporting services.

The second SME was also coordinator, here for an FP5 IST CSC project aiming at developing technologies for the integrated navigation in the framework of the Galileo project. The technical results of the project have been used for commercialising a new product where the SME is the main vehicle for commercialization. As project level factor we again identified the power on the part of the coordinator for orienting the project towards a certainly common, but also self-initiated and self-sustained goal of commercialisation. This was reflected in the management factor identified as a strong project management template that was strictly followed throughout the project. The company itself showed proof of very strong integration capability activating all internal resources to support the commercialisation goal.

The third company among these four is an engineering company, in the clean technology business, dedicated to needs-driven R&D. The project analysed was an FP5 EESD project aimed at developing a specific reduce and reuse technology for fuel combustion. Also here the SME studied was coordinator and as the previous companies this was a factor that strongly supported the commercialisation process. The vehicle for commercialisation in this case was licensing of the developed technology to process industry. Already during the project, an industry scale-up of the use of the technology was achieved. The key project success factor was the contribution by one of the partners (user) of a real case for testing the technology in the shape of a pilot production line. In terms of management factors, strong social capital built up over the years, based both on technical and managerial excellence was an important factor behind the successful process towards commercialisation.

The fourth company operating in the sector of industrial lubricants joined an FP5 IST ACM project that aimed at using non-contact technologies (RFID) for following up and managing industrial processes. The company succeeded in transforming the knowledge gained from the project into an innovative product line of lubrication devises that are currently in a pilot commercialisation phase. The vehicle for commercialisation was hence the company's own R&D process. The studied SME was not a coordinator in this project, but the ACM project setup allows for each participant organization to develop a stand-alone agenda for how to explore and exploit the technology area that is the common denominator of the projects. The goal of the SME was to develop a new product line using the technology, and strong integration and alignment was achieved to realize this goal.

or incubation money for start-ups or spin-offs. Many FP-funded projects seem to exist in quite some isolation and are not always integrated in a bigger R&D picture.

5.2.3 INDUSTRY AND MARKET CHARACTERISTICS FOR RESEARCH SUCCESS AND COMMERCIAL EXPLOITATION

Case Studies have been clustered in four classes of organisations:

1. Enterprises operating in a monopolistic/oligopolistic market with high technology/ innovation intensity,
2. Enterprises operating in a monopolistic/oligopolistic market with low technology/ innovation intensity,
3. Enterprises operating in a competitive market with high technology/innovation intensity,
4. Enterprises operating in a competitive market with low technology/innovation intensity.

Enterprises in monopolistic/oligopolistic markets with high technology/innovation intensity

About one third of the case studies are in this class which encompasses enterprises in a wide range of sectors: from aerospace with satellite communications industries to optics with technical surface producers, from automotive safety to engineering of e-papers displays, from communication and information systems to manufacturing of aeronautical parts, from information and communication technologies to pharmaceutical, cosmetics and health products, from robotized automation systems to aero transportation management. With very few exceptions, the companies are large and typically produce non-standardised products.

These enterprises tend to be R&D-intensive with long experience with FP projects. The latter are perceived to decrease the cost of R&D, increase innovative opportunities, help monitor competitors and gain visibility. The long experience with EU funding of most these enterprises has created links between the projects in the different Framework Programmes (chains of FP projects). The few companies, especially the smaller ones that are not well experienced in FP projects initially use European projects as networking opportunities. Consistent and direct commercial exploitation is rare amongst these companies. The low rate of direct innovative successes is pronounced in projects where direct competitors participate (horizontal collaboration).

Enterprises in monopolistic/oligopolistic markets with low technology/innovation intensity

Included here are companies in geographically localised markets or in mature highly concentrated markets. They represent the smallest percentage of the analyzed cases: 17%. In general enterprises belong to sectors with markets rather conservative and saturated. They range from those involved in environment services in waste management to rail transportation solutions, from lubrication automation to energy plants production, from process industry of paper and pulp to direct energy production. FP-funded R&D projects have a minor role in the overall company strategy, due to the marginal relevance of innovation in these sectors in general. Small enterprises that do not have experience with EU funding participate if the project is very close to the core business. In some cases an overweighting of public and of European funding in the overall R&D investment strategy of the company can be observed. For most, FP projects have offered at least indirect gains such as networking opportunities and development of standards, creation of databases. Direct commercial exploitation is fairly unlikely, especially in projects with horizontal collaboration.

Enterprises in competitive markets with high technology/ innovation intensity

These enterprises serve markets such as satellite navigation solutions, consultancy in IT solutions in banking and commerce, robotics, software for industrial applications, quality and risk management services, advanced recycling technologies, laser technologies, IT consultancy, automation and robotics. They represent 29% of the analysed cases. Standardization of products and services is low and customization relies on R&D added value. Many enterprises in this category show a strong involvement in Framework Programmes and a strategic role of EU funds in R&D process. The FP R&D

funding is well integrated with the company research activity. FP projects are mainly carried out to make applied research and to exploit the innovative results coming from it. The opportunity of networking has a secondary role, especially for the largest firms. In many cases innovation and commercial output are concrete.

Enterprises in competitive markets with low technology/ innovation intensity

About a quarter of the cases are enterprises in competitive markets with low technology and innovation intensity. Examples of these sectors are chemistry for surface protection of industrial components, telecommunications through private phone switchboards, injection plastic moulding presses, glass solutions for indoors and outdoors areas, surface processing, design and building of machineries for the automotive sector, industrial plastic products, prefabricated structures. Medium to long product life cycles and high product standardization characterise of such sectors. Many of these organisations have a very close network of partners to collaborate in research activity. In the case of the small part of enterprises that base their activity on R&D and have long experience in FP projects, the European projects have become a structural instrument of financing the company development, technological development through networking, and acquiring qualified competences.

For the remaining enterprises of this class the FP projects funds are not part of an integrated research activity. For some, the EU-funded research is essentially the only type of research activity. For others with a structured research shaped by market needs, the EU projects represents only an occasional instrument not primary devoted to fund research activities. In this class of enterprises a great number of projects have been successful in terms of product/ process innovation, but a good part hasn't reached the commercial exploitation phases. Commercial exploitation occurred in cases more connected to the core activity of the company and those involving end-users.

5.3 Summary conclusions organisation, project, and market impacts on innovation

The empirical analysis provided very weak support for the proposition that market conditions strongly influence the various aspects of project success (product-process innovation, technical knowledge creation). A plausible explanation is that the very nature of the projects undertaken in the Framework Programme is of the "technology-push" variety rather than "technology-pull". In other words, it may be that the typical project is driven by a promising emerging technology, usually in its very early stage of development, and for which there is no clear market opportunity for exploiting it, at least in the short to medium term. As such, the partners are driven by a motive to explore rather than exploit a technology, which presumably is not mature enough for prospective commercialization. In such circumstances market conditions may be largely "irrelevant".[23]

Another plausible explanation is that the measures used to capture market conditions in the survey were specified at an aggregate level not allowing for expressing the differences between and across sectors and technological trajectories. The analysis of case studies, for instance, indicated differences in behaviour among enterprises in four types of markets. Companies operating in competitive markets with high technology/ innovation intensity tended to make better and more direct use of FP projects in their commercialization plans. Many of enterprises in this category show a strong involvement in Framework Programmes and a strategic role of EU funds in R&D process. The FP R&D funding is well integrated with the company research activity. FP projects are mainly carried out to make applied research and to exploit the innovative results coming from it. In contrast, FP projects seemed much less directly linked to innovation plans and competitiveness for enterprises in other types of sectors. The reasons

[23] Differences between sectors or broad thematic areas are expected, of course. For example, R&D projects in the IST programme are often considered to be closer to the market than, for instance, life sciences. Still, the variation within the IST programme is quite significant, with many projects looking at futuristic technologies or standards which are not directly applicable to the market.

varied by the type of competitive situation and type of technology in the sector. For enterprises in monopolistic/oligopolistic sectors with high technology/innovation intensity, examples of direct and consistent commercial exploitation of FP project results are fairly rare even though these companies tend to be well experienced with FP projects. Exploitation, when it happened, was in niche markets. For enterprises in monopolistic/oligopolistic sectors with low technology/innovation intensity FP-funded R&D projects seemingly have a minor role in the overall company strategy, largely due to the marginal relevance of innovation in these sectors. For most such companies FP projects have offered at least indirect gains such as networking opportunities and development of standards, creation of databases. Direct commercial exploitation is fairly unlikely. Finally, for enterprises in competitive sectors with low technology/innovation intensity, the answers vary. In the case of the small part of enterprises that base their activity on R&D and have long experience in FP projects the European projects have become a structural instrument of financing the company development, technological development through networking, acquiring qualified competences. For the remaining enterprises of this class the FP projects funds are not part of an integrated research activity.

The empirical analysis has also indicated a positive effect of firm size on process innovation, but not on product innovation or the production of technical knowledge from FP projects. This may indicate that larger firms are more inclined to pursue process innovation, presumably as they have more pressing needs to optimize their large-scale productive operations.

Case study analysis showed a more variegated picture. SMEs reported a generally strong strategic alignment with FP projects and explicit goals related to innovation outputs such as developing a prototype, developing a patentable technology, or developing a complementary technology that will enhance competitiveness. Medium-sized companies seem to have reaped the largest innovation benefits from FP project participation, as these organizations can achieve critical mass for R&D in a focused area. They are often either established players in their industry or quickly growing players that have overcome the threshold of successful commercialisation of a first generation of innovation-based products or process technology. Generally speaking, these companies have explicit strategy and goals for innovation. They often take a leading role in projects, and are most frequently found as coordinators, in parallel with Research Organizations. Small sized firms (<50 employees), on the other hand, often remain too focused on a core technology and too centred on research (compared to on development) in order to be able to sustain market-driven development and commercialisation in their own right.

It is noteworthy that the organizations presumably best positioned to commercialise an innovation, i.e., that large firms with a full blown marketing and sales organization, were much less inclined to do so compared to a number of highly committed-to-commercialization SMEs. In larger companies, mission was rarely referred to in the context of the EU FP projects. Because of the often more marginal role of FP projects, larger companies often reported weaker strategic alignment and less explicit goals. If goals were clear, they would typically be very focused and limited to project dimensions such as developing new knowledge, building partnerships, or exploring a new technology area. Only exceptionally interviewees in larger companies referred to the external dimension of market-related goals.

A rather intriguing finding of the empirical analysis pertains to the positive effect of first-time participation in FP projects on both product and process innovation. One would be tempted to attribute this to greater motivation of "newcomers". There is no reason to believe that they are systematically more capable to drive FP projects to success than repeat participants. Or, there may be a tentative link here with the size findings above: SMEs will on average tend to participate less, and many of them only once.

A strong empirical result is that prior experience of an organization with R&D, both intramural and extramural, positively and significantly affects the likelihood of obtaining product innovation from FP projects. Extramural R&D and past innovation experience also positively influence process innovation. Past innovation performance also has a positive effect on process innovation. On the contrary, firms that have a history of imitative strategy (i.e., introduction of new-to-the-firm products, as opposed to new-to-the-market innovations) are relatively less likely to report process innovation. Overall, the results concerning the “innovation history” of both firms and research organizations largely confirm the hypothesis of a positive association between prior innovation experience and project success.

Case analysis corroborated this result by showing that building up a broader innovation culture was an important underpinning factor behind product and process innovation success. Firms with an explicit R&D / innovation structure and model proved more successful in producing innovation results.

The nature of the project appears to be a very important determinant of project success. Strong empirical evidence was obtained that projects that are commercially driven, risky, complex, and new area (for process innovation) tend to be more successful. A project idea generated by industrial partners affects positively knowledge creation. Projects that build on past R&D activities are more likely to result in process innovation and technical knowledge creation.

Experience with innovation activity in terms of conducting both intramural and extramural R&D was a common characteristic of case study organizations. From there and onwards, successful projects were strongly characterized by clarity of mission for R&D in general, strategic alignment of the project, and explicit goals of what the participating organizations expected from the project.

Both the empirical and the qualitative analysis showed a strong relationship between explicit intension to commercialize from the outset of the R&D project and project success. Yet, the extent to which commercialization is an issue and explicit goal within the FP RTD projects, from an institutional viewpoint, seems to be seriously questioned by a significant number of the interviewed organizations.

Dissemination was seen with mixed feelings among the interviewees. Opinions about dissemination ranged from “a core activity” or “very important for image building” or still “an opportunity to make ourselves known”, to “an activity without substance” or “a half-hearted and insufficient effort to reach a market” (firms irrespective of size).

What happens after the research project ends varies widely. Some partners decide to ‘couple’ for exploiting further some of the results without necessarily informing the other partners. In other cases there is indecision about who will roll the ball next. Other times EU project ‘n’ generates the conditions for a proposal for EU project ‘n+1’, which, if leading to accumulated knowledge or a further exploitation of the results, can be seen as a positive outcome of a project. In other cases still, the outcome of a project is exploited by one partner together with some other organization that was not part of the initial project.

It is critical that before the project consortium splits up it draws out a plan for commercialising the outcome. Unfortunately, many projects end up in a kind of dead-end with respect to commercialization. The cases indicated a gap between an inability of companies to commercialise the project output due to a lack of full R&D chain control and an incapacity or even strategic misalignment from the side of the research organizations to enter into spin-off or spin-out activities. A potentially logical bridge over this gap would be the SME. But SMEs that had taken on this bridging role are weary of the risk involved. They call upon the larger companies to commit to the risk-sharing mechanism in the EU collaborative projects by providing access to specific internal resources, act as pilot market (i.e., customer) for the new product/process/service, or even support financially a spin-off activity. Many of the Research Organizations studies also have developed specific collaboration structures with SMEs. A critical issue that was also often mentioned as a party spoiler in commercialization was the unclear situation around intellectual property protection.

Case study interviewees emphasized the importance of management during the implementation of the

R&D projects. They referred to the continuous support and follow-up on the part of the coordinator with respect to the scientific and administrative obligations contracted between the project consortium and the EU.

Successful projects shared a positive assessment of the capabilities of the coordinator, both as an R&D performer and as an administrator. Each of these capabilities seem necessary but not sufficient for success, as there were cases where even such well-managed projects failed at the level of innovation outcomes, due to e.g., insufficiency of the R&D results, rights conflicts between partners beyond the control of the coordinator or the frameworks of the instruments, or changing market conditions rendering project outcomes obsolete.

Interviewees indicated a wide disparity of motives for participation which affect the likelihood of project success. Coordinators naturally show a strong strategic alignment of their activities with the core subject of the project. Non-coordinators vary widely in their motives to participate. Some vet the projects carefully, others join because they've known the partners from before, others join with no real intention to connect the project to their core activities. The ability of the coordinator to align interests is critical.

Empirical results were weak regarding the effect of innovation-related capabilities of individual organizations – e.g., ability to introduce new products speedily, legal means of innovation protection, integration capability – on the likelihood of product/process innovation and technical knowledge creation. The integration capability was found to have a positive effect on process innovation. Also, the ability to protect innovation through complex technology had a positive effect on product innovation.

Finally, the positive effect of EU rules on partner selection and negotiation were found to have on product innovation and on technical knowledge does not imply that these rules have a direct effect on project success. It does, however, suggest that the organizations most comfortable with those kinds of rules are able to select the best possible partners, hence increasing the odds of success.

6 **Commercial outputs** and additionality[24]

6.1 Introduction

In the following section we present some findings on the "additionality" of the FPs with respect to their impact on innovation. The question on additionality explores whether the project would have been done also or in a different way than without public funding. In other words by additionality we understand the difference between 'state-of-the-world' that would have occurred with and without the programme.

Additionality can be found in three different forms:

- Input additionality: To which extend does public support of private R&D lead to an increase in overall research expenditures by the funded companies?
- Output additionality: Does publicly-funded R&D change the amount and the quality of outcomes, outputs and impacts which would not have occurred in the absence of the funding?
- Behavioural additionality: covers the changes in behaviour in the participants of a programme (e.g., increased networking), also referring to changes in the way projects are carried out as a result of the subsidy (e.g., longer duration, with more ambitious goals, with greater number of partners, etc.).

Regarding input additionality, the analysis of the CIS data presented in Chapter 3 identified some input additionality in companies of smaller size. Small enterprises (i.e., fewer than 100 employees) experienced a strong and statistically significant increase in R&D intensity, while there is no such relation for the larger firms.

As the major thrust of this project was to identify the innovation impact, we especially looked into output additionality, namely into the question whether participants experienced an increase in innovative output as a result of their participation. The material in this Chapter is based on findings from the survey.

[24] This chapter is based on the work of Joanneum Research: Wolfgang Polt and Gerhard Streicher

6.2 Output Additionality

6.2.1 MEASURES OF OUTPUTS

The relevant survey question covered five different types of commercial output: new or improved products / production processes / services, implementation of field trials, and new or improved standards (plus other).

Not too surprisingly, products and production processes are most important for industry, with about half reporting "new or improved products", whereas services were most important for service organisations. For research organisations, the most important commercial output consists of standards (and services).

Table 6.1: Types of commercial outputs of the specific project, by type of organisation

	industry	research & education	services & consultancy	total
New or improved products	53%	31%	43%	50%
New or improved production processes	39%	23%	29%	36%
New or improved services	40%	54%	68%	48%
Implementation of field trials	45%	42%	42%	44%
New or improved standards	25%	58%	25%	26%

(multiple answers possible)

The vast majority of participants experienced some form of commercial output from their FP project, with only 15% admitting to the absence of commercial outputs. Roughly a fifth of the participants reported to have one, more than a quarter realized two types of commercial output, a small minority claimed all five types. This is an impressive outcome in terms of participants gaining commercial output for the type of pre-competitive, collaborative R&D programmes such as the FPs. While these figures cannot give an estimate of the magnitude of economic effects, they point to the fact that even if innovation is not among the prime targets of the FP, it might be in any case a substantial by-product.

Although the share of projects with commercial output is high, however, two caveats have to be considered when interpreting these figures: first, they cover very diverse types of "commercial output" (new or improved outputs as well as field trials and new or improved standards).[25] In a narrow sense, arguably only "new or improved products" and "new or improved services" would be considered as commercial outputs; but even roughly three quarters by this definition, of the projects qualify for some "commercial output". And secondly, the term "new or improved" covers a wide range of possibilities. In these two respects, the very favourable results in terms of commercial output have to be taken *cum grano salis*.

Compared to FP5 in FP6 projects are more likely to result in commercial outputs, especially new or improved products and processes. The relatively high level of new products and services is reported across different thematic areas in FP6, which new processes are more prominent in NMP, and services are a major outcome in IST. The differences between the reported outcomes between FP5 and FP6 should be considered with care though because the FP6 projects are often in the first stages of exploitation (or still have to enter that phase), which could imply that some level of 'optimistic' expectation is included in the responses, whereas most FP5 projects have finished for five years or longer leaving less possibility of interpretation of potential results.

When comparing commercial exploitation impacts between types of participants (Table 6.2), two observations stand out:

(i) Generally, "softer" impacts – competitiveness, risk sharing, abilities – are rated more significant than hard, "bottom-line" impacts (cost reduction, licence income, and creation

[25] The categories were chosen so broadly to ensure comparability with the questions in the CIS (Community Innovation Survey).

Figure 6.1: Commercial outputs of the specific project, by type of organisation

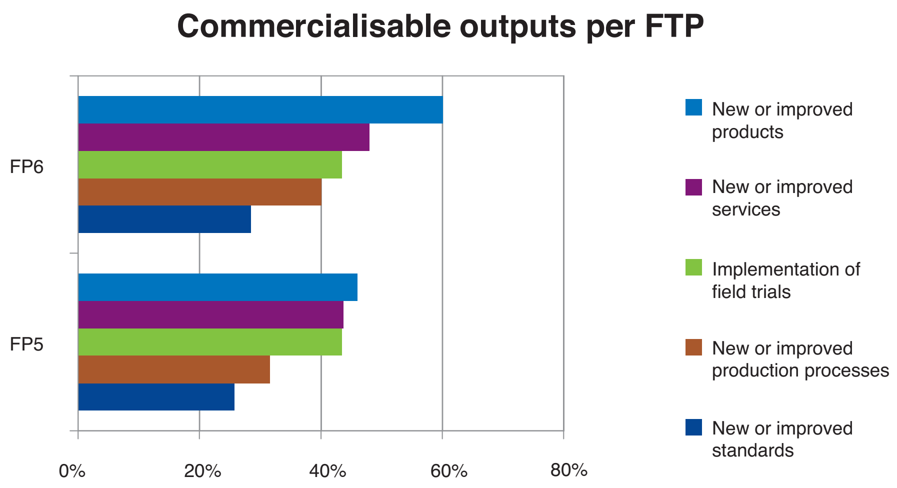
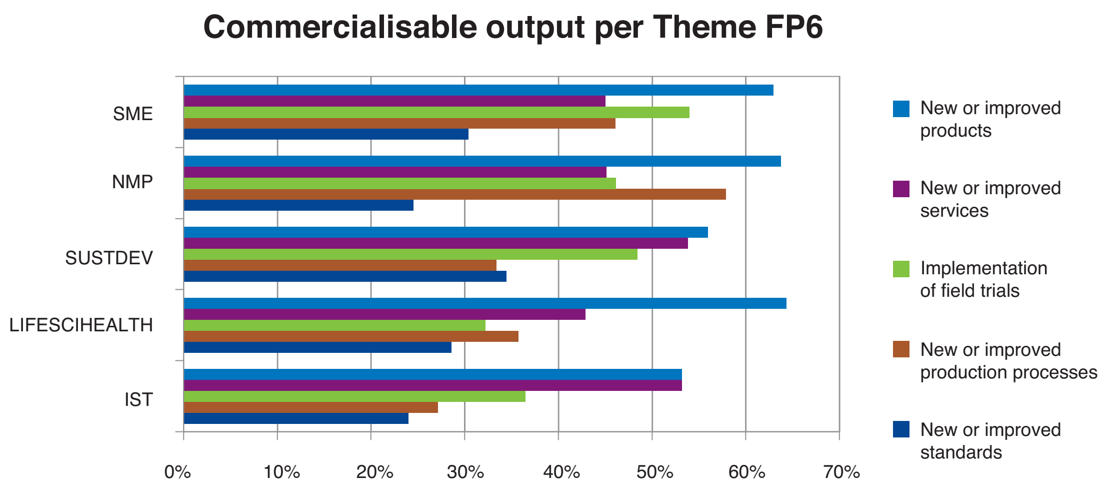


Figure 6.2: Commercial outputs per Theme FP 6



of a spin-off company are attributed with the least significance). Market share, turnover and profitability rank somewhere in the middle.

(ii) These impacts are even voted higher by research & education, and service & consultancy than by industry!

Apart from the direct commercial outputs, we surveyed also other forms of output, typically associated with collaborative R&D projects. The findings by and large support the results of previous evaluations of FG's impact, indicating that the networking and knowledge/capabilities related outputs are generally given more weight than the direct economic areas. Also, importance of output types differed somewhat between types of participants; e.g. dissemination activities, publications and PhDs are, unsurprisingly, highly valued by research & education, but are quite unimportant for other organisations.

Table 6.2: Commercial exploitation impacts of the specific project, by type of organisation

	industry	research & education	services & consultancy	total
Enhanced competitiveness	3.0	3.5	3.1	3.0
Improved ability to design and launch new products/services	2.9	3.1	3.3	3.0
Access to/learning to work in new markets	2.8	2.7	3.1	2.9
Risk sharing – reduced uncertaintly	2.6	2.8	2.6	2.6
Improved market share	2.5	2.3	2.7	2.5
Enhanced productivity	2.3	2.9	2.6	2.4
Increased turnover	2.3	2.4	2.4	2.3
Increased profitability	2.3	2.3	2.4	2.3
Reorientation of commercial strategy	2.2	2.2	2.5	2.3
Cost reduction	2.2	2.9	2.4	2.3
License incomes	1.6	2.0	1.9	1.7
Creation of a spin-off company	1.5	2.0	1.7	1.6

(multiple answers were possible) 1...not significant, 5... highly significant

Table 6.3: Knowledge-oriented, technological and network-oriented outputs of the specific project, by type of organisation

	industry	research & education	services & consul-tancy	total
Improved visibility as a competent partner	3.6	4.1	3.9	3.7
Keeping up with and exploring state-of-art technology	3.5	3.7	3.7	3.6
Improved ability to form new R&D partnerships and networks	3.3	3.8	3.5	3.4
Improved/enlarge scope of scientific & techn. skills and capabilities	3.2	4.0	3.3	3.3
Improved ability to work in different cultural contexts	3.2	3.5	3.5	3.3
Improved access to complementarity expertise	3.2	3.9	3.3	3.3
Other, specify (rating)	3.0	5.0	3.0	3.0
Improved R&D managerial capabilities	2.8	3.4	3.1	2.9
Establishment of critical mass of research	2.5	3.0	2.6	2.6
Trans-national mobility of researchers	2.5	3.3	2.6	2.5
Establishment/reorientation of training, vocational training	2.4	3.2	2.6	2.5
Reorientation of R&D strategy	2.3	2.9	2.6	2.4
Better career prospects for researchers	2.2	3.1	2.5	2.3
Increased number of research staff	2.1	2.6	2.1	2.1

(multiple answers were possible) 1...not significant, 5... highly significant

The most significant output is improved visibility as a competent partner, as in general, "soft" or network-oriented outputs (partnerships, skills) seem more significant than more firm-centered outputs. Interestingly, the projects seem not be used for increasing research staff – a fact which conforms well with some results of the case studies (organisations in research & education sometimes use FP projects for PhD students, but industrial firms typically make do with existing staff).

Table 6.4: Knowledge-oriented, technological and network-oriented impacts of the specific project, by type of organisation

	industry	research & education	services & consultancy	total
Other types of knowledge (know-how, etc)	3.6	3.9	3.7	3.6
Development of prototypes, demonstration & pilots	3.6	3.1	3.6	3.6
Development, evaluation or improvement of tools & techniques	3.5	3.9	3.6	3.6
Creation/strenghthening of links with universities and research org's	3.5	4.3	3.6	3.5
Creation/strenghthening of links with business organizations	3.2	3.8	3.5	3.3
Follow-up R&D projects	3.3	4.0	3.3	3.3
Models and simulations	3.0	3.4	3.3	3.1
Dissemination activities	2.9	4.2	3.5	3.1
Production of publications	2.6	3.9	3.1	2.7
Production of PhDs	1.7	3.0	1.8	1.8

(multiple answers were possible) 1...not significant, 5... highly significant

6.2.2 OUTPUT ADDITIONALITY BY FIRM AND PROJECT CHARACTERISTICS

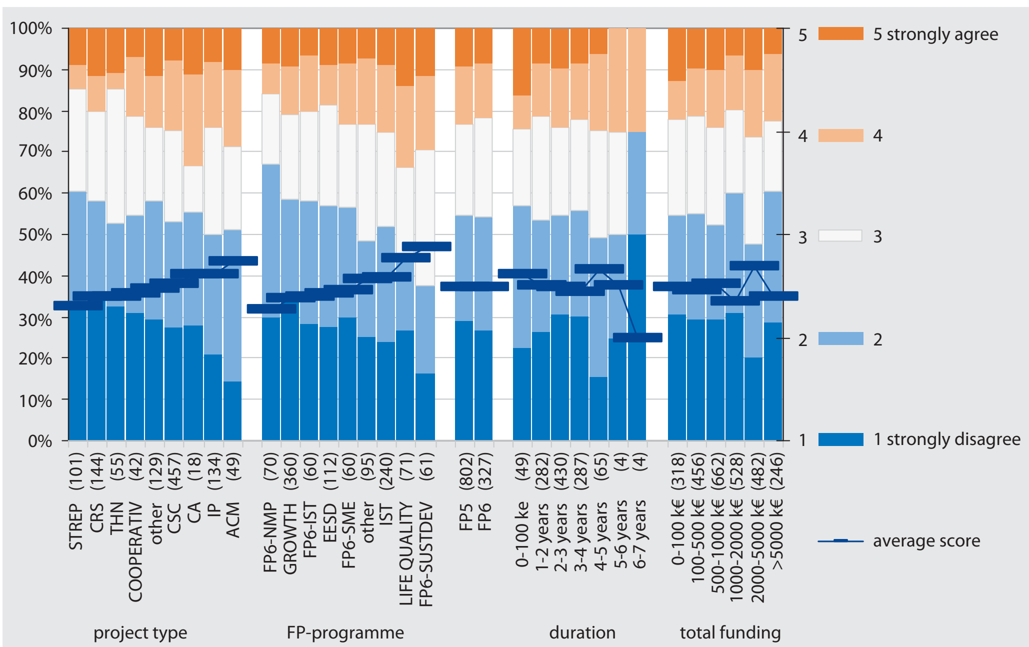
More than half of the respondents (strongly) disagree with the proposition that the commercial output would have been possible without the FP project; about 22% admit to no additionality at all. Thus, the balance is quite strongly in favour of the FP project leading to commercial output which otherwise would not have been obtainable. As with the high share of firms claiming to have realised at least some commercial output (or indeed various forms), this is a remarkable result, pointing to substantial output additionality of the FPs.

Differences among organisations of different size and type are not very pronounced. For smaller firms, however, the FP project seems to be of somewhat more importance than for larger firms.

When analysing the differences in additionality against various project dimensions, some very interesting results emerge:

- The remarkable thing here is that there are virtually no differences between FP5 and FP6. Thus, despite the changes in programme orientation and the development of new instruments, in terms of output additionality, there was no improvement between the FPs (though no decline either).

Figure 6.3: Additionality by project characteristics



- Additionality differences between projects of different duration or different funding volume are rather subdued.
- Differences are more pronounced between programme lines: Between individual instruments, STREP and CRS lead the additionality issue, participants in IP and ACM come last (although the differences are not significant at the 10% level). As for thematic areas, differences between them are statistically significant though not entirely surprising: FP6-NMP and GROWTH are "most additional" and LIFE QUALITY and FP6-SUSTDEV are "least additional" in terms of commercial output.

6.2.3 CHARACTERISTICS OF PROJECTS WITH HIGH VS. LOW OUTPUT ADDITIONALITY

Quite strinkingly, no substantial differences can be discerned when comparing the profiles with respect to firm-level characteristics in general, the role of the partner in the project, market characteristics, exploitation capacities or protection of IPR strategies. In all these respects, projects with high additionality don't differ much from those with low or no additionality.

Dimensions where there are differences include their riskiness: projects with commercial additionality were also the ones where participants incurred both higher technical and commercial risk. They were also slightly more peripheral to the core areas of the firm and complex, as well as somewhat more long-term and costly.

While projects with high output additionality score higher on every single category of objectives, risk sharing and considerations concerning skills show the most marked differences between additional and non-additional projects, followed by financial aspects (funding and cost sharing). "Soft" factors (networking, signalling) are equally important for additional and non-additional projects.

In concordance with the stated objectives, the most important impacts are seen in building access to knowledge, networking, keeping up with technology, and visibility as a competent partner. Differences are largest for factors which in a way are self-serving: R&D management capabilities, inter-cultural skills, trans-national mobility; in short, factors which are important to work successfully in FP-like projects.

More marked differences appear with respect to output: in most output categories (though interestingly not in the probably most important one: "new or improved products", where the scores are level) projects with high additionality score higher (Figure 6.4):

Exploitation of commercial outputs is more often undertaken jointly between partners in highly additional projects than in those with low additionality. This is an interesting observation as it can be interpreted that projects where partners are up for something more risky and new and have established a well working collaboration culture are more likely to overcome the typical fallacy of collaborative R&D projects with respect to joint exploitation (rather than going it alone). In the same vein, IPRs do play a lesser role in projects with higher additionality than other strategies of protection. This is quite consistent with other findings on the limited importance of IPRs made in other parts of the survey.

The most important means of protection are complexity, secrecy and lead time advantages; the last two are also those with the largest differences between additional and non-additional projects (they are more often chosen in the case of additional projects). On the other hand, individual patenting is less often chosen for additional projects.

6.3 Determinants of output additionality

To test further which factors might best "explain" whether a specific project resulted in a commercial output and whether it would not have been feasible without the FP funding ("commercial additionality"), we first estimated models for the absence or presence of commercial output. Also, models were estimated for the question which asked whether the participants considered the project a success in terms of innovation. Second, for those who reported some commercial output as defined above, a model was estimated for commercial additionality.

As for the factors 'explaining' outputs and output additionality a number of interesting observations were obtained. Throughout the sample, it could be observed that a high likelihood of producing commercial output does not imply that this output is 'additional', that is that it would have occurred only through the participation in the project:

- R&D intensity seems only to have negligible influence on commercial output, with output additionality it is even negatively correlated;
- If the consortium contained partners with whom the respondents had worked before, commercial output is significantly more probable; however, if it contained partners with whom they have not worked before, commercial additionality was significantly higher;
- If the project was commercially highly risky, this actually raised the propensity for commercial output; scientific and technical riskiness as well as complexity lowers the probability of commercial output. Scientific and technical risk, on the other hand, renders commercial output more additional;
- First participation in FP raises the probabilities of commercial output and innovative success, there seems to be a 'newcomer' advantage in this respect.
- The probability of commercial output was enhanced when the objectives were either to create a commercialisable innovation output or to jointly create or promote technical standards, to keep up with technological developments, but also when networking was a dominant objective. This finding indicates that it helps to have commercialization as a goal, but it can also be a by product of networking-related goals.
- Projects were more successful in terms of innovation whose initial goals were keeping up with technological developments, create commercialisable output, signal technological competence, and gain access to complementary resources and skills.

Figure 6.4: Commercial exploitation outputs

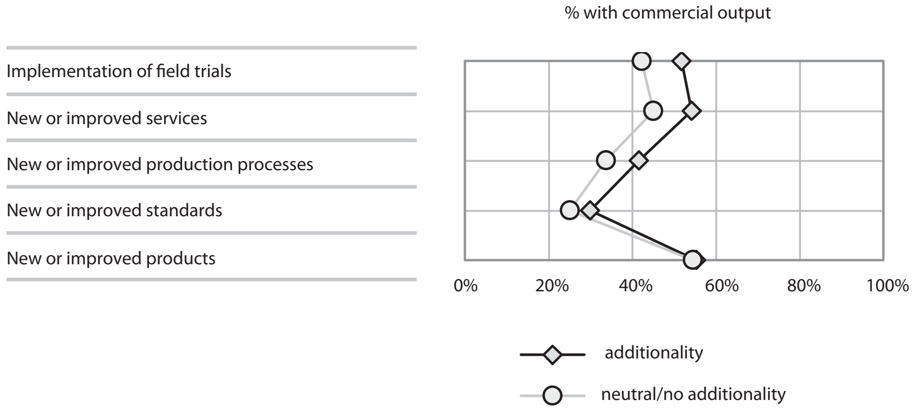
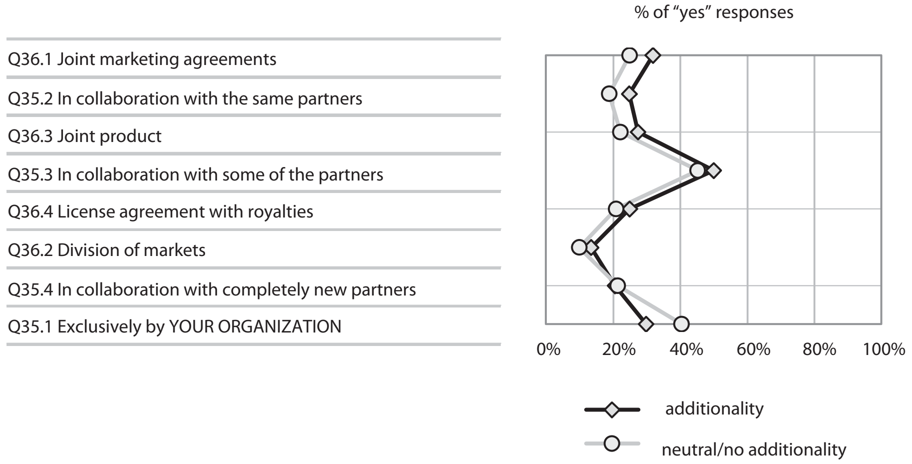


Figure 6.5: Commercial exploitation and partners



6.4 Outputs and additionality in the case studies

Almost all participants covered in the case studies claimed that they might have not done the project without funding of the EU (which can be read as a confirmation of substantial input additionality and behavioural additionality). In just three cases, participants argued that there might have been also other ways to do such projects. However, all agreed that the European funding was vital for the project and that the FPs are a major source to fund research ideas. In an overwhelming share of cases the project would have been impossible without the involvement of partners with a broad technical and commercial competence. To these projects which bring together various complementary assets and which result in the integration of the technological and scientific knowledge of the participants, substantive commercial impact is ascribed.

EU funding for one project plays a key role for acquiring other publicly-funded research projects. Especially SMEs and research institutions in the Central and Eastern European countries articulate a certain dependency on such financial resources as the public funding system in the home country is just weak.

The perceived value-added of European funding is manifold. The most common statements can be summarized as follows:

- to share risks and reduce uncertainty;
- to gain access to complementary resources and skills;
- to keep up with state-of-the-art technological developments;
- to monitor the market including business and science;
- to exploit high level and pre-competitive research and
- to build on knowledge from previous FP projects.

Some participants argue that EU funding and the different Framework Programmes have allowed them to enter into the development of projects they would otherwise not had the resources in terms of budget to commit to. Thus, the networking aspect, in particular the access to complementary resources and the establishment of new types of cooperation, is the most stated added value of European funding.

There were also some participants who achieved no results, including quite a small share who were stopped in an early project stage by the EU. The common element among most was that they were newcomers, i.e., the project in which they were involved or even took up the lead role was first funded by the EU. Surprinsingly, the failures belong to companies, both large and small, established in Central Europe. Their major objective was to gain access to new technology, knowledge and resources. Due to the outcome, the motivation of those unsuccessful companies to do further EU projects is quite low; the one part considers to reduce further participation in EU projects, the other part argues that it will not participate in EU projects anymore as there is a lack of compatibility concerning the company's innovation strategy and EU funding. The latter argument is especially true for low-tech, small companies where resources in terms of human capital are restricted to do such innovative projects at an international level.

By and large there are no major organisational changes stemming from or associated with the FP projects which can be observed among the cases. There is only little impact on human capital employed; the only observation which is made is concerning research institutions and universities that recruit PhD students to work on EU projects. Regarding companies the EU project generally has no impact on the organisation; in rare cases there is the creation of a spin-off company as a commercial vehicle - this is the case where a clear commercialisation strategy has been communicated from the beginning on. Spin-offs are created in the case where innovation results capture new and inproved production processes or even pilot testing is already done successfully; there is even one case where a spin-off company is explicitly set up to enter a new market.

A closer look at research institutions and universities reveals that the FP projects mostly succeed in terms of 'technical/technological' success. Commercialisation is not the main objective but rather the building up of new knowledge and technology and the investigation of new research areas. For this purpose, EU funding provides a potential instrument to increase research funds available for university / research institutions. Indeed, EU funding fosters the ability to join international projects, as it allows the development of projects for which the universities / research institutions would not had the budget resources to commit to. Furthermore, FP projects are seen as a good way to survey the technological enviroment, to be aware of the current state-of-the-art, to get an idea about what happens in the core domains, and also to benefit from the European market. Altogether, EU funded research is one of the main pillars of external public finance, and is a valuable instrument for both improving researchers' competence through national and international collaboration and to increase funds' availability for less-applied or medium-term perspective research projects. This implies that FP projects do not just offer networking perspectives but rather offer the possibility to work on a topic that would probably not have been developed internally. Apparently, publishing scientific papers plays a more important role for this group of actors, followed by conference contributions, new techniques and technologies, and patents.

In line with the findings of the survey, we can also find empirical evidence that successful participants in FP5 and FP6 have previous experience with projects funded by the EU; they are not just engaged in one FP project but are involved in further EU projects. In most cases such projects are already planned or even done, i.e., the majority of companies, universities and research institutions follow the strategy to increase participation in EU projects in terms of number of projects and some even consider broadening their scope. Often there is a new proposal for a follow-up project stemming from the results of the previous project, the likelihood of which increases when the organisation plays the role of the coordinator.

Finally, a common project impact is the enhancement of visibility through publicity. Due to creating knowledge and improving the ability to work in different cultural contexts, the visibility as a competent partner is enhanced considerably. As a consequence, there is not just an increase in reputation but – in the best case - an increase in competitiveness being based on technological intelligence and the establishment of new contacts.

Interviewees in the case studies were also asked what they consider as *main lessons* learned from EU-funded research projects. Several aspects were mentioned which are summarised in the following section:

- Importance of and benefits from the role as coordinator
  Quite often the role of the coordinator was stressed: in successful projects, the coordinating project partner acts as communicator and intermediary as the organisation is responsible for the project management and good team work. The communication needs to be multi-layered and must cover various fields:
  - Consensus between partners regarding objectives, tasks and scientific outputs in the beginning of the project,
  - Motivation of partners during the project,
  - Attention to different languages and cultures in order to guarantee a smooth cooperation between partners.

- The role of SMEs
  SMEs often face problems with EU-funded projects as they need to be extremely quick in developing new solutions with regard to their growth strategy. Being able to use research results immediately enhances their competitiveness. Chances to succeed in research projects of the EU FPs and bring the idea to the market successfully are improved with the support of large industrial players as they often can fall back on previous experience. The low level of funding has also been a preventive factor in most EU-funded R&D projects, as SMEs often have difficulties covering 50% of incurred costs.

- The role of Collaboration
  EU-funded projects are often used to establish long-term partnerships. The networking effect

has been identified as an important added value aspect of FP research projects. One interviewee mentioned that links to universities and research institutes are often based on personal relations of one employee. The difficulty is to tie the contacts to the company as a whole as the current fluctuation rate of staff is quite high.

In the case studies, a number of difficulties were mentioned which could act or actually acted as barriers to the commercialisation of research results:

- Project outcomes are often too general,
- Imposed specifications are overly optimistic,
- The time window for projects is too narrow,
- Not enough money is available.

In the case of 'very close to the market'-research, mainly partners with complementary knowledge agree to cooperate.

Positive effects on development of technologies can be achieved when customers and commercial partners are involved in the development phase of the project. In pre-competitive projects, competitors might work together but on non-strategic topics. A well-tested prototype was mentioned as an achievable research result in these cases.

6.5 Concluding remark

With respect to the ability to produce commercialisable output and the question of additionality, we think that we could provide some interesting findings, which were presented above. Most noteworthy are probably the observations that the factors affecting the likelihood of *producing* a commercial output are not the same as those ensuring *additionality*. While for the former, some factors well documented also in previous assessments of the FPs are important (size, experience in FP and with partners, chain of projects and the like), for the latter, factors like new partners, more risky projects or greater novelty in technological area were important. This, taken together with findings about the little influence of changes in instruments of the FPs or with the persistent barriers to SMEs can and should be points of departure for new thinking about programme design and orientation.

7 Conclusions, **policy observations**

7.1 Conceptual Underpinnings

In today's fast-paced environment innovation increasingly depends on inter-organizational collaboration. The Research Framework Programmes have promoted such collaboration, traditionally concentrating more on projects and programmes that strengthen the European research system as a whole instead of near market projects. In theory, at least, the latter were left to the private sector to undertake on its own initiative. The support of collaboration on projects that could be characterized as basic research was left to national science authorities and, more recently, also to the newly founded European Research Council (ERC).

In order to better understand the relationship between such inter-organizational arrangements and R&D outcomes, it was imperative to consider the type of learning and knowledge-based practices utilized during the various stages of the innovation development process within an R&D consortium. Our conceptual framework took this into account by concentrating on how the various stages of the R&D process motivate different types of exploration and exploitation activities by organizations collaborating in the development and commercial success of R&D results.

The conceptual distinction between exploration and exploitation capacity is important in understanding the factors influencing the outcomes of R&D consortia. It helps explain why certain collaborations are more efficient than others in using knowledge and in producing marketable results. The lack of exploitation capacity will hinder the ability to produce commercially viable R&D outputs, despite the ability to explore. Some consortia may be inefficient in leveraging their exploration potential and therefore are unable to successfully commercialize their R&D output. The distinction also allows us to conceptualize the different learning processes at work within each of these distinct phases, as well as the mechanisms that determine the efficiency and effectiveness of these processes (absorptive capacity).

It is noteworthy that other exogenous and endogenous forces may differentially impact exploration and exploitation capacity, indicating that different management and governance mechanisms are necessary to nurture and harvest these two components of R&D collaborations.

The theoretical framework hypothesized six categories of factors that affect the performance of the R&D

consortium and operate at both the consortium and at the organization levels:

- Partners' resources and capabilities (i.e., prior experience, complementarity of assets, capability to manage consortia, cultural diversity, and partners' network structure),
- Managing aspects of the R&D consortium team (i.e., demographic characteristics, social and behavioural features, communication, coordination and control mechanisms, and team leadership roles),
- Perceived characteristics of the R&D output (i.e., complexity, trialability, relative advantage, usefulness and ease of use), organizational factors (i.e., firm strategy, structure, resources and capabilities),
- R&D protection mechanisms (i.e., appropriability regimes), and
- Market conditions (i.e., technological shifts, government regulations, market structure, size and uncertainty).

The introductory chapters also tried to dispel the widespread perception that exploration and rapid innovation are orthogonal processes, meaning that exploration is linked to long-term research and radical innovation. While the fact that exploration includes "blue sky" research that might lead to radical innovation cannot be disputed, the identification of exploratory research with "blue sky" only is incorrect. It was argued that there is a second kind of exploratory research which enquires the possibilities of application of new scientific principles in new product areas. This exploratory research is of a very different kind than "blue sky" exploratory research in that the two require different antecedents, different capabilities, different exploitation capacities and channels and, thus, mostly depend on different organizational structures for effective management of the research. The second kind of exploratory research aims much more directly at commercial exploitation and, as such, it tends to be positioned much closer to the market. For-profit organizations, including business firms and other research laboratories, are better attuned to it.

Importantly, this type of exploratory research fits the characteristics of non-linear innovation models where development work and scientific research feed on each other and feedback loops between them and applications are strong and widespread. This, it was argued, is the environment spawned by research consortia where companies, research institutes, and universities mix in different combinations. The different kinds of partners participate in these consortia for different reasons but, in order to work together, they must find common ground. And this is the type of collaborative R&D promoted by the research Framework Programmes where the common ground has traditionally been described as "precompetitive" research. Such research supports development and applications and is very much informed by them but it does not purport to develop specific products and processes on its own. Yet, depending on the field, the project, the organizations involved, and market conditions, it frequently might if well managed and connected to applications.

Regarding the participant firms, an especially pertinent characteristic was pointed out: size. Different partners will join a R&D consortium for different reasons. Smaller partners will typically join for achieving economies of scale and scope and critical mass, and for accessing markets and resources. Larger partners will typically join for reducing risk, accessing information, and for shaping the competitive game in the market by influencing standards and technology platforms.

Consequently, the perceived returns from a collaborative research venture will differ according to the size of the participating organization (among others). Small and medium sized enterprises will tend to look for the complementary resources to achieve a specific objective that will typically be a new or improved product/service or process. Due to their smaller size and resource level, they will engage in a limited number of cooperative agreements each of which will be important for their immediate survival and growth. On the contrary, larger enterprises will look for the less direct returns, using the consortia primarily as "listening posts", as vehicles for building their networks, as instruments for placing bets in early-stage risky research fields, and as platforms for influencing the competitive market game. For these enterprises, collaborative R&D will mostly be a longer term deal and be part (in the best of cases) of their overall strategic outlook. Few, if any, individual collaborative agreements will be critical to these enterprises' short- to medium-term survival which primarily depends on hard-won market reputation and internal resources.

A final concept that underpinned the core thinking behind this study has been the relationship between cognitive distance among collaborating organizations and their absorptive capacity as a factor impacting the innovative performance of R&D consortia. The key concept here is the balance between novelty and absorptive capacity – which increase and decrease respectively with larger cognitive distance as partners try to combine complementary but heterogeneous resources. The challenge for an R&D alliance is, then, to combine partners at sufficient cognitive distance in order to tell something new, but not so distant as to preclude mutual understanding.

Firms should seek partners that are at an optimal cognitive distance. Such optimal distance is not fixed, but depends on one's past investment in building technological knowledge as a basis of absorptive capacity. It also depends on the positioning of the collaborative research on the exploration-exploitation spectrum.

7.2 Main results from the empirical and case analysis

An important finding from our analysis of the Community Innovation Survey (CIS 3 and 4) is that the Framework Programmes attract the highly innovative companies and research institutions in Europe. We find that FP participants are characterized by:

- R&D intensities that are above the average of their sector of principal activity;
- They are significantly more networked with clients and universities than average;
- They are significantly more orientated towards international markets than average; and
- Their patenting activity is significantly higher than average.

The innovative sales of organisations are not negatively affected by their participation in the FPs, despite the fact that the FP projects are generally more complex and more risky (technically and scientifically), carry more overhead and have longer term objectives; thus it can be argued that participation in FPs has an added value.

When trying to identify whether the FP did make a difference with respect to input additionality at the level of the participating organisation (that is whether the organisation as a whole increased R&D spending as a consequence of FP participation), using CIS micro-data for three countries, we arrived at mixed results: while there was no overall input additionality for the participants as a whole, there is substantial input additionality among smaller firms. For them, participation in FP 4 and/or FP 5 results in a significant increase of R&D intensity between 2000 and 2004 among firms of up to 100 employees (R&D intensity is roughly doubled!); this however does not hold for larger firms.

An extensive FP participant survey has found that technology-related objectives dominate all other objectives, including market, cost-risk sharing and network-related objectives, when choosing to participate in FP projects. This ranking is highly stable over the different categories of participants. It holds across FP 5 and FP 6 projects, with some differences among FP thematic areas and instruments (NoE and CA, for instance, stand apart in FP 6).

Participants that do not have commercial/innovation goals at the start of the project are very unlikely to achieve any commercialisation (even if there are commercialisable results). SMEs demonstrate more economically-driven objectives (innovation, commercialisation and market-related) than large companies.

Networks of Excellence and Integrated Projects appear to be used for projects of a bit more exploratory nature. In contrast, self-funded cooperative R&D projects are used more for projects of the exploitation type. Larger companies seemed to have better established strategies for diverse contexts of collaborative R&D.

In general, the surveyed organizations were not very keen in keeping knowledge private with traditional intellectual property protection mechanisms such as patents. In the specific context of FP, patents are also reportedly used less frequently. Firms do not change their IP protection strategies radically in FP projects, although some of them – such as those with no previous experience in FP projects – tend to use secrecy slightly more often and technological complexity in this specific context. While FP 5 and FP 6 seem to be approximately the same in this respect, there are some differences between thematic areas and instruments. Not surprisingly, there are significant differences in the desirability of formal IP protection mechanisms among sectors and technology areas.

Project roles are almost evenly split between R&D performers, technology producers and users. The roles of specific organizations change across projects. Research organizations tended to collaborate more often with partners with whom they had worked before and to collaborate less with industry. To some extent this is the same for service organisations. In contrast, manufacturing participants were engaged with relatively fewer partners with whom they had worked before and more with other industry participants. Interestingly, newcomers were involved in projects with a significantly lower proportion of partners with which they had worked before than old timers.

The origin of the idea on which the FP projects are based seems to have gradually shifted towards a more important role for research and education partners in FP 6. There are, however, differences between programmes. For instance, IST remains largely industry driven.

In both FP 5 and FP 6, more than forty percent of the projects were reported to be related to emerging markets. In contrast to widespread belief, this study unveiled an absence of sharp differences between the different collaborative R&D portfolios in terms of average project characteristics including costs, risks, flexibility, distance from the core activity of the firm, etc. Participating firms reported that FP 5 and FP 6 projects exhibit similar characteristics that set them apart from cooperative projects exclusively funded via internal R&D budgets.

Compared to the average R&D project, FP projects are more complex and more long-term oriented. They are also slightly riskier from a scientific and technical point of view. They are closer to the core R&D field of the participants than the average RD project. Finally, FP very much looks like the "average R&D project" regarding commercial risk and project cost. All these results are remarkably stable over most of the classification of participants. This picture is the same across companies of different type and size. Also it holds for both FP 5 and FP 6.

In more than half the cases, in-house R&D projects in a specific topic had preceded the FP projects of the organization in question on a similar (or same) topic. In both FP 5 and FP 6 the proportion of a past FP project cited as a source for a subsequent FP specific project is about one third of the total. This proportion is significantly higher in Sustainable Development (FP6) and IST (FP6) and lower in SME (FP6). In a third of the cases, FP projects opened a new area for the participants. This result is stable across all types of participants.

The empirical analysis based on the survey of FP participants provided very weak support of the proposition that market conditions strongly influence the various aspects of project success (product-process innovation, technical knowledge creation). A plausible explanation is that the nature of the typical project undertaken in the Framework Programme is of the "technology-push" variety, rather than "technology-pull", driven by some promising emerging technology at an early stage of development with still less well defined market opportunities for exploitation. If so, the partners are driven by a motive to explore rather than exploit a technology and market conditions could be reported "irrelevant".

Another plausible explanation is that the measures used to capture market conditions in the survey were specified at an aggregate level not allowing for expressing the differences between and across sectors and technological trajectories. The analysis of case studies, for instance, indicated differences in behaviour among enterprises in four types of markets. Companies operating in competitive markets with high technology/innovation intensity – serving markets such as satellite navigation solutions, IT consultancy, automation and robotics, industrial software, quality and risk management services, advanced recycling technologies, laser technologies – tended to make better and more direct use of FP projects in their commercialization plans. Many of enterprises in this category indicated a strong involvement in Framework Programmes and a strategic role of EU funds in the R&D process. FP funding is well integrated with the company research activity. FP projects are mainly carried out to make applied research and to exploit the innovative results coming from it.

In contrast, FP projects seemed much less directly linked to innovation plans and competitiveness for enterprises in other types of sectors. The reasons varied by the type of competitive situation and type of technology in the sector. For enterprises in monopolistic/oligopolistic sectors with high technology/innovation intensity – e.g., aerospace, satellite communications, optics with technical surface producers, manufacturing of aeronautical parts, pharmaceuticals, cosmetics and health products, robotized automation systems, aero transportation management – examples of direct and consistent commercial exploitation of FP project results were fairly rare even though these companies tend to be well experienced with FP projects. They reported generally low degree of novelty of the technical results. Exploitation, when it happened, was in niche markets. For enterprises in monopolistic/oligopolistic sectors with low technology/innovation intensity – e.g., waste management, rail transportation solutions, energy plant production, paper and pulp, energy production – FP-funded R&D projects seemingly had a minor role in the overall company strategy, largely due to the marginal relevance of innovation in these sectors. For most such companies FP projects have offered at least indirect gains such as networking opportunities and development of standards, creation of databases. Direct commercial exploitation was reported fairly unlikely. Finally, for enterprises in competitive sectors with low technology/innovation intensity – e.g., chemistry for surface protection of industrial components, injection plastic moulding presses, glass solutions for indoors and outdoors areas, surface processing, automotive sector machinery, industrial plastic products, prefabricated structures – the answers vary. In the case of the small part of enterprises that base their activity on R&D and have long experience in FP projects, the European projects have become a structural instrument of financing the company development, technological development through networking, and acquiring qualified competences. For the remaining enterprises of this class the FP projects are not part of an integrated research activity.

The empirical analysis has also indicated a positive effect of firm size on process innovation, but not on product innovation or the production of technical knowledge from FP projects. This may indicate that larger firms are more inclined to pursue process innovation, presumably as they have more pressing needs to optimize their large-scale productive operations.

Case studies showed a more diverse picture. SMEs reported a generally strong strategic alignment with FP projects and explicit goals related to innovation outputs such as developing a prototype, developing a patentable technology, or developing a complementary technology that will enhance competitiveness. Medium-sized companies seemed to have reaped the largest innovation benefits from FP project participation. These organizations can achieve critical mass for R&D in a focused area. They are often either established players in their industry or quickly growing players that have overcome the threshold of successful commercialisation of a first generation of innovation based products or process technology. Generally speaking, these companies have explicit strategy and goals for innovation. They often took a leading role in projects and were most frequently found as coordinators, in parallel with research organizations. Small-sized firms (<50 employees), on the other hand, often remain too focused on a core technology and too centred on research (compared to on development) in order to be able to sustain market driven development and commercialisation in their own right.

Large firms, on the other hand, which are presumably best positioned to commercialise an innovation, were much less inclined to do so directly from FP projects as compared to a number of highly committed-to-commercialization SMEs. In larger companies, mission was rarely referred to in the context of the

FP projects. Because of the often more marginal role of FP projects for them, larger companies often reported weaker strategic alignment and less explicit goals. If goals were clear, they were typically focused and limited to project dimensions such as developing new knowledge, building partnerships, or exploring a new technology area. Only as an exception did large company interviewees refer to market-related goals. Thus, our case sample of large firms presents the least successful project participations from a product or process innovation point of view. For reasons such as weaker strategic alignment, larger distance from core activity, objective of exploration and not exploitation or still lack of overview and internalised control judged necessary for commercial projects, large firms either scoped intangible outcomes or indeed reported plain failure of the projects. Hence, the benefit that the projects could have from the participation of big companies was not fully tapped into.

First-time participation in FP projects appeared to have a positive effect on both product and process innovation. One would be tempted to attribute this to greater motivation of "newcomers"; there is no reason to believe that they are systematically more capable to drive FP projects to success than repeat participants. Or, there may be a tentative link here with the size findings above: SMEs tend, on average, to participate less and many of them only once.

Prior experience of an organization with R&D, both intramural and extramural, positively and significantly affects the likelihood of obtaining product innovation from FP projects. Extramural R&D and past innovation experience also positively influence process innovation. Past innovation performance also has a positive effect on process innovation. On the contrary, firms that have a history of imitative strategy (i.e., introduction of new-to-the-firm products, as opposed to new-to-the-market innovations) were relatively less likely to report process innovation.

Overall, the results concerning the "innovation history" of both firms and research organizations largely confirm the hypothesis of a positive association between prior innovation experience and project success. Building up a broader innovation culture was an important underpinning factor behind product and process innovation success. Firms with an explicit R&D / innovation structure and model proved more successful in producing innovations out of the collaborative research in question.

The nature of the project appeared to be a very important determinant of project success. Strong empirical evidence was obtained that projects that are commercially driven, risky, complex, and new area (for process innovation) tend to be more successful:

- Projects that are driven by commercial objectives from the outset were found more likely to result in product innovation and to lead to technical knowledge creation. In contrast, projects aiming at networking seem less successful in terms of generating new knowledge;
- The nature of a project, in terms of being risky, exploring a new technological area, or being scientifically complex, influences project success in important ways. The degree of risk affects positively both product innovation and knowledge creation. In both cases, however, the degree of project risk is subject to an inverse U-shaped relationship with the dependent variables: excessive risk appears to lead to diminishing returns as regards the likelihood for product innovation and knowledge creation;
- Exploring a new technological area has a positive effect on process and negative effect on product innovation. A positive effect of technical complexity is found on process innovation;
- The extent to which the technology resulting from a project is expected to have a relatively short life cycle and the extent to which it is distant (or unrelated) to the firm's existing stock of competencies decreases the likelihood of process innovation;
- A project idea generated by industrial partners affects positively knowledge creation;
- Projects that build on past R&D activities are more likely to result in process innovation and technical knowledge creation.

Besides experience of the interviewed organizations with innovation activity in terms of conducting both intramural and extramural R&D, successful projects were strongly characterized by clarity of mission for R&D in general, strategic alignment of the project, and explicit goals of what the participating organizations expected from the project.

There is a strong relationship between the explicit intension to commercialise from the outset of the R&D project and project success. Yet, the extent to which commercialisation has been an issue and an explicit goal in their FP R&D projects was seriously questioned by a significant number of the interviewed organizations.

Dissemination was seen with mixed feelings among the interviewees. Opinions about dissemination ranged from "a core activity" or "very important for image building" or still "an opportunity to make ourselves known", to "an activity without substance" or "a half-hearted and insufficient effort to reach a market" (firms irrespective of size).

What happens after the research project ends varies widely. Some partners decide to 'couple' for exploiting further some of the results without necessarily informing the other partners. In other cases there is indecision about who will roll the ball next. Other times FP project 'n' generates the conditions for a proposal for FP project 'n+1', which, if leading to accumulated knowledge or a further exploitation of the results, can be seen as a positive outcome of a project. In other cases still, the outcome of a project is exploited by one partner together with some other organization that was not part of the initial project.

The importance of management during the implementation of the R&D projects was emphasized by case study interviewees. They referred to the continuous support and follow-up on the part of the coordinator with respect to the scientific and administrative obligations contracted between the project consortium and the EU. Successful projects shared a positive assessment of the capabilities of the coordinator, both as an R&D performer and as an administrator. Each of these capabilities seem necessary but not sufficient for success, as there were cases where even such well-managed projects failed at the level of innovation outcomes, due to for example insufficiency of the R&D results, rights conflicts between partners beyond the control of the coordinator or the frameworks of the instruments, or changing market conditions rendering project outcomes obsolete.

Interviewees indicated a wide disparity of motives for participation which affect the likelihood of project success. Coordinators naturally show a strong strategic alignment of their activities with the core subject of the project. Non-coordinators vary widely in their motives to participate. Some vet the projects carefully, others join because they've known the partners from before, others join with no real intention to connect the project to their core activities. The ability of the coordinator to align interests is critical.

Finally, the concept of additionality (input, output, behavioural) was used to capture the difference between the 'state-of-the-world' that would have occurred with and without the programme(s) in question. Empirical analysis with CIS data in the Netherlands and Germany indicated substantial input additionality among smaller firms. Participation in FP4 and/or FP5 was associated with a significant jump in R&D intensity between 2000 and 2004 among firms of up to 100 employees (R&D intensity is roughly doubled!). This relationship was insignificant for larger firms. Case studies also pointed out substantial input additionality.

As the major thrust of this project was to identify the innovation impact, we looked especially into output additionality, namely into the question whether participants experienced an increase in innovative output as a result of their participation. Significant output additionality was reported especially for smaller firms, for services and for consulting, in traditional instruments, and for projects with higher risk (commercial, technological, scientific) which are being exploited jointly. Differences between thematic areas were reported – e.g., nanotechnology ranked higher than life quality and sustainability. In contrast, no difference was detected in the degree of output additionality between FP 5 and FP 6.

7.3 Policy relevant issues and observations

The results reported in this document give rise to a long list of issues with relevance for policy and strategy that should be of interest to the designers and managers of the Framework Programmes as well as to higher level policy makers who consider the Framework Programmes in the broader context of the European Research Area and the European systems of innovation. There are important implications here for science, technology and innovation policy, competition policy, intellectual property protection policy, and policies that affect the incentives of public research organizations and of organizations from the private sector to join research networks.

A most important message for policy decision-makers is the reconfirmation in this study of a finding that has stood repeatedly in evaluations of the Research Framework Programme: the Programmes attract the 'elite' of private sector innovators in Europe. The Framework Programmes attract these highly capable organizations not only – or, better, not just – to do a little bit more of what they have been doing on their own initiative but also because participation allows them to be more ambitious in terms of technology-related objectives. The dominant objectives for participation were reported to be "access to complementary knowledge and skills", "keeping up with state-of-the-art technological development", and to a lesser extent "explore different technological opportunities". In contrast, "joint creation of technical standards" and "market control" were the least important objectives as reported. We form the impression that market related factors, cost/risk reduction and sharing are not the main reasons why companies enter FP projects. FP projects are not primarily considered by firms as a way to develop outputs that could be immediately commercializable. The argument put forward by companies regarding public support of R&D is as much related to the remedy of "system failures" or "cognitive failures" as to the remedy of classic "market failures".

FP 5 and FP 6 projects tend to be viewed by participating organizations as vehicles for exploring new areas. More than forty percent of the projects were reported to be related to emerging markets. Among the various funding instruments, Networks of Excellence and Integrated Projects appear to be used for projects of more exploratory nature. This contrasts with self-funded cooperative R&D projects which are primarily used by the respondents for technology exploitation projects (closer to the market).

Compared to cooperative R&D projects funded exclusively with own internal funds, FP projects were reported, on average, to be characterised by longer term R&D horizon, greater interest in peripheral (read new area) technologies, more explorative nature, lower degree of flexibility and higher administrative burden. Compared to the average R&D project, FP projects were reported to be more complex, more long-term oriented, and somewhat riskier from a scientific and technical point of view. Finally, FP projects were reported similar to the average R&D project in terms of commercial risk.

Going against popular contemporary perceptions, but agreeing with a long stream of economic research, surveyed organizations were not very keen in keeping knowledge private with traditional intellectual property protection mechanisms such as patents. In fact, firms appeared set on maintaining their IP protection strategies and they do not change them drastically. Some, nevertheless, may use a bit more often secrecy and technological complexity in this specific context. While there are no significant differences among FP 5 and FP 6 in this respect, some differences exist between thematic areas and instruments.

The origin of the idea on which the FP projects are based seems to have gradually shifted towards a more important role for research and education partners in FP 6. There are, however, differences between programmes. For instance, IST remains largely industry-driven. Assuming that the originator of the idea most times ends up in the role of the coordinator and combined with the fact that the coordinator is the most critical partner in FP projects, this finding tends to point to an even closer orientation towards explorative research but away from market exploitation of the research results.

An important perspective was opened by the finding that, in contrast to widespread belief, the expected sharp differences between the different collaborative R&D portfolios in terms of average project characteristics including costs, risks, flexibility, distance from the core activity of the firm, etc., are largely absent.

Enterprises working under pressure in competitive markets with high innovation/ technology intensity tend to exploit the research results of FP projects faster and to a larger extent than enterprises in other high as well as low innovation/technology intensity markets. Moreover, for larger companies FP projects play a somewhat peripheral role, less critical in terms of budgets, more exploratory, and with main objectives defined by indirect benefits such as networking and building new knowledge. In contrast, SMEs reported stronger strategic alignment with FP projects and explicit goals related to innovation outputs, apparently in reflection of the higher budget criticality of these projects for them. Medium-sized companies seem to have reaped the largest innovation benefits from FP project participation.

First-time participation in FP projects was found to be positively associated with both product and process innovation.

Prior experience of an organization with R&D positively and significantly affects the likelihood of obtaining product innovation from FP projects. Extramural R&D and past innovation experience also positively influence process innovation. Past innovation performance also has a positive effect on process innovation. On the contrary, firms that have a history of imitative strategy are relatively less likely to report process innovation. Overall, the results concerning the "innovation history" and "innovation culture" of both firms and research organizations largely confirmed the hypothesis of a positive association between prior innovation experience and project success.

The nature of the project is a very important determinant of project success. We found strong evidence that projects that are commercially driven, risky, complex, and new area (for process innovation) tend to have higher chances for success.

Projects that are driven by commercial objectives from the outset are found more likely to result in product innovation and to lead to technical knowledge creation. Yet, the extent to which commercialization is an issue and explicit goal within the FP RTD projects, from an institutional viewpoint, seems to be seriously questioned by quite a few of the interviewed organizations.

When it comes to the importance of management during the implementation of the cooperative R&D projects the criticality of the role of the project coordinator cannot be overemphasized. Successful projects shared a positive assessment of the capabilities of the coordinator, both as an R&D performer and as an administrator. Importantly, while the motives for participation vary among partners, coordinators naturally show a strong strategic alignment of their activities with the core subject of the project. The ability of the coordinator to align partner interests is critical.

Finally, the results on additionality raise policy relevant observations:

- Commercial outputs and output additionality was reported high in the FPs. Is there room for further improvement?
- Output additionality is not different between FPs and not markedly different between instruments
- Risk (scientific, technological, commercial) and novelty of the technology area (e.g., nanotechnology) are related with higher likelihood of output additionality.

8 Policy recommendations

We start with a caveat: as also emphasized in earlier Sections, this study should not be seen as another evaluation of the Framework Programme. It is not. It has had a much narrower scope, concentrating on the impact of FP projects on innovation and, accordingly, on the managerial, project, firm, and market-related factors that influence the extent and speed of the commercial exploitation of the results of cooperative R&D funded by the 5th and 6th Programmes.

Policy recommendations must be viewed in this context. What we propose here is not a set of policy objectives to make the Framework Programmes more effective in achieving its core objective which is the strengthening of the overall European research system. It is rather a set of policy recommendations to enhance the innovation footprint of the Framework Programmes which, in turn, will contribute to further promoting the international competitiveness of European industry, the ultimate beneficiary of a better research system according to the Treaty of the European Union.

Policy Recommendation 1. *Directly commercialisable output has not been a core objective of Framework Programmes. Yet we find significant impact on innovation. Caution should be exercised in extensively modifying the Programme to further enhance direct innovation impact.*

Europe is rightfully in a policy mode of increasing innovation. There is a long battery of policy measures that affect the innovative performance and competitive capabilities of European industry from macroeconomic stability and labour markets, to R&D tax incentives, to market regulations for innovative products and government procurement, to borrowing costs, the availability of risk finance, and the sponsorship of R&D programmes. The Research Framework Programme belongs in the latter category. The primary objective of the FP, however, is the support of the European research infrastructure which will then affect the competitiveness of European industry indirectly by allowing them to undertake highly competent research. Direct impact on innovation in the sense of supporting research that will be quickly commercialized, although desirable and welcomed when it happens, has not been a defining characteristic of the Framework Programme. We would hesitate to prescribe radical changes that might change the rules of engagement and might result in projects that are indistinguishable from those that the companies undertake on their own. Such a result would be a failure for of two reasons: it compromises the core objective of the Programme regarding the European research infrastructure; and it crowds out privately-funded research.

Policy Recommendation 2. *Keep funding instruments simple. Maintain instrument continuity. Deep changes increase the cost of Programme administration without demonstrably significant benefits.*

The participants appear perfectly capable to work around fine divisions among funding instruments and to adapt to new environments giving the impression that the anticipated effects of the different instruments in FP 6 have not materialized at least to the extent expected. However, every time participants have to implement such an adjustment – i.e., learn something new and adapt their strategy – they incur costs. These costs may be justified when there are significant benefits to be obtained. We do not find a strong case for the new instruments introduced in FP 6. Although FP 5 and FP 6 projects were found to have differences with both the average R&D projects of the participating firm and its average collaborative R&D project, the similarities across instruments as reported by participants in terms of project characteristics and additionality are noteworthy. Differences appear across thematic areas rather than across instruments. Such differences hold across successive Framework Programmes even though the funding instruments may change dramatically.

Recommendation 3. *Rather than differences among instruments applied horizontally across all thematic areas, pay closer attention to the needs of the thematic areas at different levels and their associated markets, as well as the needs of participating organizations.*

While we were unable to draw sharp differences in many respects across funding instruments, it was clear that differences exist between thematic areas. Such differences – for instance, between ICT and pharmaceuticals – will be of decisive importance in defining the characteristics of the consortia, the way they are managed, and the speed and extent to which research results are commercialized. The reason is two-fold. On the one hand, the research needs are different across broad fields in that ICT projects tend to be typically closer to the market (irrespective whether or not they are funded through the FP) than projects in pharmaceuticals that have long gestation periods and are subject to arduous processes of clinical trials. Intellectual property is also treated (and protected) quite differently across these two areas. On the other hand, company competitive behaviour and, as a result, company alertness to the market forces which determine its 'thirst' for innovation dramatically differ across sectors. We did find evidence that companies in technology and innovation-intensive competitive sectors are the ones seemingly having the greatest success in transforming research results into products, processes and technical knowledge.

Recommendation 4. *The current setup of the Framework Programmes carries the risk of occasionally being dominated by large companies in oligopolistic sectors – whether technology and innovation-intensive, or not. Enhance the role of SMEs in the strategic development of the Programmes.*

Large companies did not appear to join FP projects in the hope of direct benefits in terms of innovation and knowledge creation. Their reported interest is much more indirect, concentrating in networking and opening up horizons in new (for them) technical areas. Could there be other reasons why they may participate?

A very extensive literature in industrial economics has studied for some time the strategic use of various mechanisms by private sector firms to prevail over their competitors (extant or potential). *Preemption can be achieved in various ways: creation of standards, partner lock, IP lock, market exclusion, etc.* What is important to notice is that the mechanisms mentioned here can be part of consortia of the type supported by the Framework Programme. The establishment of standards that exclude the technology of a competitor is a classic mechanism of firm predatory behaviour. Several FP projects, and especially the larger ones such as those promoting technology platforms, are set up to create some sort of technology standards. There are good arguments for setting up such consortia. There are also good reasons to be careful with them.

Partner lock is another mechanism of pre-emption. In this case, one attracts to its camp just about everybody who could work productively with the competitor. The pre-empting company essentially pulls the rug under the feet of the competitors who then run out of options for collaboration. IP lock is something similar: one attracts to one's network just about everyone else who has important pieces of intellectual property defining an area, thus effectively blocking out the competitor firm with a 'war chest' of patents, copyrights, trademarks, and trade secrets. Finally market exclusion refers to the practice of attracting to the network partners with preferential market positioning who then leave little room for manoeuvring to the competitor.

As everything in life, R&D collaboration can have two faces. Given the relatively peripheral importance of any single FP project to large companies in terms of knowledge generation and innovation, it is only easy to imagine such companies being attracted to these projects for such reasons. Vigilance is recommended.

Recommendation 5. *The role of the traditional IP protection mechanisms (patents) as a general instrument to promote innovation per se is generally low and highly depending on the thematic area and the specific market. Industry effects should be taken into account.*

The merits of traditional IP protection mechanisms, namely patents, for protecting intellectual property was neither dismissed by the subjects of this study nor particularly emphasized. This simply reiterated the findings of a long series of empirical studies going back at least 2-3 decades which have emphatically demonstrated that the act of taking patents by companies across sectors is not necessarily justified by their effective use in protecting IP. [It is rather justified as a competitive tool.] Our subjects use other ways to protect IP which in rapidly moving high tech sectors might be more effective, such as accelerating along the learning curve, trade secrets, keeping (or hiring away) important employees, and so forth. That being said, formal IP protection mechanisms are necessary for collaboration as they provide some level of protection to the smaller, weaker members of the consortium. Moreover, the important differences among sectors in the use of formal IP protection mechanisms should not be overlooked. The recommendation is to continue promoting the awareness of FP participants for formal IP protection mechanisms without disregarding the fact that there are limits to what these mechanisms can achieve.

Recommendation 6. *Perceive the individual FP R&D project for what it really is: a single research instance among many for a participating organization. Do not expect huge impacts from individual projects either on innovation or on the 'behaviour' of the participating organizations.*

Often debates about the potential impact of public R&D programmes are based on outright false (inflated) expectations regarding the importance of the funded projects for the participating organizations. The truth is typically very different. The importance of the individual project to a participating organization will be limited by the extent to which this project is the only one, or one of very few projects, that this organization has in the specific field. Frequently an FP project is simply one piece of the strategic R&D puzzle of larger organizations. Large companies with well-defined research strategies and multi-faceted innovation strategies will not be willing to change them extensively in order to carry out one or more FP projects. FP funding provides only a small contribution to their research budgets, anyway. This is not to say that such companies do not have an important role to play in the FP: their 'systems' capability, extent of market reach, and scale of operations can be instrumental in driving important innovations. Their coordinator role in large projects can also be decisive. But nobody should expect extensive 'behavioural additionality' contribution of the Programme *vis-à-vis* these firms. Smaller companies, on the other hand, will associate with specific FP projects much more closely given that the funding will account for a much larger percentage of their total R&D resources. Again, however, they will be willing to align closely only if the specific FP project fits well with their technology and innovation strategy.

The misrepresentation (inflation) of expectations is compounded with the classic problem of 'attribution': one of the most difficult tasks for a research-intensive organization is to disaggregate the effects (contribution) of various research projects on an innovation. This is due to the public good nature of knowledge and the rampant externalities and cross-pollination across people, projects, organizations, sectors and countries. It is also due to the fact that companies do not consider R&D projects in the same way policy makers do. Companies think of the final target – the innovation – and try to do whatever it takes to get there. Public policy makers think of the cost and characteristics of the individual projects that they support and have a burning desire to attribute, if possible, all benefits to that project.

Nothing from the above means that FP projects are not important. They are very important, not least because they are frequently a link in a long chain of research. The strength of the chain is always limited by its weakest link. What is meant, instead, is that policy decision makers must occasionally make an effort to view these projects also from the perspective of the innovating organization.

Recommendation 7. *Small and medium-sized enterprises indicate more positive results in terms of innovation in FP projects and seem more susceptible to the Framework Programmes as a policy instrument than their larger counterparts. They may deserve more attention on that basis.*

Not only did we find that SMEs tend, on average, to identify more closely with the project, but medium-sized companies apparently benefit the most in terms of gaining products and processes out of their FP experience. We also reiterated the old observation that SMEs suffer primarily from the inflexibilities of the Programme, the bureaucratic requirements, and the enhanced organizational costs of participation. Putting these two together would imply that an administratively complicated Framework Programme drives away first the participants that it wants the most as far as innovation on the basis of the research results is concerned.

SMEs should be constantly encouraged and, if necessary, treated differentially – for instance, with respect to administrative costs for both the proposal and the research project itself.

Recommendation 8. *For successful innovation, collaborative research consortia should include one or more of the following types of partners:*

1. *one or more partners with strong research and innovation experience;*
2. *highly motivated partners that may either be smaller companies that depend highly on the specific project and/or new participants;*
3. *experienced, motivated coordinators who manage to align the diverse interests of the various partners with the needs of the collaborative research project.*

The importance of all these three factors was strongly supported by the available evidence in this study. None of them is surprising or hitherto unknown to economists and business analysts but it is important that they surfaced again as factors to keep an eye on.

We do not recommend using these factors in the strict sense of the term to modify the project selection criteria. We do recommend that they remain visible to FP project selection committees that may decide, in their discretion, to use them in order to differentiate among research projects of fairly comparable research quality.

Recommendation 9. *Encourage commercialisation thinking at the proposal stage. Possibly provide the opportunity to innovators for a follow-up stage – or a follow-up project – where the commercialization of the research results is the core priority.*

Projects which indicate a strong focus on commercialization from the outset have, on average, significantly higher possibilities of success in terms of product or process innovation and the production of marketable knowledge. However, and as a result of the basic priorities of the Framework Programme as discussed earlier, this is not the case with many of the FP projects that this study examined where the exploitation of the research results often comes as an afterthought at the closing stages of the project or even later. Needless to say, there are differences between thematic areas in this respect – largely reflecting the differences of the science fields and the product markets involved (notably certain concentrations of the IST thematic area).

One may draw a lesson here from good practice in various countries whose programmes prioritize the commercialization of R&D results. The Small Business Research Innovation (SBIR) programme in the United States, and its variants implemented now in several EU country members, such as Sweden, the Netherlands, and the United Kingdom, may have important lessons here. The SBIR programme provides funding for very risky research by small companies in stages, including proof of concept, product/process prototyping, and commercialization. The third stage is considered very important, yet it is not subsidized by the programme. The idea for Europe may be one of two: either implement a follow-up stage to funded R&D projects focusing on commercialization; or create follow-up sources of funding where winners of FP project awards can apply for additional funding especially linked to commercialization of the results of the award. A further lesson of the SBIR here is procedural: companies are funded stage by stage, i.e., they compete for all three stages. However, there is some sort of 'fast track' procedure in the sense that failure rates for obtaining phase I award is much higher than the failure rate for phase II award and similarly for phase III. In the European context this might translate into a follow-up programme like the CIP where the project selection criteria may 'favour' to some extent applicants who have previously won an FP project award.

Recommendation 10. *Promote projects that are risky, technically complex, and in new areas.*

As discussed in Chapters 2 and 7, precompetitive, exploratory research is not antithetical to innovation within a fairly short time period. We find strong evidence that the nature of a project, in terms of being risky, exploring a new technological area, or being scientifically complex, influences project success in important ways. The degree of risk affects positively both product innovation and knowledge creation, but in both cases the degree of project risk is exhibiting an inverse U-shaped relationship to the dependent variables: excessive risk appears to lead to diminishing returns as regards the likelihood for product innovation and knowledge creation. Exploring a new technological area has a positive effect on process and negative effect on product innovation. Technical complexity is positively linked to process innovation.

Compared to the average R&D project of industry, FP projects were reported to be more complex, more long-term oriented, and somewhat riskier from a scientific and technical point of view. FP projects were reported similar to the average R&D project in terms of commercial risk.

Moreover, we find that when the project idea is generated by industrial partners there is a positive effect on knowledge creation. This makes sense since those who generate the basic ideas for projects tend to end up as project coordinators and, thus, have decisive effect on project implementation. To the extent that industry is more attuned to commercialization than research institutes or universities, formulating the original idea at a firm should increase the likelihood of commercialization. It may be important here to note that we also found a gradual shift in the origin of the core ideas away from industry and towards research institutes and universities as we go from FP 5 to FP 6.

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