



# Final Report

<b>Document title:</b>	Final Report
<b>Reference:</b>	Task 3.1
<b>Version:</b>	7
<b>Status:</b>	Final Approved
<b>Date:</b>	08.05.2008
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<b>Changes:</b>	
<b>Reason for Changes:</b>	
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## Executive Summary

The Innovation Impact (INNO IMPACT) study 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 5<sup>th</sup> and 6<sup>th</sup> 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 5<sup>th</sup> and/or 6<sup>th</sup> 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;
- 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.<sup>1</sup>

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

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<sup>1</sup> 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.

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 and 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 5<sup>th</sup> and 6<sup>th</sup> 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. Other 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.*

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## 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 5<sup>th</sup> and 6<sup>th</sup> 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 how 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)

The study has been carried out over the course of 20 months by an international consortium of European research teams under the guidance of a highly qualified High Level Advisory Group.

### 1.2 Rationale, Background

The rise of the global knowledge-based economy during the past several decades has brought important developments and raised fundamental questions for governments challenging conventional wisdom regarding growth and social well-being. A number of widely publicized documents in Europe during the past few years have tried to capture these developments and place a call for action.<sup>2</sup> The following excerpt from the last five-year assessment of the European Research Framework Programme is characteristic:

“[T]he overall European economic and research landscape is in flux. Global knowledge-based competition is changing fundamentally the environment in which European research and industry operate. Europe and the rest of the industrialised world can no longer take their technological leadership for granted. Whilst Europe still maintains leadership in certain industrial areas, supported by a well-educated workforce, concern about the future arises from the rapid expansion of European industry research and technological development and demonstration (RTD) outside Europe and the inability to attract the best talent into Europe from around the world. The increasing availability of high-quality, industrially relevant knowledge, efficient innovation environments, and easier access to markets outside Europe are contributing to a gradual loss of European competitiveness.” (Five-year Assessment, 2004, p.i)

The old industrial economies of Europe have appeared especially vulnerable in this global environment, reflected in a gradual loss of competitiveness vis-à-vis their main peers as well as newly industrializing countries. A continuous parade of commentators have kept arguing that the performance of some of Europe’s core economic powers, in terms of growth, productivity and job creation is not sufficient anymore to maintain rising levels of prosperity in the future. In some important way, the European core economies seem less than fully prepared to manage the rapid processes of economic renewal and structural change necessary for maintaining and raising the standard of living in an increasingly competitive global economic environment.

The broad consensus is that research, education and innovation are at the heart of any response to these challenges. Policies for improving the innovation system have become a major focus for governments in most member countries and regions, as well as for the European Union as a whole.

<sup>2</sup> 5-year Assessment Report (2004), Aho Report (2006), Sapir (2003), Kok (2004), 7<sup>th</sup> Framework Programme for RTD, etc.

In this context, INNOIMPACT, together with its sister study IMPLORE, have concentrated on the impact on innovation of one of the pillars of the European system of innovation: publicly-funded research programmes. INNOIMPACT has specifically focused on an important slice of such public programmes: the Framework Programmes for Research and Development. 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 present study is, thus, not an appraisal of the overall innovation system in Europe, but rather 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*,<sup>3</sup> 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<sup>4</sup>) 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 5<sup>th</sup> and 6<sup>th</sup> Framework Programme for Research and Development.

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<sup>3</sup> The core objective of the Research Framework Programmes has been the strengthening of the European research system as a whole.

<sup>4</sup> 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

### 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.

The focus of this Report is exclusively on collaborative R&D schemes as vehicles through which two or more organizations join forces to develop new knowledge that can be applied to innovative products/services and processes. The exclusive emphasis on collaborative R&D reflects the funding schemes supported by the European Framework Programmes on RTD.

For this purpose, 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.

#### ***2.1.1 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.

March (1991) described exploration as 'experimentation with new alternatives' having returns that 'are uncertain, distant, and often negative' and exploitation as 'the refinement and extension of existing competencies, technologies, and paradigms' exhibiting returns that 'are positive, proximate, and predictable.' He thus concluded that 'the distance in time and space between the locus of learning and the locus for realization of returns is generally greater in the case of exploration than in the case of exploitation, as is the uncertainty' (March, 1991: 85). Later, Levinthal and March (1993: 105) defined exploration as 'the pursuit of knowledge, of things that might come to be known,' and exploitation as 'the use and development of things already known'.

Viewed in this light, 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.

This conceptual distinction between exploration and exploitation capacity helps explain why certain collaborations are more efficient than others in using knowledge and producing marketable R&D 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 commercialize their R&D output successfully.

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:<sup>5</sup>

- 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),

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<sup>5</sup> For a more analytical description of this framework, including the explanation of its constituting components, the several development paths, and the factors determining its evolution and success from initial formation activities to the final phase of commercialization of research results, see the original background document “Critical Literature Review” (Spanos et al., 2006).

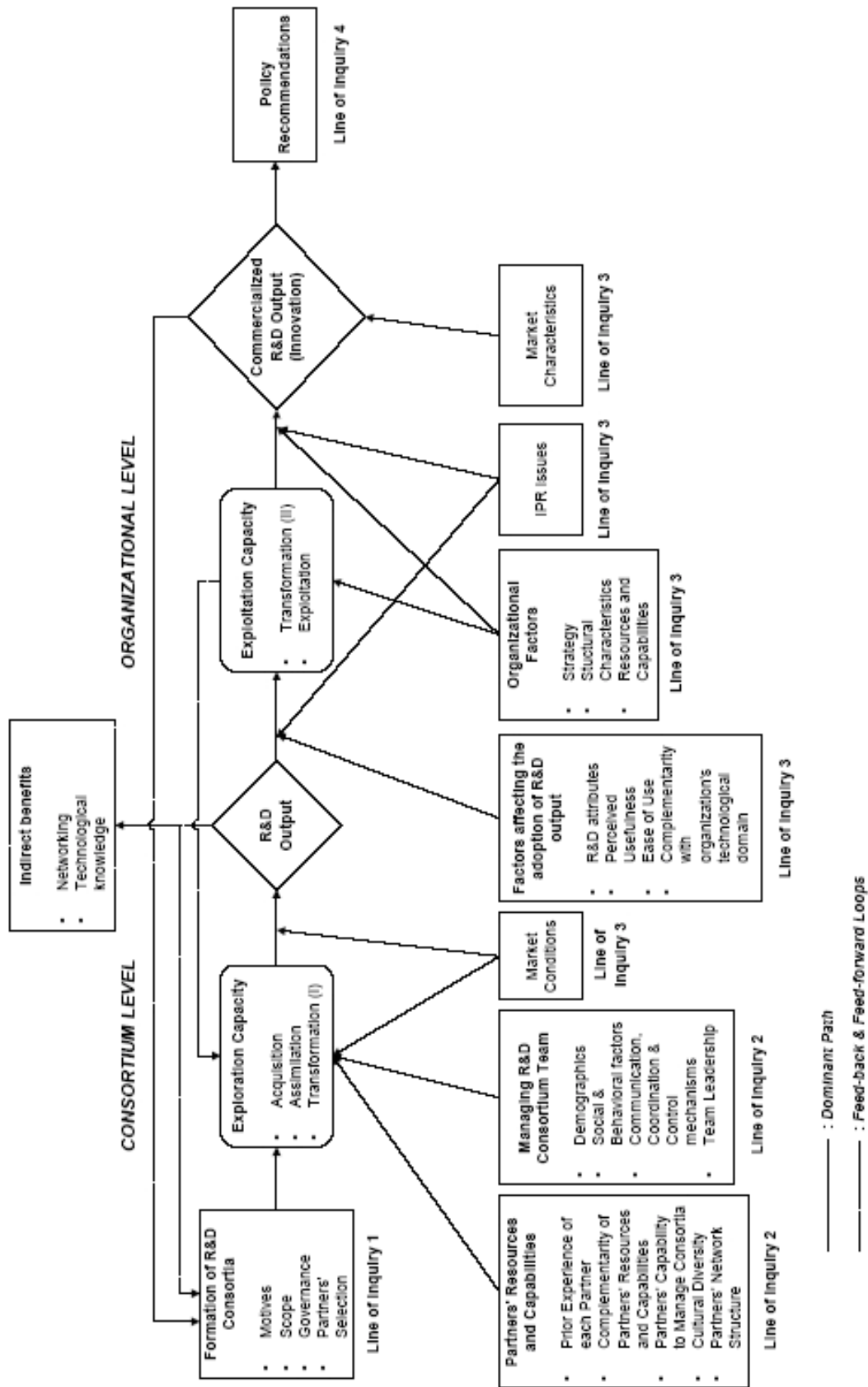
- Perceived characteristics of the R&D output (i.e., complexity, trialability, relative advantage, usefulness and ease of use),
- organizational factors (i.e., firm strategy, structure, resources and capabilities),
- R&D protection mechanisms (i.e., appropriability regimes), and
- Market conditions (i.e., technological shifts, government regulations, market structure, size and uncertainty).

### ***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. Exploration is notionally linked to long-term research leading to radical innovation, the “big ideas” that form the basis of blockbuster products and changes in technological paradigms.

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.

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



Research in the Framework Programmes has traditionally been described as “precompetitive”. The term has been perceived to mean research that falls between basic and near market. 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 – in terms of programme efficiency – 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, relatedly, between market concentration and innovation.<sup>6</sup> 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. 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.

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<sup>6</sup> 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, 3<sup>rd</sup> ed., The MIT Press; Gerhard Rosegger (1996) The Economics of Production and Innovation, 3<sup>rd</sup> ed., Butterworth-Heinemann; and Jan Fagerberg, David C. Mowery and Richard R. Nelson (eds.) (2005) The Oxford Handbook of Innovation, Oxford University Press.

#### **2.1.4 Cognitive Distance, Absorptive Capacity and the Innovative Performance of R&D Consortia<sup>7</sup>**

Resource heterogeneity provides a clear potential for learning and innovation, a potential that can be effectuated by collaborative R&D agreements. 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.

Resource heterogeneity can be perceived in terms of the cognitive distance between the partners that hold these resources. In the relationship between cognitive distance and innovation 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.

Based on such reasoning, Nootboom (1999) has advanced the argument of an inverted-U shaped relationship between cognitive distance among partners and innovation. The challenge is to find partners at sufficient cognitive distance to tell something new, but not so distant as to preclude mutual understanding.

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.

## **2.2 Methodology**

We have chosen a variety of analytical techniques combining quantitative and qualitative approaches 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. The data utilized in the study is described in Section 2.3 below.

Three types of analytical approaches were pursued:

- Empirical analysis based primarily on the information obtained from the extensive survey of FP participating organizations. This was largely based on econometric techniques, such as factor analysis, logistic analysis and OLS,
- Tabulations of the answers to the survey,
- Qualitative analysis of a large number of case studies of FP participants.

Regarding the empirical analysis, the example below indicates the general approach to hypothesis formulation and linkage to the quantifiable information obtained from the survey of FP participating organizations.

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<sup>7</sup> The argument in this Section is based on Bart Nootboom, 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 Nootboom (1999) Inter-firm Alliances: Analysis and Design, London: Routledge.

### 2.2.1 *Empirical Analysis Example: Innovation Impact of Project, Firm and Market Factors*

A core objective of this study is to identify determinants of the innovation impacts of publicly funded R&D projects along three broad directions, namely project, firm, and market-related factors. We may think that, to some significant extent, the determinants refer to the ways a project is managed (RQ5 & RQ6), the resources, experience and capabilities of partners (RQ7), and market characteristics (RQ8) (Section 1.1).

Innovation impact comprises the following specific dimensions in this study: a) *project outputs*, including knowledge, technological, and networking outputs; b) *project impacts* resulting from those outputs, which again are classified in the same sub-dimensions as before; c) *commercial exploitation outputs*, which represent concrete commercialized results such as a new product or a new technology as a final product of the project; and d) *commercial impacts* resulting from the exploitation outputs, for example increased profitability or market share.

In addition to these, we include two further dimensions of project performance that, both theoretically and pragmatically, are closely related to the aforementioned innovation impacts: e) *project-team performance* and f) *“nature” of research results*. The former refers to the “immediate”, direct level of satisfaction with the performance of the team engaged in the project. The latter refers to the character of the technological outcomes of the project (i.e., a new technology or product, *irrespective* of whether this outcome is eventually commercialized or not), characteristics such as the extent to which the technology is unique relative to existing technologies, the extent to which it is easily imitable, and so on.

We seek to identify determinants of project success along the dimensions of market, firm, and project-related factors. In addition, we also examine the effects of aspects related to the commercialization process of a research result and the attributes of the research result *per se*.

With the term ‘project-related factors’, we refer to “structural” features, such as the thematic area into which a given project belongs, or the size of the consortium that has undertaken the research work, as well as to management aspects of the project. These 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. The basic theoretical rationale as to the influence of these factors on project success is that how a project is managed will necessarily have a bearing on its outcomes. For example, mistrust and lack of effective communication among partners will logically inhibit the degree of knowledge sharing among them, thus leading to ineffective project execution, and ultimately in failure to achieve project objectives.

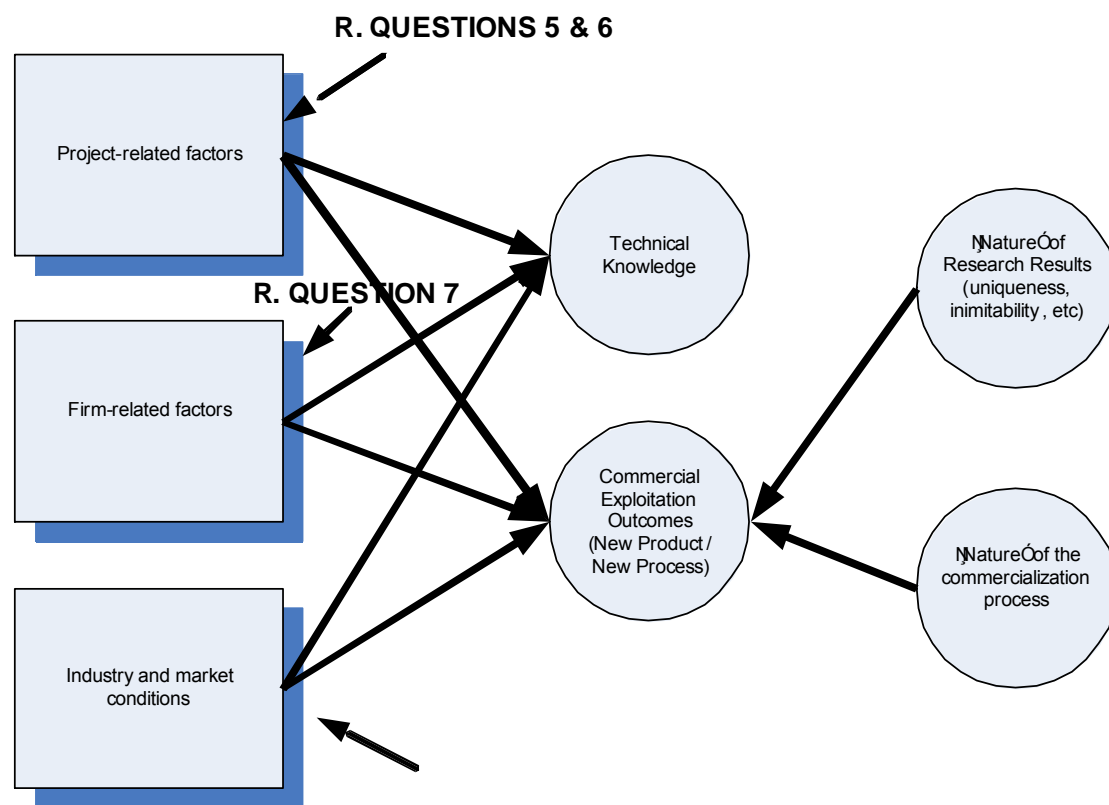
Firm-related factors pertain to the resources, experience, and innovation-related competencies of the partners involved in the project. More specifically, in this category we include factors such as firm size and age, previous experience in innovation activities, resources and skills for innovation, etc. It is important to note at this point, however, that the data we ultimately use for our analyses (see below) 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.

Market-related factors, on the other hand, 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 in project success.

The likelihood that a project results into product or process innovation is theoretically also influenced by two additional factors. First, it is affected by the character of the commercialization process and the ensuing difficulties. Serious problems during commercialization as well as the mechanisms employed for collaboration will likely affect the odds of the project ultimately producing results for the participant. Second, the attributes of the research result *per se*, such as whether it is unique technology or one difficult to be imitated, will naturally have a bearing on the chances for final commercialization of a new product or process technology. Commercialization factors and the nature of research results are only relevant for product/process innovation.

The following diagram depicts schematically the relations implied by the arguments above, summarizing the logic of the econometric analysis on the basis of the survey data of participating organizations (Section 5).

**Figure 2.2: Conceptual Model**



### 2.2.2 Qualitative Analysis (Case Studies)

The case study analysis has been a very important part of the study as the cases inform most of the research questions, providing deeper explanations, vivid illustrations from the reality of the RTD projects, and insights into cause-effect relations beyond what can be achieved from the quantitative analysis.

The cases were conducted using a very detailed interview guide that was standardized across all cases and complemented by a table synthesizing the major findings categorized along a range of indicators identified in the literature review. Findings were initially written down along the sections and questions of the interview guide, and then the key issues were

extracted and reported in the indicator template. This double reporting scheme facilitated cross comparisons on the particular questions and also enabled the identification of the more complete story behind the findings.

In addition, each case study also comprised an overview of the company / organization, its RTD activities and background information on the selected project. For this information we used secondary information sources including organization and project websites, official documentation and media sources.

Selection of the case studies followed the criterion sample strategy (Miles and Huberman, 1994; Eisenhardt, 1989; Eisenhardt & Graebner, 2007). This ensured that out of the sample of organizations having engaged in FP5 or FP6, studied organisations fulfilled a certain number of criteria that enabled controlling for contingency factors critical for defining the limits of the study and its findings (criteria 1-3 below), *and* it enabled replication and extension of the emerging findings with respect to the research questions, until theoretical saturation (criteria 4-5 below). These criteria were:

1. Be representative for one of three categories manufacturing company, service company or research institute – controlling for variation in innovation goals, innovation strategy, innovation process and innovation focus;
2. Be representative for the different geographical areas of the EU, north, south, east and central, as well as displaying balance between smaller and larger countries and new member states – controlling for specific spatial / environmental conditions;
3. Be representative for the different instruments within the Framework Programmes – controlling for variation in their structure and efficiency with respect to innovation outputs;
4. Consider participation in EU-funded RTD projects as an important endeavour. This controls for the theoretically sampled strategic importance of RTD in general and EU-funded RTD in particular - enabling a replication and extension logic of the findings;
5. Have an explicit experience and story to tell about an EU-funded RTD project and the extent to which it contributed or not to innovation (product / service or process innovation) and indirect effects in terms of knowledge and competency development. This controls for the theoretically sampled importance of integrating exploration and exploitation logics in the RTD process - enabling a replication and extension logic of the findings.

In addition, the cases were defined to cover both SMEs and large sized organizations.

Using the CORDIS database and the gradually incoming questionnaires, lists of potential case study organizations were generated in each country and a large number of contacts were made with organisations ensuring fulfilment of the above criteria. Even though the intention of the present study was to analyze both successful and unsuccessful projects, there is a natural self selection bias in the case study sample towards successful projects. This is for the simple reason that the respondents contacted and indicating a low satisfaction basically were not interested to "waste more time" on the project in question.

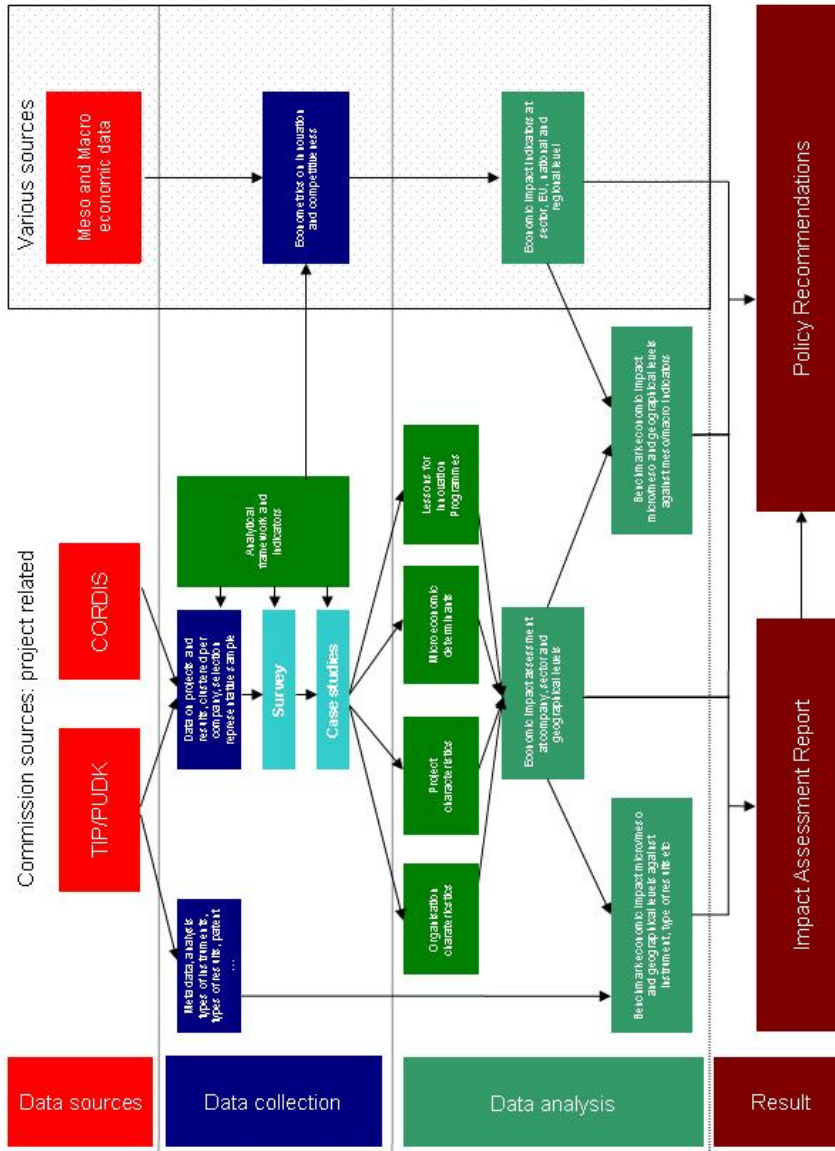
## **2.3 Data**

### **2.3.1 Introduction**

The study has used several data collection routes, including (1) desk research to support descriptive and empirical work (2) an extensive survey among FP participants where data has been collected to perform descriptive and econometric work and (3) case studies.

### **2.3.2 Main quantitative data sources**

Figure 2.3: Data sources and collection



2.3.3 CIS

2.3.3.1 Introduction

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, until now, 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)<sup>8</sup>.

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).

### 2.3.3.2 Justification

The Community Innovation Survey is the only source of data that enables the comparison of (innovative) firms that participated in EU Framework Programmes and (innovative) firms that did not. This is crucial when answering the question about “Characteristics and strategies of organizations in the Framework Programme” (LI 1). With the help of the CIS data we can compare the characteristics of Framework Programme participants to the characteristics of potentially innovative firms that did not participate in such programmes.

Furthermore when we want to investigate the eventual results of participation, in terms of innovation output or input additionality, we need to correct for potential selection bias. Participants in the Framework Programme could have very different characteristics from non participants and this could partly explain the differences in innovation output. This is a major advantage of the CIS data over the survey data that only contains FP participants.

### 2.3.3.3 Sampling methodology and merging CIS3 and CIS4

For the sampling methodology and the numbers of observations of the national CIS surveys we refer the reader to the relevant paragraphs in the following pages.

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.

### 2.3.3.4 Questionnaire routing

The routing of the CIS questionnaire is such that firms that answer negatively to all so-called filter questions on innovation do not have to answer much of the remaining questions, including the question on research and development (R&D) expenditure and questions about public funding of R&D. This means that in our analyses on the impact of Framework Programme participation (Section 5.3.1) we are obliged to work with the restricted sample of firms that can be characterized as ‘innovators’.

<sup>8</sup> 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

## 2.3.4 Survey

### 2.3.4.1 Justification

The database used for the survey is CORDIS (Community Research & Development Information Service), which is the main information service that keeps up-to-date with European Community activities and initiatives in the field of Research & Development (R&D) and Innovation. CORDIS 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.).

### 2.3.4.2 Sampling methodology

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 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.<sup>9</sup>

A sample of 54492 organisations was thus selected. Of these, 38375 (70.42%) were selected for FP5 and 16117 for FP6 (29.58%).<sup>10</sup> These organisations received the invitation to participate in the survey by post.

### 2.3.4.3 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.

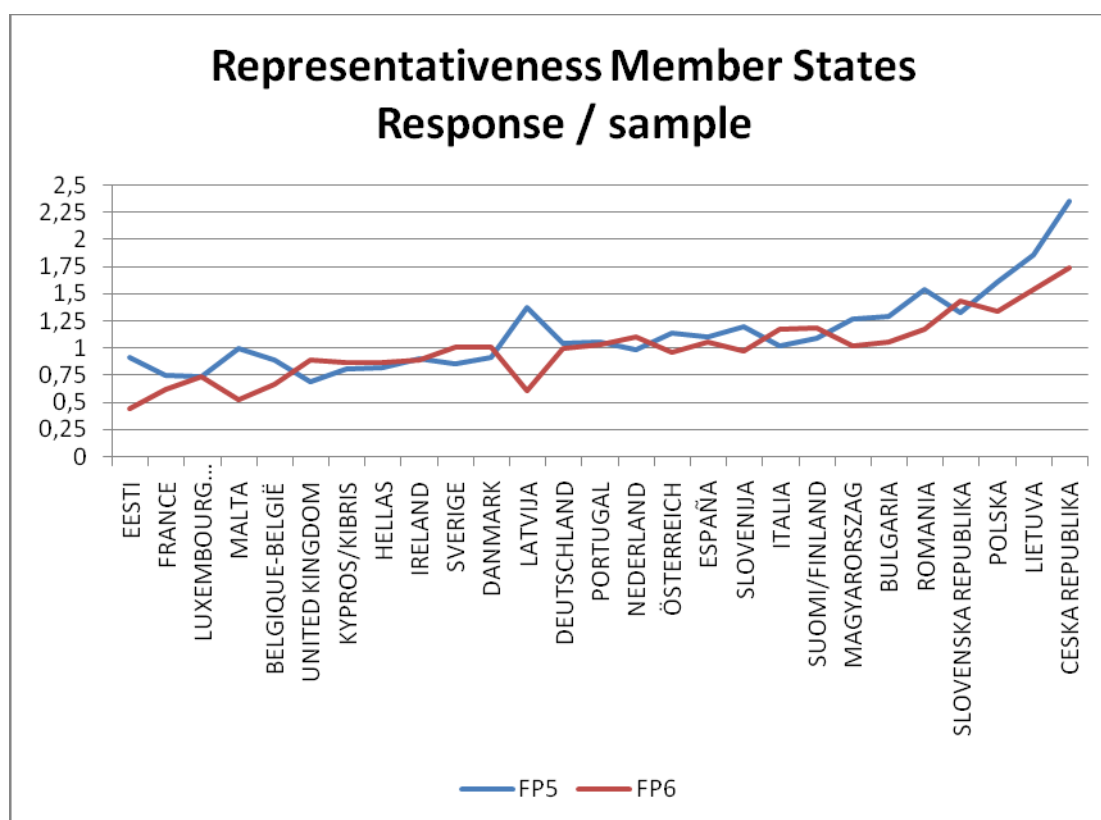
More interesting however than the absolute numbers is the representativeness of the response. Our analysis shows that the majority of countries fall within the 0.75-1.25 bracket of responses compared to the sample (1 is an optimal representation), which is very satisfactory and shows there is little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

The new Member States seem to have been more diligent in responding to the questionnaires, the majority of them having a higher response rate than 1, with the Czech Republic scoring highest. This however does not bias the total result of the survey since the new Member States have relatively fewer projects than the larger countries. The response rate for FP5 and FP6 per Member State follows the same pattern for most countries, with the notable exception for Estonia and Latvia who both have significantly lower response rates for FP6.

## Figure 2.4: Representativeness Member States Response / Sample

<sup>9</sup> This was done in order to decrease the possibility that large organizations dominated the survey and thus bias the results.

<sup>10</sup> 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.



#### 2.3.4.4 Representativeness of sample and responses FPs, Instruments and Thematic areas

Of the 54 492 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.

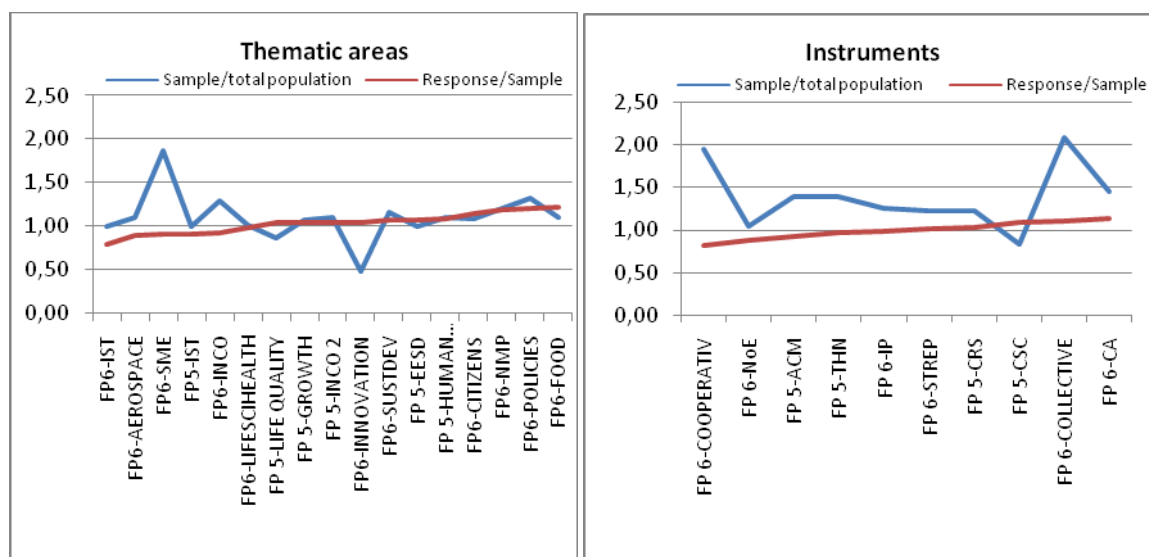
**Table 2.1: Representativeness total sample per FP**

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

The overall representativeness per Thematic Area and per theme is high across the board, especially for the main areas and instruments. Annex 3 gives a more detailed overview of the representativeness. 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<sup>11</sup> (described above).

#### Figure 2.5: Representativeness FP 5 and FP 6 Thematic areas and Instruments

<sup>11</sup> 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



### 2.3.5 Non response analysis

#### 2.3.5.1 Approach

Although the response to the questionnaire has been relatively high in percentage (over 15%), high in absolute numbers, and as shown in the previous paragraphs is highly representative in terms of coverage of the FPs, the thematic areas, the instruments and the participating organisations, there is a risk (as in any survey) that the response is still biased. In this survey there could have been a response bias towards more successful projects, since the subject of the study and the survey is innovation and impact, which might have discouraged less successful project participants from completing the survey. This could obviously bias the results of the survey and require a qualification of those results, which would need to be taken into account in the conclusions and eventually the policy recommendations that can be drawn from them.

An analysis of the non respondents of the same sample is an accepted way in which the potential bias can be tested. Eurostat recommends for the non response analysis in the Community Innovation Survey<sup>12</sup> as follows:

«If non-respondents, as an unweighted percentage of all relevant enterprises in the sampling frame, exceed 30%, then a simple random sample of **at least** 10% of the non-respondents (excluding non-relevant enterprises) should be selected. »

In this study we have adopted the recommended Eurostat methodology. The key question of the study is whether the project participant has effectively produced an innovation output of the project. This question mainly relates to the enterprises that have participated in the Framework Programmes, the universities and research institutes were presented with a separate questionnaire in which this question (for obvious reasons) was not asked in the same way. Therefore we have decided to limit ourselves to a non response analysis of enterprises.

A non-response analysis normally collects information about “structural” features of those who did not respond at all. In other words, we would need to know if there are any systematic reasons behind non-response independent of whether or not they innovated as a result of the project.

<sup>12</sup>

The Fourth Community Innovation Survey (CIS 4), Methodological recommendations, (In accordance with section 7 of the annex to the Commission Regulation on innovation statistics No 1450/2004)

Given, however, that the entire sample is **representative** of the entire population, we have limited ourselves to two questions in the non response analysis:

- 1) The reason for not participating in the survey: not received information, no time, person in charge has left, project was a failure, etc.,
- 2) information about the dependent variables, i.e., product innovation, process innovation, and aspects of technical knowledge.

Other potentially relevant information (e.g., thematic area, size of the consortium, number of partners from industry and academia, etc.) on all participants are already present in our sample database.

#### 2.3.5.2 Implementation of the non response survey

For the non response analysis we used two sources: the feedback from the follow up at the end of the survey period (around 15500 phone calls made to invited respondents, see above) in which people were asked why they had not yet responded, and a dedicated non response survey after the survey had closed. The first set of data only included feedback for the question why people had not responded, whereas the second also included the question on commercialisable results from the project.

Of the 15500 calls, the majority of people answered that they were in the process of completing the questionnaire, no feedback or unclassifiable feedback was recorded.

#### 2.3.6 *Findings from the non response survey*

Based on the 288 responses of those enterprises (manufacturing and services firms) that did not respond in the survey, the next Table shows the main reasons for non response. As can be seen from the Table, the vast majority of respondents indicated either that they did not receive information about the survey or stated “other” reasons. “Other”, in our context, basically translates in different versions of the statement “too busy to respond”. A very small number indicated that the questionnaire was “too difficult or complex to answer”. None of the respondents falling in this category provided any indication that non response was due to negative or no-results stemming from the project in question. Only four respondents said that non response was the result of “bad experience”; those were related to experiences in the project itself, either in terms of project failure, the process or the cooperation, in some cases projects had never been funded or participants had not received their money.

**Table 2.2: Reason for not responding**

<i>Reason for not responding</i>	<i>Non response survey</i>		<i>Follow-up</i>	
Bad experience	4	1.39%	35	0.67%
Don't respond to surveys	15	5.21%	137	2.63%
Did not receive info	121	42.01%	4637	89.17%
Other	108	37.50%	22	0.42%
The person has left	40	13.89%	369	7.10%
<i>Grand Total</i>	288		5200	

These results are generally in line with reasons for non response emerging from the follow-up survey, which – as noted above - was carried out during the later stages of the main survey as a means to increase the response rate. As can be seen from the Table above, the vast majority of respondents indicated that they had not received any information about the survey.

Taken overall, these results provide **no** indication that non response in the original data collection exercise was related to bad experience/project failure.

Turning to the issue of item non response, that is, to non response related to the dependent variables used in our analyses, we asked respondents in the follow up survey to indicate

whether *their organizations* had obtained innovative outputs from their participation in the focal FP project (i.e., Q32 of the research instrument). Out of the 288 respondents, 215 answered this question, and the results are shown in the next Table. With respect to product innovation, the majority of respondents (55%) indicated that their organizations had indeed benefited from participating in the project. The same holds for the remaining commercial exploitation outputs, with new or improved processes and services being the most important benefits (70 and 68% respectively).

**Table 2.3: Results**

<b>Results</b>	<b>Non response survey</b>		<b>Original survey</b>	
	Yes	No	Yes	No
New or improved Products	55%	45%	50%	50%
New or improved Processes	70%	30%	36%	64%
New or improved Services	68%	32%	48%	52%
Implementation of Field Trials	63%	37%	44%	56%
New or improved Standards	58%	42%	25%	75%

Comparison of the above mentioned results with the findings from the main survey (see next Table) shows that, *on average*, our analysis sample comprising manufacturing and services firms was less successful than the non response sample. Hence, it could be argued that if our analysis sample was indeed biased, it was in the opposite direction relative to what one might expect. For example, whereas in the non response sample 30% of respondents indicated no innovation in production processes as a result of project participation, the same percentage in the analysis sample was more than double, i.e., 64%. Simple inspection of the corresponding percentages in Tables 2.2 and 2.3 shows that this pattern holds true for all possible output categories. Obviously, these figures are not directly comparable, mainly because of the very large difference in the respective sample sizes (i.e., 1342 respondents in the original sample and only 215 in the non response survey); the fact remains, however, that there is strong indication that the sample on which our reported results is based appears to be less successful than the non-response sample. Put differently, if there exists evidence of over-representation in the analysis sample, it is not of projects that are successful, but instead, of projects that are “failures”.

To summarize, 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.

### 3 Organisation characteristics<sup>13</sup>

#### 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.

The first question (who participates) is analysed along firm characteristics extracted from the Community Innovation Survey, which allowed us to compare participants with non participants. Although these data are restricted to three countries (reasons are provided in the following paragraphs) and to enterprises, this analysis gives insight into the types of organisations that participate, their innovation and R&D profile and what the effect of participation seems to be on those firms, compared to those not participating.

The question why do organisations participate is based on the results from our survey and the case studies. Organisation characteristics, such as type and size, are related to the different objectives, and the objectives are related to the actual (stated) achievements. Chapter 4 also looks at the objectives to participate but at the level of project rather than the organisation characteristics.

The final question (how are organisations participating,) is also based on the results of the survey and the case studies and is split in two parts: the strategic considerations for an organisation (including the way project results are protected) and secondly the way portfolios of different projects (new FP instruments, 'old' instruments, and self funded projects) are being managed by different organisations.

#### 3.2 Framework Programme participants versus non participants

##### 3.2.1 Introduction

In this paragraph, 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 are interested in products new to the market (rather than new to the firm). 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 say something about 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 have to correct. Therefore, we first estimate a "selection equation" that informs us about typical properties of firms which participate in FPs. Subsequently, we use the information from the selection equation for correction of our estimates that explain the innovativeness of

<sup>13</sup> This chapter is based on contributions of TUD: Alfred Kleinknecht and Ronald Dekker, Intrasoft: Robbert Fisher Anders Gjoen and Babis Ipeksidis, and Beta: Mireille Matt and Laurent Bach

firms. A possible outcome can be that participants in FPs are (or are not) more innovative, due to participation.

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 Data requirements**

The Community Innovation Survey (CIS) has, in recent years, allowed performing numerous innovation studies, which greatly enhanced our knowledge about innovation. The core questionnaire of the CIS includes a 'yes'/no' question on whether a firm participated in Framework Programmes. Unfortunately, the relevant question makes no distinction between FP 4 (1994-98) and FP 5 (1998-2002). Nor does it make a distinction by type of programme. We believe that, nonetheless, we can make an appropriate test as outlined above.

For the purpose of this study, we need to link CIS 3 (covering year 2000) with CIS 4 (covering 2004). Such a linking of two subsequent surveys allows having a time lag between the variable to be explained (i.e., sales of innovative products) and factors that influence innovative sales (e.g., R&D input, R&D collaboration, participation in FPs, etc.). At present, Eurostat has not yet realized the linking of CIS 3 and CIS 4. This forced us to search ourselves for access to CIS data in various European countries, using our personal network. In a few countries, we happened to succeed. We obtained access to linked CIS 3 and CIS 4 data in the Netherlands, in Germany and in France. Before starting with our test on the impact of FPs on innovative output, we first analyse the typical properties of firms that participate in FPs.

### **3.2.3 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. In the following, we take data from CIS 4 (covering year 2004) in the Netherlands, in Germany and in France in order to test what are the typical properties of FP participants. The table in Annex 3 covers our logit model estimates. The logit model is a probability model that is suitable for analysing discrete variables. The simplest version of the logit model can be used for the analysis of binary variables, for example: 'yes'/no' answers. In the table below, the model informs us about factors that influence the probability that a firm would answer 'yes' to the question: 'Did you participate in a Framework Programme?' A z-value of around two or higher indicates that a coefficient is large enough to be considered significantly different from zero. Our estimates are summarized in table 3.1 (Annex 3).

As to R&D collaboration, 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.

Summarizing, we can say that participants in FPs are better-networked innovators, although, in the Netherlands and Germany they are less networked than we had a priori expected. As expected, larger firms have higher probabilities of being involved in Framework Programmes.

Many larger firms are likely to possess market power leading to monopoly profits that allow financing of substantial R&D facilities over longer periods. It therefore comes as no surprise that participants in FPs 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, which allows spreading the fixed (and often sunk) costs of R&D over larger markets.

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. Confronting innovative output to patenting activities, Brouwer & Kleinknecht conclude that firms that collaborate on R&D (with the same innovative output) have higher propensities of applying for patent protection. The most likely explanation is that they do not trust their partners. Before engaging into R&D collaboration, they want to protect their most precious knowledge.<sup>14</sup> One should therefore note that FP participants having higher numbers of patents does not necessarily prove that they are more innovative<sup>15</sup>.

### 3.2.4 Do PF participants have higher sales of innovative products?

Does participation in a Framework Programme of the EU have an impact on sales of innovative products ('first on the market')? As was already indicated above, it is not sufficient to check whether FP participants have higher than average sales of innovative products. As could be seen from the previous section, participants in FPs belong to the innovative 'elite' of Europe: they have R&D intensities above the average of their sector; they are large and export-oriented, etc. Seemingly, the FPs are picking winners. When analyzing the sales of innovative products of FP participants, we have to consider this self-selection effect explicitly. We have to 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, as they enjoy a number of advantages. First, they can share costs and risks. Lower innovation costs should enhance subsequent sales. Second, they can exploit complementary knowledge, which should save costs and shorten the time-to-market. Being earlier on the market should favour sales. Third, firms that collaborate can 'internalize' positive externalities; this implies that their collaboration partner turns from a competitor (or imitator) into a supporter of the new product, which should be favourable for sales. Finally, firms that collaborate should have a higher chance of determining a dominant standard. All this would lead us to expect that firms that engage in R&D collaboration should have (*ceteris paribus*) higher sales of innovative products than those who do it alone;
- 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 FP 4 (1994-98) and FP 5 (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 inno-

<sup>14</sup> Brouwer, E. & A. Kleinknecht: 'Innovative output and a firm's propensity to patent', *Research Policy*, Vol. 28 (1999), p. 615-624.

<sup>15</sup> For more information please check in Annex 3 Table 3.1

vative products in the year 2004. Perhaps this holds less for FP 5, but it should certainly hold for FP 4;

- 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. For example, in the food or clothing industry, life cycles may be quite short, while in aircraft construction, new models tend to be produced over many years. An industry with shorter life cycles will exhibit higher rates of new product introduction, and vice versa.<sup>16</sup> 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. This variable should also capture unobserved sector-specific influences on innovation. In a number of tentative estimates, it turned out that sector dummies became insignificant, once we included this variable.
- 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. Of course, we expect firms with above-average R&D intensities to also show sales of innovative products above sector average;
- 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,<sup>17</sup> 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, without necessarily performing R&D themselves. Second, we control for firms that underwent a major organizational change due to a merger or acquisition. The problem with these types of firms is that, due to organizational turbulence, the quality of data reporting in a survey may be poor.

Our results are summarized in Annex 3 Table 3.2. A number of observations differ between the three countries. First, industry average logs of sales of innovative products per employee are highly significant in the Netherlands and in France, but not in Germany. Second, the deviation of a firm's R&D intensity from the average of its sector of principal activity has a significantly positive influence on new product sales in the Netherlands, a weakly significant influence in France and is insignificant in Germany. Third, the 'demand-pull' variable is

<sup>16</sup> Explaining a firm's innovative sales, Brouwer & Kleinknecht found that life cycle length is indeed highly significantly negative. This confirms that the longer are the life cycles in a sector, the lower is the probability that a firm will have introduced new products and the higher are the shares of new product sales in total sales. See Brouwer, E. & A. Kleinknecht: 'Firm size, small business presence and sales of innovative products', in *Small Business Economics*, Vol. 8 (1996), p. 189-201.

<sup>17</sup> 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.

highly significant in the Netherlands but is insignificant in Germany and France. Fourth, firms holding valid patents in year 2000 have significantly higher sales of innovative products in the Netherlands, but not in Germany and France. Fifth, firm size does not make a difference in the Netherlands and France; in Germany, smaller firms seem to have higher sales of innovative products (significant at 10% level).

The following observations are consistent across the three countries:

- R&D collaboration with whatever partner (suppliers, clients, competitors or universities) has no impact on innovative sales in all the three countries;
- Not surprisingly, in all the three countries, a firm's innovative sales in 2000 are a strong predictor of innovative sales in 2004;
- Being part of a foreign conglomerate or having had a merger or acquisition has, in all three countries, no significant influence on innovative sales;
- Participation in FP 4 (1994-98) and/or FP 5 (1998-2002) has in both countries only little or no impact on innovative sales. This generally holds for other versions of our estimates, e.g., when taking simply a dummy variable for 'participation' or when using various types of interaction terms (e.g., firm's size times 'participation' or type of sector times participation).

One should note that, besides the versions documented in the table, we experimented with numerous alternative regression specifications in order to test the robustness of the results. These robustness checks were satisfactory. Most of the coefficients in the table changed only very little when adding (or omitting) some control variables or when defining them slightly differently.

While many outcomes are intuitively plausible, 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 FP 4 and/or 5 do not have more innovative sales than non-participants. In both cases, there are good reasons to expect that innovative inputs should be used more efficiently as firms that collaborate on R&D or participate in Framework Programmes have a number of distinct advantages:

- They can share costs and risks;
- They can use complementary knowledge;
- They can internalize each other's knowledge spillovers; i.e., the project partners are being turned from competitors (or imitators) into defenders of the innovation;
- They have a higher chance of determining the dominant standard in the market.

How does it come that we nonetheless find no significant effect of R&D collaboration or of FP participation on sales of innovative products? 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 FP 4 (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. This could also apply to somewhat exotic technologies such as nano technology or super conductivity where it is important to keep up with developments, although commercial use may be far away. In this case, cost sharing through collaborative research may be more than welcome.

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 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?"

**Table 3.1:** Answers on a five-point Lickert scale to the question: "How would you describe the specific FP project along the following dimensions in comparison to an average R&D project?"

Answers on a five-point Lickert scale to the question: "How would you describe the specific FP project along the following dimensions in comparison to an average R&D project?"					
	1	2	3	4	5
Project costs*	7.8%	17.9%	45.3%	20.7%	8.4%
Scientific and technical risk*	7.2%	19.7%	31.6%	30.2%	11.3%
Commercial risk*	13.0%	21.4%	29.0%	22.6%	13.9%
Scientific and technical complexity*	1.2%	7.1%	26.4%	43.9%	21.5%
Short-term vs. long-term**	2.7%	9.2%	35.3%	34.7%	18.2%
Core vs. peripheral***	16.3%	24.8%	33.1%	19.6%	6.2%
* 1 = low; 5 = high.					
** 1 = short term; 5 = long term					
*** 1 = in core tech. area; 5 = in peripheral tech. area					
Source: InnolImpact survey among FP participants.					

The table shows that, when 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 insignificant 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.

Independently of this, one can also investigate whether participation in FPs leads to extra R&D efforts. If it holds that subsidization of R&D through the Framework Programmes leads to extra R&D efforts, then the above insignificant coefficients imply that the extra R&D (due to subsidization by the EU) is not less efficient than the R&D that firms would be ready to undertake from their own money (without subsidization).

### **3.2.5 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 FP 4 and/or FP 5. It would have been better if we had information only on participation in FP 5 (1998-2000), but participation in FP 4 and/or FP 5 is not asked for separately in the CIS questionnaire.

In interpreting our results, one should be aware that the impact of participation in an FP on a firm's R&D budget is likely to differ considerably between smaller and larger firms. The smaller a firm, the bigger should be the impact of participation, simply because the relative importance of the R&D subsidy to the firm's total R&D budget is likely to be higher among smaller firms. In larger firms the EU subsidy may only be a minor share of the total R&D budget. This is likely to result in smaller (and possibly insignificant) coefficients among larger firms. We therefore include a cross-term in our equation: participation in FPs times firm size class. In order to correct for self selection we again include a Heckman selection equation. The results are summarized in Annex 3 Tables 3.3 and 3.4.

Our estimates (Annex 3) 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. Participation by smaller firms (less than 100 employees) leads to a strong and significant increase in R&D intensities. Participation in FPs by medium-sized (100-499 employees) and by large (500 and more employees) firms, however, has no significant impact on R&D intensities.

The coefficients for firms with less than a hundred employees are 0.69 in the Netherlands and 0.71 in Germany. Tentative calculations suggest that these coefficients come down to quite a substantial change in R&D intensities. 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 FP 4 and/or FP 5. In the case of

France, the larger coefficient indicates that R&D intensity would even more than double. 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.

### 3.2.6 Participants in FP 5 and 6 - a closer look

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

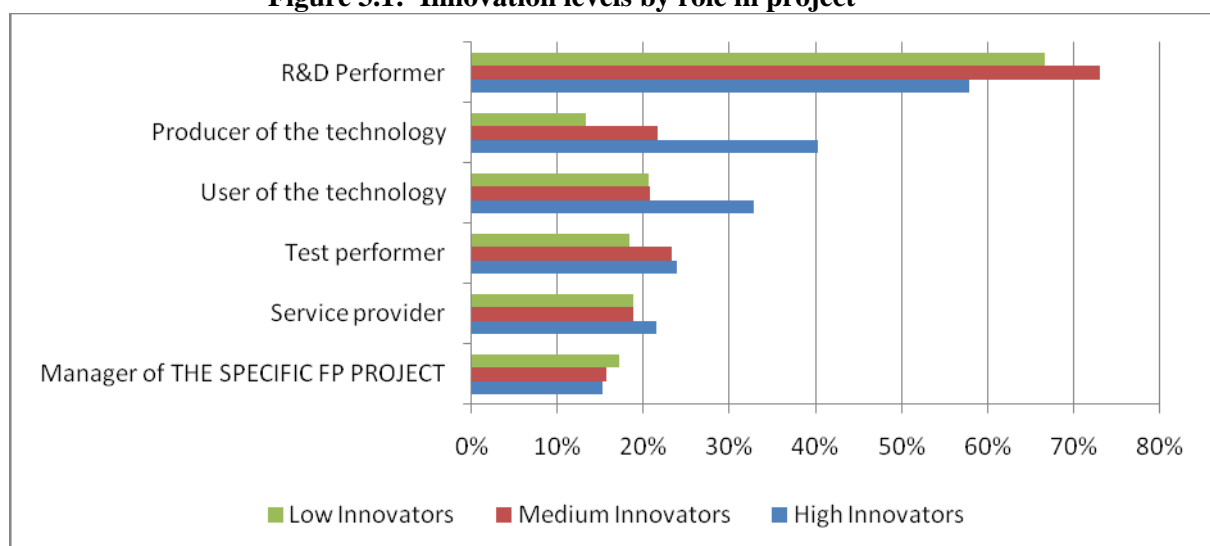
The survey data confirm the high innovator participation from industry (manufacturing and services). As high innovators we have defined those who have introduced a new product or service into the market in the past three years. Medium innovators are those who have introduced products or services new 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.

When looking at the different roles the participants play in the projects, the technology producers and technology users have the highest percentage of high innovators, whereas R&D performers (in general universities and research institutes) are mainly medium innovators. Test performers and service providers have balanced innovation profiles while interestingly the project managers also show a 'flat' profile between the levels of innovation, which may indicate that the project managers are not always the drivers for innovation outputs of a project.

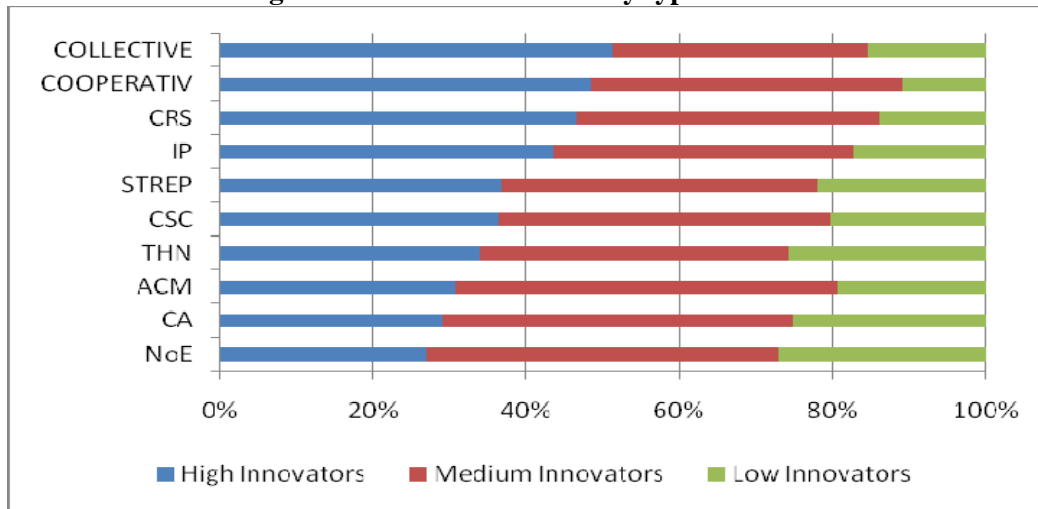
**Figure 3.1: Innovation levels by role in project**



The innovation levels of participants do not differ significantly between the Framework Programmes although FP 6 seems to have attracted marginally more high innovators than FP 5.

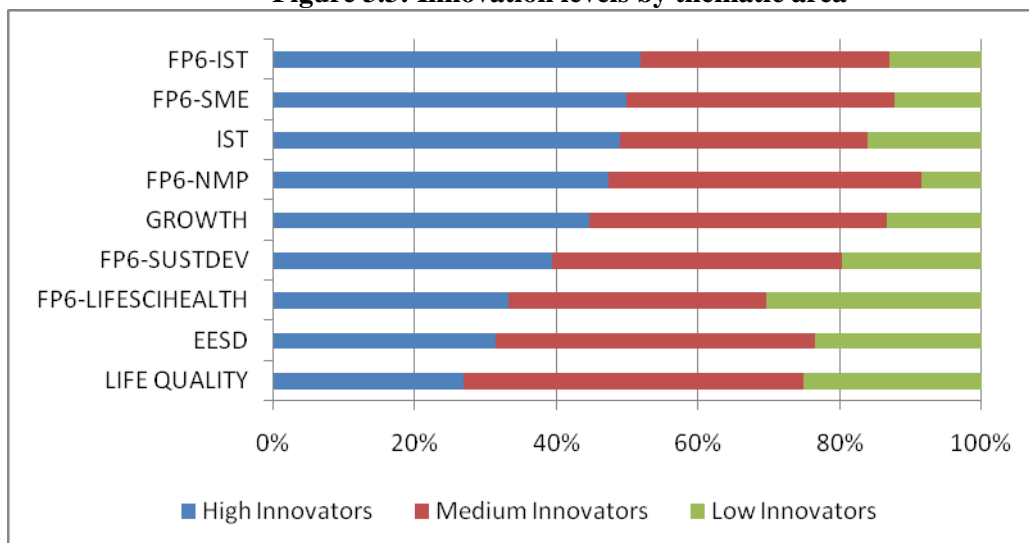
The different types of instruments and thematic areas show more diversity in terms of participation of the different levels of innovators. The specific SME instruments (Collective and Cooperative research projects) attract relatively high numbers of high innovators, as do CRS and IPs, whereas the network-oriented 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.

**Figure 3.2: Innovation levels by type of instrument**



That the level of innovators would differ between the different instruments was to be expected. We also see major discrepancies between the different thematic areas. 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.

**Figure 3.3: Innovation levels by thematic area**



### 3.3 Motivation for participation

The objectives for participation (motivation) of an organisation to participate in a project define the starting point of the project and the expectations of the organisation. It defines the impact on the efforts made in a project and its eventual outcome.

It is to be expected that the objectives will differ per type of organisation, type of project and thematic area. This chapter 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. The table below details the specific objectives in the following categories:

**Table 3.2:** *Specific objectives/motives for participation per category*

<b>Technological/knowledge</b>	<ul style="list-style-type: none"> <li>• Accessing complementary resources and skills</li> <li>• Allowing your organization to reach a critical mass of resources and skills in a given technological field</li> <li>• Keeping up with state-of-the-art technological developments</li> <li>• Exploring different technological opportunities</li> </ul>
<b>Network</b>	<ul style="list-style-type: none"> <li>• Highlight technological competences</li> <li>• Networking / finding new partners</li> <li>• Promoting user/producer interaction</li> <li>• Joint creation and promotion of technical standards</li> </ul>
<b>Cost and risk</b>	<ul style="list-style-type: none"> <li>• R&amp;D cost sharing</li> <li>• Risk sharing- reduce uncertainty</li> <li>• Obtaining funding</li> </ul>
<b>Market and commercial</b>	<ul style="list-style-type: none"> <li>• Creating a commercialisable innovation output</li> <li>• Improving speed of bringing innovation to market</li> <li>• Allowing entry into a new market</li> <li>• Controlling future market developments</li> </ul>

Subsequent chapters also look at the alignment of the objectives with the achievements in terms of creating innovative output. This chapter largely limits itself to the participant, market and project characteristics.

#### 3.3.1 General objectives of all participants

In principle all objectives in all categories indicated above are considered relevant in themselves; our analysis focuses therefore on the relative importance that is given to the individual objectives. The technology/knowledge related objectives are clearly dominant. On the other side of spectrum, "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. These findings also shed some light on the role of public support to R&D: the motivation to participate put forward by the organisations often seems more related to remedy "system failures" or "cognitive failures" than to remedy classical "market failures".

#### 3.3.2 Organization characteristics and objectives

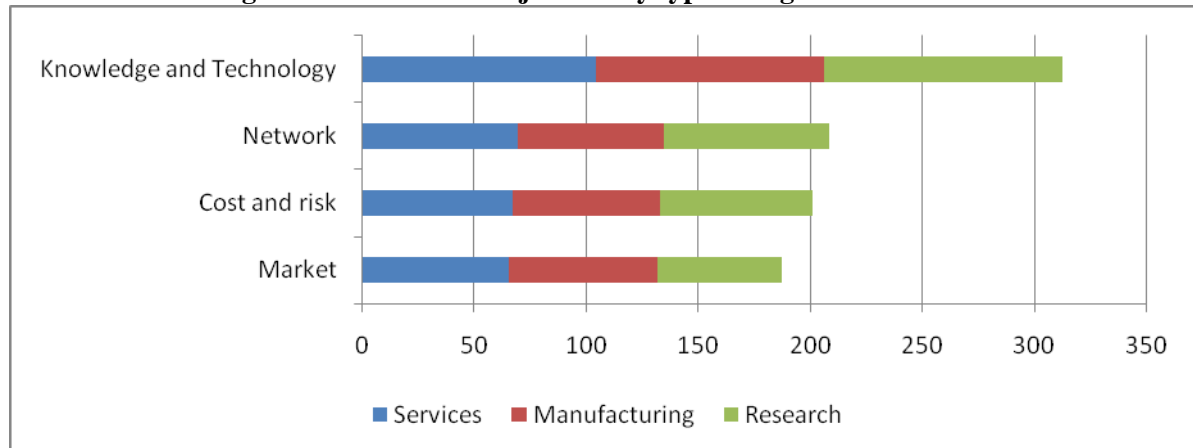
The results described in the previous paragraph are fully confirmed by the results when distinguishing between type and size of organisations with regards to the most and least relevant objectives. This section looks at the differences between types of organisation (manufacturing, services and research, including education), the sizes of organisations, and

whether there are differences between first time participants (newcomers) and those organisations which have participated in previous Framework Programmes.

### 3.3.2.1 Type of organisation

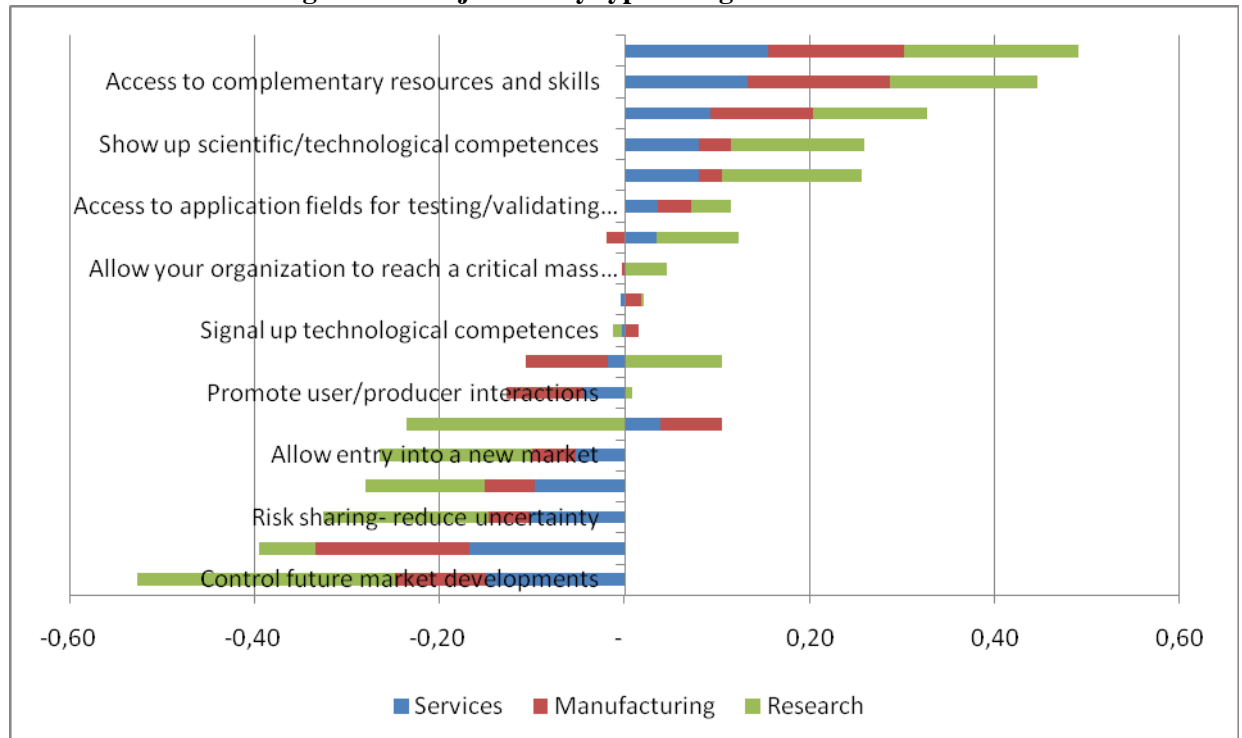
When analysing the different categories of objectives per type of organisation, the Technology and Knowledge related objectives clearly stand out as being most relevant for all types of organisations, whereas market-related objectives feature low for research organisations. The other categories seem to be fairly evenly distributed across the different types of organisations as well as between themselves.

**Figure 3.4: Clustered objectives by type of organisation**



The main findings can be summarised as follows:

- Manufacturing and services companies rate the importance of the different objectives almost systematically in the same way, they rate the creation of a commercialisable output as the 4<sup>th</sup> most relevant objective, whereas the objective seems less important for service companies;
- Research organisations exhibit a somewhat different profile of objectives. They rank “Networking / find new partners” as the most important objective whereas “Promote user/producer interactions” and “Obtain funding” are also highly relevant (in contrast to the manufacturing companies).

**Figure 3.5: Objectives by type of organisation**

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.

*“The main reason for using EU projects was the possibility to finance a development project (...)”*

*“Without EU funding, development would be just incremental and much more limited in scope and potential for leading to innovation”.*

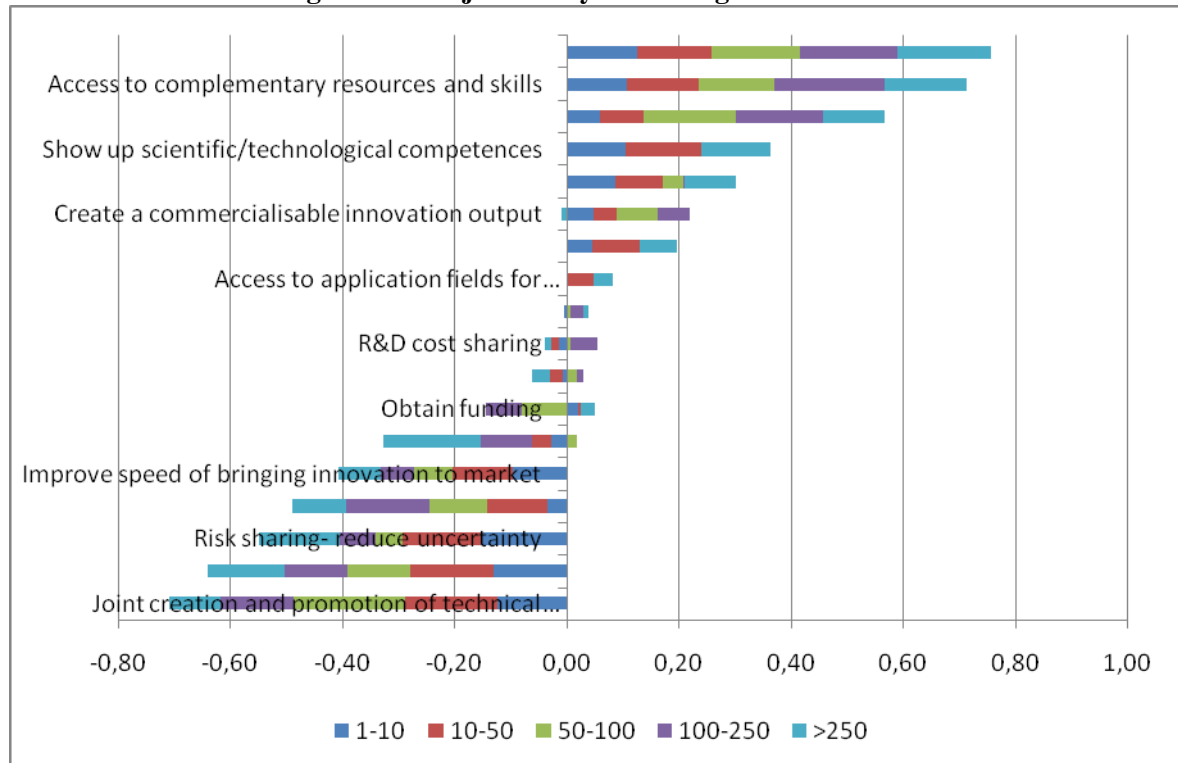
In other cases where funding was not referred to as the main objective, funding from the EU’s FP programmes was said to be one of the main sources of R&D financing, indicating that funding has played a role in the firm’s decision to join EU-funded research projects.

*“Since the Second framework programme our company has funded part of its RD activity through European funds.”*

As stated at the beginning of this chapter, in fact all objectives that the respondents could choose from were described as relevant. The perceived difference with the case studies can be partially explained by the fact that the case study interviews did not present the interviewees with a list of options.

### 3.3.2.2 Size of organisation

There are only minor differences between the motivation for participation of the different size classes of organisations.

**Figure 3.6: Objectives by size of organisation**

The figure above shows a clear distinction between SMEs and larger companies when it comes to ‘creating a commercial innovation output’, ‘allow entry into a new market’ (negative for both, but for small companies less so) and ‘obtain funding’ as objectives for participation in the Framework Programmes. These objectives are distinctly more important for SMEs than larger companies. Hence, 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. One can say that these objectives underline the economic realities facing SMEs compared to larger companies that are more likely to fund participation in EU-funded projects from revenues. Larger companies are also less dependent on economic returns on their investment in the EU funded R&D project.

These differences in objectives on the firm size level do not imply that large companies never give any of these reasons for project participation. A larger Swedish company with 540 employees stated that:

*“There was not a clear overall commercialization goal (project level), but the rationale for our company as a user partner was of course that our involvement would result in exploitable outcomes”*

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.

From the case studies there are anecdotes supporting these findings. A Norwegian consultancy company with fewer than 50 employees said, when referring to the different funding opportunities from the EU, that

*'... the 50 percent cost sharing model made it difficult for them to participate. The level of funding was not sufficient to allocate resources to an EU-funded project if the same resources could be used in a project entirely paid for by a customer. In other words, it was difficult for them to participate for other reasons if the funding element was not in place. '*

### **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. This may mean that the level of uncertainty (related to the competitors, the clients or the technology) does not affect the objectives of participants.

There seems to be only a small relation between the technological environment and the motives for being involved in FP projects. In fast growing markets, networking is 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, this in contrast to the achievements of highly ranked market and commercialisation objectives.

When an objective is scored low, the likelihood of achieving a result for that objective is also low. Interestingly the exception to this overall assessment is that market related objectives do not score high, but market related achievements are major outcomes.

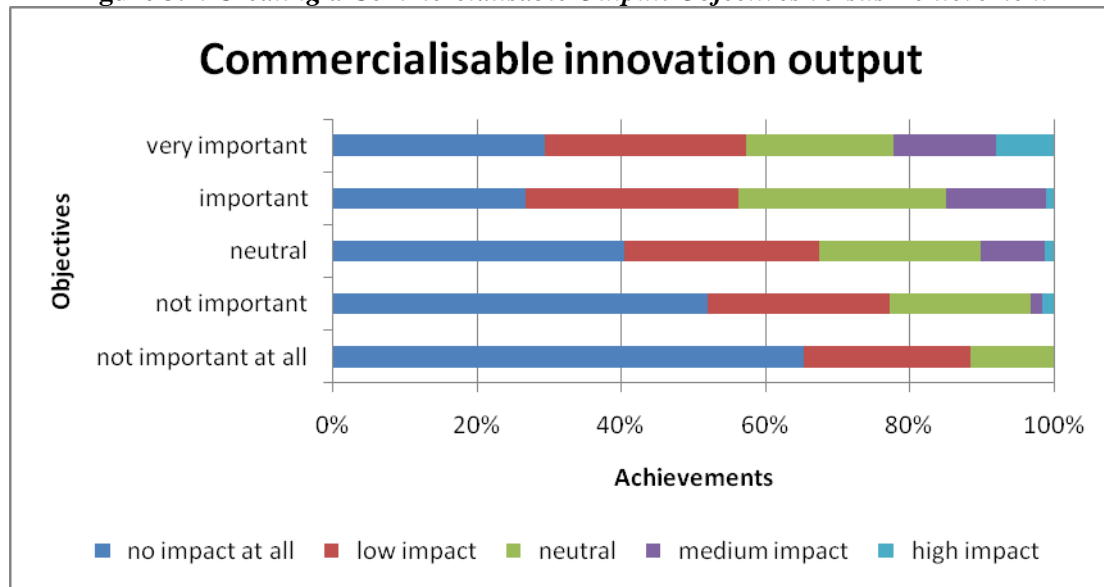
The knowledge and technology related objectives as indicated in the previous paragraphs are ranked highest amongst the objectives in general and the achievements are considerable. Keeping up with the state-of-the-art technology is considered a key objective as seen in the previous sections. Close to 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.

Of those who state a commercialisable output as a very important objective only a little over 20% consider that there has been an impact on licence incomes, increased turnover or increased profitability. This indicates that putting results of a project directly in the market and generating revenue from it is a daunting task, which is (amongst others) related to the design of the Framework Programmes and their pre-competitive nature.

A more important message from this analysis 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. 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.

**Figure 3.7: Creating a Commercialisable Output: Objectives versus Achievement**

The impacts seem higher (especially in relation to the objectives) when looking at the competitiveness and market access achievements. In both cases the actual achievements are better in line with the objectives.

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. The analysis demonstrates the importance of assuring that the objectives of project partners are essential for the project outcome.

### 3.4 Strategic considerations

#### 3.4.1 Technological strategy : exploration vs exploitation <sup>18</sup>

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.

##### 3.4.1.1 All participants (enterprises only)

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.

##### 3.4.1.2 Relations between organization's characteristics and technological strategy

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.

- There is a small difference between services companies who are closer to exploitation for all three types of projects than manufacturing companies.
- The larger the firm, the stronger the difference is: whereas for very small firms, there is no difference among the FP instruments and few between FP instruments and self-

<sup>18</sup> It is not possible to investigate the relations between technological strategy and characteristics of FP projects, since we do not know whether the assessment of the technological strategy adopted in general for the FP projects by one given organization (given by Q8) is the same as the technological strategy adopted by the same organization in the specific FP projects that were surveyed.

funded projects, the large companies clearly are exploring in FP projects (and especially in other than IPs or NoEs) and exploiting in the self-funded ones. This result, statistically significant, also confirms the higher capability of large firms to design clear strategy.

- Low or non-innovators and medium process-oriented innovators are the only ones who carry out IP and NoE projects more close to the exploration than their other FP projects. High innovators show very few differences between the three types of projects.

**Table 3.3: Technological strategy, from Exploration (1) to Exploitation (5) (n=702 to 896)**

Organization size	NoE & IP	Other FP	Self-funded
<10 employees	2.90	2.88	2.94
10 to 50 employees	2.81	2.74	3.02
>250 employees	2.96	2.70	3.19

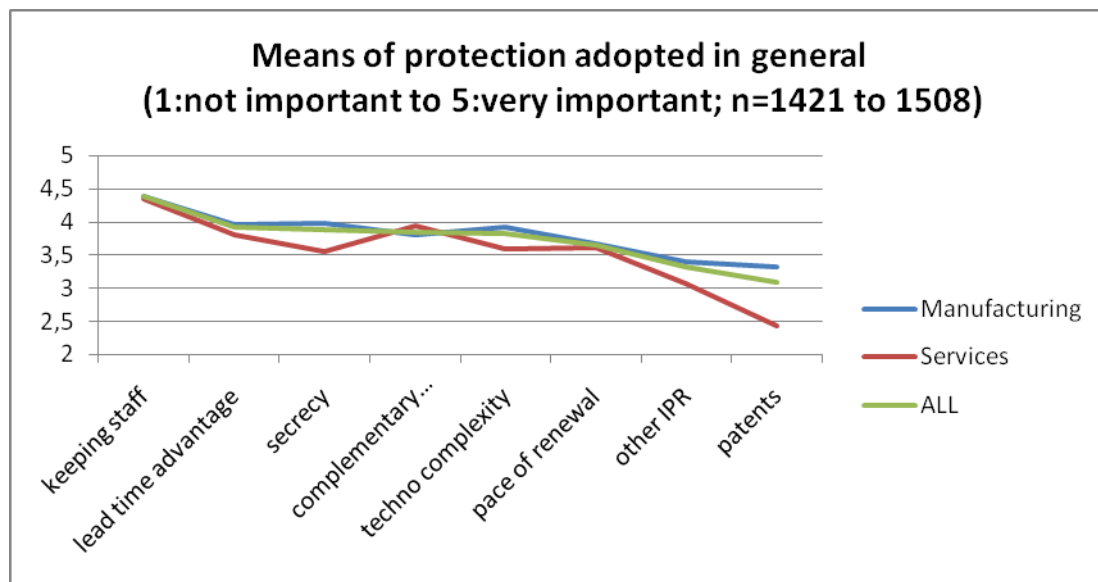
### 3.4.2 Means of protection of innovation adopted in general

The general protection strategies of the organisations are first analyzed, and subsequently related to the organisation characteristics and the type of innovations they develop.

#### 3.4.2.1 All enterprises

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

**Figure 3.8: Means of protection adopted in general**



#### 3.4.2.2 Relations between organization's characteristics and protection strategy

When looking at protection means by sub-samples of organizations (type and size), the same protection preferences appear at the upper and lower ends. The order among the other means of protection varies from one category to the other, with "secrecy", "lead time advantage" and "complementary services" being most often ranked at the highest level.

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.

Higher R&D/turnover ratio seems to go with a higher importance of the use of patents and "technological complexity". Also, it seems that a higher the share of sales of new products in the company turnover is related to a higher importance of patents.

### 3.4.3 Protection strategy adopted in FP projects

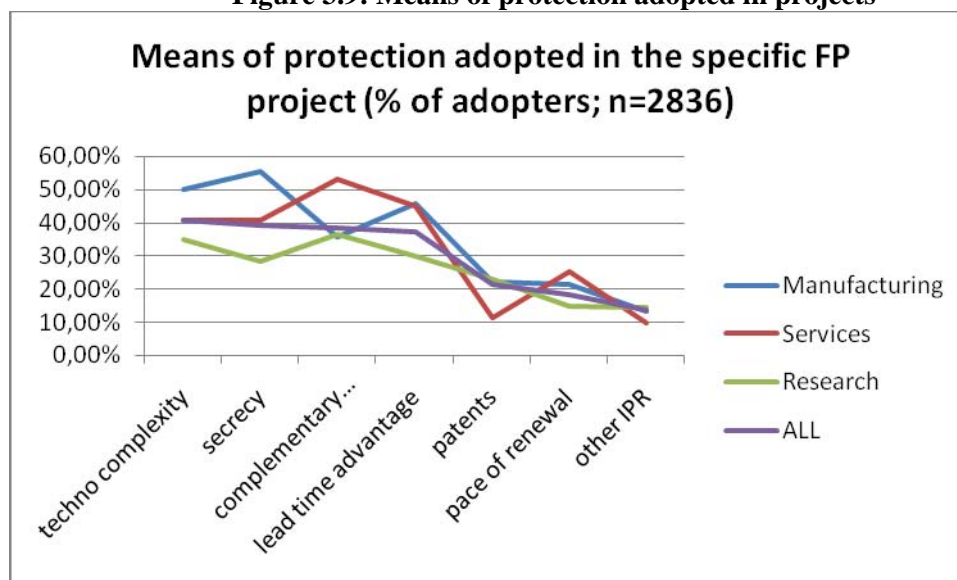
We now look at the specific strategy of protection adopted in the context of the surveyed project, and we relate this specific strategy again to the organisation characteristics and the type of innovations they generate from the surveyed project.

#### 3.4.3.1 All participants

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.

Interesting is the low score for protection by "pace of renewal". It may illustrate the difficulty for participants to align the project time frame and pace of market and technology evolutions, a problem that is often expressed by the participants themselves.

Figure 3.9: Means of protection adopted in projects



#### 3.4.3.2 Relations between organization's characteristics and protection strategy

With regards to the type of firms, the means of protection ranked first for the general protection strategy are also ranked first for the specific strategy: “secrecy” and then “technological complexity”. Compared to companies, research participants are almost

systematically scoring all protection means low, except for "patent" and are also quite naturally less interested in "secrecy" and "pace of renewal". The differences between the three categories of participants are statistically significant for all of the protection means (except "other IPR").

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".

As was the case for the general protection strategy, 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".

#### 3.4.3.3 Relations between protection strategy and outputs from the projects

Two sets of project results are taken into consideration: the Knowledge and Technological oriented outputs on the one hand, and the Commercial exploitation outputs on the other. Two extreme means of protection are analyzed: patent (with full public release), and secrecy (no public release).

Those participants applying patents generally report more outputs across the board than those applying secrecy. Interesting is the increasing number of research organisations applying patents, although the outputs are naturally more PhD and Publications oriented, compared to companies. Nevertheless this confirms findings of recent studies on the possible and even frequent compatibility between high level academic outputs and more traditionally market oriented outputs.

Outputs for those applying secrecy as a main form of protection are fairly straightforward: 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).

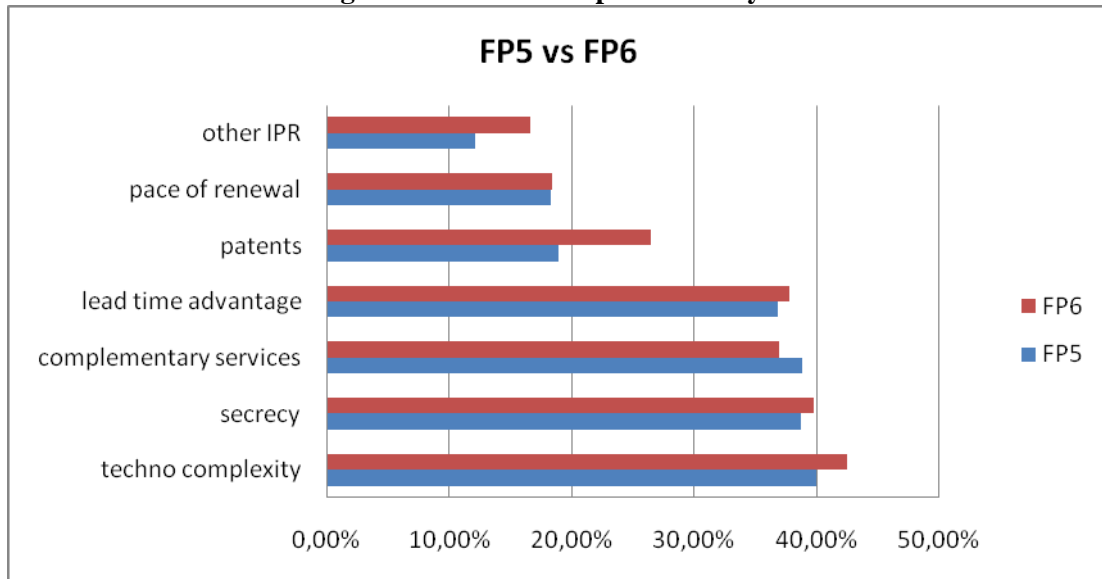
With regards to the use of secrecy, enterprises respond fully coherent with expectations: secrecy is more often used by those who have developed products, processes and field trials (around 55% of each of the corresponding categories), and less by those who have developed services and standards. Research participants using secrecy are systematically declaring higher levels of outputs.

#### 3.4.3.4 Relations between protection strategies and characteristics of projects: type of project: funding instrument and thematic area

FP 5 and FP 6 show a very similar profile for the preferred ways to protect innovation. FP 6 projects "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 FP 6.

**Figure 3.10: Means of protection by FP**



In FP 5 Growth and EESD have a very similar profile, while FP5-IST projects and FP6-IST also have similar profiles. FP6 Lifesciencehealth and NMP put the largest emphasis on patents as means of protection.

**Figure 3.11: Means of protection by FP areas**

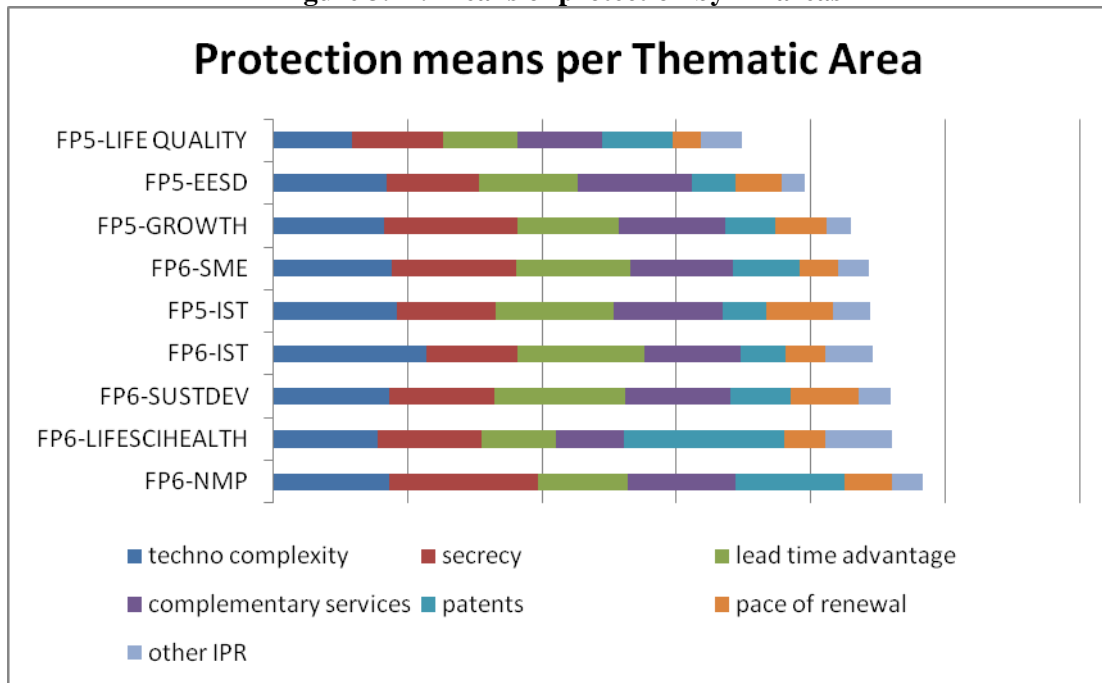
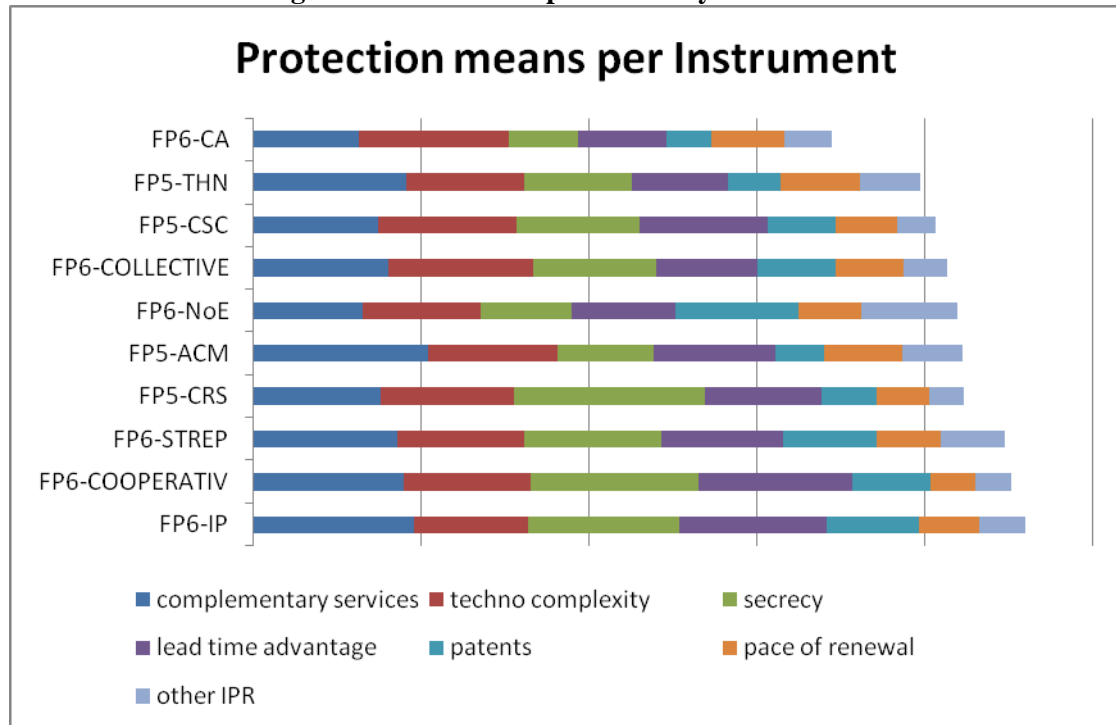


Figure 3.12: Means of protection by instrument



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

#### 3.4.3.5 Relations between means of protection and other project characteristics

The relation between other project characteristics (such as the project origin, risk, cost, complexity, etc.) and the use of protection is quite straightforward. 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, this is similar to when organizations are entering a new area with the project.

When the origin of the project idea comes from the respondent, patents and pace of renewal seem to be more frequently used.

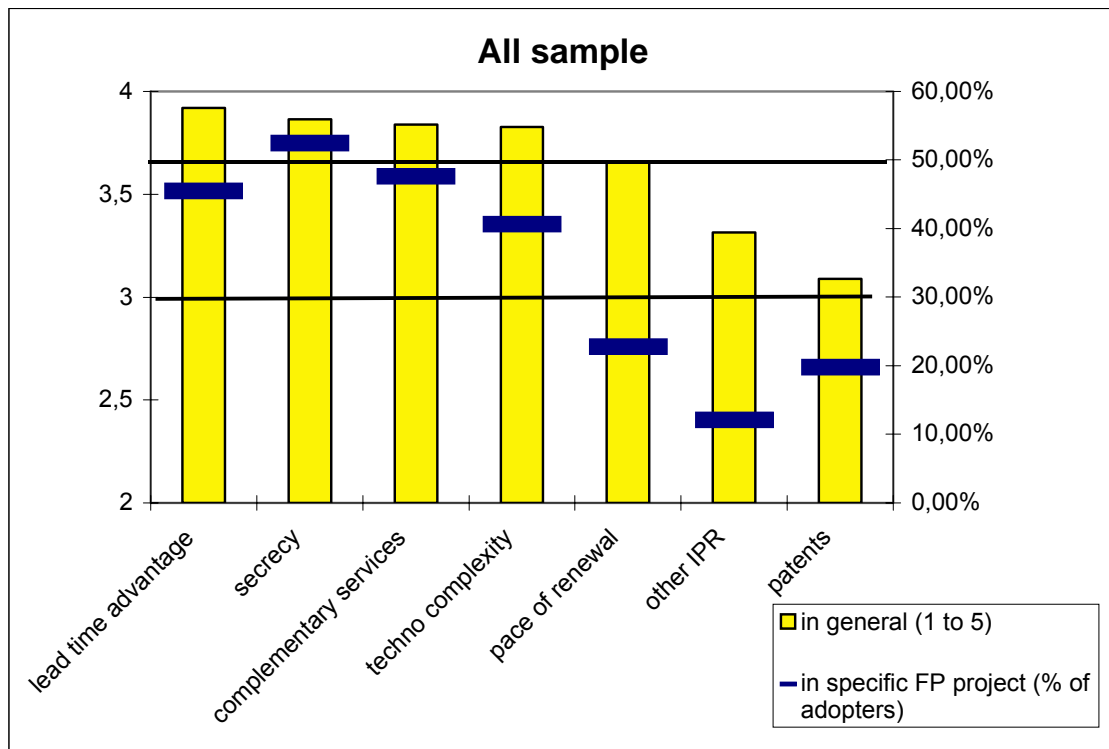
The proportion of industrial partners in project is positively correlated to the use of all means of protection, except with "other IPR" (negatively correlated) and "technological complexity" (no correlation).

### 3.4.4 *Comparison of protection strategies*

#### 3.4.4.1 All enterprises

General protection strategies and specific strategies used for the FP projects is similar. "Secrecy", "lead time advantage" and "technological complexity" appear at the highest level in both strategies: their average mark is between 3.5 and 4 and they have been used in nearly 50% of the specific projects covered. Only "Pace of renewal" and "other IPR" seem to be less important in FP projects compared to the normal strategy.

Figure 3.13: Comparison of protection strategies



#### 3.4.4.2 Comparison of protection strategies for the different sub-sample of organization

When looking at specific categories of firms, some differences appear between general and specific strategies.

For Manufacturing companies, “complementary services” seem to play a bigger role in specific project than in general. The other results are similar to the ones observed at the level of the whole sample. For service companies the differences are the most important. “Technological complexity”, “patents” and to a lesser extent “complementary services” to play a more prominent role in FP projects.

In very small and small firms, there is great similarity between general and specific strategies. Only again “Pace of renewal and “other IPR” are less important in specific FP projects. To some extent, the same is true for large firms, be it that “patents” are not very common in specific projects, while “technological complexity” seems to play a bigger role in specific projects than in general.

### 3.5 Management of RTD collaborative portfolios

#### 3.5.1 Introduction

This section provides a descriptive statistical analysis of the portfolios of R&D collaborative projects of 857 companies having answered the Innovation Impact Survey. The portfolios we consider here include EU FP projects as well as non-subsidized collaborative projects. FP projects are further decomposed into the new instruments: NoE/IP and the traditional instruments: other FP projects such as CSC, CRS and STREP. In the following paragraphs project types are referred to as New Instruments (NewInst), Traditional Instruments (TradInst) and Self Funded projects (SelfFund).

Portfolio data concern the propensity to execute each type of project and its weight in the R&D budget of the firm. In order to better understand the role of FP projects in the overall strategy, we also used average characteristics of EU projects obtained from a question about

their costs, risks, term, distance from core, flexibility and so on. Finally we took some of the company characteristics into account, namely their size and innovativeness (in terms of product innovation).

The study was conducted in two steps: first we used correlation analysis to explore the eventuality of privileged combinations of projects, as well as possible associations between EU projects characteristics and the weight of NewInst, TradInst or SelfFund type projects in the firms R&D budgets.

Second we elaborated a classification of six types of portfolios according to their content and we examine if these portfolios correspond to different companies characteristics or to different perceptions of EU projects by the respondents.

### ***3.5.2 Correlation analyses between types of projects and characteristics of EU projects***

We first consider the propensity to have or not (dichotomic variable) a R&D project of a given type together with another type (at a given point in time, i.e., the start of 2007 when the survey was sent). The propensity to have EU project of NewInst is negatively correlated to the propensity to have EU projects of TradInst<sup>19</sup>. On the contrary, each type of EU project is positively correlated with SelfFund projects, that is to say non subsidized (internally funded) collaborative projects. This might indicate that both kinds of EU instruments, NoE / IP versus other FP projects, are somewhat substitutable, whereas EU versus non-EU projects have a more complementary nature.

A deeper inquiry seems to support the idea that EU instrument are, in fact, substitutable from the point of view of the companies.

We then used three variables (ordered variables on a five level scale<sup>20</sup>) representing the percentage of R&D budget devoted respectively to NewInst, TradInst and SelfFund. Here again the correlation between the weight of NewInst and TradInst is negative and significant. The more a company spends R&D budget in NewInst projects, the less it tends to spend in TradInst projects, and conversely. An immediate policy implication arises: does it make sense to create a wide span of policy instruments if the prime concerned users do not make any difference among them?

The last set of correlation calculations aims to identify possible links between the way EU projects are characterized by the firm's respondents (in terms of costs, flexibility distance from the core, etc.) as well as the size of the firm on the one hand, and the weight of the different types of projects in the agreement portfolio (in terms of percentage of R&D budget) on the other. Significant correlations can be synthesized as follows:

- The larger the company, the smaller the part of TradInst and the larger the part of SelfFund projects. In other words and unsurprisingly, big firms seem to be less dependent upon European funding;
- The more a company considers that the cost of average EU projects is high, the more it devoted an important part of its R&D budget to TradInst and SelfFund. This might be explained by the fact that the costs of expensive projects have to be shared and co-financed;
- The more a company considers that the (technological and/or commercial) risk of average EU projects is high, the more it devoted an important part of its R&D budget to TradInst (similar reason as above for costs, in terms of risk sharing);
- The higher complexity of average EU projects, the higher proportion of the companies R&D budget is devoted to TradInst and SelfFund;

<sup>19</sup> See annex 3, Table 3.7 for the detailed table

<sup>20</sup> The scale entails: 1: 0 %; 2: <10%; 3: 10 to 30%; 4: 30 to 50% to 5: >50%.

- The more a company considers that average EU projects are long term oriented, the more it invests an important part of its R&D budget in SelfFund, i.e., non-subsidized projects. If EU projects are perceived as long term oriented, then they concern basic research. Probably this kind of research is not a strategic priority, nor is it the most expensive. Maybe also it is undertaken only in case of organizational slack;
- The more a company considers that average EU projects are far from its core activity, the less it devoted an important part of its R&D budget to TradInst. Here again, it might be said that investments are primarily done in strategic fields, i.e., fields which are close to the core. This rule applies for any kind of R&D projects including EU projects;
- The more a company considers that average EU projects are exploration-oriented (vs. exploitation), the more it invests an important part of its R&D budget in TradInst;
- The more a company considers that the administrative burden of average EU projects is high, the more it devoted an important part of its R&D budget to SelfFund. Our interpretation is that heavy administrative, reporting costs might cause some firms to divest from EU programmes. This interpretation is largely supported by several case studies. For instance a small German biotech company explicitly mentioned that increased administrative burden pushed them to decrease their participation in FP;
- The more a company considers that average EU projects are flexible, the more it invests an important part of its R&D budget in NewInst. Several explanations can be envisaged. Maybe the very large projects typical of NoE and IP, with their numerous partners, organizational complexity, etc. show a high level of "coordination slack" or inefficiencies and thus make it possible to change research topics rather easily. But the other sense of causality might also be considered: such projects are so complex that the companies who consider that EU projects are flexible tend to invest more and to be more active in NewInst.

### 3.5.3 Analysis of six types of portfolios of collaborative projects

We elaborated *ad hoc* classification<sup>21</sup> of all the feasible portfolios according to the types of projects they contend. We obtained six categories of portfolios (see Table 3.8 below).

**Table 3.8 : Categories of portfolios of projects**

Portfolio type	Abbreviation	Number (total: 857)	% of total
<i>portfolios entailing only New Instrument projects</i>	NewInst only	75	8.8%
<i>portfolios entailing only Traditional Instrument projects</i>	TradInst only	149	17.4%
<i>portfolios entailing NewInst and TradInst projects</i>	NewInst/TradInst	63	7.4%
<i>portfolios entailing NewInst and SelfFund projects</i>	NewInst/SelfFund	74	8.6%
<i>portfolios entailing TradInst and SelfFund projects</i>	TradInst/SelfFund	179	20.9%
<i>portfolios entailing NewInst, TradInst and SelfFund projects</i>	NewInst/TradInst/SelfFund	317	37.0%

<sup>21</sup> We made an unsuccessful attempt at running a multiple correspondance analysis in order to elaborate an ascendant hierarchical classification. The poorness of results lead us to build our own, intuitive, classification.

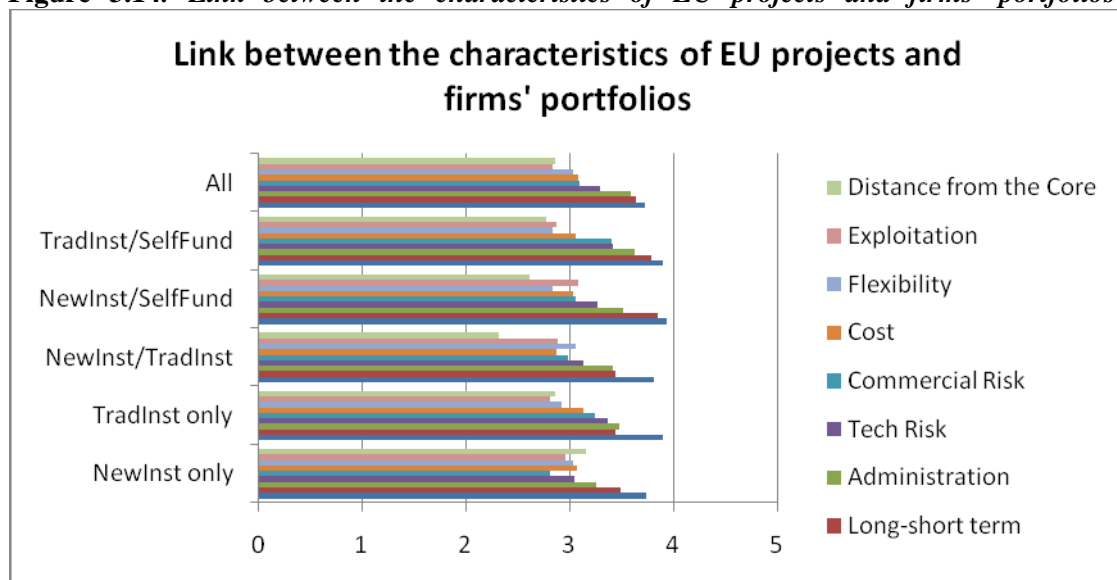
Two categories of portfolios are specialised in a single type of EU projects: NewInst only, respectively TradInst only,). We may note in the table above (Table 3.8) that companies belonging to the second category are twice as numerous as the ones specialised in NewInst (149 instead of 75). Since only firms having EU projects have answered the Innovimpact survey, we exclude the case of specialisation in SelfFund, i.e., non sponsored projects.

- Companies specialised in EU projects of both types, corresponding to the NewInst/TradInst portfolios, with no privately funded collaborative projects at all, number only 63.
- Then we have two categories of mixed portfolios entailing two types of projects: EU projects (either NewInst or TradInst) simultaneously with privately funded projects. As in the specialised portfolios cases, the category showing the larger size is the one including Type2 projects.
- The category which is by far the most important corresponds to the portfolios including all types of projects: with 317 companies, NewInst/TradInst/SelfFund represents more than one third of the population.

Probably one of the most outstanding results is the absence of a clear difference between the different portfolios (at least for the data we collected thanks to the survey).

Matching the different portfolios and the average projects characteristics of EU projects (in terms of costs, risks, flexibility, etc. as perceived by the companies themselves) gives the following, very similar profiles of Figure 3.14 below. The more (and single) discriminating EU project characteristic seems to be core distance. Companies whose portfolio is highly specialised in EU projects of both kinds (no NewInst/TradInst/SelfFund at all) consider that EU projects in general concern activities located rather close to the core (compared to other firms). On the other side, companies specialised in NewInst projects consider that EU projects are relatively far from the core.

**Figure 3.14: Link between the characteristics of EU projects and firms' portfolios**



Finally, in order to identify which kind of companies implement which kind of portfolio, we realized some cross-tables between firm intrinsic characteristics and categories of portfolios. The most promising results are about firm's size and product innovativeness.

As far as firm size is concerned (see detailed results in Annex 3, Table 3.8), it is worth observing that very small companies (i.e., with fewer than 10 employees) tend to specialize in EU focussed portfolios (NewInst only and TradInst only) more than does the whole

population. For instance very small companies represent 42.7% among NewInst only portfolios whereas they represent only 24.5% of the whole set of firms. Unsurprisingly very small enterprises are under-represented in the case of large, NewInst/TradInst/SelfFund project portfolios. All in all, SMEs tend to rely more heavily on European funding than large companies. This is quite in line with EU focus on SMEs.

At the other side of size scale, large companies (more than 500 employees) are somewhat under represented in terms of specialised, monotype portfolios, compared to the whole population of firms (they represent only 16% of NewInst only and 14% of TradInst only portfolios). But large firms represent 29% of diversified, NewInst/TradInst/SelfFund portfolios, to be compared to 23% in the case of the whole set of firms.

Ability to achieve product innovation is another discriminating firm characteristic. Product innovativeness is a dichotomic variable which is positive when the company has introduced new or significantly improved goods during the past three years. Product innovators tend to be active in non subsidized collaborations (SF projects) more than average. They represent 75.7% of companies having NewInst/SelfFund portfolios, 71.5% of those having TradInst/SelfFund and 72.9% of those having NI/TradInst/SelfFund. By contrast product innovators represent only 67.8% of the whole population of firms (see detailed results in Annex 3, Table 3.9).

### *3.6 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 (not with suppliers);
- they are significantly more orientated towards international markets;
- patenting is significantly higher.

There is substantial input additionality among smaller firms. 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.

Generally speaking, when choosing to participate in an FP project, technology-related objectives are clearly dominating all 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. This results are also similar in FP 5 and FP 6 projects, however some differences appear among FP areas and among instruments (e.g., NoE and CA showing differences in FP 6). Characteristics of projects in terms of cost, commercial risk, time perspective echo the objectives of partners when entering in FPs. Various projects characteristics of projects are (however not very strongly) related to specific patterns of objectives.

As regards 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 and IPR (incl. patent) are the less important. The other preferred means of protection depend on the characteristics of firms. In the specific context of FPs, IPR related means are also the least often used, the most frequent means being context dependent. In general, firms do not change

their favourite means of protection in FP projects, although some of them (for instance those with no previous experience in FP projects) tend to use secrecy more often and technological complexity in this specific context. Innovations from FP 5 and from FP 6 are protected roughly in the same way, but some differences appear within FPs according to areas and instruments. Means of protection are quite clearly aligned with the type of innovation usually produced by companies and with the type of outputs from the projects.

Having no commercial intent at the beginning of the specific FP project is not a very high barrier for further commercial exploitation (with less than 40% of participants considering this as a non important barrier). Only large firms and research-oriented participants seem to consider it as sometimes impeding the exploitation.

The propensity to have New Instruments projects is negatively correlated to the propensity to have Traditional Instrument projects. On the contrary, each type of EU project is positively correlated with Self Funded projects. This seems to indicate that the different instruments tend to be substitutable from the strategic point of view of the companies.

The larger the company, the smaller the part of Traditional Instruments and the larger the part of Self Funded projects. Unsurprisingly, this shows that large firms seem to be less dependent upon European funding.

The more a company considers that the administrative burden of average EU projects to be high, the more it devoted an important part of its R&D budget to Self Funded projects. Our interpretation is that heavy administrative, reporting costs might cause some firms to divest from EU programmes.

The portfolio which is by far the most important is the full mix of project types: with 317 companies, this category represents more than one third of the population.

Probably one of the most outstanding results is the absence of a clear difference between the different portfolios in terms of average EU project characteristics. Matching the different portfolios and the average projects characteristics of EU projects (in terms of costs, risks, flexibility, core distance, etc.) gives quasi identical profiles.

Very small companies (i.e., with fewer than 10 employees, size category number 1) tend to specialize in EU focussed portfolios more than average, whereas large companies tend to have diversified portfolios including all type of projects more than average.

Product innovators tend to be active in non subsidized collaborations more than average.

## 4 Project Characteristics<sup>22</sup>

### 4.1 Key characteristics

#### 4.1.1 Objectives and project characteristics projects: thematic area and type of instrument

There is no real difference in motivations between FP 5 and FP 6 projects. In FP 5, EESD, Growth and IST projects exhibit almost the same profile. An interesting result is the different profile of Life Quality projects (apart from the dominant objectives) from projects in other thematic areas, especially where the market related objectives seem to score much lower than the other areas.

In FP 6, the dominant objectives are the same (as in FP 5) but the profile of the different areas exhibit more diversity. Notably, Sustdev and IST projects put less emphasis on “Create a commercialisable innovation output”, whereas they are the two thematic areas that consider Access to application fields for testing/validating theories as an important objective. SME and NMP projects put less emphasis on “Obtain funding”.

**Table 4.1: Objectives by thematic area**

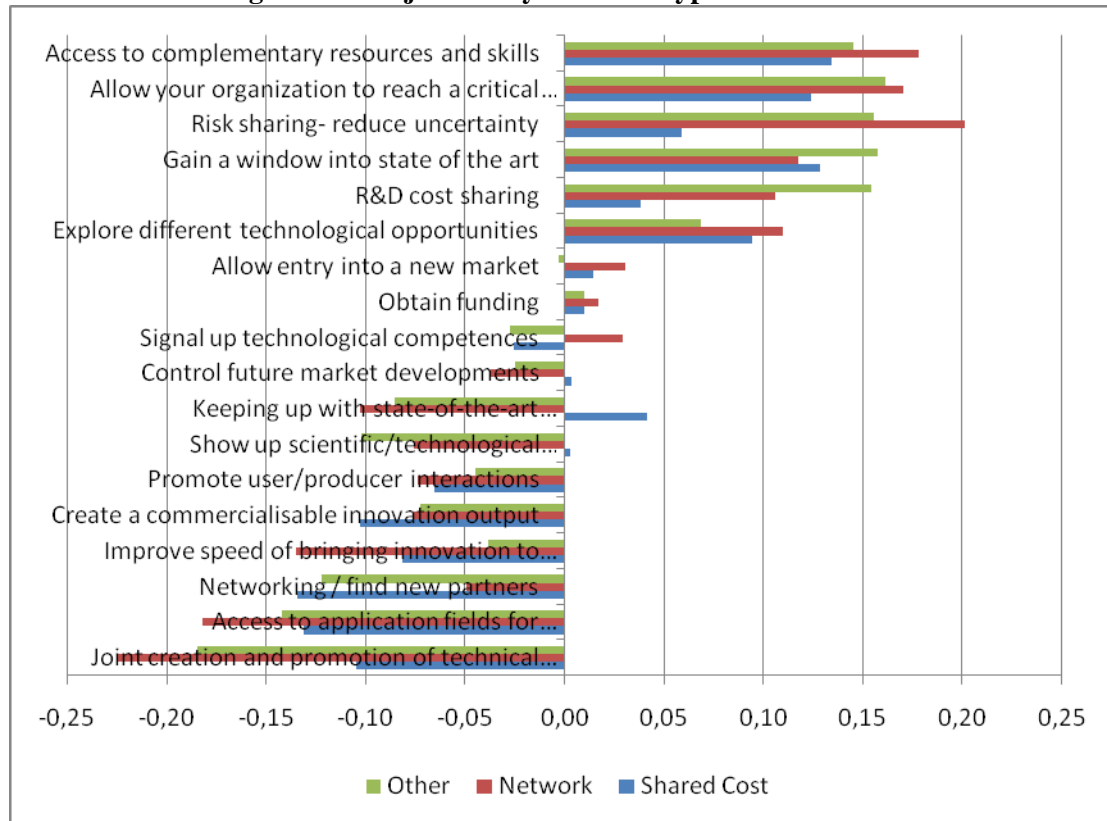
	FP5				FP6				
	GROWTH	IST	LQ	EESD	IST	LSH	NMP	SME	SUSTDEV
Access to complementary resources and skills	++	++	++	++	++	++	++	++	++
Keeping up with state-of-the-art technological developments	++	++	++	++	++	++	++	++	++
Show up scientific/technological competences	++	++	++	++	++	+	++	++	++
Networking / 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	--	--	--	--	--	--	--	--	--

<sup>22</sup> 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.

It is obvious that different types of projects would have different objectives; a network project is different in nature from a shared cost project. The Instruments could be clustered as follows:

1. collaborative shared cost projects (CSC, CRS, IP, STREP, COOP, COLL),
2. Network oriented projects (THN, NoE),
3. Other projects as ACM and CA.

**Figure 4.1: Objectives by clustered type of instrument**



The objectives and motivations of the network-oriented projects are stronger (higher amplitude) than the other categories. Major differences appear in cost and risk objectives, as well as SMEs of the knowledge-related objectives, which for shared cost projects seem more important. The market-oriented objectives give a mixed picture; controlling future market developments are more important for shared cost projects.

Taking this analysis one step further to distinguish between the cost sharing projects we see that the FP 5 instruments (CSC and CRS) have a strong focus on creating a commercialisable product, similarly for IPs and STREPs in FP 6. The commercialisation drive is strongest for Cooperative projects in FP6, which is particularly focussed on market related objectives.

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: Objectives by type of instrument**

	FP5				FP6					
	CSC	ACM	CRS	THN	IP	NoE	STREP	CA	COOP	COLL
Access to complementary resources and skills	++	++	++	++	++	++	++	++	++	++

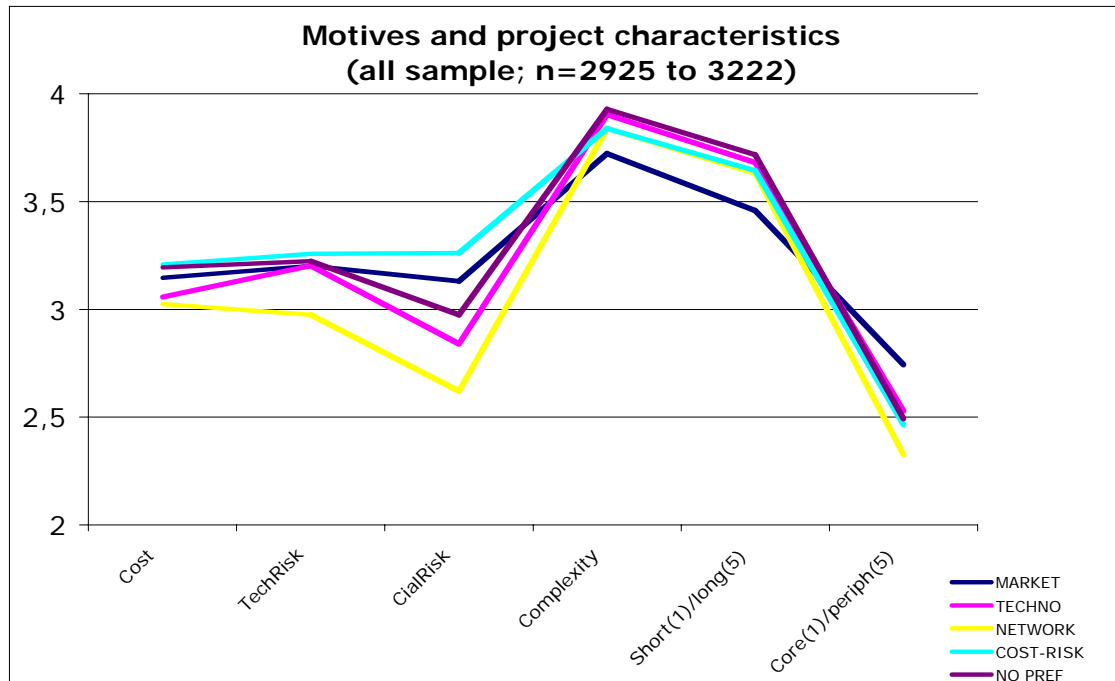
Show up scientific/technological competences	++	++	++	++	++	++	++	++	++	++
Keeping up with state-of-the-art technological developments	++	++	+	++	++	++	++	++	+	++
Networking / find new partners	+	++	+	++	+	++	+	++	+	+
Gain a window into state of the art	+	++	+	++	+	+	+	++	+	+
Explore different technological 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 networking, and a "dominant" type of objectives is associated to each project.

Project characteristics (as examined in previous part of the report : cost, risk, time horizon and distance to the core R&D field of the participants) are 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.

Figure 4.2: Relation between objectives and other project characteristics



The fact that the project idea was generated by the responding participant has an impact on the objectives: objectives are in those cases more related to market and cost-risk sharing, while in the reverse situation the objectives are more related to technology and networks.

The fact the project comprised and 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 in projects is higher in projects carried where market-related objectives are dominant, then in projects with technology, cost-risk-sharing and network objectives, respectively.

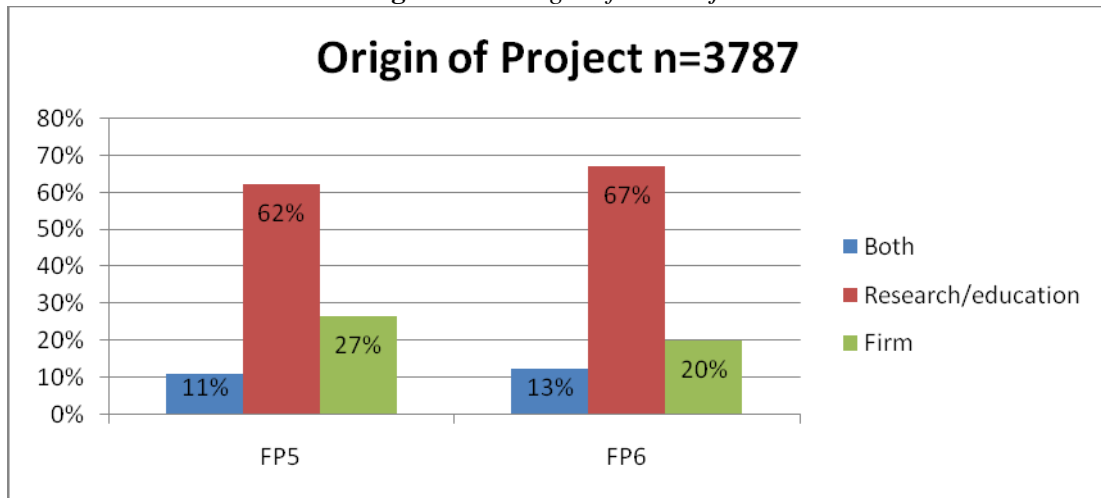
#### 4.1.3 Origin of the project<sup>23</sup>

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). While in FP 5, in 27% of the cases it was an industrial or service company that provided the original idea and in 62% of the cases research or education partners, the proportions were respectively 20% and 67% in FP 6. The impulse for R&D activities carried out in FP projects has appeared to have shifted. Note that a common origin is more frequent in FP6, which could indicate more collaboration in the preparation of the projects<sup>24</sup>.

<sup>23</sup> 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.

<sup>24</sup> This change is much more dramatic in the answers to the enterprise questionnaire: for the companies, the proportion of projects with research origin has increased from 39% to 47% and the projects originating from the firms has decreased from 49% to 35%. However, it is not clear whether this more dramatic shift is due to the perception of the answering organizations or due to the projects themselves.

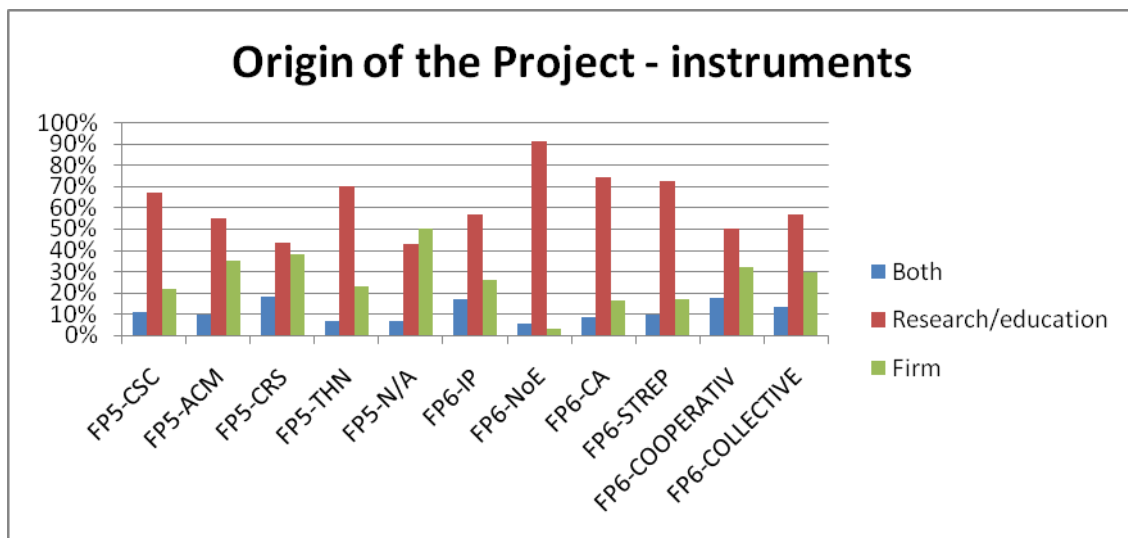
Figure 4.3: Origin of the Project



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<sup>25</sup>.

The origin of projects by instruments is more or less logical, with for instance CRS and ACM (in FP5) largely inspired by companies and NoE by the research/education side. But one could note that in FP6, IPs seem to be generated by research/education, which does not necessarily correspond to the basic idea of an IP. The same is true to a lesser extent for STREPs.

Figure 4.4: Origin of the Project by Instrument

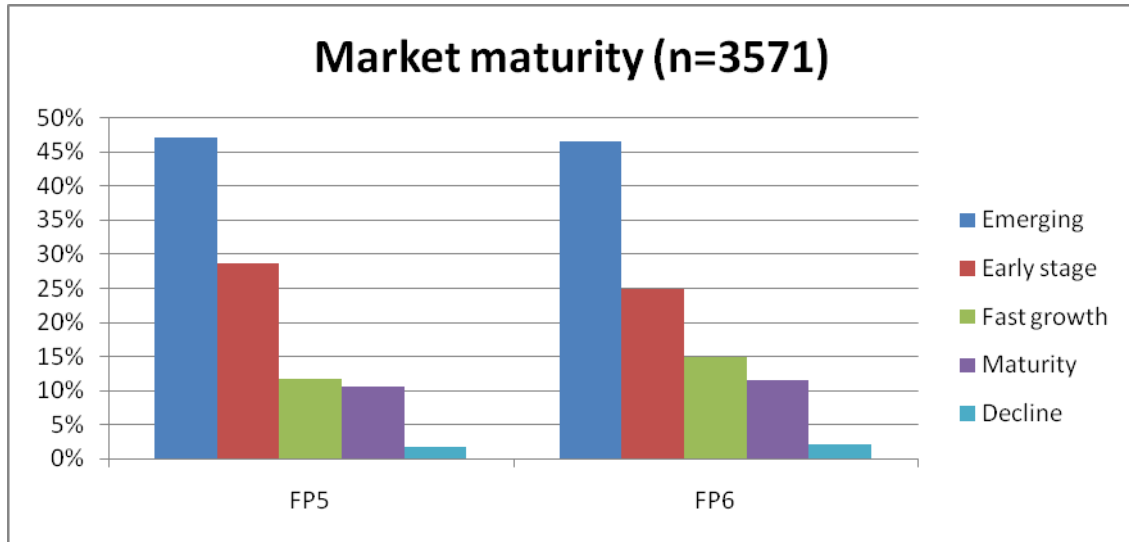


<sup>25</sup> Again, according to companies the shift from Industry to Research origin can be traced over all areas, except in IST which remains company-driven.

**4.1.4 Market conditions**

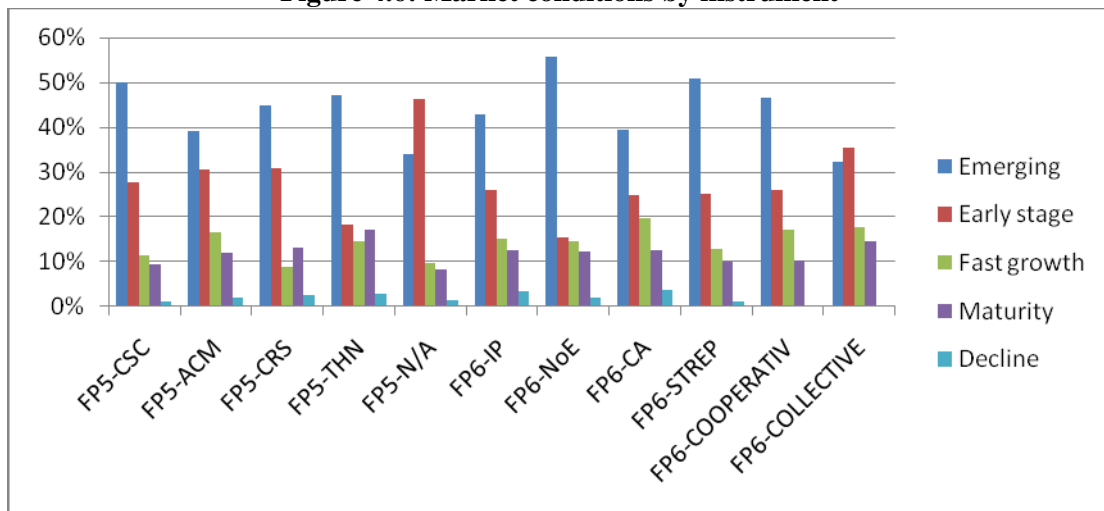
In their majority, FP projects are reportedly focused on markets at an emerging stage or an early stage of development. The partition of projects according to the stage of market development is almost the same in FP5 and FP6, with a very light (but statistically significant) downstream shift in FP6.

**Figure 4.5: Market conditions**



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. Notably, in FP5 N/A and FP6 Collective projects are at more early stage of development and the proportion of mature market projects is higher in CRS and THN. NoE projects are especially focused on emerging markets.

**Figure 4.6: Market conditions by instrument**



**4.1.5 The involvement of participants in projects**

Different aspects of participant involvement are put in relation to the basic categories of participants used in the report (according to type, size, innovativeness and experience in FP):

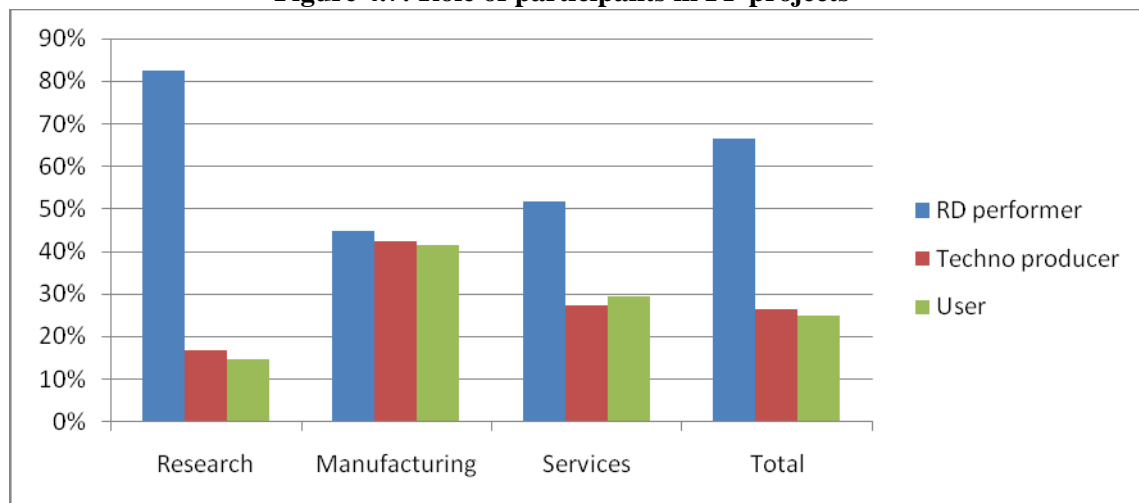
origin of the project's idea, role of partners, relations between partners before the project, and the total number of partners and of industrial partners.

#### 4.1.5.1 The role of participants in FP 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 4.7: Role of participants in FP projects**



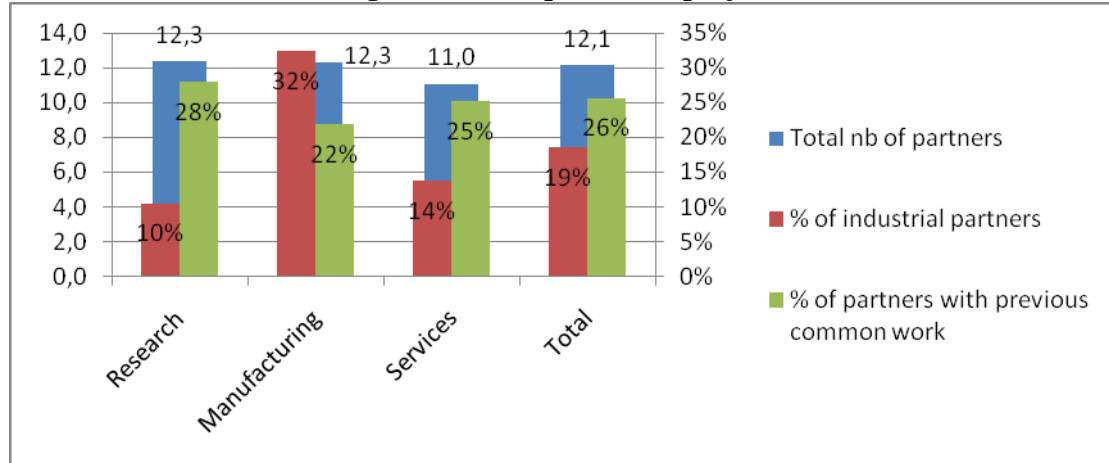
Very small firms are more frequently R&D performers (nearly 50% of them), whereas large companies are more often technology users (over 50%).

The more innovative the organisation, the more often it plays the role of technology producer or user. There is, however, no difference as regards the role of R&D producer, probably due to the research participants.

Newcomers in FP projects are less often R&D performers than the insiders, the latter being comparatively more often users.

#### 4.1.5.2 Composition of consortia

The average total number of partners in projects is just over 12 (12.1), 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.

**Figure 4.8: Composition of projects**

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, 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.

Participants with previous FP experience are involved in projects with fewer industry participants. Newcomers are involved in projects with a significantly lower proportion of partners with whom they had previously worked (18% against 29% for the insiders). This may mean that once an organization has been involved in FP projects the opportunity to keep on working in such projects with the same partners becomes larger.

#### 4.2 How do FP projects compare to other projects

It is not possible to make all potential comparisons between the different types of projects carried out by firms (own projects vs collaborative, collaborative in FP vs collaborative in other programme, etc.). We have selected two possible comparisons:

- The surveyed FP project versus “the average R&D project” of the firm (cf. Q19),
- FP5/6 projects (among which two broad families are distinguished: NoE and IP on the one hand, other projects on the other) and self-funded collaborative projects (Q8)

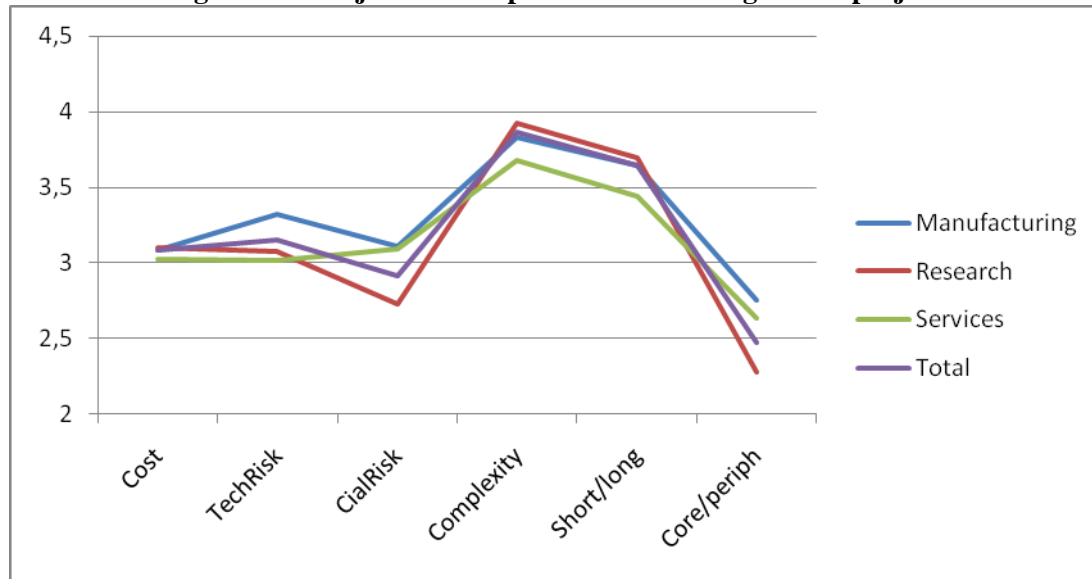
Question Q19 provides the basis for analyzing the first point. The second point is treated with ad-hoc econometric analysis.

##### 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.

**Figure 4.9: 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

#### 4.2.1.1 Relation between organization characteristics and project characteristics

There are only slight differences between the types of organizations regarding the comparison between FP and average R&D projects, which are less pronounced in service companies, and more noticeable in manufacturing firms (for Scientific and Technological risk) and research partners (as regards commercial risk, complexity, time horizon and distance to core).

Answers from different classes of firm size are again following the same trend (i.e., the same ranking and the same range of attributed notes), with less pronounced differences between FP and average R&D projects revealed by large firms, as regards project cost and commercial risk. Profiles of very small and small firms are almost the same, with the exception that the very small firms carry out FP projects even closer to the core than the small and medium sized ones.

Again, the general trend is the same for the different categories of innovators, with one main exception: FP projects of non-innovators are clearly less risky (from both standpoints) than their average R&D projects.

Firms with prior FP experience tend to carry out FP projects which are a little more risky (from both points of view), more complex and closer to the core (as compared to the average R&D projects) than those of firms without prior FP experience. Those differences are marginal, but statistically significant, except with respect to the time horizon.

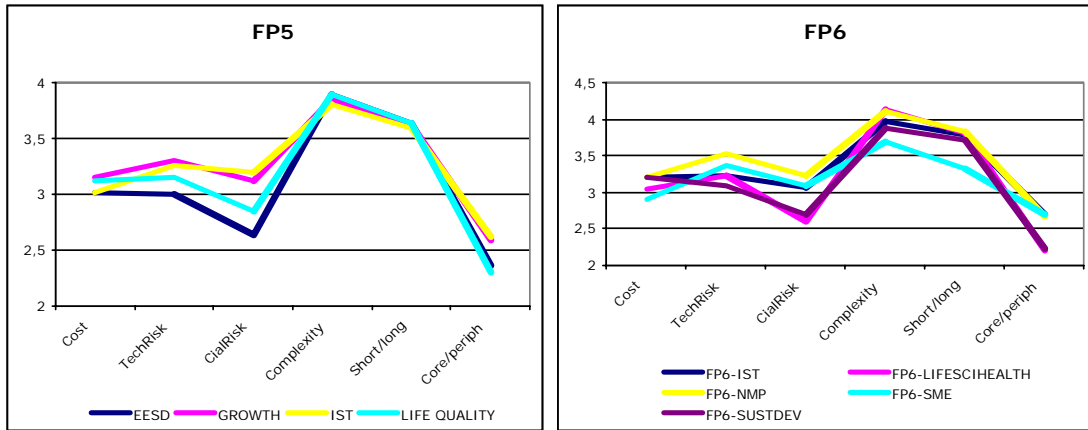
#### 4.2.1.2 Relation between characteristics of FP projects and EU project classification

On average, FP5 and FP6 projects show similar characteristics.

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

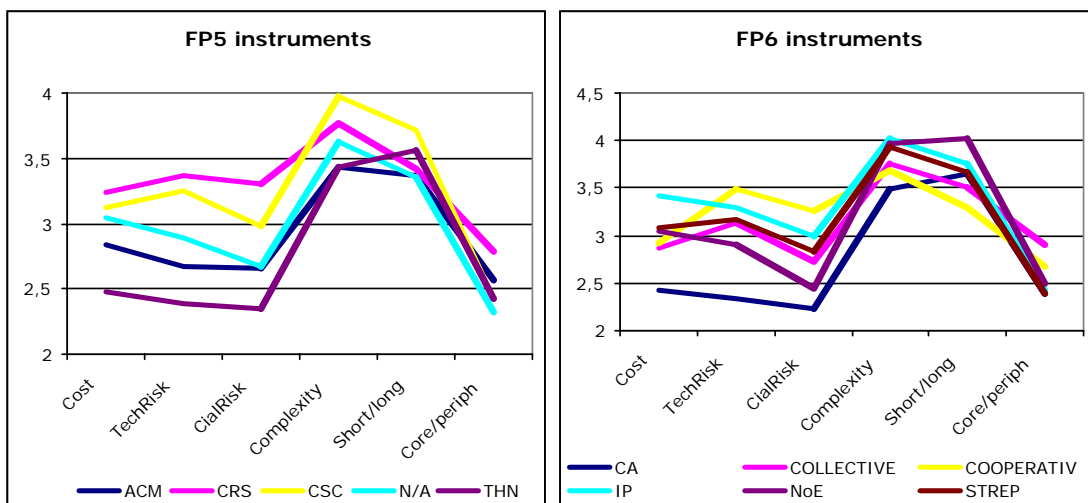
difference can be found in Life Sciences and Health and Sustainable Development (less commercially risky and very close to the core), while SME projects are less complex and less long-term oriented.

**Figure 4.10: Relations between characteristics of FP projects and EU project classification**



The main differences appear when looking at FP instruments. 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.

**Figure 4.11: Relation between characteristics of FP projects and EU project classification**



#### 4.2.1.3 Relation between market and technological environment and project characteristics

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.

#### 4.2.1.4 Project characteristics and partners involvement in project

This analysis identifies interesting relationships between the two elements, which once again confirms the initial findings.

Being 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 last result 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.

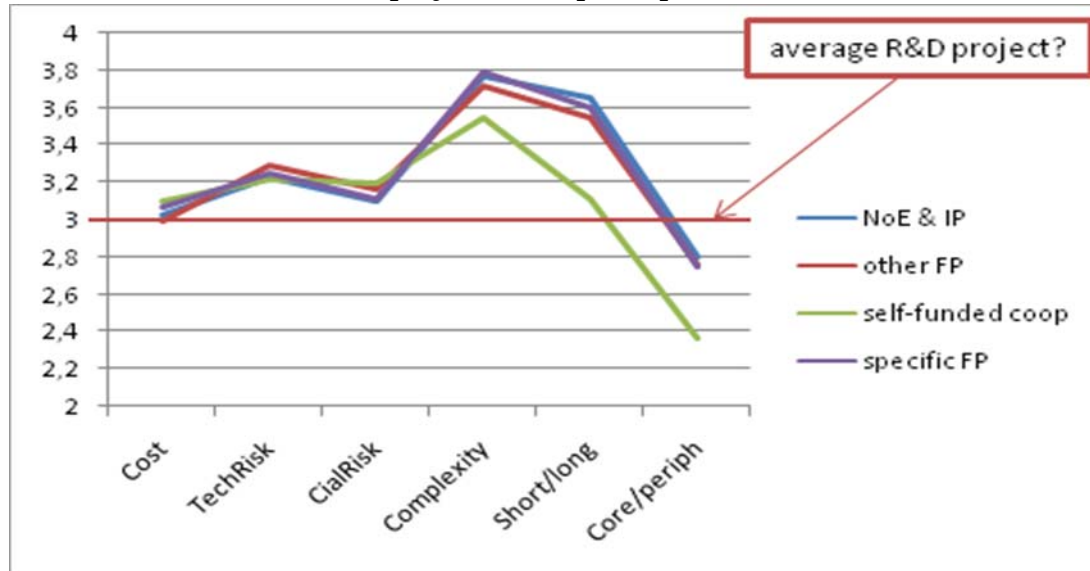
#### 4.2.1.5 Comparison of the characteristics of the specific FP project surveyed with the characteristics of the overall FP projects of the participants

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). These points are extensively treated in the following section, but it is interesting to superimpose some basic results of the two comparisons.

**Figure 4.12: Comparison of characteristics of the specific FP to the overall FP projects of the participants**



The characteristics of the specific project are valued at almost exactly the same as those for the FP projects of the organisation in "general". Those characteristics are thus likely to be very robust.

The similarity is also relatively clear when particular categories of participants are analysed. Actually, the more the NoE and IP projects are different from other FP projects, the more specific FP projects are divergent from the two others.

The profiles of the FP projects issued from the two independent comparisons are then very similar. Various (not necessarily mutually exclusive) interpretations can be provided for this quite surprising result. For some of the respondents, the specific FP project is the only one ever carried out, where it is then obvious that the similarity is likely to be found. It could also mean that the respondents had the same "implicit reference" when they did both comparisons, i.e., that the comparison between the three contexts of collaborative work was based on a fourth "baseline" context corresponding to an "average R&D project".

The use of Lickert 1 to 5 scale, with 3 as a medium value, would favour this hypothesis. Another way of looking at this result would be to take into account the possibility that respondents were focusing on the specific project whose characteristics appeared to him/her as the "generic" and representative of those of all the FP projects of his/her organisation. It could also be the case that there are some inherent properties of the FP projects which are quite stable over all the analysed categories; many results provided in this report could be in favour of this hypothesis. Then it would mean that the sample of FP projects covered is representative of all the FP projects, not only at the level of the sample, but also at the level of each surveyed participant. More precisely, we could then assume that the specific project surveyed in one given organisation is representative of all the FP projects carried out by this organisation when these six characteristics are taken into account. However, there is no evidence that *all* characteristics of the specific projects of the organisation are representative of the ones of all the FP projects carried out by the same organisation.

#### 4.2.2 Comparison between FP5/6 projects and self-funded collaborative projects

Our objective here is to characterize two types of inter-firm agreements from a micro-analytical perspective: FP 5 and FP 6 R&D cooperative projects versus spontaneous, privately funded research projects. Except for previous work by members of this consortium (Matt & Wolff, 2004, 2005 in the case of fuel cell technology and Brite Euram) and for Hagedoorn and Schakenraad (1993) in the case of big IT firms<sup>26</sup>, there is no explicit mention of similar issues in the literature about inter-firm collaboration. Although Hagedoorn and Schakenraad did not identify substantial differences between the two kinds of agreements in terms of number and/or intensity of the inter-firm linkages (i.e., the general shape of the networks), we contend that sharp differences may appear when opening the 'organizational black box' of inter-firm relationships. More precisely, we suggest that the two types of agreements may exhibit contrasted characteristics in terms of motivation, risks and coordination features.

##### 4.2.2.1 Motivation in participating in FP projects shaped by information disclosure and subsidy provision

On the one hand, participation in a FP means that certain information concerning the project becomes publicly available. The EU CORDIS database provides free access to a list of funded projects, including a summary of the research objectives and the list of the different partners. From the strategic point of view of a specific company, several assumptions can be made about this information disclosure:

- the firm does not mind revealing this kind of information because the project is not critical for it, in the sense that it is one of its peripheral activities;
- the firm wants to reveal this information as a signalling strategy. For instance, it wishes to signal to the external world a specific technical competence, its willingness to cooperate, or intention to enter a new research area, etc. This signalling strategy is *a priori* compatible with the hypothesis that the project is connected with peripheral activities, insofar as competitors, clients and suppliers would generally be familiar with the core activities of the firm. Thus, signalling of a core activity seems to be less important for the firm than signalling other domains of interests that might attract new partners.

Spontaneous research collaboration represent an alternative means to access external complementary knowledge, without necessarily disclosing this strategy publicly. In other words, partners can choose whether or not to advertise the existence of their collaboration. If the R&D project is closely connected to the core activity of the firms, they may prefer to keep the cooperation secret<sup>27</sup>. Spontaneous agreements are thus more compatible with the preservation of secrecy, often required for highly strategic activities.

On the other hand, the decision to finance research collaboration (using public or internal private funds) is connected with the way companies manage their knowledge. The more strategic the knowledge (i.e., close to the core competences), the more the company will be prompted to invest on its own. Here, again, we find the idea that the spontaneous strategy is

<sup>26</sup> Hagedoorn J, Schakenraad J. 1993. A comparison of private and subsidized R&D partnerships in the European information technology industry. *Journal of Common Market Studies* 31(3): 373-390.

Matt M., Wolff S. 2004. Incentives, coordination and learning in government-sponsored vs. spontaneous inter-firm research cooperation. *International Journal of Technology Management*, vol. 27 n°8, pp. 694-711.

Matt M., Wolff S. 2005. The organizational specificities of Brite-Euram collaborative projects: micro-analysis and policy implications. *Innovation Policy in a Knowledge-Based Economy: Theory and Practice*, P. LLERENA and M. MATT (Eds), Springer Verlag, Berlin Heidelberg.

<sup>27</sup> We do not mean that all spontaneous agreements imply secrecy. At a development stage, or subsequent to promising preliminary results, firms may have an interest in disclosing the cooperation for competitive reasons: to patent a technological innovation, to be the first to innovate, to advertize their comparative advantage, etc.

more likely to be related to the management of critical, "close to core" knowledge. Moreover, the subsidy may be considered as a direct or indirect means to open up new technological options, that is to say, to broaden the scope of exploration. It is presumed that the new options are located at the periphery of the firms' activities. They might, of course, eventually become central in the future. By contrast, private funding explores previously selected options, considered as having strategic priority and connected to the – future – core activities of the company. To some extent, government-sponsored collaboration tends to be more "exploratory" and private funded partnerships more "exploitation" oriented.

#### 4.2.2.2 Risk management<sup>28</sup>

When the FP was set up in the early 1980s, collaboration was considered a means for decreasing individual company risk or, alternatively, a means to incentivise a company to engage in riskier research than in the absence of collaboration. The argument was strong because it also seemed to tie in well with the issue of knowledge spillovers: companies would not undertake research projects if they believed that they could not keep a sufficient part of the resulting knowledge privy. Pre-competitive (or generic) research was considered to fulfill both criteria for prospective market failure/public support: it carries higher risk because it is longer-term and produces more spillovers than short-term, near-market technology development. Moreover, by focusing on such projects and by supporting collaborative approaches, the Commission was distancing itself from potential accusations of unfair support of that or the other Community Member.

Over the course of the years, however, surveys have repeatedly shown that the projects supported by the FP carry regular degrees of risk, presumably not higher than other research the same companies engage in during the course of their business. This result challenges the FP justification mentioned above and has led to calls for increasing the degree of risk in FP research projects.

How realistic is such an expectation? There can be an argument that the management tool itself (partnership) limits the incentives of, at least a good number of, companies to pursue very risky projects. Firms will typically not bring to partners – prospective competitors – ideas they consider potential blockbusters. They want to keep those to themselves. It is also well known that blockbusters are related to high levels of risk.

#### 4.2.2.3 Coordination of work and actors in FP project is shaped by the existence of pre-defined rules and arbitration procedures

In the FPs, the EU, in charge of the management and the control of the programme, requires certain information and imposes certain (minimal) rules that must be respected by all partners. For instance, the research contracts signed by partners contain provisions about the allocation of funds and budget between the partners, the duration and milestones of the agreement, the contribution to be made by each partner, and the objectives of the project. European programmes also impose certain minimal inter-partner coordination rules in terms of allocation of work: *ex ante* definition of work packages, organization of a minimum number of meetings, etc. The modular character of the projects (i.e., no or little integrated work) does not induce partners to interact intensely and very often the minimum number of required meetings (plus some additional phone conversations and bilateral meetings) is enough to exchange information and coordinate the work. Moreover, this kind of programme usually requires that the partners agree on the results and/or property rights. This pre-defined framework eases the coordination of the partners in terms of allocation of resources (money, competences, tasks, property rights), and contributes to building the channels used to communicate and exchange research results. In other words, it helps to set the initial

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<sup>28</sup> We thank Nick Vonortas for this important input in terms of risk management.

conditions of the collaboration and constitutes an important stabilizing element. The latter has a negative counterpart materialised by the high bureaucratic costs induced by the set of pre-defined rules and the tight monitoring procedures (recurrent reporting, financial and other types of justifications, administrative papers etc.).

In a spontaneous collaboration strategy, the partners have first to elaborate and agree upon the kinds of rules to be applied before specifying their content. Spontaneous agreements, therefore, have to overcome an additional problem, which is to define the “borders” of the contract. In the negotiation phase, partners must learn which rules should be created, and also how to implement and manage them. This first step confers on the partners a higher degree of freedom and flexibility compared to FP projects. To maintain or even extend this flexibility the partners may well be induced to formalize and codify fewer rules and contractual safeguards than in a government-sponsored agreement. But flexibility and informal coordination have a counterweight. This greater freedom may entail more hazards and misunderstandings, which result in the well documented, high failure rates, i.e., to the premature end of cooperation.

Furthermore in FP projects, the scientific advisor in charge of the management and control of the programme can play the role of arbitrator, in the sense of Williamson (1979), should a conflict arise. For instance, in the case of non-enforcement of the agreed rules by one of the partners, the public supervisor imposes some credible threat (no more subsidy payments, no reimbursement). The supervisor can exclude one of the partners and help the remaining group to stabilize. Another factor might explain the relatively higher stability of EU sponsored collaboration: the strategic importance of networking and reputation effects in the microcosm of firms participating in a European research programme.

In spontaneous agreements, there is no official arbitrator and the partners have to define their own solutions to conflicts. Asking a third party (very often a lawyer) to intervene is usually an expensive alternative that does not preserve the continuity of the relationship and is generally used only if the damages are significant. The absence of an arbitrator may be another reason for the relatively higher percentage of failure in spontaneous agreements compared to government-sponsored ones.

The survey allows us to distinguish between three types of projects: NoE and IP (Type 1); Other FP5 and FP6 projects (Type2); Cooperative projects exclusively funded from internal R&D budget (Type3). We would like to underline that the above mentioned hypotheses were built to analyse Type 2 projects vs. Type 3 ones. However, NoE and IP projects (Type 1) exhibit the same features in terms of information disclosure, subsidies, risk management, pre-defined rules and arbitration as Type 2 and thus they should not differ very much.

After briefly presenting the sampling mode, we will present the results of the use of different econometric models aiming at testing these hypotheses. We first (firm-level analysis) highlight the characteristics of firms which are more likely to participate in a given type of project (Type1, Type2 or Type 3), and then (project-level analysis) we characterize Type 1 and Type 2 projects as compared to Type 3 ones along various project features and firm characteristics.

#### 4.2.2.4 Sample selection

The Innovimpact survey allowed us to gather a database of 3379 firms participating in a European Programme. A cleaning process allow us to keep 1 490 for the purpose of the analysis (see Annex 3, Tables 4.1 and 4.2 for details). This sample was found to be representative of the original dataset, according to key variables: firm age / date of establishment, firm turnover, number of employees, and R&D expenditure, type of activity (manufacturing firms, however, being slightly higher in the original dataset than in the final sample, whereas the proportion of “other” firms is lower in the final sample).

From the selected sample, and after some further cleaning operations, we built a database on 2930 typical projects, each project being of a single type (1: NoE and IP (FP6); 2: Other FP5 and FP6 R&D project; 3: Co-operative projects exclusively from internal R&D budget). We conducted our analysis in two steps: firstly, on the selected sample of 1490 firms (firm-level analysis); secondly, on the population of 2930 projects (project-level analysis).

#### 4.2.2.5 Firm-level analysis

The objective of this analysis was to identify firms more likely to participate in a given type of project. There are three possible project types:

- Type 1: NoE and IP (FP6);
- Type 2: Other FP5 and FP6 R&D project;
- Type 3: Co-operative projects exclusively from internal R&D budget

We evaluated the probability that firm  $i$  participates in project type  $j$  ( $j = 1, 2, 3$ ), taking into account the following explanatory variables: firm size (measured by the number of employees), firm age, an indicator of firm relative experience / inexperience of European Framework Programmes (built using survey Question 11), indicators of the means used to protect innovation within the firm (built using items from survey Question 7), and 2-digit industry dummy variables (a.k.a. “industry fixed-effect”)<sup>29</sup>. The characterisation of the model used and the results of the estimation are extensively presented in Annex 3, Table 4.3. Since the model is nonlinear and we have not computed the marginal effects, we can only interpret these results qualitatively, using the signs of the coefficients (estimated parameters).

Our main findings are as follows:

- Only the largest firms (over 250 employees) are more likely to participate in any type of project, whereas all firms except the smallest ones are likely to participate in Type 3 projects;
- The older a firm, the more likely it is to participate in Type 1 projects, and the less likely it is to participate in Type 2 projects;
- Firms without previous experience of participation in FP projects are less likely to get involved in any type of project.

For the sake of convenience, it is better to examine the impact of innovation protection measures by type of project. We find that:

- Firms that are more likely to participate in Type 1 projects are those which rely heavily on IPR alternative to patents (e.g., copyright, trademarks, registered designs);
- Firms that display a high use of patenting and a high pace of renewal are more likely to get involved in Type 3 projects.

#### 4.2.2.6 1.2.4. Project-level analysis

Each of the 2930 projects can be of one – and only one – of the following three types:

- Type 1: NoE and IP (FP6);
- Type 2: Other FP5 and FP6 R&D project;
- Type 3: Co-operative projects exclusively from internal R&D budget.

There were 854 Type 1 projects, 1129 Type 2 projects and 947 Type 3 projects; in other words, each project type represents roughly 1/3 of the population of projects, with Type 2 projects being slightly more represented. For each typical project, we have information on

<sup>29</sup> We used a trivariate probit model estimated using simulated likelihood. We also experimented with an alternative specification of the model, using items from survey Question 6 (type of innovation activities conducted within the firm) instead of Question 7, but few of these items were significant.

project characteristics (based on the various items of survey Question 8) and on the characteristics of the firm in which the project was conducted. Of course, there can be different types of projects conducted within one firm, so two different typical projects (say, project  $i$  of Type 1 and project  $j$  of Type 2) can have the same firm identifier.

We evaluate the probability that a project  $i$  be of type  $j$  ( $j = 0, 1, \dots, M$ ), taking into account different vectors of explanatory variables. We estimated a first model using only project-specific variables (i.e., the different items related to research Question 8), and a second model in which we added firm characteristics (i.e., the characteristics of the firms where each typical project was conducted. Firm characteristics include: size (number of employees), age, previous experience with European Framework Programmes, a four-category indicator of industry, and indicators of the means to protect innovation (i.e., the various items pertaining to survey Question 7)<sup>30</sup>. The characterisation of the model used and the results of the estimation are extensively presented in Annex 3, Table 4.4.

We present only the results of our most complete models (i.e., with project characteristics and firm characteristics, including the means to protect innovation). We find a strong effect of project characteristics on the type of project, whereas the characteristics of the firm where the project was conducted are overall less significant. Our findings are as follows (Type 3 is the category of reference and, as before, we are interested in the sign of the estimated coefficient):

- As compared to Type 3 projects, Type 1 and Type 2 projects are less likely to involve a high commercial risk. Moreover, Type 1 projects are also less likely to involve a high technological risk;
- As compared to Type 3 projects, both Type 1 and Type 2 projects are characterized:
  - by a long-term R&D horizon,
  - an interest in peripheral technologies (rather than core technologies),
  - and exploration strategies (i.e., exploration the potential of new technologies rather than exploitation or existing technologies);
- Recurrent conflicts are less likely to occur in Type 2 projects than in Type 3 projects, whereas they are as likely to occur in Type 1 and Type 3 projects;
- As compared to Type 3 projects, both Type 1 and Type 2 projects seem :
  - less flexible,
  - to involve more red tape and bureaucracy;
- Both Type 1 and Type 2 projects are characterized by either few or frequent interactions between partners (but not by personnel mobility and joint team creation), however, this result is more significant in Type 2 projects;
- Finally, the characteristics of the firm where the project was conducted matter, especially for Type 2 projects. These projects are more likely to occur in medium-sized firms (50 to 250 employees), and less likely to occur in small (10 to 50 employees) and large (over 250 employees) firms. They are also less likely to occur in firms that make a high use of patents, whereas Type 1 projects are more likely to occur in firms that make a high use of other IPR (i.e., alternative to patents).

In a nutshell, Type 1 and Type 2 projects share similar characteristics that set them apart from Type 3 projects. Type 2 projects, however, seem to involve fewer conflicts and more interactions, whereas Type 1 projects involve a lower technological risk. Moreover, Type 1 and Type 2 projects do not occur in the same type of firms: Type 2 projects are more likely to

<sup>30</sup> We used two specifications of a multinomial Logit model estimated by Maximum Likelihood. We also implemented a third model in which indicators of innovation activity were used instead of indicators of innovation protection, but this did not significantly change the results. We also tested a multinomial Logit with a firm random-effect and found results similar to those presented here.

take place in medium-sized firms that do not rely heavily on patents, whereas Type 1 projects are more likely to occur in firms that rely strongly on IPR alternatives to patents.

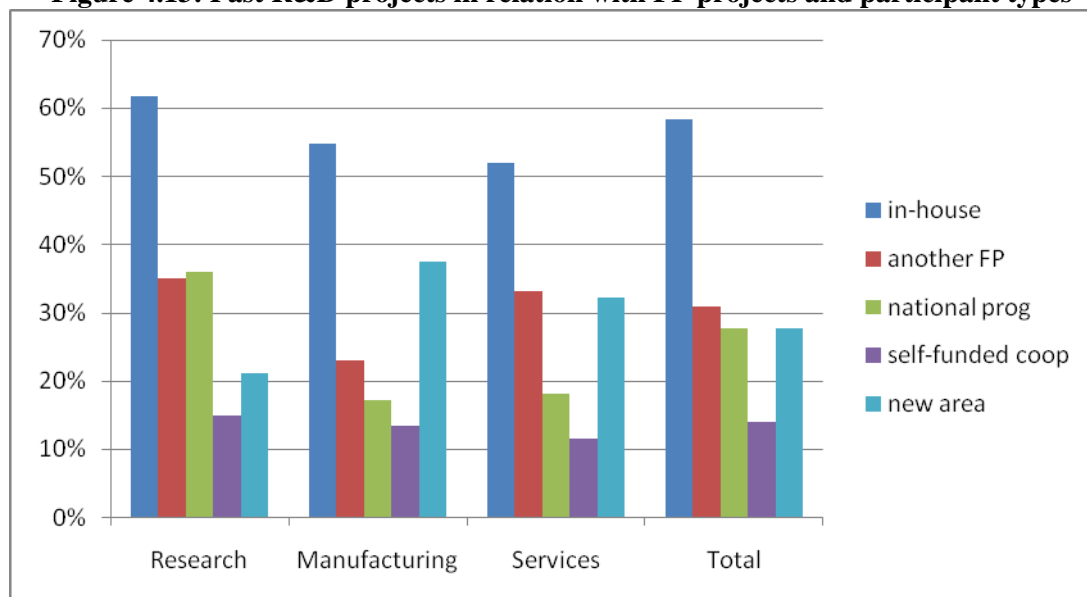
#### 4.3 How do FP projects relate to other projects

Two related analyses are provided here. The first investigates what R&D the specific project built on, focusing on the context in which this past R&D was carried out. In the second, an attempt is made to identify a "projects chain" linking past projects, FP project and subsequent R&D projects.

##### 4.3.1 Past R&D projects in relation with FP 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.

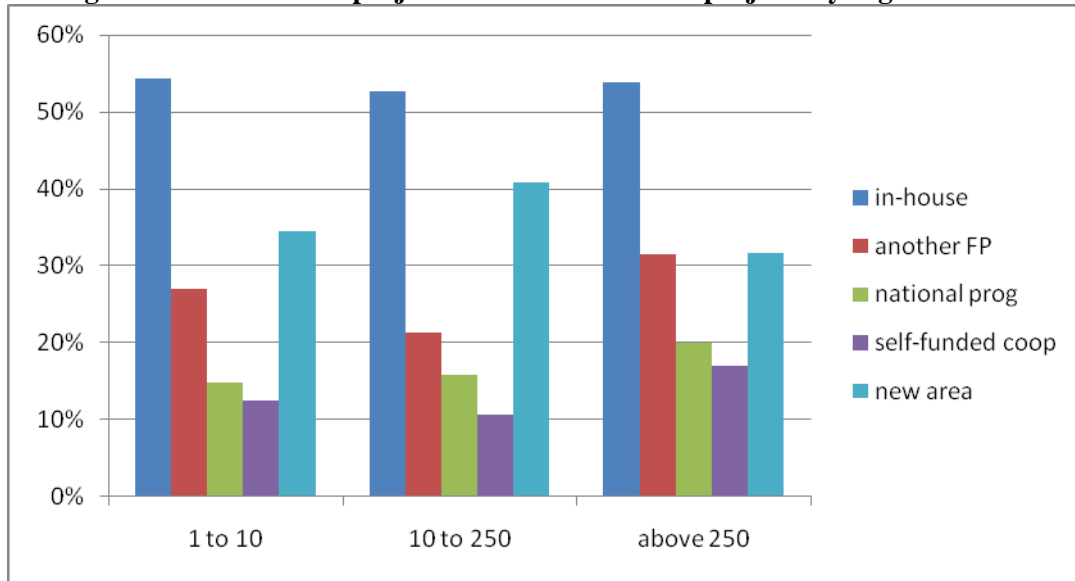
**Figure 4.13: Past R&D projects in relation with FP projects and participant types**



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) and new area (for all firms) are highlighted significantly. This may be due to the fact that FP projects are less aimed at basic research, i.e., the ones that could only be considered as an opportunity for research partners to enter new fields.

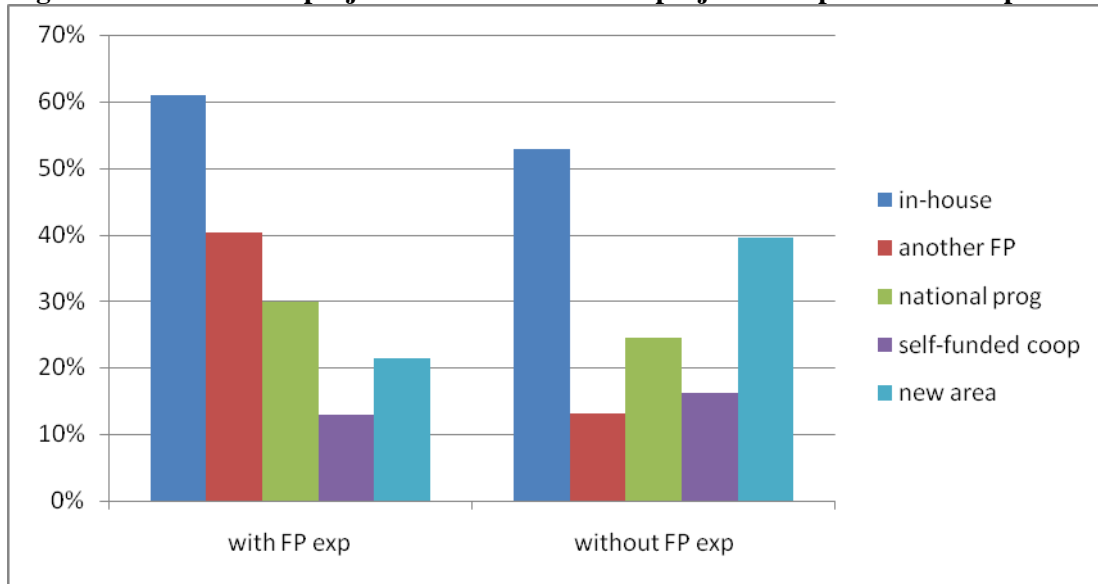
The ranking of past R&D contexts is the same whatever the size of the partners. Small firms more often acknowledge an entry in new area, while other FP projects, and to a lesser extent self-funded cooperative projects, are more common for large firms.

**Figure 4.14: Past R&D projects in relation with FP projects by organization size**



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.

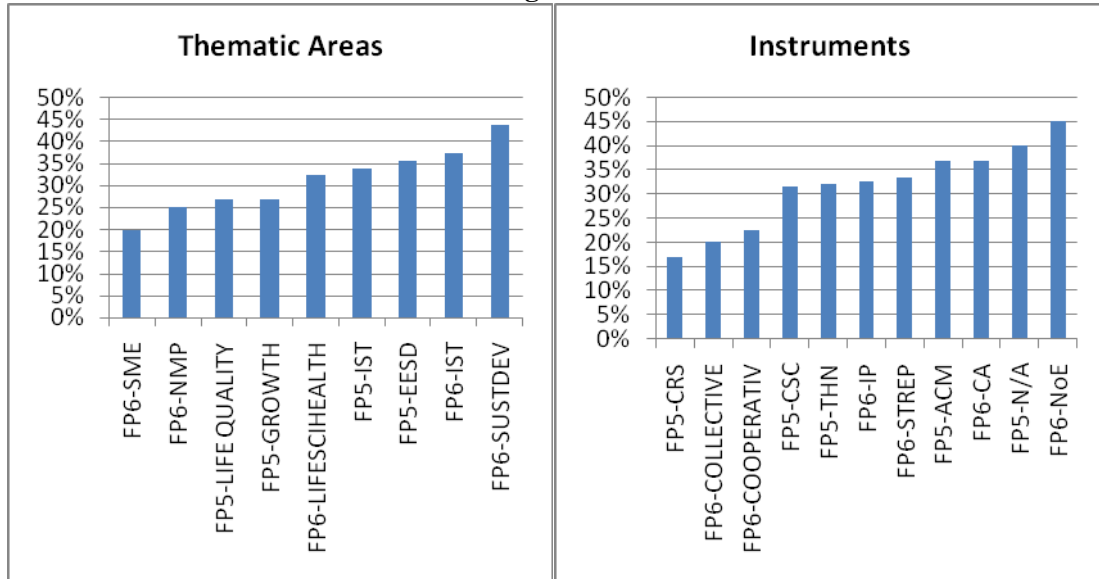
**Figure 4.15: Past R&D projects in relation with FP projects and previous FP experience**



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).

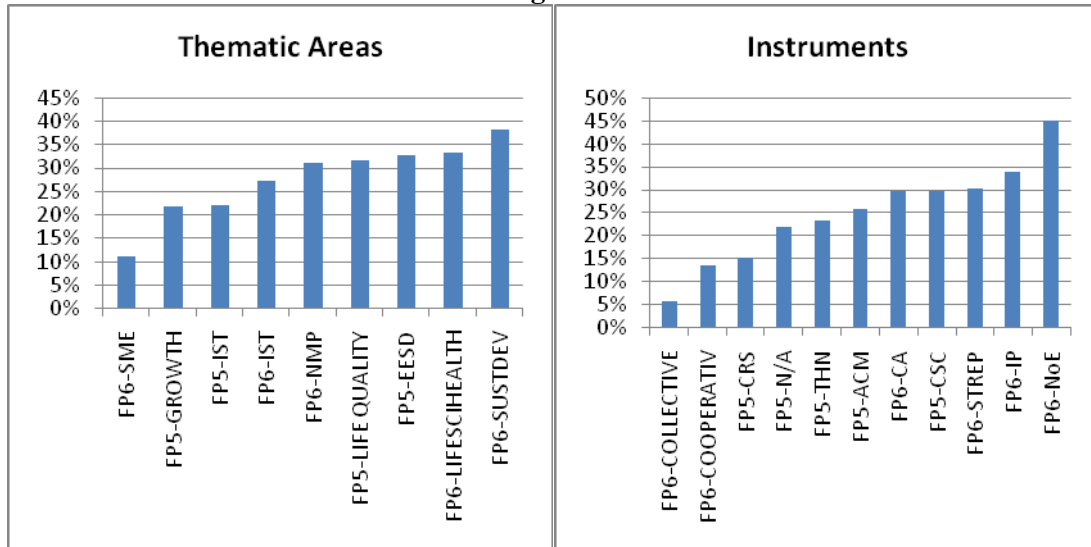
The proportion of projects that have a national programme as an origin is slightly higher in FP6 than FP5 (31% against 26%). This is particularly true for Sustainable Development and for the instruments IP and NoE. Conversely, SME (FP6), CRS (FP5), and Cooperative and Collaborative (FP6) are lower than average in that respect.

**Figure 4.16: Past R&D projects in relation with FP projects per Instrument and Programmes**



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.

**Figure 4.17: Past R&D projects in relation with national projects per Instrument and Programme**



**4.3.2 A "chain of projects"**

This section explores the line of research (for enterprises only) from past R&D to the specific FP project to follow-up R&D projects.<sup>31</sup> The first part has already been analysed separately.

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. All

<sup>31</sup> For the detailed results please look Annex 3, Figure 4.6.

roles seem somehow negatively correlated with past experience, although in many cases only slightly so. Interestingly, the role of manager of the specific FP projects seems to be largely independent of past R&D experience (past experience in another FP project even seems to lower the propensity to act as manager).

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.

#### *4.4 Summary conclusions project characteristics*

The origin of the idea on which the FP projects are based seems to have developed slightly from one FP to the next, with a reinforcement of the influence of research or education partners in FP6. Only IST seems to remain primarily industry-driven.

In both FP5 and FP6, more than 40% of the projects are related to emerging markets.

Project roles are relatively balanced split almost evenly 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 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 whom they had worked before, than old timers.

In the case of firms, Type 1 (NoE and IP in FP6) and Type 2 (other FP5 and FP6) projects exhibit similar characteristics that set them apart from cooperative projects exclusively funded via internal R&D budget.

Type 1 and Type 2 have also specific features: Type 2 projects are less conflicting and characterised by few or frequent interaction and Type 1 projects involve a lower technological risk.

Type 1 and Type 2 are not conducted by the same kind of firms: Firms which strongly rely on IPR alternative to patents have a higher probability to conduct Type 1 projects and Type 2 projects are more likely to take place in medium-sized firms which do not highly patent.

Compared to average R&D project, FP projects are more complex and more long term oriented. They are also bit more risky from a scientific and technical point of view. They are closer to the core R&D field of the participants than the average R&D project. Finally, FP projects very much look like "average R&D projects" with respect to commercial risk and project cost. All these results are remarkably stable over most of the classification of participants. It also holds for both FP5 and FP6.

In more than half the cases, in-house R&D projects had preceded the FP projects. In a third of the cases, it was a new area for participants, and the result is stable across all types of participants. In FP5 and FP6, the proportion of past FP projects cited as a source for a

subsequent FP specific projects is about about one-third. This proportion is significantly higher in Sustainable Development (FP6) and IST (FP6) and lower in SMEs (FP6). National programmes also accounted for a similar share as origins of the idea. Projects funded by their own funds came a far third as originators.

Previous FP experience obviously has an impact on the importance of FPs as a source: participants without previous FP experience cite other FPs less frequently.

## 5 Market, Firm, and Project-level effects on the innovation impact of FP R&D projects<sup>32</sup>

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.<sup>33,34</sup> 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.

### 5.1 Econometric Analysis (Survey)

We utilize survey responses collected on collaborative R&D behaviour and outcomes via an ambitious pan-European data collection effort during January-May 2007 (see Section 2.3). We have employed a variety of statistical techniques – including factor analyses, logistic regressions, and OLS regressions – to arrive at substantive conclusions about the impact of the aforementioned factors on R&D project success. The empirical analysis is also supplemented and enhanced by the qualitative findings from a large number of case studies of participating organizations in FP5 and FP6.

#### 5.1.1 Innovation Impacts Defined

Innovation impact as a general term is a broad and multidimensional concept. It is therefore necessary to define this term in the particular context of publicly funded R&D projects examined herein.

As already introduced in Section 2.2.1, 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

<sup>32</sup> This chapter is based on contributions from AUEB: Nick Vonortas, Yiannis Spanos and Eric Söderquist, and Formit: Luca Remotti

<sup>33</sup> These “classes” of effects correspond to the following research questions (Lines of Inquiry II and III):

**Research Question 5:** Management practice for collaborative RTD projects at all stages (design, application, implementation, post-project monitoring and exploitation).

**Research Question 6:** Project-level characteristics and their effects on (a) research success and (b) on innovation and commercialization.

**Research Question 7:** Firm-level characteristics and their effects on (a) research success and (b) on innovation and commercialization.

**Research Question 8:** Industry and market-level characteristics and their effects on (a) research success and (b) on innovation and commercialization.

<sup>34</sup> It is worth noting that in the early stages of the Innovation Impact study, management practices and project-level characteristics have been categorized as two distinct research questions (RQ5 and RQ6, respectively). The conceptual difference between the two, however, is rather ambiguous; without loss of generality, management practice for collaborative R&D could be subsumed under the broader heading of project-related characteristics.

aspects of the commercialization process of a research result and the attributes of the research result *per se*.

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.<sup>35</sup> 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.

Figure 2.2 in the opening Chapters of this Report has already sketched the logic of the econometric analysis in this Section.

### **5.1.2 Sample**

Two separate questionnaires were developed corresponding to business enterprises and research organizations (ROs) (universities, research institutes, etc.). In principle, we expect qualitatively different behaviour between firms and ROs in terms of their capabilities and idiosyncratic characteristics, the project management practices they employ, and ultimately their motives and objectives in participating in collaborative R&D projects. We only discuss analytically the results from the enterprise questionnaire here. Enterprises have been the centrepiece of our analysis, focusing on innovation as it was. Both sets of data have been analysed with similar methodologies, nonetheless occasionally we may refer to the results from the RO sample.

Data were collected from business enterprises from all over Europe and beyond. The technicalities of data collection (i.e., target populations, methods, etc.) as well as descriptive statistics of the two samples have been detailed earlier in Section 2.3. A total of 3379 enterprises had provided data at the time of this analysis, but we had a very large proportion of missing values. As a result, the effective sample size used for the substantive analyses is much lower (see below).

### **5.1.3 Variables and Measures Validation**

The constructs of interest in this analysis were tapped using both multiple questionnaire items (scales) and categorical (dummy-coded) variables. With respect to the former, respondents rated each item on one-to-five Likert-type scales in which higher values were always associated with higher levels of the construct. To increase the content validity of our measures, most of the variables were derived and adopted from previous studies. Following

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<sup>35</sup> 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.

confirmatory factor analyses, we constructed composite measures of these constructs by averaging the respective individual items.

Our measures reflect the theoretical concepts that were hypothesized to affect project success. 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. More specifically, using CFA we tested various models where we entered one independent construct at a time together with the items measuring technical knowledge (our only dependent variable measured through a scale). Common method bias is present when a one-factor model (i.e. a factor loading on items reflecting both the independent and dependent constructs) fits better than a two-factor model. In effect, we are testing whether a "common factor" accounts for the majority of the observed variance among the items in the model. The results from these analyses show clearly that common method bias is not a main concern for this study.

The following Table provides an overview of the measurement of all constructs used in this analysis for which we have developed specific hypotheses – with three exceptions. The latter refer to *control* variables that are included in the analysis that follow, and for which we did not formulate specific hypotheses. Based on their order of appearance in the Table, the first control variable concerns whether the respondent organization is a manufacturing or a services firm (MANUF). This variable is used to distinguish between these two organizational "types". The next control variable, EU, represents the country of origin of the respondent organization. It is a nominal variable with three categories: EU-15; EU-27 (i.e., it reflects respondents from the 12 countries that accessed more recently the EU); and "other" (i.e. respondents from third countries). FP is another control variable denoting whether the project in question belongs to FP6 (vs. FP5). Finally, the control variable ROLE is used to denote whether the respondent has a major role in the project. Specifically, it takes the value 1 when the respondent is project manager and/or user and/or technology producer, and 0 otherwise.

The first column in Table 5.1 gives the question codes for the enterprise sample. The second provides a brief explanation of the construct. The third column shows the type of measurement of the construct, that is, whether it is a scale of Likert-type ordinal measures, a single "objective" variable (e.g., number of months or number of partners in the project), or a nominal dummy-coded variable. The final column shows the hypothesis tested by the respective variable and the expected sign.<sup>36</sup>

**Table 5.1: Constructs and Hypotheses**

Industry Quest. Code	Construct		Hypotheses
<b>MARKET-RELATED</b>			
Q10_factor1	Market environment: competitive & technological dynamism	Scale	Hypothesis 1a: (?)*
Q10_factor2	Market environment: dynamism in customer preferences	Scale	Hypothesis 1a: (?)
ILC	Industry Life-cycle	Single likert type item	Hypothesis 1b: (+)
<b>FIRM-RELATED</b>			
	"Basic"		

<sup>36</sup> Research hypotheses are listed in .

Industry Quest. Code	Construct		Hypotheses
	<b>MARKET-RELATED</b>		
Q2new	Age	Single objective variable	Hypothesis 2: (?)*
Q3_2	Size class	Single likert type item	Hypothesis 3: (?)*
EU	Country (1: EU-15; 2: EU-27; 3: other)	Nominal	Control variable
Manuf	Manufacturing (vs. Services)	Dummy variable	Control variable
	<b>"Firm's resources and capabilities"</b>		
Q9_factor1	Marketing skills	Scale	Hypothesis 4: (+)
Q9_factor2	Capacity for "speed"	Scale	Hypothesis 4: (+)
Q9_factor3	Integration capability	Scale	Hypothesis 4: (+)
Q7_factor1	Innovation protection: Legal means	Scale	Hypothesis 4: (+)
Q7_factor2	Innovation protection: competitive means	Scale	Hypothesis 4: (+)
Q7_factor3	Innovation protection: "complex" technology	Scale	Hypothesis 4: (+)
	<b>"Firm's innovation history"</b>		
Q6_1	Intramural R&D in the past 3 years	Dummy variable	Hypothesis 5: (+)
Q6_2	Extramural R&D in the past 3 years	Dummy variable	Hypothesis 5: (+)
Q4_3	Product Innov (New-To-The-Market) introduced in the past 3 years:	Dummy variable	Hypothesis 5: (+)
Q4_4	Product Innov (New-To-The -Firm) introduced in the past 3 years:	Dummy variable	Hypothesis 5: (+)
Q4_5	New Process Innovation introduced in the past 3 years:	Dummy variable	Hypothesis 5: (+)
	Development of new or improved goods and services introduced in the past 3 years:	Dummy variable	Hypothesis 5: (+)
	Creation of spin-off introduced in the past 3 years:	Dummy variable	Hypothesis 5: (+)
	Patents introduced in the past 3 years	Dummy variable	Hypothesis 5: (+)
	IPR introduced in the past 3 years:	Dummy variable	Hypothesis 5: (+)
	Award licenses to firms introduced in the past 3 years	Dummy variable	Hypothesis 5: (+)
Q5_1	Innovation performance (% turnover from new/improved products):	Single likert type item	Hypothesis 5: (+)
Q11_1	First participation in FP? (yes/no)	Dummy variable	Hypothesis 5: (+)
	<b>PROJECT-RELATED</b>		
	<b>"Basic"</b>		
FP	FP6 (vs.FP5 )	Dummy variable	Control variable
Proj_dure	Project duration (in months)	Single objective variable	Hypothesis 7: (+)
Total	Consortium size	Single objective variable	Hypothesis 6: (+)**
Fraction	% of partners from industry	Single objective variable	Hypothesis 8a: (+)
Leader (1)	consortium Leader from industry (yes/no)	Dummy variable	Hypothesis 8b: (+)
	<b>"EU rules"</b>		
Q20_factor1	Practices in line with EU rules	Scale	Hypothesis 8c: (unrelated)
Q21_factor 1	EU rules' impact on: project implementation	Scale	Hypothesis 8d: (+)
Q21_factor 2	EU rules' impact on: partners selection/negotiations	Scale	Hypothesis 8d: (+)
	<b>"Nature" of the project</b>		
Q17_1	Innovation reflected in selection criteria	Single Likert-type item	Hypothesis 9: (+)
IDEA	The project's IDEA comes from industrial partners (yes/no)	Dummy variable	Hypothesis 9: (+)
PAST-RD	The project builds on past R&D activities (yes/no)	Dummy variable	Hypothesis 10: (+)
Q18_factor1	Project objectives: commercial	Scale	Hypothesis 9: (+)
Q18_factor2	Project objectives: funding & reduce risk	Scale	Hypothesis 9: (+)
Q18_factor3	Project objectives: "technological"	Scale	Hypothesis 9: (+)
Q18_factor4	Project objectives: "networking"	Scale	Hypothesis 9: (+)
Q19_factor1	Nature of project: "risky"	Scale	Hypothesis 11: (+)**
Q19_factor2	Nature of project: "new area"	Scale	Hypothesis 11: (+)**
Q19_factor3	Nature of project: "complex"	Scale	Hypothesis 11: (+)**
Role	Respondent is manager/ or user/ or technology producer (yes/no)	Dummy Variable	Control variable
	<b>Project Management</b>		
Q16_1	# of partners having worked with	Single objective variable	Hypothesis 12: (+)
Q16_2	# of partners having <b>not</b> worked with	Single objective variable	Hypothesis 12: (-)
Q22_factor1	Clear project objectives	Scale	Hypothesis 13: (+)
Q23_factor1	Communication (within team)	Scale	Hypothesis 14: (+)
Q24_factor1	Coordination (within team)	Scale	Hypothesis 14: (+)
Q25_factor1	Cohesion/Trust	Scale	Hypothesis 15: (+)
Q26_factor1	Learning within team: Intuition	Scale	Hypothesis 16: (+)
Q27_factor1	Learning within team: Interpretation	Scale	Hypothesis 16: (+)
Q28_factor1	Learning within team: Integration	Scale	Hypothesis 16: (+)
	<b>COMMERCIALIZATION-RELATED</b>		
PATENT	Project output protected with patent (yes/no)	Dummy variable	Hypothesis 18: (+)
EXPL_COLLAB:	Exploitation was made through collaboration (yes/no)	Dummy variable	Hypothesis 17: (+)
Q37_1	Time to market (months)	Single objective variable	Hypothesis 19 (-)

Industry Quest. Code	Construct		Hypotheses
<b>MARKET-RELATED</b>			
Q38_factor1	Problems in commercialization: No plan/no intention	Scale	Hypothesis 20: (-)
Q38_factor2	Problems in commercialization: IPR issues	Scale	Hypothesis 22: (-)
Q38_factor3	Problems in commercialization: technology-related	Scale	Hypothesis 21: (-)
Q38_factor4	Problems in commercialization: consortium-related	Scale	Hypothesis 22: (-)
<b>"NATURE" OF RESEARCH RESULT</b>			
Q39_factor1	"Nature" of research result: unique	Scale	Hypothesis 23: (+)
Q39_factor2	"Nature" of research result: inimitable	Scale	Hypothesis 24: (+)
Q39_factor3	"Nature" of research result: uncertain	Scale	Hypothesis 25: (-)
Q39_factor4	"Nature" of research result: dynamic	Scale	Hypothesis 26: (-)
Q39_factor5	"Nature" of research result: "distance" from key technological area	Scale	Hypothesis 27: (-)
<b>DEPENDENT VARIABLES</b>			
Q30_factor2	Technical Knowledge	Scale	
Q32_1	Commercial exploitation outputs: new product	Dummy variable	
Q32_2	Commercial exploitation outputs: new process	Dummy variable	

- \*(?) Indicates that we do not hypothesize any specific directional effects (positive or negative) for this construct on project success
- \*\* It indicates that positive but curvilinear (i.e. inverted U-shape) effects are hypothesized

The construct validity of our measures was tested by *confirmatory factor analysis* (CFA) to confirm the "dimensionality" of the items used to measure a specific factor. Put simply, this means that the items *a priori* hypothesized to reflect a particular underlying factor (e.g., "risky" project) do indeed capture this factor and not another. We performed the analysis separately for the two sub-samples of manufacturing firms and service firms. All analyses provide reasonable confidence that the measures used are valid and reliable. Moreover, the results confirm that the measurement properties of constructs obtained from manufacturing and services firms are identical. Hence, we decided to combine these observations in one sample (henceforth, the "enterprises" sample).

## 5.2 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 (OLS).<sup>37</sup> The results are presented in the order: (a) product innovation, (b) process innovation, and (c) technical knowledge.

### 5.2.1 New Product Innovation

The analysis was based on 280 observations for which the project in question was completed at the time of the survey and the respondents provided complete answers to all the variables used in the model. The full model is significant. The percentage of model-implied correct classifications is also satisfactory.

Not all classes of effects contribute significantly to the explanation of new product innovation as a result of an FP project. The most significant contributors, statistically, 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

<sup>37</sup> Logistic regression models are appropriate in situations where the dependent variable is a categorical, dummy-coded variable (i.e., 1 if project resulted in product/process innovation and 0 otherwise). The variable gauging technical knowledge was constructed as the sum of the individual questionnaire items measuring this construct. The level of measurement of technical knowledge may then be considered as (quasi) interval, and therefore we employed ordinary least square regression.

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 (Annex 3, Table 5.1), we find the following statistically significant effects:<sup>38</sup>

**“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 (PDI14) 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 (PDI15) and extramural (PDI16) 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 (PDI15) 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, something which 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 (PDI21) suggests a rather intriguing result. Firms for which participation in the focal project was their 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 (PDI29 - EU rules’ 2). 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 (PDI33) and that are considered *risky* (PDI37) 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 (PDI38) are significantly less likely to produce innovative products.

In order to examine more closely the effects of “risky” projects (PDI37) and “new area” projects (PDI38) and more specifically to test the possibility of an inverted U-shaped

<sup>38</sup> For this, as for all analyses that follow, we have estimated models that include an additional categorical variable to control for the different funding instruments. The results obtained are virtually identical with those reported here. Moreover, the additional control proved insignificant.

relationship between innovation and the extent to which a project is risky or exploring “new areas”, we included in two separate runs the quadratic terms of these variables. The LR tests revealed that the inclusion of the quadratic term of ‘risky project’ is significant and negative, thus supporting the hypothesis of an inverted U-shaped relationship. In contrast, the corresponding test for “new area” project was not significant.<sup>39</sup> When we only consider the main effect of PDI37, as the degree of risk increases a project’s probability to produce an innovative product increases. But when in addition to the main effect we include the squared term, the probability decreases after a certain point when the project becomes more and more risky.

In comparison, the main and quadratic effects of “new-area projects” (PDI38) are virtually identical, and in the same negative direction, in line with the insignificant effect of the quadratic effect reported above. Taken in combination, *these 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.*

**“Role of respondent in the project” (PDI40):** When the respondent organization had an “active” role in the focal project (i.e., it is the project manager, or the user, or the producer of the technology) the odds of reporting product innovation is more than three times higher than in the case it had a “secondary” role (i.e., it is either an R&D performer, or a test performer, or a service provider to the project). This result does not imply a “causal” effect between the “role in the project” and product innovation. It simply controls and partials out whatever positive effects an active role in the project has on the dependent variable thus providing unbiased estimates for the remaining explanatory variables of substantive interest.

**“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” (PDI53) 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”) (PDI54) 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 arises 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” (PDI60) and “Nature of research result 5: “distance” from key technological area” (PDI61) 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.

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<sup>39</sup> We have also tested for an inverted U-shaped relationship between project complexity (PDI39) and product innovation. The test was found insignificant (LR(1)= 1.19 (p=0.16)). In addition, we examined for possible quadratic effects of the “age” (PDI4) of the responding organization and of the “size of the consortium” (PDI24). In both cases, the corresponding univariate LR tests showed no statistical significance (i.e., 2.39(1), p=0.12; and 0.55(1), p=0.46, respectively).

The analyses reported above concern the “enterprises” sample which contains both manufacturing and services firms. We have also seen that manufacturing firms are more likely to report product innovation relative to their counterparts from service sectors. Further tests indicated that “being a manufacturing firm” (vs. a service firm) does not modify the effects of the remaining explanatory variables discussed above.

### 5.2.2 *New Process Innovation*

The same set of analyses as in the previous subsection is performed with respect to process innovation as a manifestation of project success for the participating firm. The results are obtained from the same effective sample of 280 observations for which the project in question was completed at the time of the survey and the responding firms have provided complete answers to all the variables used in the model.

The full model is significant. Moreover, the percentage of model-implied correct classifications is also satisfactory.

Not all classes of effects significantly contribute in the explanation of new process innovation as a result of an FP project. The statistically most significant contributors 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.

Turning to the individual coefficients (Annex 3, Table 5.2), we find the following statistically significant effects.

**“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 (PCI5) is found positive and significant. Larger firms appear somewhat more likely to report process innovation. The Manufacturing dummy (PCI8) is positive but insignificant.

**“Firm resources and capabilities”:** A firm’s capacity to “introduce new products speedily” (Capacity for “speed”- PCI10) is found to be *negatively* associated with process innovation. In contrast, the coefficient for “integration capabilities” (PCI11) 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” (Innovation protection 1- PCI12). 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.<sup>40</sup>

**“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*

<sup>40</sup> But note that a whole new class of business process patents has developed in the United States.

*innovation*. Specifically, we find that a firm that has engaged in “extramural R&D” (Extramural R&D in the past 3 years – PCI16) 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” (PCI19), and for the “percentage of turnover from new/improved products introduced in the past three years” (PCI20). *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 less likely to report process innovation, as shown by the significant negative coefficient for Product Innov (New-To-The-Firm) introduced in the past 3 years (PCI18). The final significant coefficient in this set is the positive effect of “first participation in FP” (PCI21). This is consistent with the result obtained for product innovation; there appears to exist 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” (PCI22). It suggests that FP6 projects compared to those of FP5 are about 15 times 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” (PCI38) and “complex” (PCI39) 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.

As before, we have examined more closely the effects of Nature of project 1: “risky” (PCI37), Nature of project 2: “new area” (PCI38), and Nature of project 3: “complex” (PCI39) to test the possibility of an inverted U-shaped relationship between these variables and process innovation. Following the same procedure described earlier, the LR tests proved *insignificant*, suggesting no significant quadratic effects in the sample.

**“Role of respondent in the project”:** Similarly to the results for product innovation, we find a strong positive effect for ROLE (PCI40). For both product and process innovation respondents having an “active” role in the focal project are more likely to indicate project success. Again, this result does not imply a “causal” effect between the “role in the project” and innovation, either product or process. It simply controls and partials out whatever positive effects an active role in the project has on our dependent variables.

**“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 negative. More specifically, we find that “intuition in team-learning” (PCI47), 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. This is a rather surprising finding, as is the absence of any significant positive effect of variables reflecting “cohesion and trust” or the “level of communication” within the project team.

**“Commercialization-related effects”:** This set of explanatory variables is, in principle, more closely related to product rather than process innovation, in the sense that the former

necessitates “delicate” activities and problem-solving for finally introducing a new product into the market. In effect, product innovation is an “outward” looking activity whereas process innovation as a final output of a collaborative R&D project is more “inward” looking. Hence, it is perhaps not surprising that the only significant coefficient found is “Exploitation was made through collaboration” (PCI51). This dummy variable indicates whether the output of the project has been “exploited” by means of collaboration (with existing and/or new partners) 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. This is perhaps not surprising if one takes into account the substantive meaning of the variables used. Recall that the “nature of research results” reflects the extent to which the technology developed in the project is “unique” (PCI57), “inimitable” (PCI58), “uncertain” (PCI59) (i.e., uncertain as to its technological “content” and its commercial success), “dynamic” (PCI60) (i.e., a technology with an expected *short* life-cycle), and “distant” (PCI61) (i.e., with respect to the responding organization’s core technological area). These factors correspond more closely to the intrinsic character of a product rather than a process technology.

### 5.2.3 *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 the previous sections. This time we do not model the effects of commercialization-related variables and of factors concerning the nature of research results. This is so for obvious reasons: both these sets of effects concern, in principle, the tangible aspects of project success, that is, a new product or a new process technology.

Because our dependent variable is a scale, we perform OLS regression to obtain results. In this analysis the effective sample consists of 526 observations for which the focal project had been completed at the time of the survey and the responding firms provided complete answers to all the variables used in the model.

The full model is significant. “Firm basic characteristics”, “innovation history”, “project basic characteristics”, and the “role” of the respondent do not contribute significantly in technical knowledge creation as a project output. The remaining classes of effects contribute significantly, and from these the most important effects are “firm resources and capabilities” and the “nature of the project”.

Annex 3, Table 5.3 presents the results on the individual coefficients. The results also indicate that there is not a serious problem of collinearity in our data (VIF statistics are much lower than the recommended cut point of 10).

**“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 (TEK2) has a positive effect in knowledge creation. It appears that volatility in customer preferences and tastes induce project participants to develop technological knowledge, which presumably will enable them to meet customer demands.

**“Basic firm effects:** We find no significant coefficients in this set of explanatory variables. The Manufacturing (TEK7) dummy is negative but insignificant.

**“Firm resources and capabilities”:** As noted above, “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 Innovation protection 1: Legal means (TEK11) (i.e., “legal means as a means for innovation protection”) is found positive and significant. This finding may be interpreted to suggest that patenting, motivated by a strong appropriation regime, induces firms to develop technological knowledge, which presumably they can later further develop *and protect* from imitators.

**“Innovation History”:** In contrast to product and process innovation for which “innovation history” was found to exert a strong influence, no significant effect was found in relation to knowledge creation.

**“Basic project characteristics”:** The only significant coefficient found here concerns the “percentage of participating organizations coming from the industry” (FRACTION) (TEK24). Even if at first glance this seems counter-intuitive, since one would normally expect that the more ROs participate in a project the more this will lead to intangible knowledge creation as opposed to tangible results, it should be noted that in our context technical knowledge connotes the development of prototypes, simulations, tools and techniques, etc. These are the types of technical knowledge that are more useful for industry compared to ROs, which would normally be interested in more abstract forms of technical knowledge (e.g., publications).

**“EU rules”:** In this set of variables, we find a significant positive influence from EU rules’ 2: impact on: partner selection/negotiations (TEK28) (i.e., “impact of EC rules on partner selection and negotiation”). This result should not be taken to represent a causal effect; it should be better interpreted to indicate that firms comfortable with EC rules have no difficulty in selecting and negotiating with partners who are more promising for delivering positive project results.

**“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 (TEK30), 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 (TEK24). It appears that 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” (TEK31), having clear “commercial objectives” (TEK32), and characterized as “risky” (TEK36) are more likely to result in knowledge creation. Interestingly, we also find that “networking objectives” (TEK35) has a negative effect. Taken together, these results are generally in line with our previous findings about the factors affecting product and process innovation.

As before, we have examined more closely the effects of Nature of project 1: “risky” (TEK36), Nature of project 2: “new area” (TEK37), and Nature of project 3: “complex” (TEK38) to test the possibility of an inverted U-shaped relationship between these variables and technical knowledge creation. Specifically we are interested to test whether the extent to which a project is characterised as risky, “new area” or complex has a curvilinear (i.e., concave) association with our dependent variable. Following the same procedure described earlier, the F-tests proved that only the quadratic effect of TEK36 is statistically significant. 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 point of inflection beyond which excessive degrees of risk are associated with worsening technical knowledge creation.

**“Role of respondent in the project”:** This variable acts as a control to partial out whatever effects an “active role in the project” (TEK39) has on our dependent variables. With respect to knowledge creation the coefficient of (TEK39) was found positive but insignificant.

**“Project Management effects”:** The coefficient of “clear project objectives” (TEK42) is found negative and significant. At first sight this finding looks surprising. However, new knowledge creation is, in principle at least, a complex process of exploration and discovery, where clear objectives set out from the beginning are seldom valid or productive for creative problem solving. Another significant coefficient in this set of explanatory variables concerns the positive effect on knowledge creation of “cohesion and trust” within the project team (TEK45). It is generally agreed in the literature on group dynamics that the level of cohesion and trust among members of a team has positive effects on group performance. Trust enables productive interaction and sharing among team members, and as a consequence knowledge creation. Finally, interpretation as a learning mechanism (TEK47 - Learning within team: Interpretation) is also found to positively affect technical knowledge, again a logical result.

### 5.3 Discussion and conclusions from the empirical analysis

In this Section we have examined questions pertaining to the factors affecting the innovation impact of FP-funded R&D projects. Innovation impacts in this study have been equated with the advent of product or process innovation, as an immediate tangible consequence of the project for the participant. In addition, project success is conceptualized to include the development of technical knowledge, viewed as an “intermediate” outcome of the project that may or may not be eventually transformed in a concrete new product or process technology to be commercialized. We examined antecedent factors influencing project success thus defined. Specifically, we were interested in the effects of market, firm, and project-related factors, together with aspects of the commercialization process of research results and the attributes of the technology itself. We developed and tested hypotheses about the effects of these factors based on the extant literature and received wisdom about collaborative R&D in the European context.

Table 5.2 summarizes the econometric results. 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 even though the analysis producing these was not reported explicitly in this Chapter.

**Table 5.2: Summary of Econometric Results**

Ind. Variables	ENTREPRISES			RESEARCH ORGANIZATIONS	
	Product	Process	Technical Knowledge	Product	Process
<b>MARKET-RELATED</b>					
Market environment: competitive & technological dynamism					
Market environment: dynamism in customer preferences			+		
Emerging prospective field				-	-
<b>FIRM-RELATED</b>					
“Basic”					
Age					
Size class		+			
EU(15)					
EU(27)				+	
Manufacturing (vs. Services)					

Ind. Variables	ENTREPRISES			RESEARCH ORGANIZATIONS	
	Product	Process	Technical Knowledge	Product	Process
<b>"Firm's resources and capabilities"</b>					
Marketing skills					
Capacity for "speed"		-			
Integration capability		+			
Innovation protection: legal means		-	+		
Innovation protection: competitive means					
Innovation protection: "complex" technology	+				
<b>"Firm's innovation history"</b>					
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)	+	+			
<b>PROJECT-RELATED</b>					
<b>"Basic"</b>					
FP - FP6 (vs.FP5 )		+			
Proj_type					
Proj_dure - Project duration (in months)					
Funding					
Total - Consortium size					
Fraction - % of partners from industry			+		
Leader - consortium Leader from industry (yes/no)					
<b>"Eu rules"</b>					
Practices in line with EU rules					+
EU rules' impact on: project implementation					
EU rules' impact on: partner selection/negotiations	+		+		
<b>"Nature" of the project</b>					
Innovation reflected in selection criteria					
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"		+			

Ind. Variables	ENTREPRISES			RESEARCH ORGANIZATIONS	
	Product	Process	Technical Knowledge	Product	Process
Role - Respondent is manager/ or user/ or technology producer (yes/no)	+	+			
"Project management"					
# of partners having worked with				+	
# of partners having not worked with				-	
Clear project objectives			-		+
Communication (within team)					-
Coordination (within team)					
Cohesion/Trust			+		
Learning within team: Intuition		-			
Learning within team: Interpretation			+		+
Learning within team: Integration					
<b>COMMERCIALIZATION-RELATED</b>					
PATENT - Project output protected with patent (yes/no)					
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: unique					
"Nature" of research result: inimitable					+
"Nature" of research result: uncertain					
"Nature" of research result: dynamic	-				
"Nature" of research result: "distance" from key technological area	-				

In *hypothesis 1a* we predicted tentatively that **market conditions**, specifically the intensity of competition and velocity of customer preferences, would be significantly related to project success without, however, postulating a specific direction for the hypothesized effect. We also argued that the stage of the life-cycle of the relevant market at the time the project was initiated would positively relate to success (*hypothesis 1b*). We find limited support for both these hypotheses; the Table shows that only dynamism in customer preferences affects technical knowledge creation.

Why market conditions do not appear to *strongly* influence project success? 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, our hypotheses have been rather tentative (*hypotheses 2-3*). There is no compelling theoretical reason why large sized and established firms (as opposed to small and young) would be more likely to report project success.<sup>41</sup> Nevertheless, 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.

In *hypothesis 4* we reasoned 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 enable the partner to commit valuable resources in the project, and as result, will positively influence the likelihood that the project does indeed result in success. Some of the results obtained here look, initially, surprising. Beginning with the latter of these, we estimate negative coefficients for the capacity to introduce new products speedily and for innovation protection through legal mechanisms on process innovation. With respect to speed, one could argue that the ability to introduce new products quickly is irrelevant to *process* innovation. But an insignificant as opposed to a significant negative coefficient would be less puzzling.

Regarding the coefficient of legal means of innovation protection, the results are contradictory in that 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. On the other hand, of course, an insignificant coefficient would seem more reasonable. 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.

Turning to those coefficients that are in line with hypothesis 4, we find a significant positive effect of the integration capability on process innovation. It is generally agreed in the extant literature that innovation is a complex (and uncertain) process, which necessitates the effective integration of various specializations and activities within (e.g., cross-functional teams) and across firm boundaries (e.g, systematic interaction with lead-users and suppliers). As such, the positive coefficient found is very much in line with expectations. A firm with such integration skills is presumably able to work effectively with its partners, thus contributing to project success. Finally, we find a significant positive coefficient for the effect of the capability to protect innovation through complex technology on product innovation. Again this is reasonable. 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.

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<sup>41</sup> The neo-Schumpeterian hypotheses, whereby size and market concentration positively affect the chances for innovation, have long been found rather shaky when out of context (Cohen and Levin, 1989).

In *hypothesis 5* we argued 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. It appears that only "genuine" past innovation activities matter in the likelihood for process innovation. This negative effect implies that a "history" of imitation in fact inhibits the likelihood for project success. Another result, which appears reasonable and in line with our hypothesis, is the positive coefficient of process innovation introduced in the past on the likelihood of achieving process innovation in the project in question.

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.

Turning our attention to project-related factors, we begin with **basic project characteristics**. We find very limited support for *hypotheses 6-8d* with respect to these characteristics. The only significant coefficient concerns the positive effect on technical knowledge of the percentage of partners coming from the industry. This indicates that industrial partners are more interested in developing technical knowledge in the hope to eventually develop it into product or process innovation.

Regarding the effects of **EU rules**, we argued that they should not have a *causal* effect on success; 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 a common set of bureaucratic rules to be obeyed by partners and hence to create an administrative platform, within which internal activities are developed, implemented, and monitored. More important, these rules serve as the official mechanisms by which the project manager (and by extension the project consortium as a whole) 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 does not imply that these rules have a direct *effect* on project success. It does suggest, however, 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, a result generally in line with *hypotheses 9-11*. 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. Networking as an objective seemingly distracts from the pursuit of knowledge in favour of developing new contacts that may prove useful in the future.

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.

Exploring a new technological area has mixed effects: positive on process and negative on product innovation. This result may not be as puzzling as seems at first sight: an entirely new technology is overly precarious as far as commercialization of a new product is concerned, whereas developing a new area process technology to be installed and implemented in-house allows room for experimentation and for taking calculated risks that would not be feasible in the former case. The same argument may apply in the case of the positive coefficient of technical complexity on process innovation.

Similar results are obtained with respect to the origin of the idea and whether the project builds on past R&D activities. We find that when the project idea is generated by industrial partners (as opposed to ROs) this has a positive effect on knowledge creation. This is in line with expectations, in that industrial partners are more motivated to pursue their own ideas and thus to drive the project towards success. Moreover, our results suggest that projects that do not begin from scratch but instead build on past, and presumably related, R&D activities are more likely to result in process innovation and to technical 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, that are risky, complex, and new area (for process innovation) tend to be more successful.

In contrast, the **management aspects of project implementation** appear to be less decisive to project success, providing limited support to *hypotheses 12-16*. More specifically, and with respect to survey responses from the industry sample, we find that clear and agreed upon objectives 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. We also find a negative effect of intuitive learning on process innovation, a finding difficult to interpret. In contrast we estimate positive effects for cohesion and trust and interpretative learning on technical knowledge creation. That cohesion and trust among project team members leads to new knowledge creation is, of course, not surprising. The same could be argued for interpretative learning; the extent to which project team members can engage in creative dialogue, knowledge sharing, and develop a common frame of reference for framing the problems at hand is only natural to lead to knowledge creation.

Turning to aspects of the **commercialization process** and their effects on project success, we find again limited support for the set of *hypotheses 17-22*. Contrary to expectations, we note that IPR-related problems during commercialization have in fact a positive effect on product innovation. This finding may imply that confronted with a promising technology, and despite IPR problems, a consortium will tend to commercialize. Hence, it could be argued that the positive coefficient found in fact connotes a situation where the technology is promising enough to trigger IPR-related problems, which however are usually overcome. In other words, those kinds of problems emerge when the technology developed provides significant opportunities for commercialization, and therefore, the significant coefficient does not imply a “causal” effect; it simply indicates that these problems are usually surpassed in view of the market opportunities for the project participants. In contrast, no plan/no intention to commercialize in the first place is found to have a negative effect on product innovation, as predicted. In addition, implementation of the commercialization process through collaboration increases the likelihood for *process* innovation. The lack of significance of this variable on *product* innovation may be taken to confirm received wisdom which suggests that firms usually prefer to commercialize alone.

Finally, we examined the impact of the **attributes of the technology** resulting from a project. *Hypotheses 26-27* have generally been confirmed for the enterprise sample. Specifically, 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.

### 5.3.1 Limitations

The reported empirical results on the market-, firm- and project-related factors affecting the innovation impact of FP-funded R&D projects should be evaluated against the limitations of the analysis. These are of four types:

- The model is not exhaustive,
- Lack of objective data; extreme reliance on subjective information,
- Inability to obtain multiple responses per R&D project for triangulation,
- Possibility of self-selection.

These limitations are discussed in greater detail in Annex 2. On the whole, testing for the most serious of these limitations (self-selection) leaves us fairly confident of the validity and robustness of our results.

## 5.4 Qualitative Analysis (Case Studies)

### 5.4.1 Project-level Characteristics for Research Success and Commercial Exploitation

#### 5.4.1.1 Main Managerial Activities during Project Planning and Set Up

Concerning the planning and set up of the projects, some of the case studies indicate a rather unstructured and ad-hoc initiation. A typical comment reflecting this is "We were contacted by a partner that we know well, and we decided to get into the project and see what would come out". Under these circumstances, the existence of previous collaboration with at least one of the partners, was more important for entering a project than a specific development goal. Quite naturally, these *ad-hoc project participants* are organizations where the strategic role of the EU funded RTD projects was rather insignificant. Another group of non-coordinator organizations are those companies that evaluate very carefully each opportunity or proposal of joining projects in the light of their strategic orientations. The typical positioning reflecting this is "We only undertake projects directly related to our core competencies". These *focused project exploiters* are characterized by a strong reputation in their technology field. They receive many requests for project participation from other organizations and can be highly selective in their project engagements.

Turning to coordinators - whether they were ROs or companies - they 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". Conversely, when they participate as partners (comparing to their experience as coordinators) many of them perceived these projects as being "less relevant, with less control, and with less use of the project outcomes".

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* (Box 5.1). *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.

#### Box 5.1: Coordinator Power & Coordinator Strength

*Coordinator power* represents the advantage that coordinators have in terms of shaping the research agenda, structure projects according to their core interests

and needs, and aligning the partners around a core objective that is originally theirs. In many of the successful projects studied, traces of this coordinator power could be found. It represents the 'award' that coordinators can obtain, the other side of the picture being the administrative coordination 'burden' including reporting and the challenge of keeping all partners on track both scientifically and administratively. It must be noted that this issue only concerns coordinators that are themselves are R&D performers, and thus have a direct interest in the scientific, technological and innovation related outputs from projects.

A slightly different, but related, concept is that of *coordinator strength*. It refers to the ability of the coordinator to face and overcome different crises that might occur during the unfolding of the project. Among the cases were projects where one or even two partners suddenly fell out for various reasons from filing for bankruptcy to simply failing to deliver a critical part. Coordinator strength then partly concerns the ability of the coordinator to identify and mobilize players outside the consortium to fill in the gap from the partner at fault, partly the ability to take on these obligations itself. Similarly to the slack resources crucial for exploration<sup>42</sup>, coordinators are in need of slack resources in terms of taking on an unanticipated workload as a result of unforeseen incidents in the projects. Case examples show that a combination of external and internal mobilization not only saved the project but resulted in successful innovation output.

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. Hence, in case of success of a project where the case was studied from the lens of an ad-hoc participant, the latter might well be a contributor to this success, but not really a driver. For the focused project exploiters, projects turn out successfully if the objective is narrowly defined and the organization pursuing in this mode is sole representative of the specific contribution input –whether being a user or a developer / producer of a specific technology component. Conversely, problems seem deemed to occur if there are conflicts of interests with other partners who might, on the one hand, claim rights to the specific outcome without necessarily having the intention to explore it, or, on the other, block the exploitation by placing conditions on the use of supporting components such as, e.g., software.

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". If indeed very difficult to anticipate at the moment of set up and proposal writing, the negative effect of such "sleeping partners" on the project results must be minimized by a strict project management and follow-up. 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. Such inhibiting factors will be analysed further in the subsequent sections.

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<sup>42</sup> For a discussion of slack resources and legacy related to exploration and exploitation, see, e.g., Lewin, A.Y., Long, C.P. & Carroll, T.N. (1999), "The Coevolution of New Organizational Forms", *Organization Science*, vol. 10, no. 5, pp. 535-550.

### 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. A problem perceived 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 (Box 5.2).

#### *Box 5.2: End of Project Pressure*

For companies, both large and small, which often engage in the projects as user partners, the frequent delays and deviations from original plans that result from other partners and/or difficulties in the projects, create a great pressure on the later phases. As a result, the intended pilot applications are not implemented fully. This means that "the most critical phase for achieving innovation output is compressed to a maximum", as one interviewee expresses it. As the technology is often cutting edge with high complexity and uncertainty during the development, delays are the rule rather than an exception, and user partners end up doing some quite limited testing. In other words, there are projects with not enough time to complete a correct testing and evaluation process necessary for a clearer judgement of the potential to taking the results further. This critical part of the project is pushed backwards and then the activities are executed under pressure, with often not enough time to reach any significant result.

To come to terms with some of these problems, good implementation practice is undertaken by consortia where much time and attention was paid to project management. 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.

### 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; "now we wait for them to come back with some ideas for how to take this further" as another interviewee expressed it. It also happens that 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 the most positive outcome of a project. 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 5.3). 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 front-end' of R&D*<sup>43</sup>. 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 5.4).

*Box 5.3 (From the Field): 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.

*Box 5.4: 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

<sup>43</sup> 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.

(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.

To sum up, the critical threshold that must be overcome before the project consortium splits up, is to plan substantially as to how to take the outcome further, including taking it towards commercialisation. Unfortunately, many projects end up in a kind of dead-end with respect to commercialisation, as companies sometimes find themselves in a position that one interviewee summarized as follows "As a profit-making company we have to master the entire chain of research, development and commercialisation. But when it comes to EU projects, we can only open up the development part [for competitive reasons]. Then, as the technology is often cutting edge, we end up doing some quite limited testing and concluding that it might be commercializable later but neither we nor the labs developing the technology are in a position to take it any further.

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. Especially the spin-off activity can be a problem in some university labs, where the spin-off activity remains a grey zone with respect to the regulatory frameworks in each country. A potentially relevant bridge over this gap (Box 5.5) might be the SME. An SME could possibly more easily integrate the scientific and the applied part, from its more focused and less scale dependent development path compared to the large company. The SME could also be a test bench for both the labs and the larger company, of course not without commercial risk.

*Box 5.5: Bridging the Research Output – Innovation Impact Gap*

The commercial focus and the knowledge of how to bring products or services to the market, that companies possess, are indispensable ingredients if the results of RTD projects are to reach the market within a logical time frame. Many scientific results are produced that never reach the market because of this missing ingredient, a *too small dose* of this ingredient or still a *much too slow process* for market launch. The role of companies is to provide this capability, by taking a few steps upstream in the RTD cycle, and for a return in terms of access to emerging technologies. From the side of research organizations there must be steps taken downstream towards the commercialisation phases, for example through an increased integration of spin-off activities or collaborative schemes with existing SMEs.

The case studies allowed not only to confirm this gap and its importance as an inhibitor for innovation impact, but also to identify the important role that companies, and most fundamentally SMEs can play in bridging this gap. Hence,

it seems that one could almost talk about a 'niche market' for companies that decide to act in this blind spot and realise a mission of bridging the gap.

#### 5.4.1.2 Enabling and Inhibiting Factors for Project Success Enablers – Success Factors Identified in Projects Leading to Product or Process Innovation

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:** This refers to the extent to which customers / user are involved either directly in the consortium, either indirectly being informed about and engaged in the project as third party, to the extent this is allowed by the agreement;
- **Complementarity Among Partners:** A broad and representative group of partners seems to be important if the project outcomes are to reach a market. Users, suppliers, but also intermediaries and policy makers of different kind are needed besides the core R&D performers if the results are to reach beyond the laboratory desks. The notion of "Technology Eco System" further informs this complementarity (Box 5.6);
- **Core (or Driving) Partners:** This refers to what many interviewees characterised as the backbone or the catalysts of the RTD projects. In many of the case studies, interviewees referred to two or three partners that crystallize as those that "take the project most seriously" or "find a common stake and push it through for the best of all", or still "keep the project motivation and momentum going". Undoubtedly the coordinator is often one of these partners, and the other(s) are also normally those that have the highest stake in terms of strategic and/or financial benefit of the project. The likeliness of those partners to start off on new projects together, within or without the frame of the FP projects quite naturally increases. Successful exploitation of results often materialize from the continued collaboration between such core partners;
- **Issues of Trust:** There is an important reputation factor involved in the participation in the EU projects in the sense that a company or lab that performs poorly or incorrectly will have difficulties in finding partners in the future and pursuing its participation in new projects. Moreover, in most consortia, there are some cross links between partners in the sense that, bilaterally, several of them know each other from previous FP or other types of collaboration;
- **Issues of IPR and Protection Nature:** Problems of this nature are minimized due, first, to the fact that direct horizontal competitors are unlikely to join the same project (an opinion shared among almost all interviewees), and, second, to the fact that the R&D activities in the EU-funded projects normally are not immediately commercializable competitive projects. If, in spite of this, any issue of IPR nature would come up, most interviewees considered the rules integrated in the instruments as satisfactory for regulating them. There were exceptions to this, however, as illustrated in Box 5.7.

#### *Box 5.6: The Technology EcoSystem*

The notion business eco system is frequently used in the popularised press and its more scientific dimension is reflected in the notions of innovation clusters and innovation hot spots. In the case studies, it was often referred that the corresponding notion when it comes to technology is the collection of science, technology and development providers that make up the platform for the emergence, development and finally commercialisation of new technology. The EU FP-funded RTD projects provide the infrastructure for bringing together all the players in this technology eco system and thus has a very positive leverage effect and efficiency factor. Interviewees considered this still being a "ticking innovation bomb" that hopefully will enable Europe to reach its ambitions innovation goals, although not within the originally set timeframe. The extent to

which a project reflects this Eco System depends on the complementarity and completeness of the actors involved. Hence, it is a design issue that should be taken into serious consideration in the conceptualisation of instruments, and then at a more pragmatic level at the initiation and set up of individual projects. Hence it needs to be integrated both at the EU and the project performer levels.

*Box 5.7 (From the Field): Confusion about Legal Matters: A Reason for Avoiding FP-Funded Projects*

A high-growth medium sized technology services company has encountered several legal problems in their experiences of FP-funded projects. The FP5 CSC project under study, although implemented and managed satisfactory with a clear goal of commercialisation (the company would fall in the category Focused Project Exploiter) and a significant outcome in terms of a fully functioning software, failed to produce a commercialisable innovation due to a "stumbling block" of legal nature. The company perceived that other partners, holding the rights to the software, imposed unreasonable conditions for its introduction in the market. Besides licensing at a cost above market price, installation support and complementary technology were charged as extras and also made the software unnecessary complex and heavy for the average user.

This lack of legal control, confusion of what is valid within the frame of the instrument, and perceived lack of support from the EU, has been so demotivating to the company that they currently have decided to freeze all engagement in future projects and only pursue market-based projects with direct customers.

*Inhibitors - Failure 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, 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. "In our innovation model, the word market is omnipresent, from the orientation of lab experiments to the launching decision. I cannot recall seeing the word market anywhere in the context of the EU projects", as he expressed it.

*Weak inter-firm integration* was an issue that emerged in spite of the fact that many case studies reported on successful new knowledge development as well as innovation. This must be put in the light of what R&D managers and staff consider as relevant inter-firm integration in commercial R&D projects. In the latter case it can involve guest engineers from suppliers working in the technical centre of an OEM, broadband and direct communication channels between project participants at all levels and in all involved organizations, and very strong organizational identity of the project group (in spite of the fact that it involves people from different organizations). In the light of such organizational schemes, the collaborative efforts that characterize the EU-funded projects are indeed very far from true integration. It is

actually not about integration of tasks and inter-firm knowledge, but in the best case relevant coordination for bringing the project to an end, and weak ties in terms of communication and exchanges. As one interviewee formulated it: "It [the collaborative scheme and structure of the EU project] does not resemble what it would have looked like if we had set it up ourselves with the objective of commercialising an innovative product". In the same vein, another interviewee expressed "Communication and collaboration work at the level one could expect when one puts together a big group of more or less well acquainted people to work on a more or less well defined project. This, however, does not mean that it works for a commercially driven and tighter defined project".

### *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 (Box 5.8).

#### *Box 5.8: The Project Specification vs. Project Adaptation Dilemma*

This refers to the difficulty of making changes during the unfolding of the project, due to the strict and detailed specification in the contractual agreements. In a commercial R&D project it is the technology and market reality that decides how the project will unfold, while in the FP RTD projects it is the contract, based on a proposal that might have been drafted several years ago. As the formal rules for changing project characteristics are complex and time consuming, interviewees sometimes blamed failed innovation output on the fact that projects are pursued even though it seems clear to partner(s) that the project will be out of date when it theoretically can reach the market. The fact that the time laps between proposal and final output often is very long, this further plays in disfavour of the efficiency of sticking blindly to the original approach.

As a direct consequence of the above, there is a dilemma between following the procedures and walk on with the project for its own sake, or be able to make changes for maximum value creation.

The overall conclusion with respect to how the EU rules act and interact with the management procedures of participating organizations seems to be that the "rules can break but not make" successful innovation impact results from the projects. In no case were the rules referred to as a major reasons for project success, while in several they were referred to as adding difficulties to the management and execution process, and in a few even as actually the cause behind failure.

#### ***5.4.2 Firm-level Characteristics for Research Success and Commercial Exploitation*** ***Planning & Set-up: Factors Related to Mission, Strategy and Goals***

Innovation activity in terms of conducting both intra-mural and extra-mural R&D was, except for the fact of having participated in an FP5 or FP6 RTD project, the common characteristic of all 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 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 such as "Science to Achieve Results", or "Translating Scientific Knowledge into Practice". Most of the SMEs reported generally a strong strategic alignment, and explicit goals related to innovation outputs (Box 5.9). 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 (Box 5.10).

##### *Box 5.9 (From the Field): 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.

*Box 5.10 (From the Field): The Power of Mission, Strategy and Goals in a RO*

Pertaining to the group of research institutes that position strategically as devoted to bridging fundamental and applied research, and collaborating very actively with the corporate world, this large research centre (470 people) owes its rapid growth (20% annual budget growth the last 10 years) and strong track record of patented technologies developed in collaboration with industry partners to a clear mission, consequently implemented strategy, and strong deployment of operational goals. The management of the centre has implemented what it labels a "sustainable system of doing R&D". The main pillars of this system are a strong integration with the market, an imperative of attracting competitive (and not state) funding to the R&D programmes, and a competency based personnel policy with a limited number of researchers on tenure track and a large pool of contracted researchers.

The strong market integration has led the centre to collaborate with more than 1000 partners from academia, research organizations and industry worldwide. The competitive funding focus has led to a - for its country - record breaking 80% funding coming from competitive bidding projects, of which 30% comes directly from industry. The competency-based personnel policy, finally, has contributed to developing a pool of highly qualified researchers with an excellent track record of academic and research careers, also internationally. The competency focus is not only related to R&D activities, but also to the ability of writing proposals. Here, the seven research institutes of the centre benefit from a centralized and dedicated structure that has implemented a modular system for proposal writing, which has brought the success rate of accepted proposals to about 25% compared to an average of 10% among research centres in the EU.

*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, where, if a generalization can be made from the case sample, *the medium-sized firms seem to be those that have reaped the largest innovation benefits from their participation.*

Small-sized firms (<50 employees), with a gradual diminishing of the problems as their size increases towards 30-40 people, 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. Hence, if such firms partner up with research organizations, there is very little chance for the project to conduct to innovation. These SMEs have typically started up and developed, unfortunately not really prospering, through and with the FP projects as their dominating source of funding. Part of the explanation can be that there is no supporting of the local market. Another explanation is that over time, the participation in a series of projects also might lead to a certain 'dilution' of core focus and core competence. This 'dilution' stems from the fact that each FP project has a consensus agenda for all involved partners, which is not always aligned with what would be the best path for this type of SME to follow for reaching a commercial innovation-based breakthrough. However, opportunities for breaking out of this somewhat artificial existence also comes from the projects, if these SMEs can succeed in developing commercially viable partnerships with other firms that have a better / closer access to international offset markets.

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" referred to above. 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 5.11).

*Box 5.11 (From the Field): 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.

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-heartedly in an EU-funded RTD project, the result has a good chance of becoming a success (Box 5.12).

*Box 5.12 (From the Field): Activating the Capacity of an R&D Driven Multinational*

The FP5 IST project analysed in this company, part of a global group present in more than 190 countries with the studied unit employing 8000 people in 10 divisions, was among the most successful innovation cases in our study. The project ended in late

2004 and became an independent company in late 2005 with some original project partners and several new, having concluded contracts with two major customers of the technology developed through the project.

The mobilization of the knowledge, resources and competencies of the large R&D driven multinational set the frame and objective of achieving innovation (basically a process innovation), from the initiation of the project. The technology area is characterized by high entry barriers. Nevertheless speed of commercialisation plays an important role as customers are pushing for integrating the latest technology advances. These industry and market factors played in favour of the presence of a big company with necessary resource infrastructure and competence in commercialising innovation.

In terms of innovation project structure, the company has clear templates for how different kinds of projects are managed for maximized return. Finally, in terms of technology eco systems, the project was also supported by the wide and broad vertical network of the large company and its internal broad portfolio of neighbouring technologies and development projects.

A number of other resource/capability factors not explicitly hypothesized and analysed in the quantitative research were identified in the case studies as being at play and exercising influence on the process of bringing the RTD projects towards innovation. The most significant were a broader innovation culture in the organizations and the social capital that organizations build up as partners and/or coordinators in the FP-funded RTD projects.

### Innovation Culture

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 'n', and that are reinforced and readapted dynamically in order to provide this advantage over time (moment n+1, n+2, ...). This building of competitive advantage should be maintained despite of changing external and internal conditions – the only constant is the quest for optimised innovation performance<sup>44</sup>. A culture that systematizes the generation and testing of innovative ideas is an important organizational factor among innovation leaders and it has "everything to do with organization and attitude, and very little to do with nurturing solitary genius"<sup>45</sup>. Several of the older companies (e.g., with a history of 20-30 years or more) indeed showed a long path of innovation-based growth and development.

### Social Capital

Social capital refers to "the goodwill that is engendered by the fabric of social relations and that can be mobilized to facilitate action"<sup>46</sup>. The importance of social capital for innovation performance has been documented in many instances already<sup>47</sup>. However, it is still a much

<sup>44</sup> Innovation culture has been referred to and studied from a variety of perspectives, c.f., e.g., Zien, K. A. & Buckler, S. A. (1997), "Dreams to Market: Crafting a Culture of Innovation", *Journal of Product Innovation Management*, 14(4): 274-287.

<sup>45</sup> Hargadon, A & Sutton, R. I. (2000), "Building and Innovation Factory", *Harvard Business Review*, May-June: 157-166.

<sup>46</sup> Adler, P.S. & Kwon, S-W. (2002), "Social Capital: Prospects for a New Concept", *Academy of Management Review*, 27: 17-40, quote p. 17.

<sup>47</sup> 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.

neglected factor at the level of day-to-day project management and project work, even though it is precisely from there it has to be built up (Box 5.13).

*Box 5.13: Partner / Coordinator Social Capital*

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.

Coordinator / partner social capital has the conceptual and policy making power of bringing together several of the softer issues advanced as essential for project success (e.g., trust, communication, motivation) and integrating them with the time dimension. This is because social capital building is a longitudinal process that can be easily broken due to just a few mishaps in a particular instance. Scientific and technology excellence is a necessary but not sufficient condition for building up this social capital. Complementary factors identified from the cases include commitment to the success of the project as a collaborative effort, openness, fairness, visionary leadership, reactivity, and excellent relational sensitivity and skills.

#### 5.4.2.1 Implementation: Factors Related to Innovation Capabilities

The hypothesized capabilities include marketing, ability for quick product introduction, integration and protection. During implementation, integration is a central issue, and so is the learning capability inside the participating organization. Market, product introduction and protection capabilities are more directly related to commercialisation and will be analysed in the sections focusing on that phase.

##### Integration Capability

Contrary to expectations, the problem of *organizational integration* and especially the extent to which other functions such as marketing, finance and production support or not the R&D activities turned out to be quite minor in most of the studied firms (it is not directly applicable to the Research Institutions). The main explanatory factor was that most case companies characterize themselves as "R&D driven" or "innovation driven". Firms with an explicit R&D and NPD structure and model proved more successful in producing innovation results. In those cases where such a framework existed, it always included some dimension of marketing considerations as well as some related to production and industrialization considerations. Hence, the device "Structure Produces Behaviour"<sup>48</sup> seemed to be confirmed; when functional integration is an imperative, it also happens and it produces results.

Most of the SMEs studied also had a strong R&D focus. Amongst the SMEs R&D problem-solving is more spontaneous and integrated "everyone works a little bit on everything and helps out when and where needed", as one interviewee expressed it. Conversely, SMEs that

<sup>48</sup> See, e.g., Senge, P.M. (1990), *The Fifth Discipline: The Art & Practice of The Learning Organization*, New York: Currency Doubleday.

were on a clear growth path towards production and commercialization of their R&D efforts also indicated their ambition for developing a more formal and integrated R&D and commercialization structure. Some of them referred to the use of frameworks such as the ISO 9001:2000 in order to achieve this formalized support for integration. Hence, the extent to which there is a specific structure and R&D model seems to be positively correlated with the size, but it is also heavily industry dependent. The more regulated the industry, the greater the requirement and practical need for formalized processes.

There were also cases of SMEs with stand alone R&D activities. For example, some companies might "diversify" into R&D and build this diversification strongly on the execution on FP-funded projects, while the production and other operations remain engaged in producing and commercializing standardized products/commodities, or even doing imports/exports. Quite naturally, no successful innovations stemming from FP RTD projects could be identified in these organizations.

### Learning Capability

Innovation is a knowledge intensive process; knowledge that is distributed among and/or embedded in firms' employees, technologies, resources, routines and procedures makes up the raw material for innovation, which can be activated through relevant structural, organizational, procedural and operational arrangements<sup>49</sup>. When it comes to the knowledge created in the RTD projects, the extent to which it can be leveraged and used for innovation outcomes and, ultimately, innovation impact depends on the *learning capability* (absorptive capacity) of the organization involved.

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 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.

#### 5.4.2.2 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. First, the population of Research Organizations is not really concerned by the issue: commercialisation is not their core competence.. Second, and as analysed among the inhibiting factors at the project level, neither market considerations, nor the strong integration that are rule in a commercially driven project are considered in their own right and therefore commercialisation might be left aside from the very beginning of a project. Hence,

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<sup>49</sup> See, e.g., Hargadon A. and Fanelli A., (2002), "Action and Possibility: Reconciling Dual Perspectives of knowledge in organizations", *Organization Science*, 12(3): 290-302, Hoopes D.G. & Postrel S., (1999), "Shared Knowledge 'Glitches', and Product Development Performance", *Strategic Management Journal*, 20(9), 837-865, and Soderquist, K.E. (2006), "Organising Knowledge Management and Dissemination in New Product Development: Lessons from 12 Global Corporations", *Long Range Planning*, 39(5): 497-523.

commercialisation is much left to the willingness and motivation of the organizations (read companies) involved in each specific project, and on the organizational capabilities possessed by the partners concerned by an eventual commercialisation process (Box 5.14).

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. 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 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.

*Box 5.14: 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.

#### 5.4.2.3 Dissemination, Evaluation and Closure: Factors Related to Mechanisms of Protection

The issue of protection has been discussed at the project level of analysis and was identified as manageable, although there were exceptions where the failure to reach agreements on rights issues blocked a promising innovation from reaching the market and led the concerned organizations to look at the FP-funded RTD projects with scepticism (c.f., the concept of the impact-stopping stumbling block and the example related to confusion about legal matters).

Concerning enterprises, protection mechanisms are analysed as a capability possessed or not in the individual organizations studied. Different types of protection mechanisms can be relevant: patents, trademarks and copyright are *explicit or legal mechanisms* (different forms of licensing agreements can also be integrated here), while technology complexity, knowledge embeddedness and integrating the project outcomes -whatever they are - into the processes and procedures of the organization are *implicit or competitive mechanisms*. It must be stressed that the issue of protection is strongly industry dependent with, e.g., the pharmaceutical industry relying much more heavily on patents than others.

When it comes to the difference between product and process innovation, the latter comes out as very difficult to protect through explicit means. Patents were referred to only by companies doing product innovation in the cases. This seems to be a quite natural result as the "patent institutions are built up with product protection in mind", as one interviewee expressed it, and that also "a process cannot be protected through patents or licences, only some component of it can", as another R&D executive put it. Hence, one could argue that it is more 'difficult' to protect process than product innovation.

The pros and cons of patenting are debatable. There are organizations among the cases (producers) that have a long record of patents that truly are the backbone for exploitation and a successful record of innovation. There are also companies that operate with an 'open' innovation model and where the philosophy seems to be that at the time they might be copied they are already a few steps down the road or down another road. Patenting is also an important issue for the research organizations, but it is not always that the EU-funded FP projects are the best vehicles for patenting from their perspective, as illustrated in Box 5.15.

*Box 5.15 (From the Field): Patenting: An Imperative for Successful RO – Corporation Cooperation*

This Research Organization, which undertook an FP6 STREP project, pursues a consequent approach of always striving for patenting their discoveries as a prime priority. The normal *modus operandi* of the centre is to identify and define a research topic, develop R&D collaboration with an exclusive industry partner and then patent the resulting outcomes before publishing scientific publications.

Between 2000 and 2005 researchers in the institute applied for 42 patents of which almost all are extended beyond the EU. The interviewees' firm position is that non-patented research has no value for innovation and has no chance of being developed by an industrial partner. In this perspective, EU-funded research should focus only on projects integrating complementary partners and having a

clear innovation objective. It should strive to maximize dissemination and technology spill-over to SMEs with growth potential. Advanced R&D with involvement of large companies can be executed only in the frame of exclusive collaboration contracts with strict bi-lateral rules for IPR and exploitation.

#### ***5.4.3 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 are R&D based 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. On the negative side, there can be overweighing of public funding in their overall R&D investment strategy. 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). Especially in the case of SMEs, the FP experience is not so easy to handle. The formalisation of R&D units often causes rigidity in a small business. Although most of the companies in this group are very large, they often avoid being prime contractors due to the perceived heavy administrative burden. For small enterprises, an FP experience could represent an opportunity to restructure efficiently its research process.

##### *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 overweighing 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, acquiring qualified competences. The negative side of a development strategy funded on EU projects is a not-selective participation in projects.

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.

In sectors in which products and services embody low degree of innovation and have long life cycle, the pioneer innovators are usually followed by a great wave of imitators: the risk for innovators is to lose quickly their competitive advantage. Thus, protecting the secret for market power becomes the main strategy. In this category the consortium structure has had an important role in the project success. The competitive environment and the innovation focus of almost all the analyzed companies have influenced the innovation results.

### *5.5 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”.<sup>50</sup>

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<sup>51</sup> 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 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<sup>52</sup>, 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 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<sup>53</sup> 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<sup>54</sup>, 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.

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<sup>50</sup> 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.

<sup>51</sup> 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.

<sup>52</sup> These enterprises belong to 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 for safety-critical applications to manufacturing of aeronautical parts, from information and communication technologies to pharmaceutical, cosmetics and health products, from robotized automation systems to aero transportation management.

<sup>53</sup> These tend to be 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.

<sup>54</sup> 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 characterize such sectors.

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. Thus, with respect to large sized firms, our case study sample 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 scope intangible outcomes or indeed reported plain failure of the projects. 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 suboptimised.

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:

- 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 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. 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.

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 intention 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.

The empirical analysis did not provide strong support regarding the hypothesized importance of aspects of project implementation on project success. This is somewhat surprising and calls for further attention to the variables used to capture project management as some of them resulted in counterintuitive results. On the contrary, 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

### 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, in its most simple meaning, we understand the difference between ‘state-of-the-world’ that would have occurred with and without the programme” (Polt and Streicher 2005, p. 367).

The effectiveness and efficiency of any public R&D program thus can be assessed by using the concept of additionality. Additionality can be found in three different forms (see OECD 2006):

- **Input additionality:** To which extent does public support of private R&D lead to an increase in overall research expenditures by the funded companies? Thus, it assesses whether publicly-funded R&D crowds out or stimulates additional private R&D spending;
- **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.).

As regards input additionality, from the analysis of the CIS data presented in chapter 3.3.2, one could identify some input additionality, as Dutch firms reported a significant increase in their R&D intensity during the period of participation (while there is no significant relation for German firms). When comparing size classes, it turned out that at least 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. Taken together, we interpret this as a sign of some input additionality, if on a small scale.

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.

### 6.2 Output Additionality

In our survey, we covered the question of output additionality in various ways: first, we directly asked for the types of output the participants realized (and whether the participants considered the project a success in terms of innovation at all). Second, we asked directly whether the commercial output would have been achieved in the absence of the FP funding. The results are presented below. In addition, we constructed a probit model to test the ability of various factors to ‘explain’ differences in additionality.

### 6.2.1 Measures of outputs

In terms of output, Q32 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). 48% respondents answered this block of questions.

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 organisation, the most important commercial output consists of standards (and services).

**Table 6.1:** *Types of commercial outputs of the SPECIFIC FP 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)*

From Table 6.1 and 6.2 it seems that 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 (see also the comparatively low ranking of the related commercial impacts in table 6.2), it might be in any case a substantial by-product.

**Table 6.2:** *Commercial outputs of the SPECIFIC FP PROJECT, all organisations*

#commercial outputs	% of responding participants
no	15%
1	22%
2	27%
3	20%
4	10%
5	5%

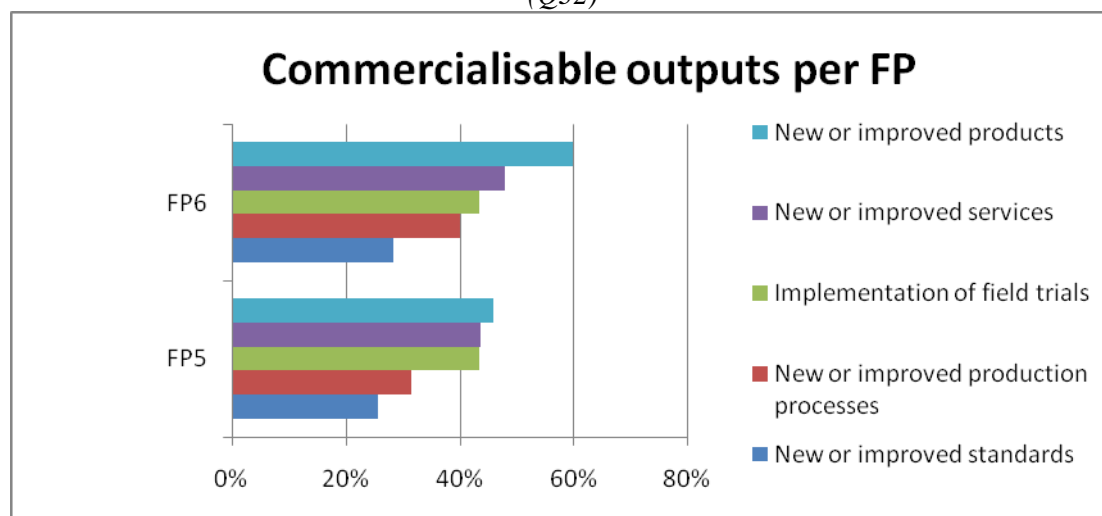
*(multiple answers were possible)*

	industry	research & education	services & consultancy	total
# projects	962	53	380	1395
answering %	51%	67%	53%	52%
no comm. output	17%	12%	11%	15%
1 comm. output	21%	31%	25%	22%
2 comm. outputs	26%	27%	29%	27%
3 comm. outputs	20%	8%	19%	20%
4 comm. outputs	10%	15%	11%	10%
5 comm. outputs	5%	8%	5%	5%

(multiple answers were possible)

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).<sup>55</sup> 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*.

**Figure 6.1:** Commercial outputs of the SPECIFIC FP PROJECT, by type of organisation (Q32)

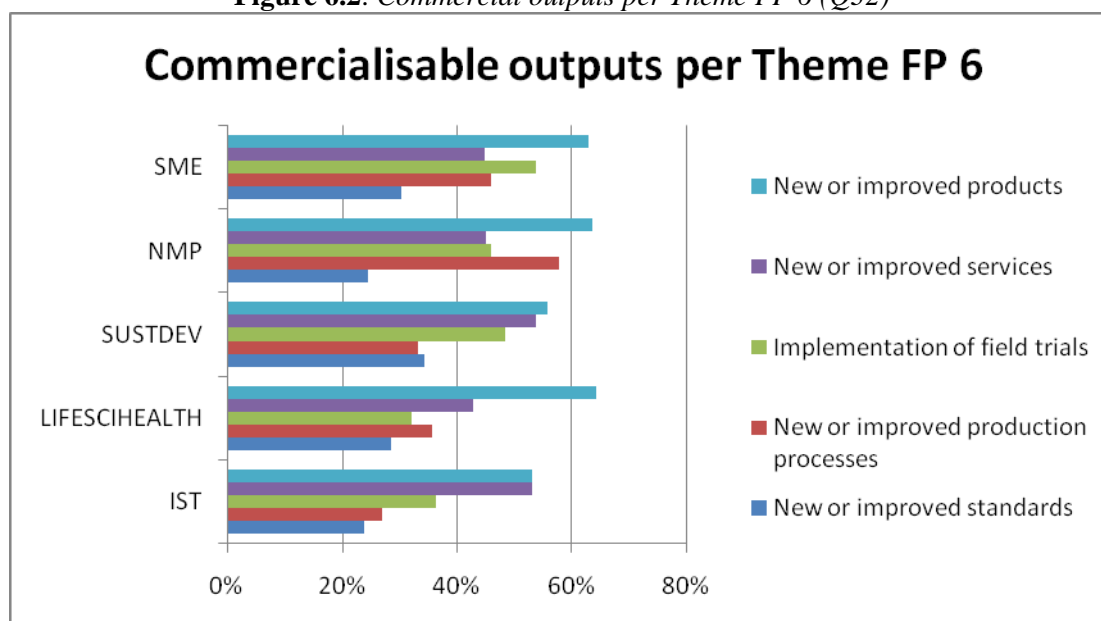


Compared to FP5 in FP6 projects are more likely to result in commercial outputs, especially new or improved products and processes. The relatively high level of new products and services is reported across different thematic areas in FP6, which new processes are more prominent in NMP, and services are 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,

<sup>55</sup> The categories were chosen so broadly to ensure comparability with the questions in the CIS (Community Innovation Survey).

whereas most FP5 projects have finished for five years or longer leaving less possibility of interpretation of potential results.

**Figure 6.2:** Commercial outputs per Theme FP 6 (Q32)



When comparing commercial exploitation impacts between types of participants (see Table 6.3.), 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 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!

**Table 6.3:** Commercial exploitation impacts of the SPECIFIC FP PROJECT (Q33), 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 uncertainty	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)  
significant

1...not significant, 5... highly

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 (see Polt/Psarra 2006), 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; eg. dissemination activities, publications and PhDs are, unsurprisingly, highly valued by research & education, but are quite unimportant for other organisations.

**Table 6.4:** Knowledge-oriented, technological and network-oriented outputs of the SPECIFIC FP PROJECT (Q30), by type of organisation

	industry	research & education	services & consultancy	total
Improved visibility as a competent partner	3.6	4.1	3.9	3.7
Keeping up with and exploring state-of-the-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 complementary 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)  
significant

1...not significant, 5... highly

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 6.5:** Knowledge-oriented, technological and network-oriented impacts of the SPECIFIC FP PROJECT (Q31), 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/strengthening of links with universities and research org's	3.5	4.3	3.6	3.5
Creation/strengthening 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)  
significant

1...not significant, 5... highly

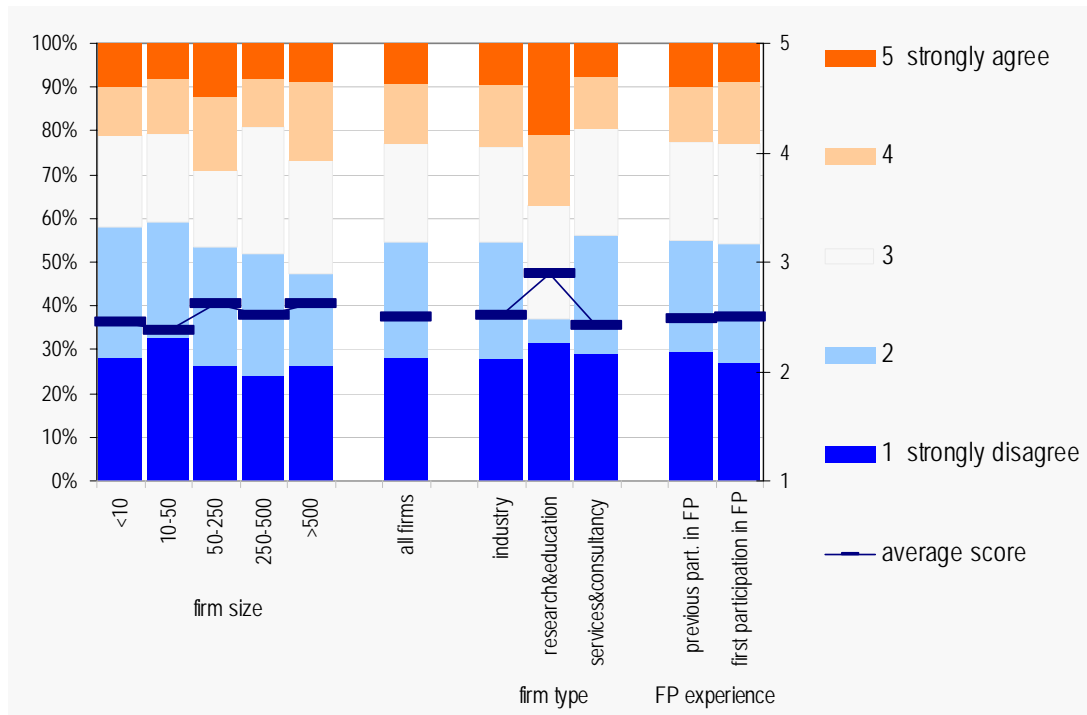
**6.2.2 Output additionality by firm and project characteristics**

Question 40 directly addressed the issue of output additionality by asking about the likelihood of the project’s commercial output had it not been funded by the FP. It does NOT ask if the project as such would have been possible without the FP (as was the formulation of the question in the previous assessment of FP5, see Polt/Streicher 2005). Bearing this in mind, the following section tries to shed some light on the structure of commercially successful projects.

Overall, more than half (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.<sup>56</sup>

Differences between organisations of different size and type are not very pronounced, but some interesting differences seem to appear:

**Figure 6.3: Additionality by firm characteristics (Q40.1 x Q3; n=1129)**

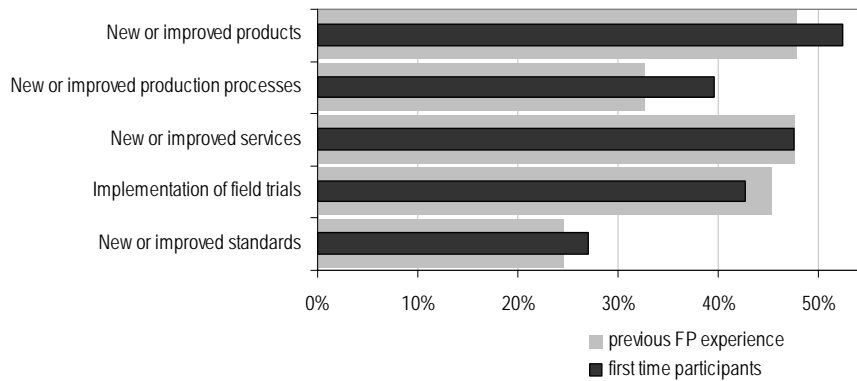


- For smaller firms, the FP project seems to be of somewhat more importance than for larger firms.
- There is a marked difference for research & education organisations. However, it is less significant than it looks, as only about 3% of the respondents belong to this category.
- Virtually no difference can be observed between respondents who report previous experience with FP programmes and “newcomers” without former FP participation

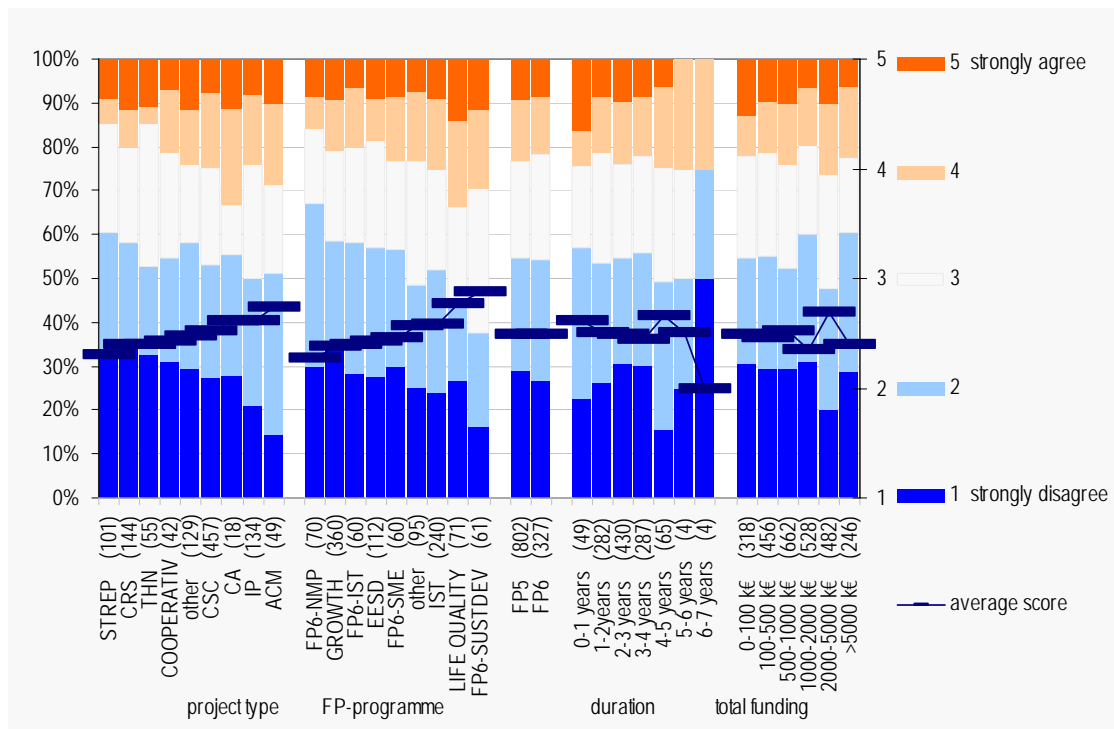
<sup>56</sup> It has to be stated again that this observation cannot quantify the amount of the economic effect.

(in the sample, both make up roughly 50%), despite the interesting fact that newcomers report somewhat higher rates of commercial outputs:

**Figure 6.4: Commercial outputs per FP experience**



**Figure 6.5: Additionality by project characteristics (n=1129)**



When analysing the differences in additionality against different project dimension, again some very interesting results emerge, which have a high potential bearing on the assessment of the FPs at large:

- 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).
- Additionality differences between projects of different duration or different funding volume are rather subdued. Interestingly, projects with a volume of between 2 and 5 M€ seem the least additional. That is to say that we could not identify “scale economies” of larger projects – at least not in terms of commercial output additionality.

- 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.

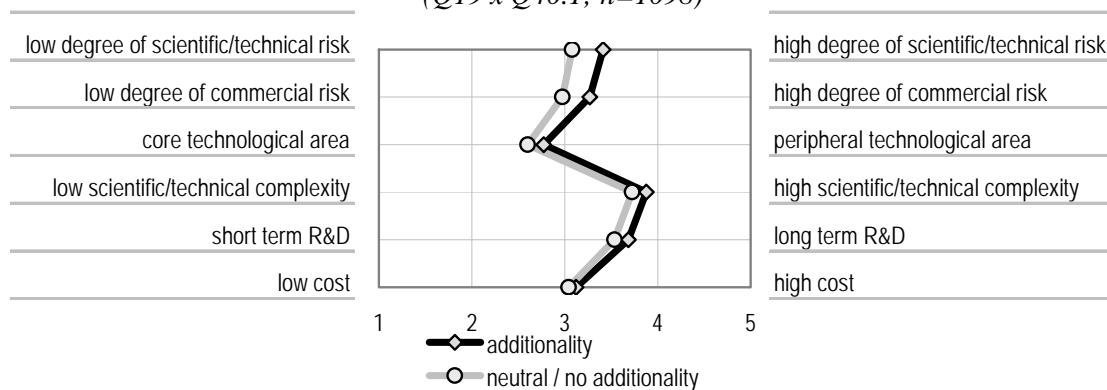
**6.2.3 Characteristics of projects with high vs. low output additionality**

The answer scale of Question 40 (“If YOUR ORGANISATION has realised (or expects to realise) some commercial output: The development of this innovation would have been possible without the FP project”) is from 1 (“strongly disagree”) to 5 (“strongly agree”). For the purpose of profiling highly additional projects against projects with low additionality, answer categories 1 and 2 are taken to imply “high commercial additionality” of the FP project; categories 3-5 are taken to imply low commercial additionality or the absence of it. These groups of projects are then compared to each other against several dimensions.

Quite strikingly, 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.

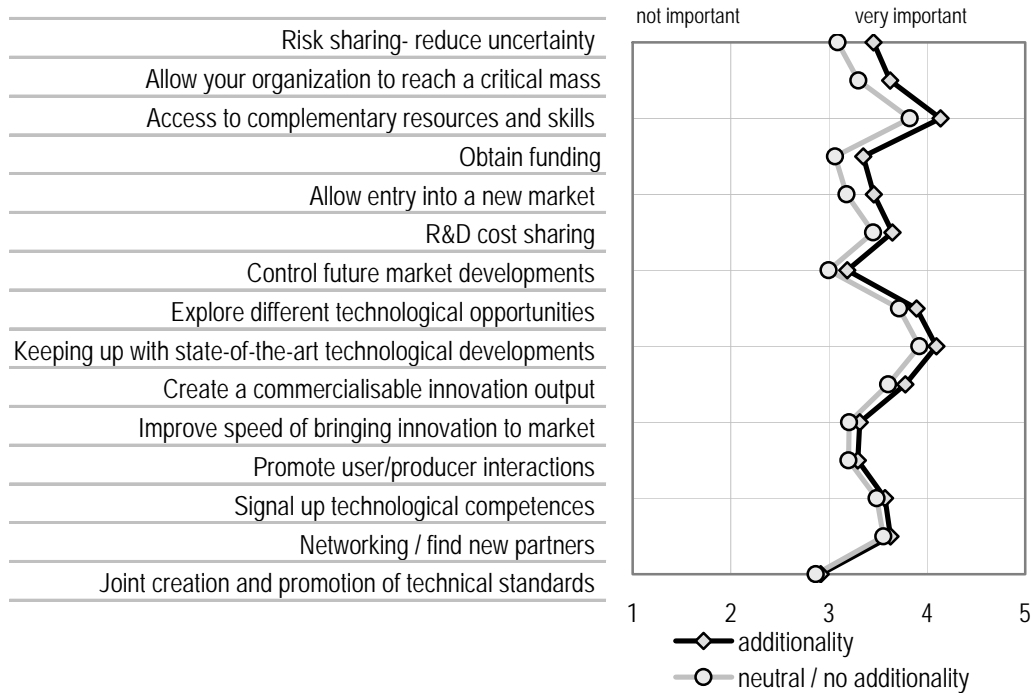
Dimensions where there are differences include their riskiness: projects with commercial additionality were also the ones where participants incurred both higher technical and commercial risk. They were also slightly more peripheral to the core areas of the firm and complex, as well as somewhat more long-term and costly. Therefore, it seems that it is mostly more risky projects from which output additionality stems (see Figure 6.6). Also, the figure reveals that FP projects are characterised mainly by their above-average complexity and duration, despite belonging rather to the core technological area.

**Figure 6.6: Characteristics of THE SPECIFIC FP PROJECT by commercial additionality (Q19 x Q40.1; n=1098)**



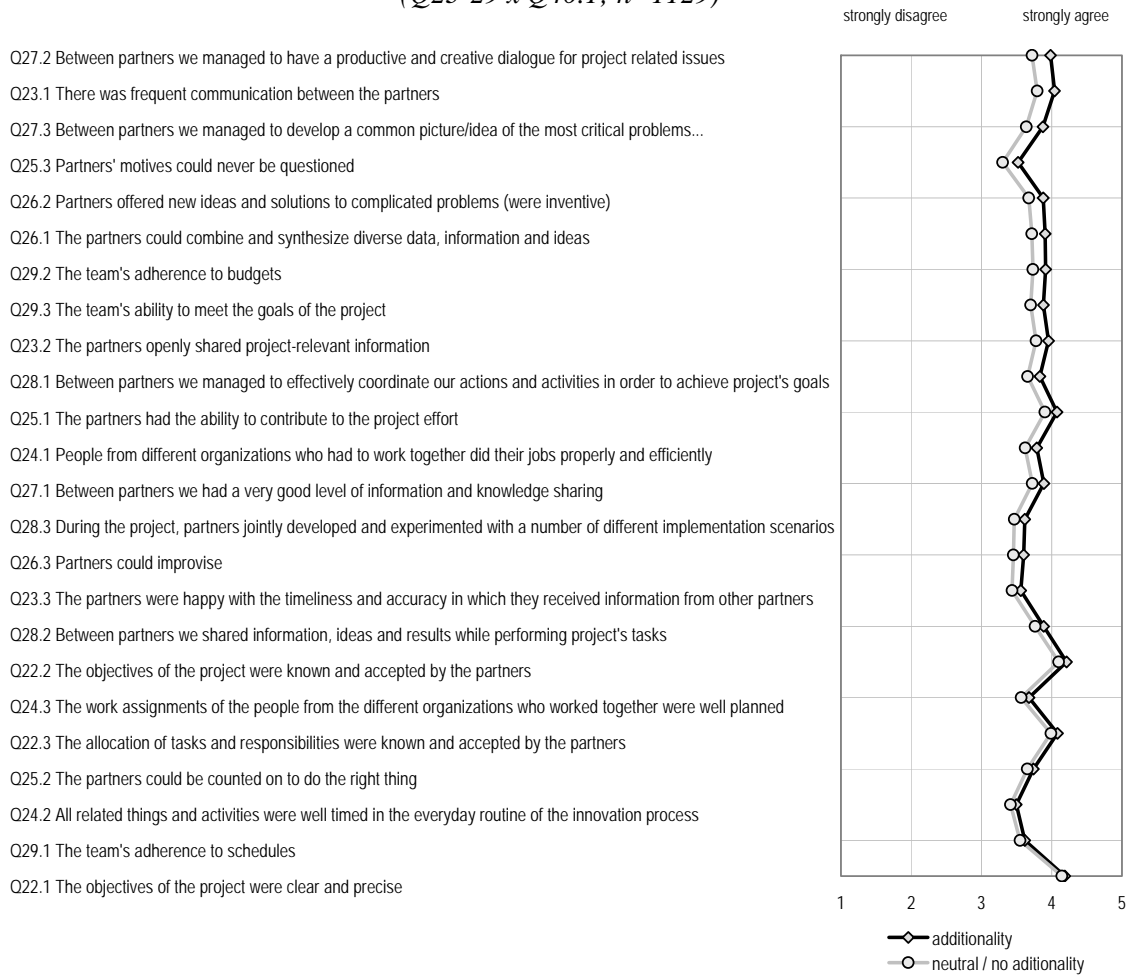
This interpretation is corroborated when looking at the respective profiles of respondents’ objectives in comparison (see Figure 6.7.):

**Figure 6.7:** *General importance of objectives in determining YOUR ORGANISATION's involvement in the SPECIFIC FP PROJECT (Q18 x Q40.1; n~1100)*



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.

**Figure 6.8:** *Communication, coordination, cohesion, collective action and performance (Q23-29 x Q40.1; n=1129)*

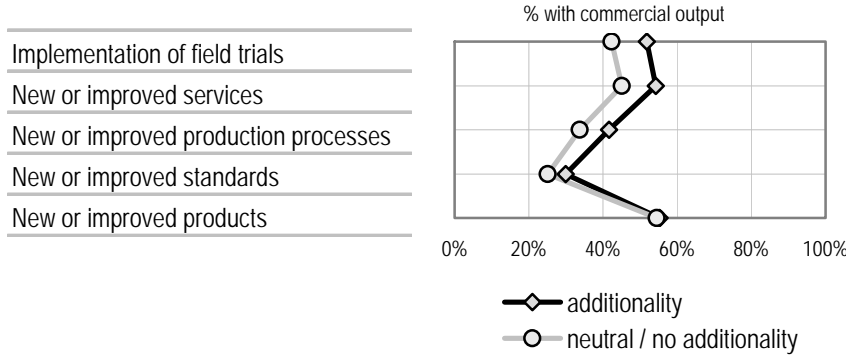


Projects with high additionality also score higher than non-additional projects on every single dimension of the “team-questions” Q23-Q29; the main distinction between projects, however, seems to be communicative: creative dialogue (Q27.2), frequent communication (Q23.1) and a ‘common picture’ (Q27.3) show the strongest links with commercial additionality, followed by partners’ competence and trustworthiness. On the other hand, the planning aspect (adherence to schedules, clear and precise objectives) seems of minor importance. Thus, apart from the project being more risky, there seems to be also a slight advantage for those projects with well-functioning cooperation culture.

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.

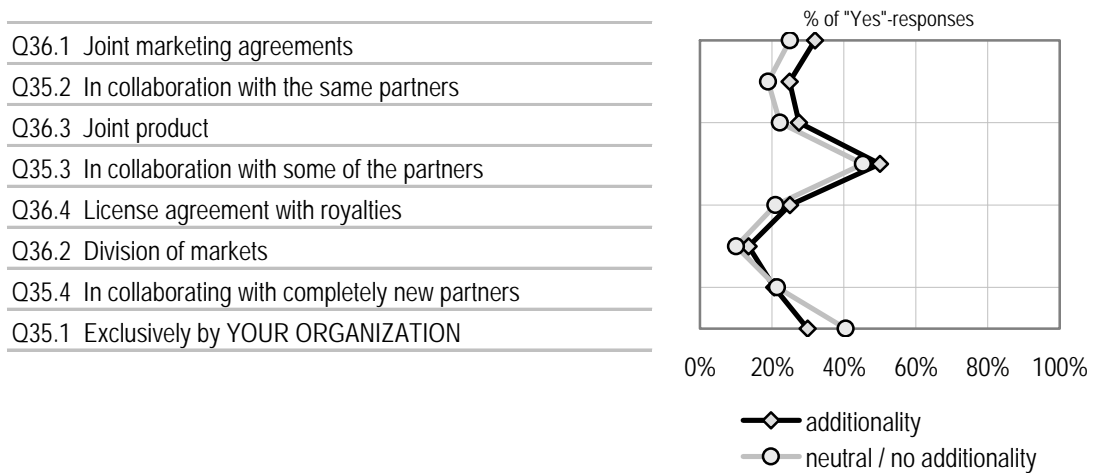
More marked differences appear (as they should) with respect to output: in most output categories (though interestingly not in the probably most important one: “new or improved products”, where the scores are level) projects with high additionality score higher (see Figure 6.9 below):

**Figure 6.9: Commercial exploitation outputs (Q32 x Q40.1; n=1129)**

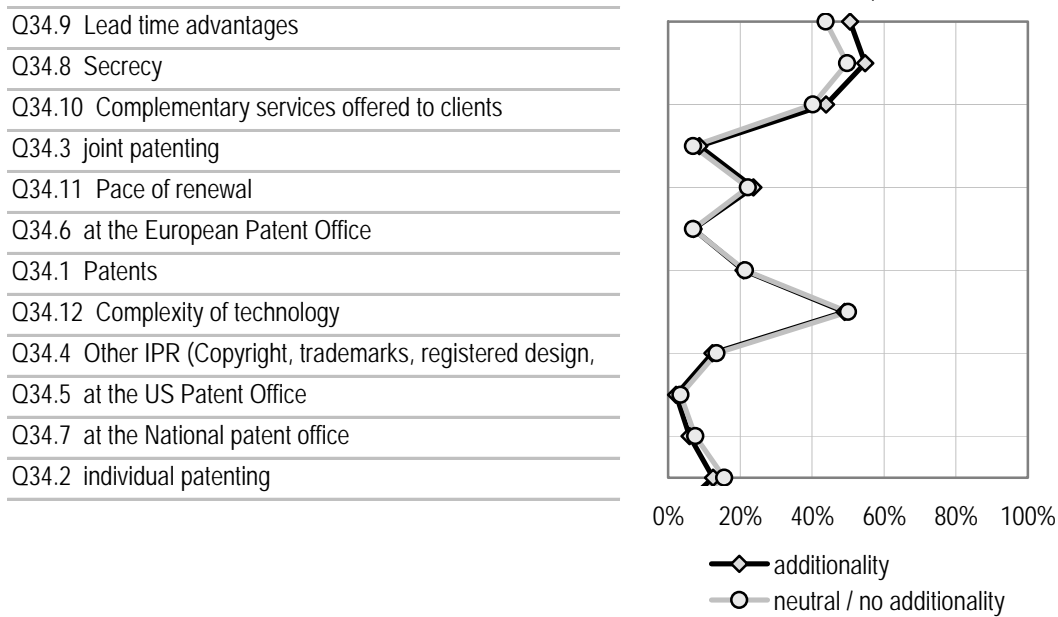


Exploitation of commercial outputs is more often undertaken jointly between partners in highly additional projects than in those with low additionality. This is an interesting observation as it can be interpreted that projects where partners are up for something more risky and new and have established 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.

**Figure 6.10: Commercial exploitation and partners (Q35/36 x Q40.1; n=1129)**



**Figure 6.11:** Protection of commercial Exploitation outputs (Q34 x Q40.1; n=1129)

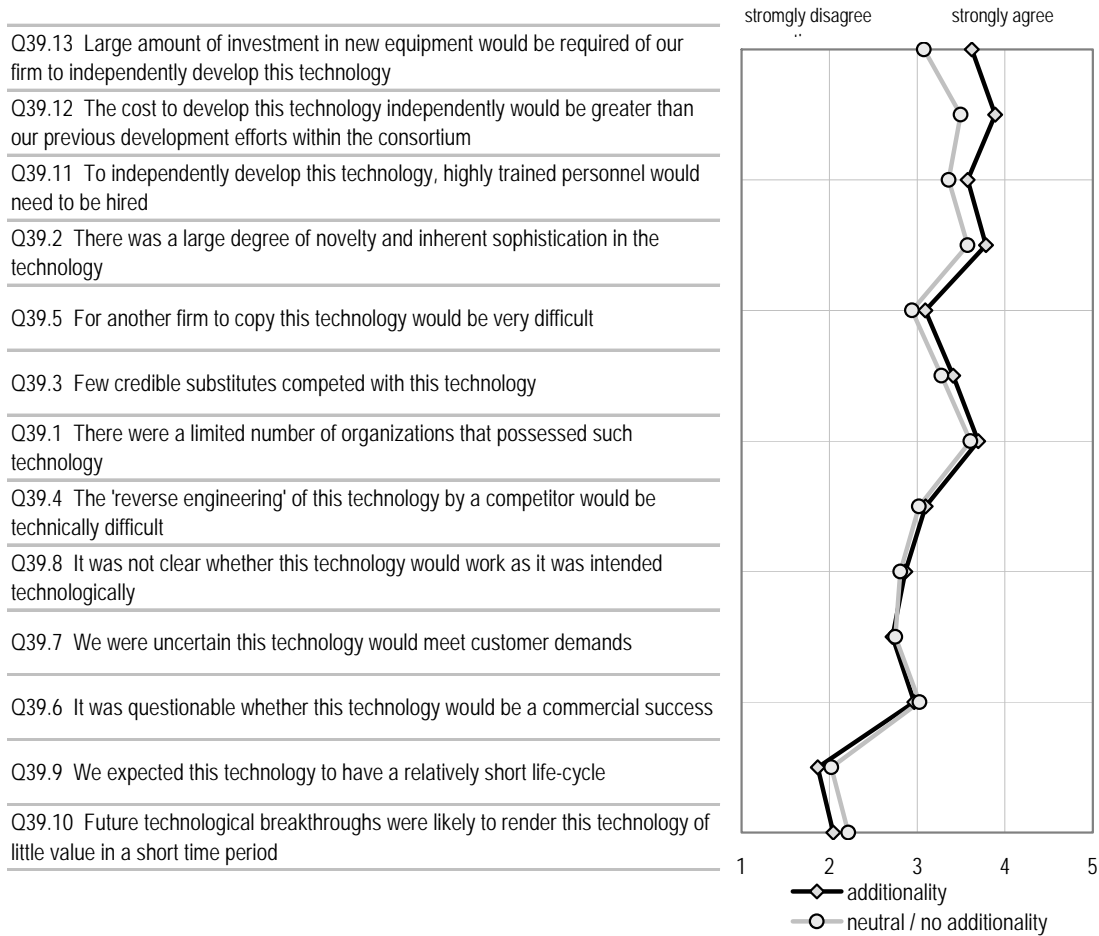


The most important means of protection are complexity, secrecy and lead time advantages; the last two are also those with the largest differences between additional and non-additional projects (they are more often chosen in the case of additional projects). On the other hand, individual patenting is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

### 6.3 Behavioural additionality

Although there were no direct questions from which we can see the various dimensions of behavioural additionality, when assessing the technological outcome, participants were also asked whether additional investments from the side of the individual participants would (have been) required to achieve the same technological outcome. From the answers to these questions (Q39 11-13, depicted on top of Figure 6.12), we can infer that there is ‘behavioural additionality’ and that it is much more pronounced in projects which also show higher output additionality. These findings also are consistent with earlier results about firms’ motives when getting involved in the specific FP project (Q18): top of the list were – besides risk-sharing – to reach critical mass, to gain access to complementary resources and skills and to obtain funding.

**Figure 6.12: Assessment of Technology Outcome (Q39 x Q40.1; n=1129)**



**6.4 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 (“commercial additionality”), we first estimated models for the absence or presence of commercial output<sup>57</sup>. Also, models were estimated for question Q40.2 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, i.e., whether this output would have been possible in the absence of FP funding<sup>58</sup> (the econometric results are included in Annex 3, Table 6.1).

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. Quite often, factors positively influencing the likelihood of producing commercial output (experience in FP participation, in collaboration with partners, R&D intensity etc.) have no or sometimes negative correlation with output additionality:

<sup>57</sup> For specification of the model, we chose this definition: a project was defined to have commercial output if at least one of these first three types of commercial output were reported.

<sup>58</sup> Here, the top two answer categories are taken to imply commercial additionality; a binary representation of Q40.1 has been constructed accordingly, with 1 indicating commercial additionality and 0 the absence thereof.

- R&D intensity seems only to have negligible influence on commercial output, with output additionality it is even negatively correlated;
- The highest probabilities for commercial output were estimated for producers of technology and R&D performers (they also reported the highest satisfaction with innovative success; last came users of technology), which, however, showed significantly lower commercial additionality. In this respect, managers of the specific FP project and service providers scored highest;
- 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;
- As a tendency (though not strongly significant), projects with higher funding are more likely to lead to commercial output, but are less likely to involve commercial additionality;

Other interesting findings concerned types of *participants* and *environments* that are conducive to commercial output and/or output additionality:

- First participation in FP raises the probabilities of commercial output and innovative success, there seems to be a ‘newcomer’ advantage in this respect.
- A good track record for innovation (as measured by the firm’s share in turnover of new products) is no recipe for also producing commercial output from an FP project
- Service and consultancy firms often show more commercial output than other groups of participants;
- If the relevant market was in decline (which was however reported by very few respondents), both the likelihood of commercial output and additionality were low;

We also checked whether the *objectives* of the project had some discernable effect on achieving a commercializable output from the project.

- We found that 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.
- Again, the objectives having a positive influence on commercial output, are not necessarily the same that increase additionality: Additionality is higher when the motives for entering the FP consortium were access to complementary skills, risk sharing, or obtaining funding;
- Projects were more successful in terms of innovation whose initial goals were keeping up with technological developments, create commercialisable output, signal up technological competence, and gain access to complementary resources and skills; but on the other hand, additionality of commercial output was significantly lower when the motives included signalling up of technological competences;

As for a comparison between the FPs, at first sight it might seem that FP6 is less successful than FP5 in producing commercial output (indicated by the respective dummies for the programmes). Actually, the contrary is true because:

- all of the specific sub-programmes of FP6 (IST, SME, NMP and SUSTDEV) exhibit positive coefficients which are large enough to more than compensate for the negative coefficient of the “general” FP6-dummy. Of these, NMP (the nanotechnology programme) shows the highest probability of commercial output.
- For commercial additionality, the situation is clearer though less positive: now, the FP6-dummy is smaller than 1, and most FP6 Programme dummies are also smaller than 1; the combined effect points unambiguously towards low additionality for FP Programmes. The exception is NMP, which can be credited with higher commercial additionality.

While the results described above refer to participants from business, we also estimated a similar model for the academic participants. Generally, the models have lower explanatory power than the models for the enterprise survey, which is unsurprising as for industrial enterprises, commercial output is certainly a (much) higher priority than it is for academic and research organisations. Main results from this analysis include the following:

- Organisations working in natural science and technology broadly show (substantially) higher probability of commercial output than social sciences (not really surprisingly);
- If the organisation had a track record in innovation, that is it had designed or developed goods or services during the past three years, commercial output is significantly more likely, but not additionality;
- If the idea for the FP project originated within the organisation, commercial output was more likely (likewise, but less significant, if it was an industrial partner who came up with it). Both possibilities also raised the probability of the project being considered successful in terms of innovation, whereas an idea by a research partner lowered this probability;
- As was the case in the enterprise survey, a decline of the relevant market (a case that was rarely reported though) markedly lowered the probabilities of commercial output, additionality and success;
- Producers of technology and managers show the highest propensities for commercial output, whereas the highest probability for additionality is reported by R&D performers. Innovative success is more evenly spread over the different roles;
- In contrast to the enterprise survey, the composition of the research consortium (old vs. new partners) seems to have no influence on commercial output or success;
- Motives for participating in the project which are conducive to commercial output are exploration of scientific/technological opportunities, access to skills and resources, to reach a critical mass and to jointly create or promote technical standards. The patterns for additionality and success are much less pronounced;

### *6.5 Outputs and additionality in the case studies*

While the results presented in the previous section were based on the survey, in the following section we will refer to the findings obtained from the case studies. The more exploratory approach of the case studies allows observing what the story is behind the findings of the quantitative data analysis on additionality. Indeed, the question ‘What can be done to improve additionality’ is the motivation to look more seriously at the background ‘Why are companies

and universities/research institutions participating in FP5 and FP6? Would have they done the project without funding of the FPs?' The question implies not just input additionality but rather output additionality on exploitation activities as well as behavioural additionality as regards to technical expertise, scientific knowledge, marketing capabilities, reputation, new partners, etc.

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. Of course, EU-funded research is one of the main pillars of external public finance. Often the EU is the main source of funding for the research activities that take place in a broad field of technologies. This asset is especially true and attractive for stakeholders in the East and South European countries. For all participants European funding has indeed one more added value compared to national funding schemes: the EU-funded research is significantly better in terms of visibility and leverage.

Increasing intra-firm knowledge is a main objective to take part in EU-projects. Therefore, the innovation results capture new knowledge, new technologies, innovative applications, testing demonstrators, doing demo and pilot tests, and in the best case developing an operational prototype with high applicability. There is empirical evidence that particularly participants of the FP6 tend to be more engaged in developing a prototype that enables the company to commercialize a new product in future. At the same time it is very rare that a product itself is the outcome of a FP project. In this respect, the findings of the case studies draw a somewhat less positive picture than the results from the survey.

Nearly the same story holds true for patents. Patent applications are usually obtained by the coordinator or by major industry partners; thus, developing a new prototype with a high

exploitation potential or even building up a new product are the innovation results the participants are highly satisfied with. We can also assume that the satisfaction level with the innovation results is dependent on the role the participant takes in the project. It is not surprising that coordinators tend to be highly satisfied with the innovation results.

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. Surprisingly, 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 improved 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.

Definitely, the extent of post-project commercialisation is influenced by the existence of a strategy to do so a priori, or in other words, a clear roadmap towards commercialisation has a major impact on the commercialisation success of EU-funded projects. Apparently, this strategy is more evident in FP6 projects than in FP5 projects. Concerning FP5 projects, in some cases the commercialisation is planned in a follow-up project. Therefore, the company often looks for a follow-up project funded by the EC. Another way is to make an offer to a main customer to commercialise, or to build up a platform where the main interests of commercialisation are involved. However, commercialisation is not always successful. Companies experience problems for instance, when they try to sell the product but the technology is not pertinent enough, or when there is an extensive need for explanation on customer's side. Furthermore, commercial failure becomes evident due to excessively high introductory costs. In this vein, a well established market including the existence of potential customers and a high public interest will have a positive effect on commercialisation.

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 environment, 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.

To correspond to the requirements of a good coordinator, a high level of organisational skills is necessary which involves among other things ethical behaviour, professionalism and an efficient quality control mechanism. In successful projects, the coordinator always acts as a trouble shooter and must be able to relieve tensions between team members, especially if the objectives of partners are conflicting. The motivation and rationale of all partners need to be clearly investigated in order to avoid discordance during the project. To summarise, the smaller the team, the higher the efficiency as coordination tasks are easier. Good social relations have to be constructed within the projects, an aspect which should not be underestimated. It was said to be helpful to build on previous experience in EU-funded projects provided by project partners or by employees of the coordinating company.

- The role of SMEs

SMEs especially often face problems with EU-funded projects as the companies 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.

It should be noted however that, although the potential for exploiting the project as such may be hampered or limited by these issues, in general the different and often partial results of the projects are taken by partners to integrate into innovative products or services.

## *6.6 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 not name but a few all can and should be points of departure for new thinking about programme design and orientation.

## 7 Conclusions, policy observations and policy context

### 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.

Synthesizing the concepts of exploration–exploitation and absorptive capacity, the theoretical framework hypothesized six major categories of factors that affect the performance of the R&D consortium and operate at both the consortium and at the commercializing 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).

Our 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 – roughly speaking, research that falls between basic and near market. 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 intention 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.

Detailed empirical analysis with CIS data in the Netherlands and Germany indicated substantial input additionality among smaller firms. Participation in FP 4 and/or FP 5 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: only a few indicated that the project would have been carried out without FP funding.

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 a generally strong strategic alignment with FP projects and explicit goals related to innovation outputs, apparently in reflection of the higher budget criticality of these projects for such companies. 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.

#### *7.4 Conclusions and observations in the context of policy development and previous assessments*

The central policy context for the Innovation Impact study is clearly the Lisbon Strategy (2005) that identifies R&D and its link to innovation as the key driver for growth in the EU.

Studies that underpin the Lisbon Strategy have identified an innovation gap between the EU and its main global competitors and see weaknesses in the links between research and industry. Higher levels of innovation and introduction into the markets of new products, processes and services are described as essential for the EU's ability to remain competitive. Risk taking and sharing, more investment in R&D and measures to improve the absorptive capacity are crucial elements to stimulate innovation, in the view of the strategy.

The Innovation Impact study has set out to assess the impact of the EU Framework Programmes on innovation, a study objective entirely in line with the Lisbon Strategy. It looks at one aspect of the growth policies, the effect of collaborative, publicly-funded EU R&D on innovation, and does not touch other relevant issues as the availability of capital, regional aspects of innovation, the impact of the use ICTs, eco-innovation. The study, within the framework of EU R&D, does however address critical elements in the process from exploration to exploitation which underpins innovation such as:

- Innovative behaviour and characteristics of the FP participants, both at the organisation level and the project level,
- The relevance of the different types of objectives of FP participants and their success in achieving those objectives in terms of market, technology/knowledge, networking and risk/cost related objectives and achievements,
- The role the FP projects play in the organisations' strategy towards R&D and innovation,
- The means of protection of innovation applied by the organisations in general and within the FPs,
- The elements within a collaborative EU R&D project that make the project more likely to produce innovation outputs such as a new product, process or service into the market.

When looking at the history of the Framework Programmes, innovation and commercialisation have increased in importance since 1984, but never have topped the list of priorities, apart from the fact that linking a research programme directly to innovation is a complex matter.

There has been continuous push for stronger involvement of industry in many aspects and especially in the design of the research agendas in the different areas. This shift indicates the

intentions to move closer to the needs of industry and indirectly to application and commercialisable innovation. As the Innovation Impact study shows that a strong role for industry (as technology producer, project initiator, leader or commercialiser) is important when aiming at innovative outcomes of projects and programmes. The establishment of the ETPs plays an important role in the process. Looking at the results of the study there is however a point of concern about the way a number of the ETPs function. Many are dominated by large industry, which is logical and the involvement of large industry is essential to create a platform and support for the ETPs. The concern however arises from the fact that the study indicates that the objectives and the results of the large companies (contrary to the objectives and results of SMEs) are much less innovation-driven and more driven by objectives as increase of knowledge and access to new technologies. If large industry becomes too dominant in setting the research agenda (naturally along their needs and objectives) there is a risk that the needs and objectives of SMEs are addressed less, while SME's actually provide the most innovation out the FPs, are more sensitive to the FPs as a policy instrument and seem to benefit the most. In order to avoid a gap between the needs of SMEs and the FPs, the process and the input into this process by large and smaller companies needs to be carefully balanced.

Another key issue in current policy is the use and importance of Intellectual Property Rights. This study has not looked at the economic value of IPRs as such, but at their relevance when measuring innovation. As the results demonstrate, their value in measuring and effectively protecting innovation is very limited. Other means as secrecy and lead time advantages are deemed more effective and more used in protecting innovation, both in general terms (as the company overall strategy) and in relation to FP projects.

The use and importance of IPRs varies heavily per sector (their role is dominant in the pharmaceutical sector for instance), and the study does not argue that IPRs are not relevant in terms of doing business, protecting the business and markets, in finding finance or generating revenue. Also there is no argument against the simplification of patent filing procedures or the European patent. The study does however raise a question mark as to the use of IPRs (such as patent counting) in measuring innovation or the heavy emphasis on IPRs when it comes to stimulating innovation per se.

In relation to previous assessments, the Innovation Impact study confirms many issues relevant to commercialisable innovative outputs, such as the role of industry as a driver for innovative output, the essence of good and strong project management, the composition of consortia and the need for a good business focus and planning.

The study differs in opinion from some of the earlier assessments on other issues. Technically complex and higher risk projects may have an implicit higher risk of failure, but the study results clearly demonstrate that they are significantly more likely to produce innovative results. Also in terms of the much expressed need for 'break through' solutions, it is not likely that technically not risky projects will actually bring those solutions.

Finally we would like to address some of the issues raised by the recently published report by the European Court of Auditors (ECA)<sup>59</sup>.

The Innovation Impact study addresses all of FP 5 and FP 6, across thematic areas and across instruments (perceived to be centralised), thereby providing both an overall view (generic

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<sup>59</sup> Special Report No 9/2007 (pursuant to Article 248(4), second subparagraph, EC) concerning "Evaluating the EU Research and Technological Development (RTD) framework programmes - could the Commission's approach be improved?" Although this report specifically assesses the broader issue of the way in which the Framework Programmes are evaluated and we limit ourselves to the results and impacts at project and organisational level, it does touch upon issues that are relevant for the Innovation Impact study, especially where it concerns the data requirements, the methodologies used and the measurement of the results, outcomes and impacts

impacts at an aggregated level) as well as more detailed disaggregated results; this approach has allowed for detailed comparisons between different elements of programmes, projects and participants. The issue identified by the ECA of longer term impact assessment has been an issue in our study. FP 5 projects normally finished 4-6 years prior to our research, which in most cases would be sufficient to see impacts from the funded work emerging, many of the FP6 projects however had only recently finished or were even in their final stages, which made it more difficult to report fully on (expected) impacts. We would fully concur with the need for longer term and continued impact measurement. It should be noted however that practical problems arise when a longer period between the project and the measurement is taken, to name two that we have most come across: the organisational memory is not always able to reproduce facts (people leave, move on or die, companies merge or cease to exist) and often only partial results are taken further by an organisation (attribution problem) which makes it difficult to relate 'current developments or impacts' in hindsight to the projects. We would therefore argue for several measurement (data collection) instants, at the start of a project, at the end of a project, and 5 years after a project has finished.

This introduces a second issue, which is the availability of data and the need for surveys. As explained in detail in this study, we have made extensive use of CORDIS as the basis for analysis, the survey and the case studies. After an acceptable level of CORDIS data manipulation (consistency validation, cleaning), the data proved to be sufficiently accurate to produce the results as presented in this study. A few comments are to be made however. The first relates to the difference in quality in FP 5 and FP 6 CORDIS data, FP 5 data were significantly more accurate and complete. A second issue relates to the fact that CORDIS only provides a basic level of information and surveys are needed to extend the data and knowledge on projects and participating organisations, because they are not included in CORDIS or another available Commission data source, or only available in a non standard format. We would strongly argue that certain data are collected at the start of a project and at the end of each project (factual data) and as part of the project. This will reduce the cost for the participants and the Commission, enrich to a high level the potential of analysis based in existing data, reduce the need for further surveys, improve consistency and quality of data and avoid the attribution in hindsight of issues that should mark the status at the start of a project. In particular certain organisational data (such as NACE, turnover, employment, R&D expenditure, innovative sales [related to the CIS], market environment, innovation protection mechanisms, etc.) and project data (such as objectives, expected results, specific role, etc.) should and could be captured at the start. At the end of the project, further project data should be collected in terms of results, problems, barriers, etc. The data quality and consistency should be improved and monitored, especially in terms of organisation name authority and proper and appropriate classifications. The study has for reasons explained in this and previous reports decided not to use the TIPs and eTIPs mainly due to the relative low numbers and the unknown quality and accuracy of the data.

With regards to measuring results, the ECA identifies the problem that insufficient evaluation has been done on the outputs, outcomes and impacts of the Framework Programmes. It recognises the methodological difficulties. Although it was not within the scope of the Innovation Impact study to assess the effectiveness of the public intervention as such, the study has collected data and analysed outputs and outcomes (in the definition of the ECA) at project and organisation level, including aspects of additionality. The wider socio-economic and political impacts (as defined by the ECA) fell outside the scope of the study.

## 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 5<sup>th</sup> and 6<sup>th</sup> 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.

