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IMPACTS OF THE FRAMEWORK PROGRAMME IN SWEDEN

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by funding *needs-driven research*
and developing *effective innovation systems*.

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Impacts of EU Framework Programmes in Sweden

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Foreword

VINNOVA, together with the Swedish Research Council, the Swedish Energy Agency, the Swedish Council for Working Life and Social Research and the Swedish Research Council Formas, was in 2007 instructed by the Swedish government to conduct an impact analysis of EU framework programmes for research and development at the level of industrial sectors and universities in the period 1990 to date.

A steering group with representatives from these research councils and agencies agreed on the foundation for the analysis. VINNOVA coordinated the work in the steering group. Representatives were Gunnel Dreborg, Lennart Norgren and Erica Tenevall (VINNOVA), Carl Jacobsson, Johan Fröberg, Anette Gröjer and Andreas Augustsson (the Swedish Research Council), Uno Svedin (the Swedish Research Council Formas), Cecilia Grevby (the Swedish Council for Working Life and Social Research) and Peter Rohlin (the Swedish Energy Agency).

The impact analysis was conducted by Technopolis Ltd. The scope covers four industrial sectors: Sustainable energy; Life Science and Health; ICT; and Vehicles, as well as the universities: Chalmers Institute of Technology; Karolinska Institute; and the Universities of Lund, Gothenburg and Växjö. Swedish participation in FP3 to FP6 and its impact on research at universities and on innovation in industrial sectors is at the forefront of analysis. The bibliometric study (appendix J) was carried out by the Swedish Research Council. The presented policy implications in the report are the conclusions of Technopolis Ltd.

The study will hopefully inspire new policy action in the field of research and innovation on the national and the supranational level in Europe. The Swedish agencies will be inspired by the report. VINNOVA would like to thank Technopolis Ltd. for their work and also the participating agencies contributing to the result in a most constructive way.

VINNOVA in November 2008

Per Eriksson
Director General

Göran Marklund
Director and Head of
Strategy Development Division

Summary

This report describes the result of a study aiming to understand the impacts of the EU Framework Programmes on Sweden in the period 1990 to date. Our scope covers four clusters of technology and five universities, namely

- Sustainable energy; Life sciences and health; ICT and Vehicles
- The Universities of Lund, Gothenburg and Växjö, the Karolinska Institute and the Chalmers Institute of Technology

Together these are expected to give a fair representation of the overall impacts. This is, as far as we can tell, the first study that looks over a longer period and tries to understand impacts at an overall level as well as considering sectoral effects and the impacts on the university system. It has been conducted in response to an instruction from the Swedish government to the Swedish Energy Agency, FAS, FORMAS, the Swedish Research Council and VINNOVA.

The Framework Programmes (FPs)

The Framework Programmes date from the mid-1980s: the First (FP1) in 1984-7; the Second (FP2) in 1987-91. Their initial focus was nuclear energy but by the second Framework Programme this had shifted towards IT – actually as part of an OECD-wide push to increase IT research that followed the spectacular successes of Japanese industry in consumer electronics and telecommunications of the latter 1970s.

Our study begins with FP3 in 1990-94, which was the first in which Sweden systematically participated by the Swedish state funding Swedish participants. Once Sweden joined the EU at the start of 1995, Swedish participants were put on the same footing as other EU participants.

Over time, the Framework Programmes' scope have tended to widen, so that they now cover a very wide range of themes and the repertoire of instruments has increased from the early focus on collaborative research to areas like human mobility. One strand in the programmes has been strongly driven by the desire to achieve social and economic impacts. The early efforts in IT and industrial technology exemplify this strand, which is sometimes informally described as 'the Commission's industry policy'. Another strand has been more directed at research.

Up to and including FP4, European Added Value in the form of networking, cohesion, scale benefits and so on was largely seen as sufficient justification for the FPs. In FP5, the focus shifted towards socio-economic benefits. FP6 was designed at the time when the Commission launched the European Research Area (ERA) policy, aiming to concentrate research resources and create a system whose most excellent parts could compete readily with those of the USA and Japan. This led to increased concern with research (as

against the earlier industry policy and impact focus), which should be excellent and in which Europe should build scale. FP6 therefore included new, larger instruments. The previous industrial strand continued but was less of a focus and – especially outside ICT – involved less effort. FP6 also marked the creation of Technology Platforms and ERA-NETs, in which the Commission encouraged groupings within the union to self-organise and try to develop cross-border groupings that would drive R&D and innovation policies for their sectors or technologies. By and large, these groups together existing strong interests and the thrust of the Technology Platforms is continued in FP7's JTIs (Joint Technology Initiatives) and increased interest in Article 169 consortium arrangements.

Swedish Participation – Evidence from Other Studies

Swedish companies spearheaded national participation in the FPs in the 1980s, but the universities entered in strength from FP3 and by FP6 accounted for 60% of the FP funding flowing to Sweden. Volvo; Ericsson; Saab; Vattenfall; and Telia/Teliasonera have dominated the industrial participation. Few other companies have a large or persistent presence. Therefore, vehicles (including aerospace), telecommunications and energy are strongly represented while sectors like pulp and paper, pharmaceuticals and chemicals are not conspicuous. Much of the major industrial participation is in areas where there have in the past been 'development pairs' between industry and the state. The Swedish industrial research institutes are small and poorly funded by international standards, so their participation has been limited.

Swedish participants are more successful in winning projects than most: Sweden tends to get a bigger share of the FP money back than it contributes. Most successful participants get into the FPs on he basis of their earlier success at national level. Past studies show that Swedish participants joint the FPs to network, work on industrial standards, produce 'intermediate knowledge outputs' and train new generations of researchers. Networking includes establishing business relations – it is not just about technology. National programmes could not have created equivalent benefits. The quality of FP research was equal to or better than national work.

The Swedish Research Council has, as part of this study, conducted a bibliometric analysis of Swedish academic participants in the Framework Programmes by comparing the publication and citation performance of participants with the wider pool of Swedish university researchers of which they are members.

The analysis does not provide evidence about whether participants' performance (in bibliometric terms) improves once they participate. It does clearly indicate that the participants are among the best researchers at their universities but it also shows that the gap between these and other researchers is closing as the benefits of internationalisation become more evenly spread through academia.

Effects of Participation on the Universities Studied

In the university context, the FPs have added quite a substantial amount of money to external research income. In so far as research (and education) are good things, then these are good things that should broadly lead to increased social and economic welfare. This funding is **additional** to national funding; we have not found suggestions that national funding has been reduced to compensate. Sweden's excellent performance in bringing money home from the FPs means the bargain for Sweden has been a good one: she takes out more than she puts in and most of that additional money goes to the universities.

There is evidence that the additional money complements national resources, though it does so in a range of different ways. In some places, it allows more applied and innovation-orientated work to be done by companies as well as academics. It allows some themes that are overlooked or otherwise difficult to fund at the national level nonetheless to be funded. Perhaps the most interesting thing is that by adding **diversity** to a system that some of our interviewees saw as overly focused on basic research the FP funding adds robustness to the Swedish system as a whole.

The FPs have had more influence at the level of individual research groups than they have had on overall university strategies. They clearly added size and scope to researchers' networks, probably increasing quality and including them in more international 'invisible colleges' that make them 'insiders' in groups of researchers working at or near the leading edge in their fields. The practice of staffing FP projects largely with doctorands ensures that they play an important role in doctoral education and also exposes those doctorands to the international partnerships of the FPs, with beneficial effects on their educational, research and career prospects.

Swedish universities essentially obtain these benefits because they can apply bottom-up for project funding, largely unconstrained by any strategic considerations of the FPs, national programmes or their own universities – even though winning FP projects can bring a financial penalty to those universities by not covering the full economic cost of the projects.

However, the fact that the universities largely lack thematic strategies for their own operations and consistently lack strategies for handling the FPs is an important missed opportunity to use FP resources systematically to promote the development of critical masses and therefore to combat the fragmentation in the university system. This fragmentation puts it at risk, both in terms of the general need for critical mass and specialisation in an increasingly globalised university system (and, indeed, in support of the knowledge and manpower needs of key parts of Swedish industry) but also the specific need to specialise in the context of the focusing of resources that is intended within the future European Research Area.

Effects of Participation on Swedish Industry

Major pharmaceuticals companies tend to do little in the FPs, so their effects reach these companies by strengthening their university partners. The FPs have added considerable resources to the Swedish university research effort in life sciences and health. These are areas of pre-existing strength in which Swedish research is highly competitive and Swedish institutions – notably Karolinska – have seized the opportunities provided to widen their thematic research areas in areas prioritised by the FPs. The nature of intellectual property in the industry means that large pharma barely participates in the FPs. The small amount of industrial participation largely involves SMEs, which can derive considerable support from the programmes. This is a science-driven industry, so the focus on basic research is nonetheless the right one, with industry deriving benefits through bilateral relations with the universities inside and outside the FPs. The lack of an explicit Swedish strategy for life sciences and health research means that use of the FPs has to be opportunistic. Sweden has little influence over the FP agenda because it is not clear or agreed how Sweden would like that agenda to change. The limited presence of major Swedish industry in the emerging Innovative Medicines Initiative JTI in the area will ensure that Swedish strategic influence continues to be small.

Swedish ICT participation is dominated by universities and research institutes and has – together with national programmes – supported the need to increase the research and education areas in ICT significantly over the past 20 years or so. FP funding has broadened the research base by supporting some areas of research that were hard to fund from national resources. Numbers of large and small firms have obtained short-term support from the FPs. Ericsson and Teliasonera are the major companies that have worked with the FPs at some scale and over a long period. Teliasonera's importance as a source of technology and market power has been declining since liberalisation. However, Ericsson's participations in the FP have enabled it to build strong positions in 3G mobile technologies through influencing standards and key choices of technological direction. Innovations derived from participation in FP3 are still being implemented and others from later work are in the pipeline. In this area where Sweden had already established significant industrial power, the FPs have been a powerful lever on national industrial and technological competitiveness.

In contrast with the other industries studied, vehicles participations are more industry- than university-dominated and the work of the projects is generally more applied. Important aspects of the continuing strength of

Swedish positions in the industry build on long-term alliances with Swedish universities in areas like combustion, catalysis and safety. These alliances have been brought into FP participation, extending the scale of national efforts but also building new links to foreign institutions. FP money has been one of the factors enabling the industry in general, and Volvo AB in particular, to maintain the high level of technological capabilities that have so far protected vehicles design and production activities in Sweden, which from a scale logic are anomalous. This industry is very explicit in internally agreeing and then telling the Commission what should be put into the FP strategy via organisations such as EUCAR. As a result, the FPs address longer-term issues of relevance to industry. The complementary combination of national and FP programmes has been instrumental in the survival of the Swedish road vehicles industry in its current form and is – from a Swedish perspective – a major success.

In sustainable energy, the FPs have served to increase the amount of university research in a pattern that reproduces the pattern of national effort. The additional spending is not sufficient to overcome the fragmentation of research within the higher education sector, which essentially uses FP money to do 'more of the same' – although with the added benefits that arise from international networking. The major energy equipment suppliers have tackled the limited modifications to traditional equipment needed for thermal biofuels but are not involved in the major new potential sustainables. With neither the incumbent companies nor the state stepping up to shoulder the innovation risks, that burden falls to a number of small companies – several of them supported bottom-up through the Framework Programme. However, neither Swedish policy nor the FP seems to be able to move beyond conventional R&D policy to develop the kind of consistent industry, energy and taxation policies, developmental procurement or demonstration measures likely to be needed to accelerate the shift to sustainables – let along to seize the opportunity to establish industrial advantage in sustainable technologies. In the past, major leaps in energy technology have involved the state as a major customer and risk-taker with new technology and it is not clear that the needed rapid transition to new energy sources can be obtained without a similar type of intervention that goes well beyond the current mandate of the Framework Programmes.

Conclusions

The study suggests that the FPs have had some important impacts in Sweden and that some of the areas of limited impact result from a lack of strategic direction from the Swedish side. Where the FPs have had limited strategic impact, this is because there are not many strategies to impact. This is a vicious circle: in the absence of national strategy, it is difficult to articulate how the FPs' strategies should change in order to serve the national interest. Partly as a result of this, the FPs' ambition to 'structure' research in Sweden has not been realised at all. The FP resources have added a little scale but not changed the structure of the higher education and research sector – and certainly not helped address the long-standing problem of fragmentation in the research community. In principle the FP resources could be used to support restructuring, but only in the presence of national strategies.

Where there are strong industrial lobbies or groupings, the FP has helped generate agreement about technical directions and influenced standards – and this has been very beneficial for major Swedish companies. It has more broadly supported industrial innovation in both small and large firms.

Perhaps the most striking thing about this analysis is that it points to circularities. Where there is a national strategy or an industry strategy, the FPs can be recruited to this cause. The openness of the FPs to strategic ideas means that where there are powerful lobby groups, their ideas are likely to be adopted, and the vehicles industry example shows that this can have very positive industrial effects. (Of course, lobby groups can also degenerate into cartels.) The FP is much less good at dealing with unpredictable or SME-dominated sectors. It cannot tackle areas like sustainable energy very well, where it is not clear who its discussion counterpart is and where seems necessary to go beyond the existing rules and functions of the FP in order to effect the industrial change that is urgently required.

While the FPs have tended (with varying degrees of success) to conserve existing strong industrial structures (vehicles) and even to build on success (telecommunications) they have had no visible industrial effects in the Swedish science-based life sciences and health industries. They have not significantly been able to encourage the needed industrial risk-taking in sustainable energy, where the established players are largely leaving the risks to the little firms, presumably hoping to pick up some of the pieces once the smoke clears and it is obvious who the winners are. It is reasonable to ask whether – in the absence of 'joined up' research, energy, demonstration and investment policies for sustainable energy at either the Swedish or the European level – this is the best way to promote the rapid and large-scale change needed in our collective energy basis in order to tackle climate change. The state probably needs to step in and take over more of the innovation risks, as it did in past times of radical change in energy sources.

The shift in the FPs' goals from the earlier and rather diffuse objective of 'European Added Value' in the form of networking, cohesion and scale to building the European Research Area that took place in FP6 should have quite profound implications for the Swedish knowledge infrastructure. This is a small country on the periphery of Europe with no real research strategy and a fragmented research community that undoubtedly will need further to specialise in order to survive. Some specialisation within the more applied areas of research is happening as a function of national industrial relationships and needs. In more fundamental research, national instruments are only just beginning to appear that promote specialisation and scale. We have seen that the effect of the FPs in the universities is – with some modest exceptions – to magnify national efforts and strategies. In the absence of such strategies (formal or de facto), it is hard for the FPs to add value in their present form. European-level, redistributive instruments such as centres of excellence and competence centres would probably be needed in order to overcome such national constraints on the FPs' mission to restructure research within the ERA.

The Framework Programme's origins lie in bringing together the Round Table major computing and electronics companies in Europe in the early 1980s and agreeing with them what needed to be done in R&D support and other areas of industry policy. (Both Volvo and Ericsson were involved at this stage, even though Sweden was not yet a member of the European Communities.) It still works best in discussion with the powerful existing players. The upside of this is the ability to direct effort to areas that appear the most relevant. The downside is lock-in and our sector examples show the relative powerlessness of the FPs in the face of radical changes in technology and industry structure that disconnect the EC policymakers from lobbying by well-defined industrial constituencies.

Policy Implications

From the Swedish perspective, the most urgent policy implications of this analysis are

- An acute need to develop strategies for thematic and institutional concentration in the ERA
- A need to communicate about strategy and needs to the Commission and with the research and industrial communities
- A requirement to support increased Swedish participation in the Technology Platforms and other new structures such as the JTIs – not least because it is not clear that the FPs will continue in their present form
- A need to maintain a fully independent set of national strategies and programmes tuned to national needs but more deliberately to consider how to use the complementary resources available from the FPs. A slavish reproduction of the FP priorities is in the interests neither of Sweden nor of Europe
- A need to find policy mechanisms that can compensate or substitute for the Framework Programme's weakness as an instrument to tackle fragmented SME- and technology-based industries

- A need for new mechanisms that can go beyond R&D support to tackle some of the key innovation risks in radical technological change in areas like energy and climate change, where there is not necessarily time available to wait for a market solution to emerge but where risk-sharing between equipment supply and major users is a requirement for transition

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1 Introduction

There have been quite a number of assessments of FP impacts in the past, not only in Sweden but also among other EU member states and in connection with the FPs themselves[1]. These normally take the form of mid-term evaluations of current or recently completed programmes and sub-programmes. This report describes the result of a study aiming to understand the impacts of the EU Framework Programmes on Sweden in the period 1990 to date. Our scope covers four clusters of technology and five universities, namely

- Sustainable energy; Life sciences and health; ICT and Vehicles
- The Universities of Lund, Gothenburg and Växjö, the Karolinska Institute and the Chalmers Institute of Technology

Together these are expected to give a fair representation of the overall impacts. This is, as far as we can tell, the first study that looks over a longer period and tries to understand impacts at an overall level as well as considering sectoral effects and the impacts on the university system. It has been conducted in response to an instruction from the Swedish government to the Swedish Energy Agency, FAS, FORMAS, the Swedish Research Council and VINNOVA.

The Framework Programme (FP) represents perhaps 4% of Europe's state spending on civil R&D and a roughly similar proportion in Sweden. The likelihood of being able to pin down its effects statistically is therefore poor and our approach in the study has been largely qualitative, while making use of such statistics as are available.

We reviewed EU legislation and studies in order to write a short history of the FPs and their objectives. VINNOVA was able to supply us with databases of Swedish participation in the FPs, which is the basis for the many analyses of participation in the report. Especially in the case of the older FPs, these databases are less than wholly reliable and are to some degree incomplete – both in terms of listing all the relevant projects and in identifying partners, especially sub-contractors. We believe that our analyses and listings of participation in the report are therefore broadly correct, but there are likely to be some imperfections. Another potential source of error is that we have ourselves had to classify projects in terms of

[1] See Erik Arnold, John Clark and Alessandro Muscio, 'What the evaluation record tells us about Framework Programme performance', *Science and Public Policy,* Vol 32, No 5, 2005, pp385-397

their relevance to the four branch/technology areas studied, based on their titles and what we could find out about the participants. In addition to analysing the participant databases, we reviewed the findings of previous studies and evaluations of Swedish participation in the FPs and complemented this by looking at findings of equivalent studies in other countries.

Where possible, we have relied on official statistics for complementary information, for example about the research activities of the universities.

Team members who had some years of experience of the branches in question conducted the branch studies. We complemented the participation statistics with information from the literature, branch experts, participants and beneficiaries of the FP, conducting interviews with companies, academics and public authorities. A Swedish former academic led the work to write university case studies – again based on a mix of document study, statistics provided by the five universities and interviews with members of rectorates, grant offices and academics with experience of the FPs. In both branch and university studies, a key part of our approach was to bring lists of our interview partners' project participations and to ask them to interpret and explain their participation and its effects.

The next Chapter describes the Framework Programmes considered in this report: Framework Programme 3 to 6 (FP3-FP6). It characterises the overall pattern of Swedish participation in that time, explains what previous studies of Swedish participation have found and what the more general messages are from studies of other countries' participation. We then describe the extent to which FP participation has affected five Swedish universities before considering the effects respectively in the Life sciences and health, ICT, Vehicles and Sustainable sectors. We have deliberately not imposed a strongly common structure on these Chapters, preferring to tell the somewhat different stories of these areas in different ways. We then go on to draw some overall conclusions about participation and some broader policy lessons.

As the reader can imagine, the number of people who have helped us in this study is very large. We are grateful to them all and hope that the report is interesting enough to justify their investment in time and effort. We especially thank our reference group

- Andreas Augustsson, Vetenskapsrådet
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- Johan Fröberg, Vetenskapsrådet
- Cecilia Grevby, FAS
- Annette Groyer, Vetenskapsrådet

- Carl Jakobsson, Vetenskapsrådet
- Lennart Norgren, VINNOVA
- Peter Rohlin, Energimyndigheten
- Uno Svedin, FORMAS
- Erica Tenevall, VINNOVA

If, despite their help, there are errors of fact or interpretation in this study the responsibility remains entirely with the authors. Nor should this study be taken necessarily as reflecting the view either of the agencies – Energimyndigheten, FAS, FORMAS, Vetenskapsrådet and VINNOVA – or of the Swedish government.

2 The Framework Programmes and Swedish Participation

In this Chapter, we first outline the history of the Framework Programmes and how they fit together in technical terms, then we look at Swedish and other experience of participation through the results of previous studies.

2.1 The Framework Programmes

The Framework Programmes date from the mid-1980s: the First in 1984-7; the Second in 1987-91. The First Framework Programme was an amalgamation of existing initiatives throughout the Commission in an attempt to develop a coherent research and development strategy.[2] The Framework Programmes (FPs) had roots in earlier activities, for example the Multi-Annual Programme in the field of Data Processing (MAP, running from 1979-83 and subsequently incorporated into the ESPRIT programme, part of FP1. In the First Framework Programme the strongest effort (47% of the total budget) went into energy research, in particular nuclear energy and thermonuclear fusion. Alternative energy sources had only a minor share of the total funding (8%). A considerable part was allocated to what was called new technologies including IT, biotechnology and telecommunications (18% of the budget). It was only with the Second Framework Programme that a major shift occurred in favour of IT (42% of the total budget) and particularly the ESPRIT II programme (30% of total budget). The 'Big Twelve' major IT companies in Europe heavily dominated this programme. The focus of the FPs moved therefore strongly to IT – actually as part of an OECD-wide push to increase IT research that followed the spectacular successes of Japanese industry in consumer electronics and telecommunications of the latter 1970s[3]. The first two Framework Programmes were a mix of industry oriented applied research, and policy oriented research topics (e.g. energy, marine research, S&T for development).

Our study begins with FP3 in 1990-94, which was the first in which Sweden systematically made available money for Swedish partners to join EU Framework Programme projects. Until the start of 1995, when Sweden

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[2] Patries Boekholt, *The European Community and Innovation Policy: Reorienting Towards Diffusion*, Birmingham, 1994.
[3] Erik Arnold and Ken Guy, *Parallel Convergence: National Strategies in IT*, London: Frances Pinter, 1986

joined the EU, this money was provided through VINOVA's predecessor NUTEK. Thereafter, Sweden contributed money into the common pot for the programme and in which Swedish companies, institutes and universities competed on an equal footing with their equivalents in other countries. Prior to that, it had been possible for Swedish participants to join EU-internal consortia with the Swedish state paying the Swedish participants' costs directly.

In more than 20 years of history of the FPs a number of shifts and trends can be observed on various dimensions

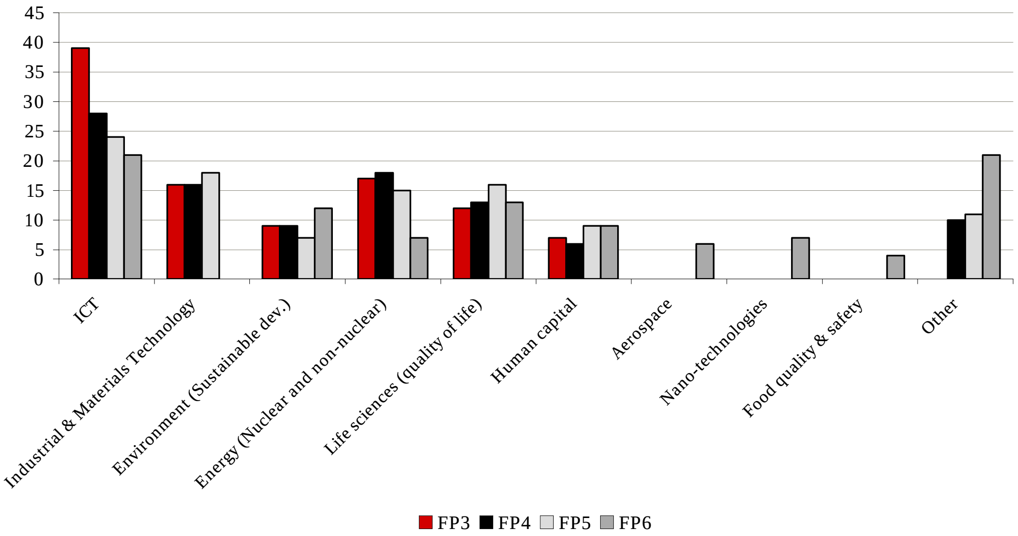
- Thematically: while the first FPs were very much focused on energy and IT the Framework Programmes became more diverse and more 'horizontal' themes were introduced. The core of the FPs remained technology focused. The 'distance-to-market' varies from programme to programme. As particularly in the early FPs the management of programmes and sub-themes was quite independent and hardly coordinated, each programme area had it own research culture and character. The ICT programmes managed in a separate DG (DG XIII later called DG INFSO) were generally more focused on reaching socio-economic impact than the programmes of DG Research (or DG XII in early FPs)
- The size of the budget: this showed a constant rise from 3.75 billion ECU (FP1), 5.4 billion ECU (FP2), 6.3 billion ECU (FP3), 13 billion ECU (FP4), 14.96 billion Euro (FP5), to 16,3 billion Euro (FP6). The total budget of FP7 is for a different time span (7 years for EC and 5 years for Euratom) thus difficult to compare, but it would be approximately €39 billion for 5 years
- The **support instruments** used: while the early Framework Programmes were mostly based on collaborative research projects, in the course of the FPs other instruments gained in weight such as Marie Curie Fellowships, Research Infrastructures, Networks of Excellence, Technology Platforms, the European Research Council, etc. The introduction of the Integrated Projects was still collaborative research but on a larger scale and with more self-organisation of the consortia
- The set of **objectives** addressed: in addition to an objective of focus on 'good science' there have always been secondary motivations involved in the selection of projects and themes. These were mostly covered under the broad term 'European Added Value'. In the early FPs these were typically cohesion, scale, financial benefits, complementarity and contribution to unification.[4] The Fifth Framework Programme explicitly aimed at creating 'socio-economic impact' (which was to be addressed

[4] Yellow Window, Technofi, Wise Guys, *Identifying the constituent elements of the European Added Value (EAV) of the EU RTD Programmes: conceptual analysis based on practical experience*, Antwerp, 2000.

in all programmes and in separate programme). In practice it proved difficult for both proposers and evaluators to describe and assess this. The explicitly stated socio-economic aim disappeared again in FP6 and was replaced by the overarching goal of 'contribution to the European Research Area', which was hardly operationalised at the start of FP6. Cohesion became less of an issue. However involving partners from the new member states was considered as positive. FP6 established a focus on research excellence, which had not been very explicit in the first Framework Programmes and increased the scale of projects. As the ERA philosophy was very much about creating excellence, improving coordination and reducing European fragmentation, these became more important drivers. They were implemented through the new instruments and particularly the Integrated Projects, which were foreseen to be large in scale to have a real impact, and the Networks of Excellence, which would support co-ordination between research organisations. Today in FP7 the 'additional' objectives are less visible. Achieving the Lisbon objectives has become a goal in itself and European competitiveness is more explicitly the ultimate aim. Criteria for project selection are reduced to quality, implementation and potential impact. The latter is defined at the sub-programme level

Figure 1 shows how the thematic focus has shifted during the course of the Framework programmes (starting with FP3). The heritage of nuclear energy research efforts was gradually reduced. Whereas ICT is still the largest component in FP6, its dominance is far reduced compared to FP3 and decreased gradually. Energy, life sciences and environmental research, remain major subjects in every FP. The 'other' category comprising horizontal themes increase in importance from FP5 onwards. It appears as if in FP6 old themes have disappeared (non-nuclear energy, transport) and new themes have come up (aerospace). However, this is partly because themes have been combined (sustainable energy and sustainable transport are now part of the environment and sustainable development) or disentangled out of former programmes (e.g. aerospace which was part of the FP5 Growth Programme, itself the successor to BRITE/EURAM). The following paragraphs will discuss this in more detail for each FP.

Figure 1 Thematic focus across Framework Programme 3 to 6



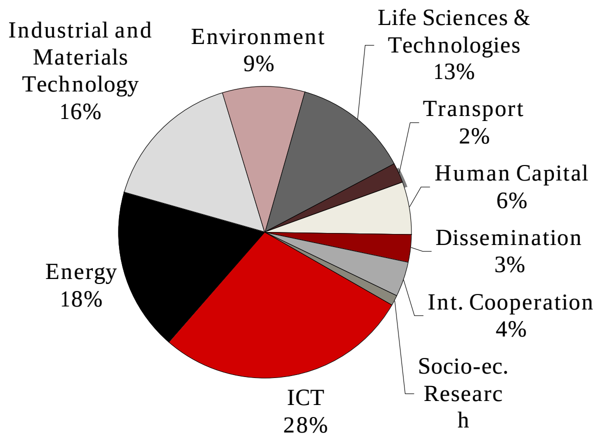
Source: Compilation of various EC documents and P. Boekholt, 1994

The Third Framework Programme, with a budget of 7.3 billion ECU introduced the Human Capital and Mobility of Researchers as a new theme. At that time the philosophy was that researchers from less developed EU countries should have the opportunity to do research in advanced S&T countries. Environmental research was introduced as a separate theme, containing programme elements that were previously in the Quality of Life programme. In the main, the programme was very similar to FP2. The diminishing role of nuclear energy in the FP had already been initiated in FP2 and continued in FP3. At that time the power struggle between the European Commission and the Member States in the Research Council was about the degree of ‘industrial policy’ that could be exercised by means of the FPs. While a part of the Commission responsible for the Framework Programme favoured industry oriented programmes (ESPRIT, BRITE/EURAM) various Member States were against a stronger role for Europe in these matters as well as against a state role in supporting industry.

The Fourth Framework Programme (FP4) had a budget of €13.2 billion, which was thematically divided as shown in Figure 2. It showed a large share of funding to ICT Research (28%), followed by Energy (18%) and Industrial Materials Technology (16%). The programme was well geared to industry oriented applied research in traditional industries as well as in new technology domains.

The Five Year Assessment of FP4, published in July 2000, was quite influential in stating that the current Framework Programme alone was not sufficient to address European challenges and serve the ambitious goals set at Lisbon.[5] It called for a restructured and expanded Framework Programme with more emphasis on social relevance, research excellence, and riskier projects. Its publication was too late to influence FP5, which was already underway. The report did have an impact on the design of FP6 with its new instruments, a considerably bigger budget, and an approach less oriented at supporting certain technology domains and more on addressing societal issues.

Figure 2 Thematic distribution of funding in FP4



Source: The Fourth Framework Programme, Brochure, European Commission, Luxembourg, 1994

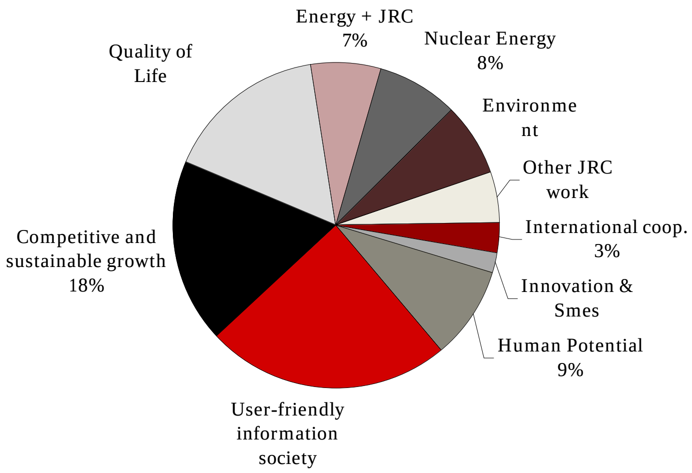
The Fifth Framework Programme (Figure 3) increased the emphasis on 'horizontal' themes that were less focused on collaborative research in particular domains

- International collaboration with Third Countries
- Promotion of innovation and encouragement of SME participation
- An increase in human capital mobility
- Socio-economic research

Although all these themes remained modest in size (totalling 14% of budget), the growth of themes can be interpreted as a shift away from 'pure' research and technological development. As innovation as a theme had mostly disappeared from the DG Enterprise agenda, it was incorporated in the Framework Programme, but at such a small scale that it hardly made an impact. Collaborative research was still the main support mechanism, which included support to 'traditional' industries as well as upcoming areas such as nano-technology and biotechnology.

[5] *Five Year Assessment of the European Union Research and Technological Development Programmes 1995-1999*, Report of the Independent Expert Panel chaired by Joan Majó, Brussels, 2000.

Figure 3 Thematic distribution of funding in FP5



FP6 continued this focus on 'horizontal themes' and introduced support actions to strengthen the foundations of the European Research Area, in particular the new ERA-NET scheme. Its thematic focus can be found in Figure 4. It is most striking in FP6 that the more traditional Industrial Technologies and materials no longer appear as research themes. This does not mean they have disappeared altogether, but they are incorporated in other more societal domains such as sustainable transport or in the new programme called 'Nanotechnologies and nano-sciences, knowledge based multifunctional materials and new production processes and devices'. The SME oriented programme closely attached to the industrial technologies programme, CRAFT was made part of a horizontal scheme to encourage SME participation, which was allocated 2% of the overall budget. Thus FP6 became a more 'high-tech' oriented programme and with the introduction of Integrated Projects better geared to large than to small actors. The Marimon report that assessed the impact of the new FP instruments criticised their initial implementation and observed that SMEs had trouble entering consortia.[6] The report states the Commission's original intention was that the share of traditional instruments, so called STREPS as well as the CRAFT-type instruments, should not be reduced.

At the same time universities and research institutions more engaged into fundamental research voiced a loud concern that the Framework Programme was hardly interesting for their purposes as it had become too industry focused and applied. With the establishment of the Technology Platforms, industry was given a channel to define the research agenda for FP7, but academia did not have its 'own' domain in the Framework Programme,

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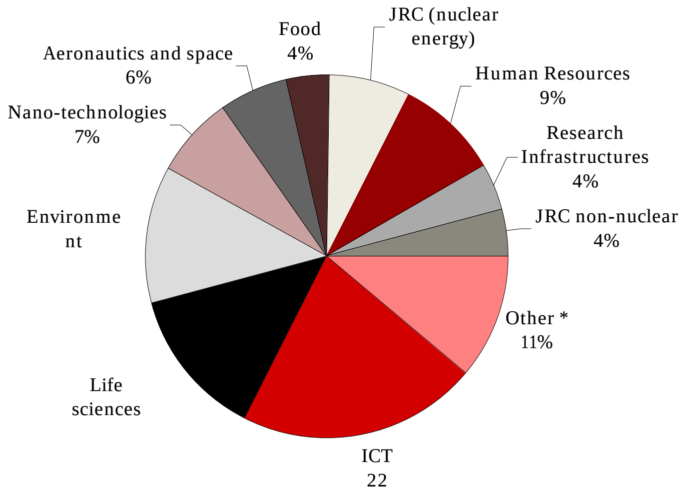
[6] *Evaluation of the Effectiveness of the New Instruments of Framework Programme VI,* Report by a High-level Expert Panel chaired by Ramon Marimon, Brussels, 2004.

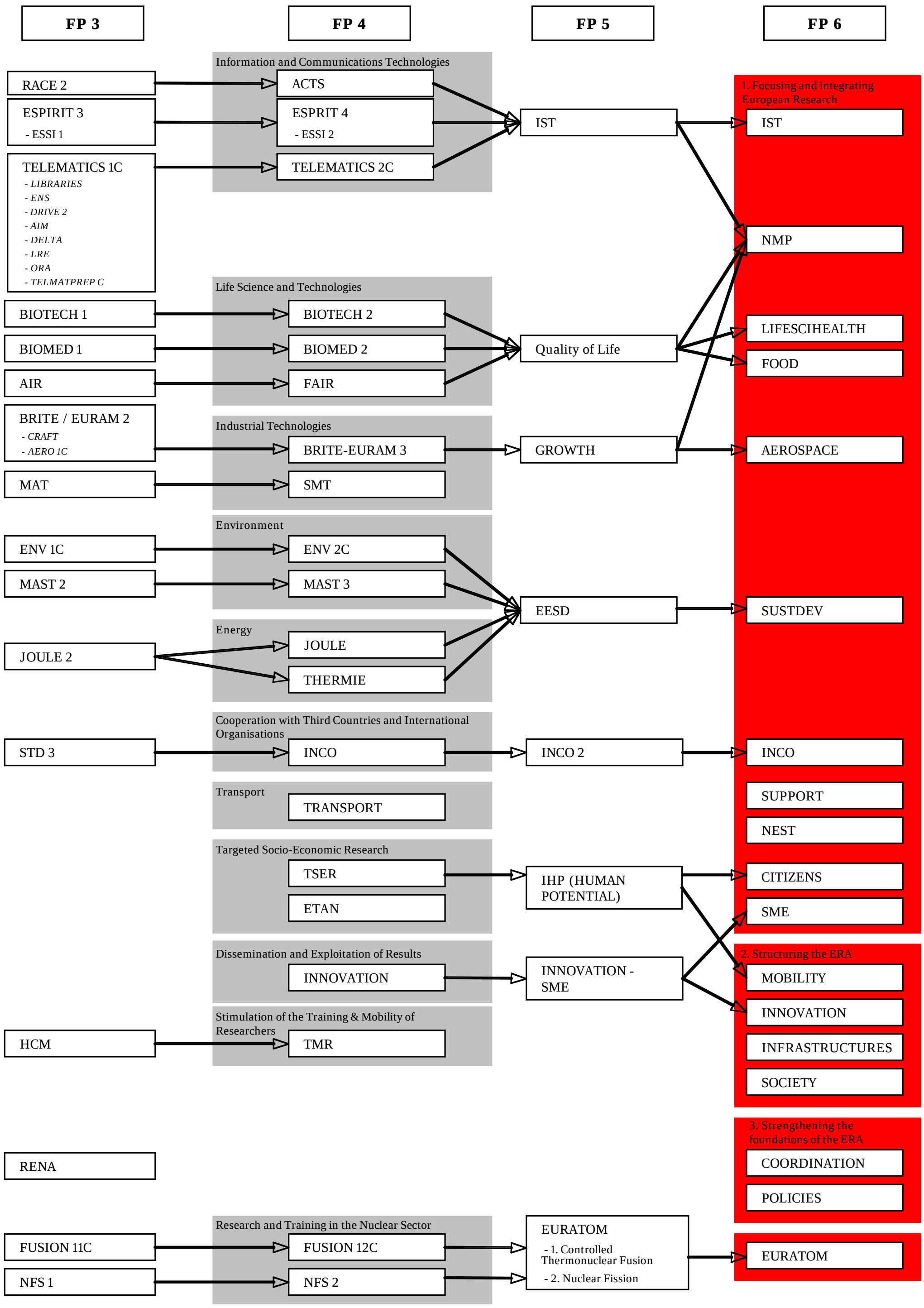
apart from the Marie Curie Fellowships. The Networks of Excellence was intended primarily as an instrument for academia. This provided networking money but no research funding. After a long decision process, which revealed many conflicting motivations and objectives between the Member States, the European Research Council was launched with FP7 money to accommodate basic research. Currently, with 15% it takes a considerable share of the total EC budget, the second largest component after ICT (18 %).

Figure 4 Thematic distribution of funding in FP6



Despite the changes in thematic focus across FPs, there are nonetheless thematic continuities, even if the weight given to different themes changes (Figure 5).

Figure 5 Thematic linkages across Framework Programme



2.2 Swedish Participation in the Framework Programmes

Sweden has been a participant in the Framework Programmes (FPs) since well before she joined the EU. Before FP3, which is the earliest time in scope to this study, participation was mainly by industry and research institutes. But the universities joined in with enthusiasm during FP3 and have come to dominate Swedish participation, getting 60% of the money in FP6. Sweden's biggest FP partners are naturally the large EU countries, but The Netherlands and the other Nordic countries are also very strongly represented, confirming that there is a degree of synergy between FP and Nordic cooperation.

Five companies dominate Sweden's industrial participation: Volvo; Ericsson; Saab; Vattenfall and (more erratically) Telia/Teliasonera. Few other companies have a large or persistent presence. In terms of branches of industry, therefore, vehicles (including aerospace), telecommunications and energy are strongly represented while sectors like pulp and paper, pharmaceuticals and chemicals are not conspicuous. Another way to think about this is to note that much of the major industrial participation is in areas where there have in the past been 'development pairs' – and they all tend to have long histories of collaborating with the Swedish universities.

A handful of industrial research institutes have participated over the longer term but the greater part of institute participation is by state institutes with 'sectoral' functions (government labs).

In terms of the amount of money Swedish participants bring home from Brussels, Sweden has become very successful and by FP6 Sweden brought home more money per head of population than any other country. The other countries with similar performance are also small and fairly wealthy – including especially the other three major Nordic countries.

Thanks to national programmes like NMP and IT in the 1980s, parts of industry had acquired experience and presence in the FPs during FP2. The universities mostly did their learning in FP3. At this stage the money was an important attraction and many in industry still saw the FPs as places where they could develop products and processes. Over time, there has been a shift towards seeing the FPs more as places to network, work on industrial standards, produce 'intermediate knowledge outputs' and train new generations of researchers. Networking includes establishing business relations – it is not just about technology. Some of the attractions of the EU work such as networking and standards setting could not be reproduced by national funding, those who succeed in the FP tend to have strong domestic research funding track records, so FP participation is a complement to, not a substitute for, national participation. There are important exceptions, but those who succeed in the FP tend to be those who have succeeded at home and they normally need other funding in order to be able to afford to take on FP projects.

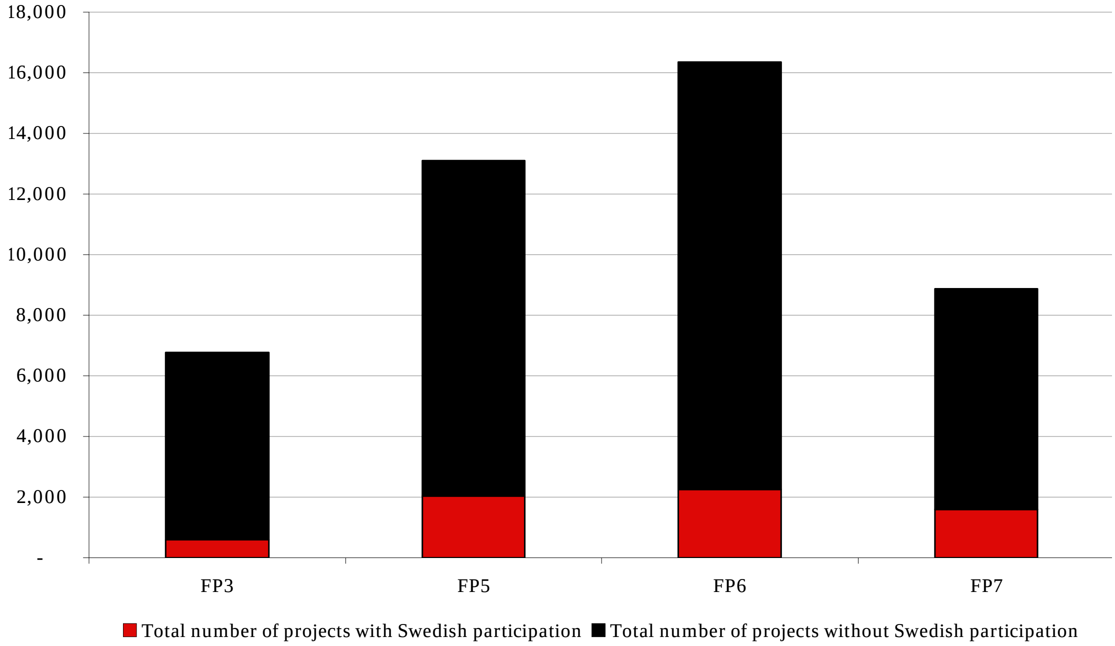
Participating in the FPs could enrich Swedish research and often tended to increase quality, but did not cause people to make fundamental shifts in discipline. Industry could diversify into areas related to what it was doing but the FPs did not tend to cause radical shifts in business direction. Participant networks can be rather stable and can persist over long periods. To some degree there are rather separate industry and university networks – but these are bridged by the cases where there are established industry-university relationships, which tend to be imported into the FPs. The FP also operates as a stepping-stone for organisations in the Swedish innovation system to reach outside to partners with expertise or resources not available nationally.

The Royal Swedish Academies of Science and Engineering have found that on a range of quality indicators FP research is equal to or better than Swedish nationally funded research.

2.2.1 The Pattern of Swedish Participation, FP3-6

Sweden has been a significant participator in the Framework Programmes since FP2 in the 1980s – before the scope of this study. Figure 6 shows the total number of projects in each Framework Programme, based on the data available to us, and the proportion of them in which there was Swedish participation. This share rose from 8.8% in FP3 to 15.5% in FP4. It then fell a little to 13.8% in FP5 before climbing to 18% in FP6 (where the larger instruments meant that the equivalent proportion should have risen for the other countries, too). For Sweden, FP3 was part of the process of learning how to use the FPs and the 15% or so in FP4 and FP5 probably represent a more stable ‘natural’ level of participation in the context of the traditional FP instruments.

Figure 6 Projects and Swedish participations FP3-6



Source: VINNOVA databases; own calculations

However, the overall number of participations in the FPs has been growing faster than Swedish participations – partly because the Union (and the number of 'Third Countries' also allowed to participate in the FPs) has been growing and partly because other countries have been learning, too. As a result, the Swedish share of total participations has fallen from 6.1% in FP3 to 3.6% in FP6.

Figure 7 Swedish share of total participations, FP3-6

	FP3	FP4	FP5	FP6	Total
Non-Swedish participations	11,231	55,681	81,305	66,774	214,991
Swedish participations	730	2,694	3,115	2,493	9,032
Swedish participations as a %	6.1%	4,6%	3.7%	3.6%	4.0%
Total participations	**11,961**	**58,375**	**84,420**	**69,267**	**224,023**

All available studies say that one of the main reasons for participating in the Framework Programmes is the networking. We have compiled Figure 7 from our lists of top-30 partner countries across FP4-6. (The FP3 data we have lack partnership details and unfortunately finding these – while possible – would be a major act of archaeology.)

As one would expect, the EU members with the biggest populations are also Sweden's biggest partners, with two exceptions. The Netherlands, with a population of under 17m, sits in the company of countries with populations in the range 60-80m. The other 'partner' is Sweden itself. Figure 8 shows that almost half the Swedish participations are in projects where there are at least 2 Swedish participants.

Figure 8 Share of Swedish participations in projects

In % of participations	FP4	FP5	FP6
One Swedish participation	58%	55%	44%
More than one Swedish participation	42%	45%	56%

Strikingly, while the UK is the main foreign partner for Sweden in FP3, from FP4 onwards this role is taken by Germany. The precursor to the Framework Programmes (the Multi-Annual Programme in Data Processing launched at the end of the 197os) and the earlier Frameworks were rather dominated by IT, while from FP4 onwards the spread of technologies became much more inclusive with engineering and the life sciences becoming more important, hence Germany becomes a more interesting partner than the UK overall. There are signs of the Nordic cooperation tradition in the relatively high rankings of Denmark, Finland and Norway – all of which are far more important than their populations would suggest. It is also interesting to see China (CN) and the USA just appearing on the partnership radar.

Figure 9 Top 30 partner countries of Swedish participants, FP4-6

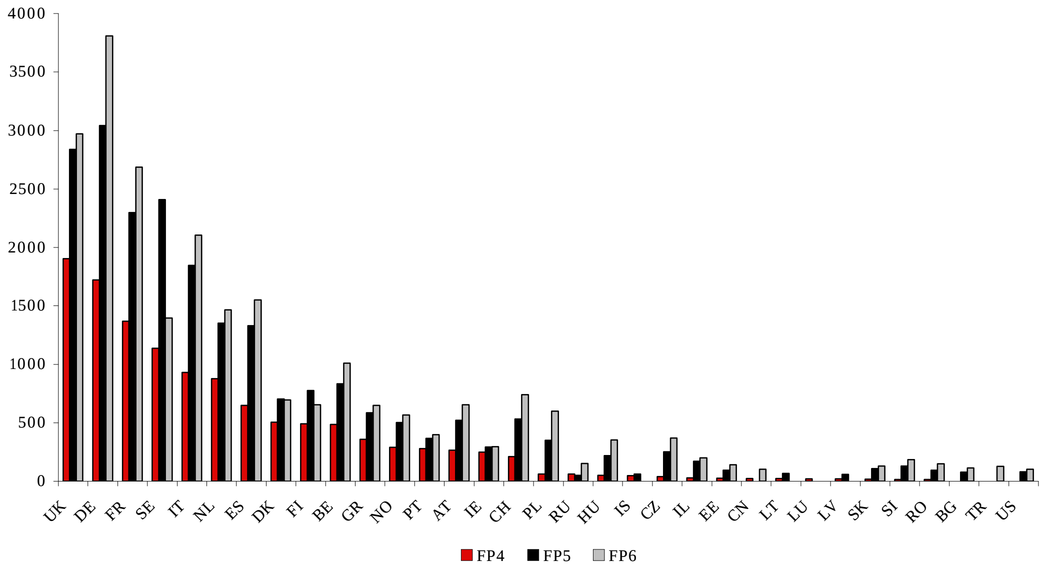


Figure 10 shows the Top-10 partner organisations of Swedish partners in FP4-6. This analysis is strongly influenced by the organisation structures used in partner countries to organise the higher education and research sector. Centralised research institute organisations such as VTT, Fraunhofer and TNO naturally appear ahead of more fragmented institute systems.

CNRS and its Spanish equivalent CSIC organise a large proportion of the research that in other systems is handled by the universities – and in fact these days about 85% of CNRS research is done in 'joint labs' on university campuses – but this more of organisation makes it hard to see whether individual universities or institutes are important partners. There are some key universities – KU Leuven, the University of Helsinki and ETH-Lausanne all appear twice - but others appear once then are not seem again.

Figure 10 Top-10 partner organisations of Swedish participants, FP4-6

FP4

Organisation name	Total	Country
VTT	93	FI
CNRS	91	FR
Fraunhofer-Gesellschaft	46	DE
Katholieke Universiteit Leuven	43	BE
University of Helsinki	39	FI
Imperial College London	35	UK
National Technical University of Athens	35	GR
Commission of the European Communities	32	IT
Consejo Superior de Investigaciones Cientificas	32	ES
Technische Universiteit Delft	29	NL

FP5

Organisation name	Total	Country
CNRS	221	FR
VTT	122	FI
Consejo Superior de Investigaciones Cientificas	102	ES
Fraunhofer-Gesellschaft	102	DE
Consiglio Nazionale delle Ricerche	95	IT
Commissariat à l'Energie Atomique	91	FR
TNO	84	NL
Max Planck-Gesellschaft	79	DE
University of Helsinki	73	FI
ETH Lausanne	68	CH

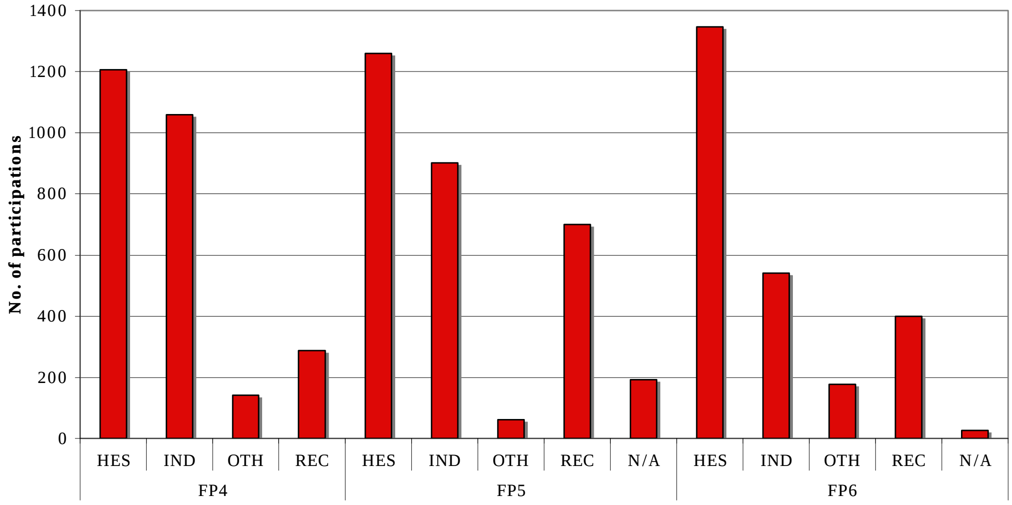
FP4

Organisation name	Total	Country
CNRS	262	FR
Fraunhofer-Gesellschaft	144	DE
Max Planck-Gesellschaft	130	NL
Consiglio Nazionale delle Ricerche	125	IT
Deutsches Zentrum für Luft-und Raumfahrt	124	DE
Consejo Superior de Investigaciones Cientificas	122	ES
Commissariat à l'Energie Atomique	120	FR
University of Cambridge	92	UK
Katholieke Universiteit Leuven	91	BE
ETH Lausanne	87	CH

Source: Analysis of VINNOVA data

Focusing on who the Swedish participants are, it is clear that from FP4 onwards the universities are an increasing factor while industry has gradually been retreating – a pattern that has also been observed at EU level but that seems particularly marked in Sweden.

Figure 11 Swedish participation by type of organisation, FP3-6



Source: analysis of VINNOVA data

We show the major Swedish industrial participants in Figure 12. In this Figure we have not counted Volvo Aero and we have excluded Volvo Car and Saab Automobile, from the points where US companies bought them. We also include only their participations **in Sweden**: Ericsson has at least 70 participations in other countries.

The industrial participation pattern is very clear. Volvo dominates (and would on a wider definition be even more important) followed at some distance by Ericsson. Saab (which includes aerospace), Vattenfall and Telia (later Teliasonera) are the three next most important participants. After these five, participation is small scale and volatile although the atomic waste handling company SK (formerly Studsvik) makes a small but consistent appearance over the three most recent FPs. All the companies mentioned (though to a lesser degree Volvo than the others) have tight links to the state and former ‘development pairs’ where state organisations such as the former Televerket[7] fostered a national equipment supplier, in this case Ericsson.

[7] Privatised as Telia and later merged with the Finnish Sonera company to become TeliaSonera

Figure 12 Top-10 industry participations, FP3-6

FP3		FP4	
Company	**Participations**	**Company**	**Participations**
Volvo	25	Volvo	49
Ericsson	12	Ericsson	29
Saab Group	14	Vattenfall	25
Telia	13	Saab Group	23
Vattenfall	3	ABB	20
ABB	2	Telia	19
AstraZeneca	2	AstraZeneca	8
Pharmacia	1	Pharmacia	8
Celsius	1	Sandvik	6
Sandvik	1	Celsius	4

FP5		FP6	
Company	**Participations**	**Company**	**Participations**
Volvo AB	86	Volvo AB	52
Ericsson	34	Ericsson	19
Saab AB	29	Teliasonera	13
Vattenfall	17	Saab AB	12
SK*	17	Vattenfall	11
Alstom Power	9	SK*	9
Tribon	8	Arexis AB	6
Sydkaft	8	Cellartis AB	5
TPS	7	Silex Microsystems AB	5
Astra Zeneca	7	Biovitrium AB	4

** Svensk Kärnbränslehantering AB*
Source: NUTEK, VINNOVA, Own calculations

In branch terms, there is participation from the majors in vehicles and telecommunications but barely from pharmaceuticals, where the two major formerly Swedish companies Astra and Pharmacia now have US owners. The forests and paper industries are notable by their absence as are chemicals and the non-aerospace parts of the defence industry. Various studies by NUTEK Analyis (discussed below) confirm that smaller-scale industrial participation is usually short-lived – a pattern also identified in the last ‘impact study’[8] of the Framework Programme as a whole.

To some degree, the applied industrial institutes also represent industry. By international standards, Sweden’s investment in this sector is low and these institutes were largely developed in the period since 1942 in order to support parts of industry where there were no ‘development pairs’. These institutes have little core funding (and therefore struggled to co-finance FP

[8] Atlantis, Wise Guys and Joanneum Research, *Assessment of the Impact of the Actions completed under the 5th Community Research Framework Programme (1999-2003),* Work in Progress Report (unpublished), 2004

participation) although since the last Research Act their core funding has typically moved from about 10% to about 15%.

Figure 13 shows the Top-10 institute participations in FP3-6. Those marked in pink are state institutes, attached to ministries. As the highlighting in Figure 13 suggests, a lot of the institute participation is actually connected to the state. FFA, FOA and FOI are successive generations of aeronautics and defence research institutes. IVL is the environmental research institute while VTI is the state traffic and transport research laboratory and SMHL works with meteorology and hydrology. The other state institutes are for public health (SMI) and radiological protection (SSI).

The others are mostly industrial research institutes, traditionally organised as Research Associations. SP (the former state metrology authority) is an intermediate case in the sense that the institute has increasingly focused on providing metrology, certification and research services to industry, even if it remains formally an agency of the industry ministry,

SIK (food and biotechnology) has had a consistent presence through the FPs. The role of the production engineering institute IVF appears twice as a heavy participant and twice is absent as a major force. The computer science institute SICS is a strong player. A Research Association set up in the late 1980s, it does very advanced research – normally partnering with institutes and universities not companies in its international project. STFI, the pulp and paper institute, no longer appears as a force after FP3 and the other industrial institutes come and go. ALI – the working life research institute has now been closed.

Figure 13 Top-10 institute participants, FP3-6

FP3		FP4		FP5		FP6	
RI	**Partici-pations**	**RI**	**Partici-pations**	**RI**	**Partici-pations**	**RI**	**Partici-pations**
FFA	12	IVF	24	SP	32	FOI	26
SICS	12	FFA	18	SMHI	29	VTI	19
KIMAB	10	VTI	17	FOA	21	IVL	19
SIK	10	SP	13	ACREO	20	SP	18
IVL	6	SMHI	9	SMI	19	IVF	16
STFI	6	IVL	9	SIK	15	SIK	15
VTI	4	SICOMP	8	VTI	15	SICS	15
ALI	4	SMI	8	SSI	13	ACREO	14
SP	4	ALI	8	SICS	12	SMHI	13
SMHI	4	SIK	7	ALI	11	SEI	12

Source: Own analysis and VINNOVA

Figure 14 shows that the same university participants have made up the Top-10 since FP3, with Lund consistently ranked first (Figure 14). KTH and Karolinska started more slowly but by FP6 ranked second and third, ahead of Chalmers. The absolute numbers of university participations are very high compared with those of the other organisations.

Figure 14 Top-10 university participants, FP3-6

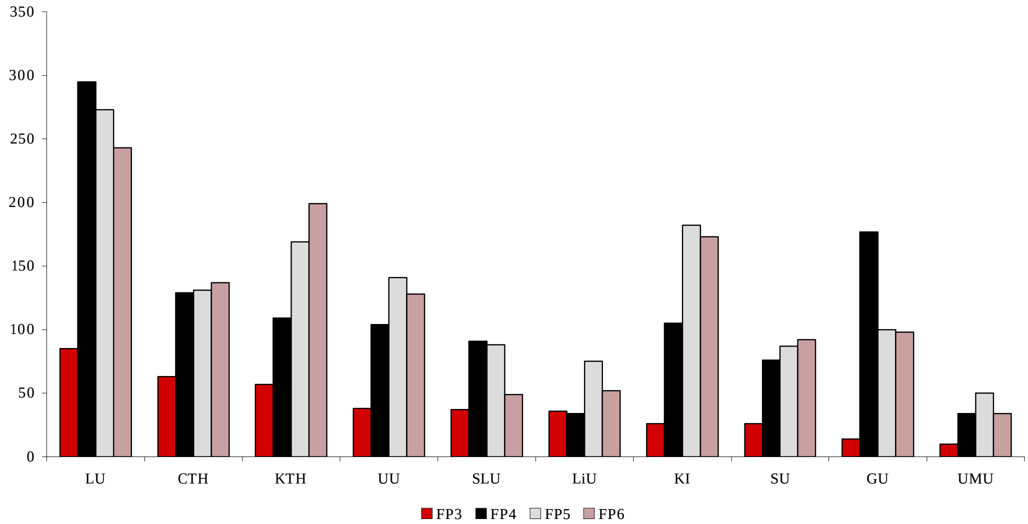
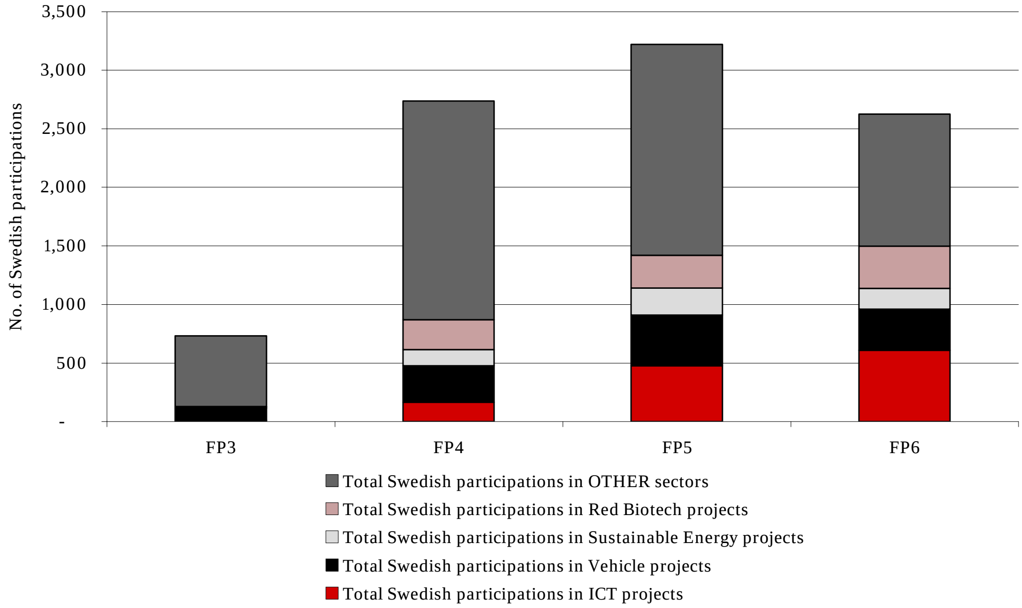


Figure 15 University participation rankings, FP3-6

Universities	FP3	FP4	FP5	FP6
LU	1	1	1	1
CTH	2	3	5	4
KTH	3	4	3	2
UU	4	6	4	5
SLU	5	7	7	9
LiU	6	9	9	8
KI	7	5	2	3
SU	8	8	8	7
GU	9	2	6	6
UMU	10	10	10	10

Figure 16 shows the relative importance of Swedish participations in the four sectors studied in more detail later in this report: ICT; Vehicles; Sustainable energy and Life sciences and health. Together these account for about half the participations.

Figure 16 Swedish participation by sector, FP3-6 ***



Source: Technopolis classification and analysis of VINNOVA data

We do not have access to data about the amount of funding the FPs have provided per project. The Commission regards these as very sensitive data, because they enable member states to calculate the amount of money flowing to them from the Framework Programme. Historically, a number of European Cooperations (such as the European Space Agency) have worked on the principle of 'juste retour' – a fair return – which effectively means that benefits should flow to the members of the cooperation in the same proportions as the membership fees they pay (which tend to be driven by population, GDP or a related indicator). The Framework Programme does not have a juste retour principle. In principle, FP funds are allocated on the basis of a range of 'objective' quality and relevance criteria. In practice, funding decisions are so decentralised that it would be close to impossible to operate juste retour. NUTEK estimated in 1994 that Sweden got back a lower proportion of the money from FP3 than she paid in. However, this proportion has been growing. In FP5, Sweden paid in 3% of the total and got back 3,3%[9].

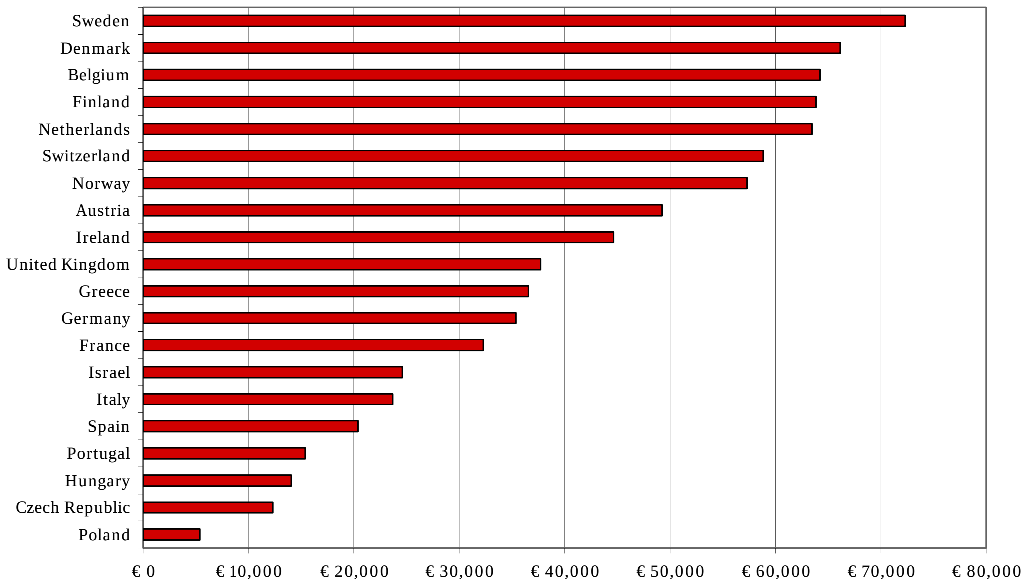
VINNOVA has been able to make some interesting calculations, normalising the national returns from the FP by population and by the total amount countries spend on R&D (via the OECD's Gross Expenditure on R&D – GERD – indicator). Figure 17 shows that in FP6 Sweden had the highest per capita income from FP projects of all member states (up from 4th

[9] EU/FoU Rådet, Svenskt deltagande i femte ramprogrammet, Stockholm: EU/FoUrådet, 2003

place in FP5). Small North European countries have dominated the top end of this ranking in both FP5 and FP6. Normalising by GERD, however, puts Sweden fourth from bottom of the ranking because Sweden has a very high GERD. Those below Sweden were France, Switzerland and Germany. (In FP5, Sweden's position was second-bottom to Germany.)

Given that Swedish participation is overwhelmingly **university** participation, this means that the universities do well in European competition, as they should – the share of GDP Sweden spends on university research is (just like GERD) high. The high GERD also means that the proportion of national R&D spending that comes from the FPs is small (about 1.4% during FP6). But most (60%) of the income from FP6 goes to the university sector and a further 10% to the research institutes. Industry gets 22% leaving a further 8% that goes to state organisations. Hence, from the financial perspective the Framework Programme has become a mechanism primarily (70%) for directing tax revenues via Brussels back towards the Swedish higher education and research sector.

Figure 17 FP resources per capita: Top-20 beneficiary countries, FP6***



Source; VINNOVA, 2008

2.2.2 Past Evaluations of Participation

2.2.2.1 Overall Studies

While FP3 was the first Framework Programme where Sweden could participate across the board, the industrial sector was involved in 92 FP2 projects at the end of the 1980s[10]. The national programme in industrial Information Technology (IT4) funded much of this participation as well as participation in the Eureka Prometheus project, which initiated a long sequence of collaborative research projects in vehicle informatics that migrated into the Third Framework Programme in the form of the DRIVE programme and which continues to this day.

Swedish participation in the Framework Programmes has been studied periodically since 1994, when NUTEK's analysis department mapped Swedish participation in FP3[11] – a rather difficult project, given the EC's reluctance at that point to supply systematic participation data. The relevant part of NUTEK Analysis moved to VINNOVA in 2001, when that new agency was established. The report observes that the areas where Swedish participation have been strongest are those where the state has traditionally been a major funder of technological change – in effect, the places where the state had fostered 'development pairs' between the public and private sectors.

In a handful of cases, Swedish participants were able to lead FP3 projects. In most cases, they were consortium members but in three-quarters of the participations they were involve in project planning from the start of the process of writing the proposal, so they were full members of the consortia. SMEs, however were less likely to be involved from the beginning with 43% of the SME participants being contacted during the proposal writing phase.

While industrial and institute participants tended to have been involved in earlier FPs, FP3 was a breakthrough for the university sector. Most of the Swedish university participants in FP3 were joining in for the first time. The participants surveyed in NUTEK's study had a range of motives for participating. Industry said it was looking for directly applicable knowledge on which to base products and processes while the research sector was more interested in new knowledge and cooperation with foreign organisations. Everyone was in it for the money (3rd most important factor) – especially the SMEs and the research sector. However, the differences in priority among reasons for participating are small: there was a lot of 'finding out what it's like in the EU' going on.

Some of the more experienced industrial participants had done their 'finding out' earlier on. Televerket/Telia followed a 'scattergun' strategy in FP2,

[10] Gunnel Dreborg, Anna Edlund, Lennart Norgren and Helena Sundblad, *EUs FoU-program och svenskt näirngsliv*, P1996:20, Stockholm: NUTEK, 1996

[11] NUTEK Analys, *EUs FoU-program: Karltläggning och analys av svenskt deltagande – erfarenheter, råd och information*, B1994:10, Stockholm: NUTEK, 1994

with 29 projects, and was so thinly spread that foreign partners complained "the Swedes just sit in the corner and listen; they don't contribute"[12] but in FP3 it narrowed the focus to 19 projects. Ericsson's 9 projects in FP2 became 13 in FP3, with the company partly benefiting from Telia's 'reconnaissance' in FP2. This was a period when the RACE programme was trying to set standards for EU telecommunications in order to build a more concentrated and competitive European Telecommunications industry, so the involvement of the telecommunications sector was vital for its continuing role in the industry. Volvo (especially the R&D department) grabbed the bull by the horns and went from 8 participations in FP2 to 29 in FP3.

Interestingly, 78% of the respondents to NUTEK's survey of FP3 participants said they saw FP funding as a complement, not a substitute, for national funding – and the interviews suggest that many of those who thought the FP was a substitute had in fact misunderstood the question. So from an early stage, participants saw the FPs as giving them different opportunities compared with those provided by national programmes. They were working on questions that they saw as involving their core technologies. One quarter of the companies, one third of the institutes and almost half the universities recruited people to help execute the projects, so the FP contributed to R&D capacity building. The companies were optimistic about exploiting the benefits of participation: 60% thought they would develop new product based on what they had learnt and almost as many thought that participation would lead to new sales. Three quarters of the universities and institutes expected to re-use the knowledge they had gained. Two-thirds of respondents said they would increase their involvement in future FPs and a fifth said their involvement would not change – so almost no-one was put off by the experience. At this stage, there was little in the way of direct application of results in product and process development that respondents could report and it was beginning to become clear that many of the projects were not directly about product or process development.

NUTEK's analysis of the partnership patterns in projects with Swedish participation suggested there were crucial differences between the industrial and university perspectives. There was one cluster of projects that essentially transported established cooperations between industry and certain universities into the FP. A second cluster involved the institutes, which tended to be doing work on behalf of their branch memberships and which therefore focused on partnerships with foreign organisations.

[12] Erik Arnold and Ken Guy, *Evaluation of the IT4 Programme,* Stockholm: IT Delegation, 1991

However, the new participations by universities had a quite different character. These involved cooperations with foreign universities and research institutes, building intra-scientific networks but rarely involving any companies. While the FPs were (and are) in effect the EU's industrial policy, this mean that they in fact contained both industrial and research policy interventions. We can in effect see the entry of the Swedish universities as one step in a long process of moving the centre of gravity away from industry policy and towards research policy, culminating in the 'capture' of the ERC.

One reason for industry's enthusiasm about the FPs was probably that they involved a new subsidy mechanism. Swedish innovation policy has long been not to fund companies directly but to develop the knowledge infrastructure of universities and (in the Swedish case to a much lesser degree) research institutes. Companies did receive innovation finance, but in the form of soft loans, repayable in the event of success – a system finally abandoned in the mid-1990s in the face of the fact that the loan system ensured that few were prepared to admit to success.

NUTEK's study of Swedish participation in FP4[13] showed that (by a small margin) industry preferred its own bilateral R&D arrangements to publicly funded ones, but among the public schemes found the FP to be the most attractive. Universities also preferred their own bilateral arrangements but were more keen to get Swedish research money than EU money. (In all cases, the margins between alternatives are small.) The reasons for finding the FPs attractive were varied but tended to include the larger project size, wider scope and greater numbers of partners involved compared with national efforts. The survey confirmed the earlier finding that capacity building was an important aspect of the FP projects and also showed more clearly that participants were involved because of the opportunities for technical learning offered.

Curiously, participants tended to see themselves as net losers in the pattern of information exchange within the projects. However, they judged that what they learnt was so significant that it did not matter much whether others gained more or less than they did themselves.

Most of the participants saw the FP project as lying within their core technologies, but a significant minority did not. So the effects of the FP were not only to deepen knowledge in existing areas but also to renew and restructure it, helping both companies and universities to diversity into new areas related to but outside their existing pattern of expertise. We saw

[13] NUTEK Analys, *Svenska deltagare om EUs fjärde ramprogram för FoU*, R1998:26, Stockholm: NUTEK, 1998

examples of this in our university interviews, where professors shifted applications within their research fields in response to signals from the FP and in the vehicles industry case, where Eureka and the FPs together opened up a whole new line of innovation in vehicle informatics.

An important finding of the FP4 study is that only the strong can play in the Framework Programme. Not least because of the cost-shared nature of funding, participants need internal money or a portfolio of grants, which they can use to for cross-subsidy. Not only FP grants but also some national schemes require co-funding and therefore a mix of cross-subsidy, generation of synergies and even creative accounting and reporting in order to satisfy multiple funders' desire to buy whole projects while only paying part of the costs. Without an established portfolio, the co-financing and creativity needed for FP participation are hard to assemble.

The FP4 analysis also finds that there is a lot of 'cascading', with similar participant networks running a succession of FP projects. Sometimes projects built on other types of cooperations. Either way, being invited to participate in an FP project increasingly relied on having worked with the same organisations before. We can see here the beginnings of a tendency to the formation of 'closed shops' at the European level. Our interviews suggest these are more important in some areas (eg aerospace) than others. Networks develop through invitations to join a project proposal. The analysis suggests that in the main companies invite companies and universities invite universities, so there is a certain tendency to lock into separate networks. However, this is counteracted by the cases where there is a **close** relationship between organisations of different types. There, the boundaries break down. If there is a transport of idea between the somewhat separate industrial and university networks, this is the mechanism. Swedish participants often wanted such close relations to be with **foreign** companies and research institutions, using the FP as a stepping-stone to internationalise their networks, probably in order to access capabilities and knowledge that is in some sense missing from the Swedish system. This benefit (which the Commission would these days describe as 'European Added Value') tends to confirm the **complementary** nature of the Framework Programme in relation to national schemes.

2.2.2.2 Swedish Companies in the FPs

NUTEK Analysis did a series of studies looking at Swedish industrial participants in the Framework Programmes.

Dreborg et al's analysis of Swedish companies participating in FP2 and 3 provided a more refined understanding of the idea that industry participated in order to make processes and products. While companies often justified their involvement in these terms, this often meant that they gained knowledge they could later use in development, so that the direct result of participation was **intermediate knowledge**, not products or processes. Among the large firms participating, it was overwhelmingly their research departments who took part and the report points out that the relationship between research and development in companies is non-linear.

The role of research departments is to look for and explore potentially applicable knowledge. Much of that knowledge goes no further. Promising things are explored more deeply and may become the subject of what the vehicles industry calls advanced engineering and the OECD terms experimental development: namely, trying to remove the uncertainties so that the knowledge can be applied in product and process development. Only after that is the knowledge applicable to business – and then only if there happens to be a fit with the market. So when people from research departments fill in questionnaires and say that their work in the FP is product-oriented they are telling the truth – but a truth that has to be understood in the context of what research departments do. Half the small Swedish companies in the FP at this point were young, technology-based university spin-offs. They were more likely to use the FP as a basis for product development because their role was often as suppliers of instrumentation or other specialised inputs to the bigger project. They could also not generally afford to get involved if the pay-off from the project was going to be too long[14].

Dreborg et al found that a fifth of the companies acquired new customers and suppliers as a result of participation and concluded, "The EU programmes function as a market for new business relations." (The Chapter of this report about vehicles provides a significant example of Volvo Aero using the FP as a vehicle for business relations.) More broadly, industrial participants developed many new network relationships, increasingly with universities. While most projects were in firms' core technologies, thirty percent of the companies undertook a change in technological direction during the project. Industrial participants' R&D activities and employment in the technology of the project tended to grow afterwards – something we should perhaps not see only as an 'effect' but also as a reflection of the companies' intentions in participating in the FP. This is part of the 'search' function of industrial research, whose intention is to find interesting areas of knowledge into which the firm can expand and which it can then exploit. Two thirds of the projects led to continuation work – the majority of it within the FPs.

[14] Although there are a number of examples of SMEs living (albeit not very well) on the '50%' contribution to costs provided by the EC

The industrial respondents stressed the importance of R&D links to universities and research institutes, with links to the EU knowledge infrastructure being only marginally more important than those to Swedish organisations. Entering the FP involved a widening of the companies' horizons. In particular, the amount of cooperation between Swedish firms and German institutes increased – probably reflecting the rising emphasis on engineering in FP3, the past under-funding of engineering in Swedish institutes and universities and also the particular strength of the Aachen cluster in vehicles and related mechanical technologies.

An analysis[15] of Swedish SME participation in FP4 confirmed that those companies that participated were young, technology-intensive (spending on average 6% of sales of R&D) and employed twice the proportion of qualifies scientists and engineers seen in large companies. Their participation was concentrated in areas of high technology; they were little involved in CRAFT, BRITE/EURAM and other activities aimed at more traditional SMEs.

A further study in 2000 looked at large Swedish companies[16]. It found that externalising R&D activity is an increasing trend among major Swedish companies, both through cooperation and via outsourcing in some sectors, while at the same time firms were focusing internal resources on their core technologies. The big companies tended to use the FPs as ways to increase the scope of their search for new ideas. They had more influence in the direction of national programmes, and the closer contact with the national universities meant that these programmes were a key source for recruiting trained specialist manpower needed by the companies.

The study mentions that US multinationals acquired two companies, whose participation in the FPs immediately declined as they were able to take advantage of the large in-house R&D resources of their new parent companies. The companies are not named but it is interesting to note that some years after their sale to US vehicles makers, Volvo Car and Saab Automobile started to reappear on a smaller scale in the FPs in areas corresponding to their role in the internal division of labour organised by their US parents. In contras, the participation of Astra and Pharmacia in the FPs was never strong and disappeared after US companies bought them.

The NUTEK study of large companies points out that there appears to be something of a life cycle in their participation, which it describes as a three-

[15] NUTEK Analys, *Svenska små och medelstora företag I EUs fjärde ramprogram för FoU*, R1997:38, Stockholm: NUTEK, 1997

[16] NUTEK Analysis, *Learning by participating: How large Swedish companies use the EU framework programme*, R2000:24, Stockholm: NUTEK, 2000

stage process (Figure 18). It seems to fit fairly well with our observations of Volvo's and Ericsson's research departments, though we would be cautious about the idea of numbers of project participations necessarily declining in the later stages.

Figure 18 NUTEK's Three-stage model of large firm FP participation

Stage 1

- Participation in a few projects
- Invitation to proposed projects and 'passive' participation
- The expected project result in terms of new technological knowledge is not the main reason for participation
- If proposals are rejected the projects are not carried out outside the Framework Programme
- Participation is not of strategic importance to in-house technological research

Stage 2

- Number of projects increases
- Begins to take initiative in proposing projects but is more often invited by others. Actively involved as coordinators of some projects (own project initiatives)
- The new technological knowledge expected to be generated by the project is becoming a reason for participation in some project (on project initiatives)
- If own proposals are rejected the projects are carried out outside the FP, but with fewer participants and fields of knowledge
- Participation starts to become important in terms of in-house technological research

Stage 3

- Number of projects may decrease due to a greater degree of selectivity (fewer and bigger projects)
- Most of the projects have been proposed by the unit itself. Actively involved as coordinator of most projects (own project initiatives)
- The expected project results in terms of new technological knowledge, is becoming a reason for participation in most projects (own project initiatives)
- If own proposals are rejected, projects are carried out outside the FP, but with fewer partners and fields of knowledge
- Participation is of strategic importance in terms of technological research

Source: NUTEK Analysis, 2000

2.2.2.3 The Scientific Quality of Framework Programme Research

It was popular within parts of the Swedish scientific establishment during the 1990s to claim that FP-funded research was of low quality. In 1997, the Ministry of Education and Science asked the Swedish academies of science (KV) and engineering (IVA) to investigate. The original intention seems to have been to peer review a sample of FP-funded projects but this proved impractical so the study used several other techniques, all of which implied that Swedish FP research was in general of the same or higher quality than that funded by the Swedish research councils. Based on analysing a large sample of projects, the report concluded that FP4 was heterogeneous, containing basic research but also a lot of applied research and development work, notably in IT, "which means that a qualitative (sic) analysis from a basic research perspective is of limited relevance. However this does not mean that the activity could not maintain a high level of quality from a customer's viewpoint." Despite the implicit assumption that only basic research can be of high scientific quality, it goes on to sample Swedish project coordinator, who described their FP projects mainly as targeted basic or applied research and said that their FP work was either the same or a little more applied than their Swedish-funded research. The coordinators mostly saw no difference in the quality or the research content of their own nationally-funded and their FP-funded research. About 42% of them said that the international contacts made in the FP work had increased the quality of their national as well as their international work; 40% said the international contacts had no effect on quality.

The authors asked the Swedish funding agencies to assess the quality of participating researchers based on their funding track record. The agencies placed 70% of the FP participants in the highest category of "Very high quality, research applications granted regularly". The authors compared success rates and found that FP applications had a lower chance of being funded than applications to any of the Swedish funders, so in terms of their ability to succeed in competition the FP projects were as good as or better than nationally funded projects. The authors interviewed twenty Swedish experts who had been involved in FP proposal assessment and concluded that the assessment process was rigorous and fair.

The authors argue the fact that almost all the coordinators work on similar research issues in FP and national funding means it cannot be argued that the FP increases national research quality in terms of new approaches. The authors did not ask coordinators why they had applied to the FP, but on the basis of the greater administrative difficulty involved they concluded at the end of Chapter 4, "It cannot be excluded that the main driving force is actually the need for additional financial resources to supplement nationally funded research programmes." By the time this speculation reached the report's final chapter, it has become a conclusion that people apply to the FP because there is too little national research funding (or that the national funders give too small proportion of their money to the best researchers).

2.2.3 International Experience of Framework Programme Impacts

The only existing meta-evaluation of the FPs[17] was done to support the Five Year Assessment of the FPs in 2004. It found that the Framework broadly funds good quality work, in which universities and research institutes play a

[17] See Erik Arnold, John Clark and Alessandro Muscio, 'What the evaluation record tells us about Framework Programme performance', *Science and Public Policy,* Vol 32, No 5, 2005, pp385-397

majority and increasing role. Framework participation is led by a 'core' of major beneficiaries, who sit at the heart of multiple European RTD networks. Administration was seen as more burdensome than that in national programmes, and – except where networking and scale are important – participants prefer to use national programmes. The FPs therefore focus in areas where they generate 'European Added Value' and are distinct from (not substitutes for) nationally-funded projects. Projects are mostly 'additional' in the sense that they would not have been conducted without European funding. Generally, SMEs were poorly served by the FPs. Framework projects primarily produce knowledge and networks. Framework Programmes have positive effects on the behaviour of the research community, competitivity, jobs, regulation and the environment.

Evaluations of the national impacts of the FPs tend to reach conclusions not very different from those reached in EU-level studies, with the exception that they tend to criticise the national ability to develop a coherent R&D strategy and to connect that with the formulation of the FPs. Mutual influence of FPs and national R&D strategies is seen as very limited.

The FPs are characterised by a rather stable 'core' of participants such as the Fraunhofer Society, who have large numbers of projects and often act as coordinators, and a 'periphery' of organisations that are involved for 1-2 projects then move on to other things. A factor promoting stability among a core of frequent participators is the fact that (like other network R&D programmes) the FP does not generate wholly new R&D networks, but causes **network extension**. Evaluations of network R&D tend to find that R&D networks evolve over time, rather than being newly constructed for each funding opportunity[18]. A Danish FP4 study[19] found that networks were based on existing networks but that 82% of companies and 90% of universities also established new international research partnerships through the projects. The Finnish university FP5 impact study[20] found that EU collaboration did not crowd out academics' other international networks. Rather, it led to an increase in participants' non-FP international

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[18] See for example Sven Faugert, Erik Arnold, Alasdair Reid, Annelie Eriksson, Tommy Jansson and Rapela Zaman, Evaluation of the Öresund Contracts for Cross-Border R&D Co-operation between Denmark and Sweden, Stockolm: VINNOVA, 2004; Sven Faugert, Erik Arnold, Ben Thuriaux and Bo Sandberg, *NUTEKs program VAMP: en utvärdering av programstrategi, genomförandet och resultat*, SIPU Utvärdering och Technopolis, Stockholm: NUTEK, 2000

[19] Ebbe K Graversen and Karen Siune, *Danish Research Co-operation in EU: Extent, Return and Participation, An analysis of co-operation in the 4th EU Framework Programme*, Report 2000/7, Århus: Danish Institute for Studies in Research and Research Policy, 2000

[20] Pirjo Niskanen, *Finnish Universities and the EU Framework Programme – Towards a New Phase*, VTT Technology Studies, Helsinki: VTT, 2001

networking. So a positive aspect of having a stable core of participants is that its composition evolves, and that – through established networks – new participants can sample participation, even if the majority then decides not to repeat the experience.

For the knowledge infrastructure, the FP is but one among a number of sources of routine project funding income. Other things being equal, participants prefer national programmes to the FP, but they recognise the need to go to the FP (or an equivalent) where international networking, socio-political objectives and exploitation are important to them[21]. Austrian university FP4 participants obtained funding from multiple sources – the FP was simply one part of a bigger funding portfolio – while 65% of Danish company participants were involved in other international R&D co-operations[22]. "Especially interviewed heads of units perceived EU collaboration as an important channel through which to obtain research funding for their units and to gain prestige. The participation of universities depends on the availability of other research funding from national or other international sources. A decline in the research funding is likely to increase researchers' interest in seeking EU funding, whereas the availability of other funding may decrease its relative attractiveness."[23]

Knowledge Infrastructure participants attach much higher importance to FP participation than do industrial participants. For them, the FP is a source of operating revenue[24]. For companies, participation is a means to other ends. Unlike members of the Knowledge Infrastructure, companies tended to regard the FP as a more marginal source of funding[25]. However, our case study of the Vehicles sector in Sweden below shows that this is a truth with modification: in certain respects the FPs have been vital to that sector, while in other sectors considered they have been of marginal importance.

Finnish university researchers found that the FPs had strengthened their European networks during the 1990s, but this phase was now largely over.[26] This was a perception echoed also in this study. At least for more senior researchers, network extension was part of the European Added Value of

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[21] ISG, *Europäische Forschungsrahmenprogramme in Deutschland*, Köln: 2001
[22] Andreas Schibany, Leonhard Joerg, Helmut Gassler, Katharina Warta, Dorothea Sturn, Wolfgang Polt, Gerhard Streicher, Terttu Luukkonen and Erik Arnold, *Evaluation of Austrian Participation in the 4th EU Framework Programme*, Technopolis Ltd, Joanneum Research and VTT, Vienna: BMVIT, 2001; Graversen and Siune, Op Cit, 2000
[23] Niskanen, Op Cit, 2001
[24] Schibany et al, Op Cit, 2000
[25] GOPA Consortium, Impact Assessment of Finished Projects of the EC Research Programmes in the Fields Covered by the Present Growth Programme, Bad Homburg: GOPA, 2003; GOPA Consortium, Evaluation of Finished Projects in the Fields Covered by the Pesent Growth Programme, Bad Homburg: GOPA, 2003
[26] Niskanen, Op Cit, 2001

the FPs but diminishing marginal returns have set in (or, arguably, the FPs and other international activities like COST and ESF have so successfully extended networks that this function is no longer needed).

Figure 19 European Added Value (EAV) of Framework[27]

Augmentation of national funds

- Framework expands the funds available to national researchers over and above that which is available to them through national research funds alone
- Intellectual gearing
- Framework provides UK participants with access to foreign researchers and research outputs in a way that national funds cannot

Other types of added value

- Scale – pooling of resources as a means by which to increase investment in common European issues, from food safety to climate change
- Scope – pooling of competence as a means by which to increase the likelihood of a breakthrough in a given area from the economic manufacture of large structural composites to the sequencing of plant genomes

Strong added value in terms of the knowledge stock (science)

- Complex issues resolved more quickly and more thoroughly as a result of larger projects and portfolios multiple projects across successive Frameworks
- Status of knowledge accelerated through diversity and competition among national research traditions

Increasing added value in terms of support to EU policy

- EU regulates a growing number of issues such as environmental protection or food safety
- Framework has made substantive additional investments in science, in areas such as climate change and infectious diseases
- Framework contributes to a more coherent EU view on risks and mitigation strategies
- However, arms-length involvement of policy makers limits real impact

Added value to EU businesses focused on key sectors

- Builds in-house competence, tools and de facto standards
- Strengthens international relationships

Danish participants believed the value added to the national research community by the FPs was improved access to international research.[28] Additionality seems also to vary according to national circumstances. In Ireland, where national funding for university research was very small before 2000, the additionality of FP projects was generally said to be very high (82% would not have gone ahead without FP money[29]. Effects of the FPs at national level are therefore context-dependent. For example, they were big in Ireland because national R&D funding was so small, but over-reliance on EC funds also had the effect of fragmenting the Irish research

[27] Paul Simmonds, James Stroyan, John Clark and Ben Thuriaux, *The Impact of the Framework Programmes in the UK*, London: Office of Science and Technology, 2004
[28] Graversen and Siune, Op Cit, 2000
[29] Ken Guy, Jane Tebbutt and James Stroyan, *The Fourth Framework Programme in Ireland: An Evaluation of the Operation and Impacts in Ireland of the EU's Fourth Framework Programme for Research and Development*, report to Forfás by Technopolis, Dublin: Forfás, 2000

community[30]. In the UK, the FPs were especially important because of the lack of national-level research and innovation funding aimed at companies. Naturally, the FPs' effects tend to be less obvious in large economies with well-established national R&D funding systems. FP was credited[31] in Ireland with playing "a vital role in maintaining and expanding the Irish research base". In the UK, it is seen[32] as important because there is so little national funding aimed at companies.

When asked directly, participants tend not to feel the FPs have changed their research agendas. While they appreciated the FP as an additional source of funding, Danish university administrations said[33] that it had no significant effects on their research priorities. In Ireland[34] "there were some examples of academic institutions following FP agendas rather than their own, but these were the exception there was little evidence that FP4 was distorting the country's scientific and technological base". The FP5 impact study on Finnish universities[35] says "respondents generally found that EU-funded research corresponds to the objectives of their units less than 10% thought that EU participation has focused attention away from issues of national importance few respondents thought that EU collaboration has brought some applied elements into their research. Rather, they considered the steering effect to be minor." Interpreting these claims is difficult. It is perhaps more likely that the FPs selectively attract and fund those whose research interests are in line with the foci of the Programme, rather than redirecting particular researchers from one research path onto another, so it is not clear that the effects of FP funding on the portfolio of projects would be visible to an individual project participant.

These findings from other national FP participation studies are in almost all ways similar to our findings in this report. The key point of difference derives from the context. As we will see, the FPs have little structuring effect in Sweden, essentially because there are few national structuring forces in place. The FPs are such a small proportion of total funding that,

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[30] Erik Arnold and Ben Thuriaux, *The Basic Research Grants Scheme: An Evaluation*, report by Technopolis to Forfás, Dublin: Forfás, 1998; James Stroyan, Ben Thuriaux, Erik Arnold, Alina Östling, Shaun Whitehouse, Sarah Teather, Kieron Flanaghan, Paul Cunningham, Mark Boden, Martin Visser and Anthony van Raan, *Baseline Assessment of the Public Research System in Ireland in the Areas of Biotechnology and Information and Communications Technolog*y, report to Forfás by Technopolis, PREST and CWTS, Dublin: Forfás, 2002

[31] Guy et al, Op Cit, 2000

[32] Simmonds et al, 2004

[33] Graversen and Siune, Op Cit , 2000

[34] Guy et al, Op Cit, 2000

[35] Niskanen, *Op Cit*, 2001

without national commitment, they are unable to contribute very much to the well-known national problem of fragmentation within the research community.

3 Effects of the Framework Programme on Five Universities

With the generous help of the rectorates, EU coordinators and faculty of the University of Gothenburg, University of Lund, Chalmers University of Technology, Karolinska Institutet and Växjö University, we have carried out case studies of these universities in order to try to understand the effects of Framework Programme (FP) participation upon their development since the start of FP3 in 1990. The detailed case studies are shown in the Appendices, while this Chapter aims to summarise key findings and lessons from them.

3.1 The Swedish University System and the Five Universities

These five universities offer a good selection of different structures and foci. Lund (LU) is an 'omniversity' spanning most disciplines. Gothenburg (GU) is a non-technological university, focusing on medicine, humanities, and social and natural sciences. Chalmers University of Technology (Chalmers or CTH) supplies the 'missing' technological ingredient in the City of Gothenburg. Chalmers is also the subject of an important experiment in the Swedish higher education system. With only three exceptions, other universities are state-owned and have the status of state agencies. Chalmers is a limited company 100% owned by a private foundation that was set up with government funding in 1994 and thus formally stands outside the public system. There are differences in governance, but for most practical purposes, Chalmers is indistinguishable from a state university. Karolinska Institutet (KI) is probably Sweden's internationally best-known university, being the medical school attached to the Karolinska University Hospital in Stockholm. Växjö (VXU) is a new regional university in the South of Sweden, which received university status in 1999 and that in 2010 plans to merge with Kalmar University (HIK) to form the Linné University.

After a long period of sustained growth, the Swedish undergraduate population stabilised in about 2002, and this trend is reflected in the undergraduate populations at the five universities, which are tending to stagnate. Growth in research has broadly kept pace with the growth of the education side of the universities in the past decade. As a result, the research intensity (by which we mean the proportion of research and graduate education in total income) of most of the universities has been fairly stable recently. Figure 20 summarises the research intensity for 1997 and 2007; where there is a peak or a trough between these years, we have shown that separately. VXU is the only one of the universities where there has been a dramatic increase in research intensity over the past decade, consistent with the fact that it is a former regional teaching college still in the process of transitioning towards being a research university. KI is exceptionally research-intensive compared with the other universities.

Figure 20 University research intensity, 1997-2007

	GU	LU	CTH	KI	VXU
1997	63%	63%	65%	80%	15%
		67% (99)	68% (01)	76% (98)	33% (02)
2007	57%	65%	65%	80%	29%

Source: Analysis of HSV data

While Swedish universities have been encouraged to develop strategies since the mid-1990s, it is only very recently that some of them have begun to set internal priorities for research, rather than to focus on excellence in research and attainment of critical mass. In practice, priorities are usually defined at department rather than at university level and these are rarely incorporated in university strategies. In cases where department priorities are echoed in university strategies, lists of 'priority' areas become fairly long. (KI is an important exception, in that it has for quite some time worked with a limited number of clear priority areas.) Rarely is there much connection between these priorities and the – in practice bottom-up – processes through which researchers decide what research grants to seek, meaning that strategic steering is not only new but rather weak in Swedish higher education institutions. It is a rather frequently voiced opinion among researchers that universities indeed should not attempt to influence the research direction and leave such choices up to researchers; the absence of strategic steering may thus possibly be seen as a strategy in itself. Moreover, university managements' tools to steer the direction of research are rather weak. It is not entirely uncommon for successful research groups to have little to no faculty funding (only grants from research councils and for example the FPs), meaning that university management has little leverage over the group. This lack of strategic governance is likely to be one of the explanations for the fragmented and often duplicative shape of the higher education research infrastructure in Sweden. On the other hand, a positive aspect is the increasing trend towards identifying cross-disciplinary research centres – some centres of excellence in the traditional academic sense, other more like the competence centres that NUTEK/VINNOVA launched in the mid-1990s as a way to encourage the build-up of industrially relevant clusters of capability within the university sector. These nationally-defined centres of excellence and competence centres have nothing to do with the FPs, but the concentrations of capability involved necessarily means that they have good prospects in applying to the FPs.

Arguably, such fragmentation has not mattered so much in the past (although we have on a number of occasions argued that it reduces the efficiency of research and research programmes[36]). However, against the background of increasing scale in many research fields internationally and the explicit intention of the European Commission to 'restructure' Europe's research landscape in order to build the European Research Area (ERA), it matters very much if a small member state fragments its research resources – and it matters more from the perspective of the member state that risks being left out of the restructured picture than from the perspective of Europe overall.

The universities studied also exhibit a typically Swedish trait of reverse internationalisation. The number of Swedish students who spend part of their degree studying abroad is rather stable (Figure 21) while the population of foreign students at Swedish universities is by and large bigger and has been increasing significantly. Compounded with Sweden's well-known problems of low post-doctoral mobility (within the country, as well as internationally) and the growing import of research manpower at the doctoral and post-doctoral level, this paints a picture suggesting that Swedes' reluctance to resettle will make Sweden increasingly dependent upon international networking instruments such as the FPs in order to sustain international relationships in a research and higher education world that it itself rapidly internationalising.

Figure 21 International student mobility at five universities, 1997 and 2007

	GU	LU	CTH	KI	VXU
Swedish students abroad 1997	470	1000	150*	<200	<300
Swedish students abroad 2007	510	1000	160	<200	<300
Foreign students in Sweden 1997	430	800	1000*	>200	300
Foreign students in Sweden 2007	830	1700	1300	>200	800

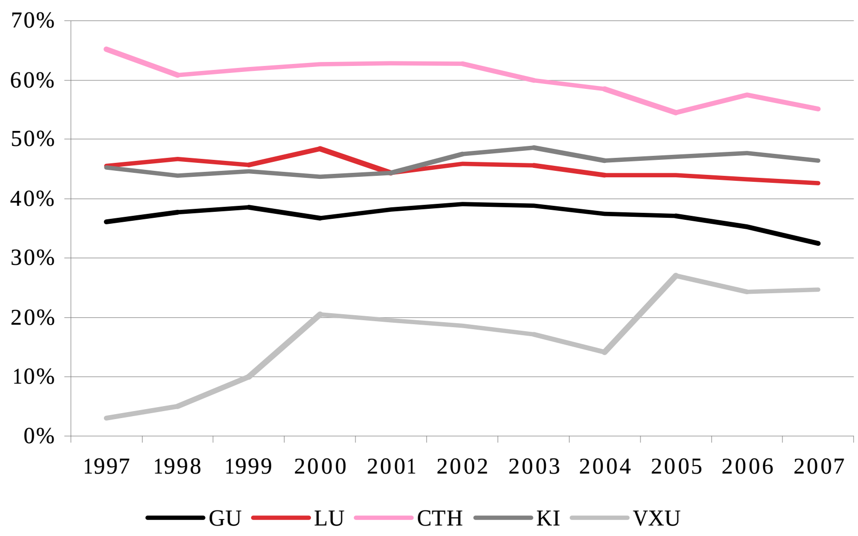
*Source: University annual reports. Figures rounded off. * In 2003*

With two exceptions, the universities have over the last decade come to depend less on grants for research and graduate education sought in competition. Figure 22 shows the proportion of grants sought in competition in total funding for research and graduate education (i.e. including government grants and commissioned research). While GU, LU and Chalmers have seen their ratios decrease, KI's has increased marginally,

[36] See for example Erik Arnold, John Chessire, Enrico Deiaco, Shaun Whitehouse and Rapela Zaman, *Evaluation of the Swedish Long-Range Energy Research Programme, 1998-2004,* report to the Ministry of Industry, Stockholm: Brighton: Technopolis, 2003

while VXU’s has increased notably for the same reasons as discussed above in relation to research intensity. It should be noted that this ratio ought to be higher for universities with a strong emphasis on medicine, engineering and to some extent the natural sciences, since funds available from external funding agencies are far greater in these fields than in for example the humanities and the social sciences. It is thus unsurprising that Chalmers, KI and LU have higher ratios than GU and VXU.

Figure 22 Proportion of grants sought in competition in universities research Income

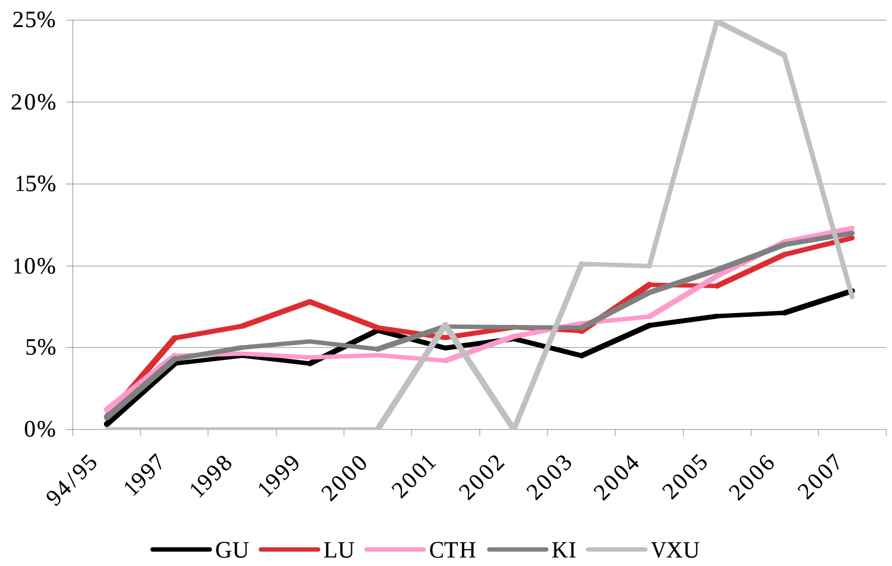


Analysis of HSV data

3.2 Participation in Framework Programmes

An increasing share of research funds come from the FPs and for the four established universities (LU, GU, Chalmers and KI), the EU is the second most important source of grants sought in competition only surpassed by the Swedish Research Council, meaning that the EU has become a significant ‘customer’. It should be noted that prior to 2007, statistics did not distinguish between FP funding and other EU funding, but for the five universities studied EU funding is heavily dominated by FP funding.

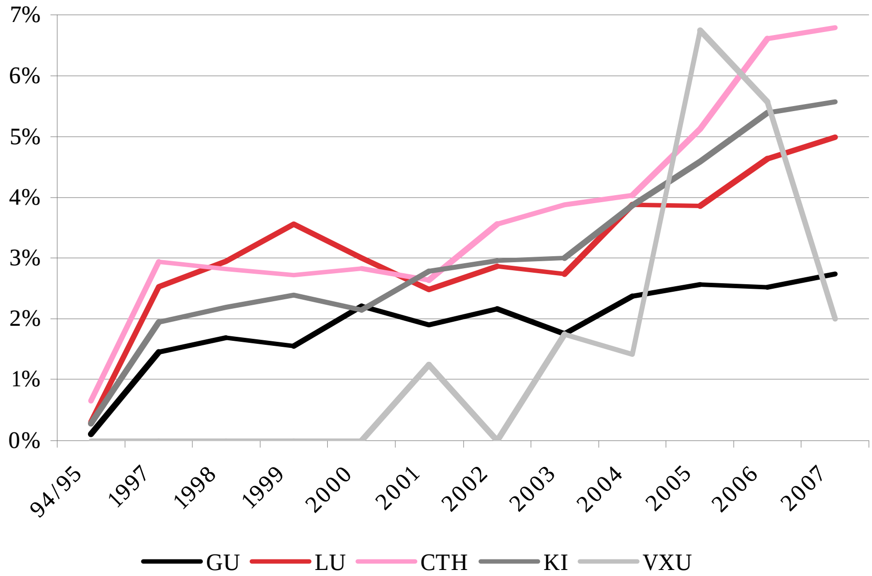
Figure 23 Proportion of EU funding in grant income



Source: Analysis of HSV data. Note that most but not all of this EU income corresponds to the FPs

Figure 24, which illustrates the proportion of total funding for research and graduate education that comes from the EU, paints a somewhat different picture due to the different proportions of grants sought in competition in total funding for research and graduate education. The proportion of research grants sought in competition that comes from the EU has increased from insignificant levels in 1994/1995 to 12% in 2007 for LU, Chalmers and KI and to 8% for GU. For VXU the development appears somewhat erratic due on the one hand to a modest (absolute) volume of grants and on the other hand to the 2005 start of an FP6 integrated project that VXU coordinates.

Figure 24 Proportion of EU funding in universities' total research income

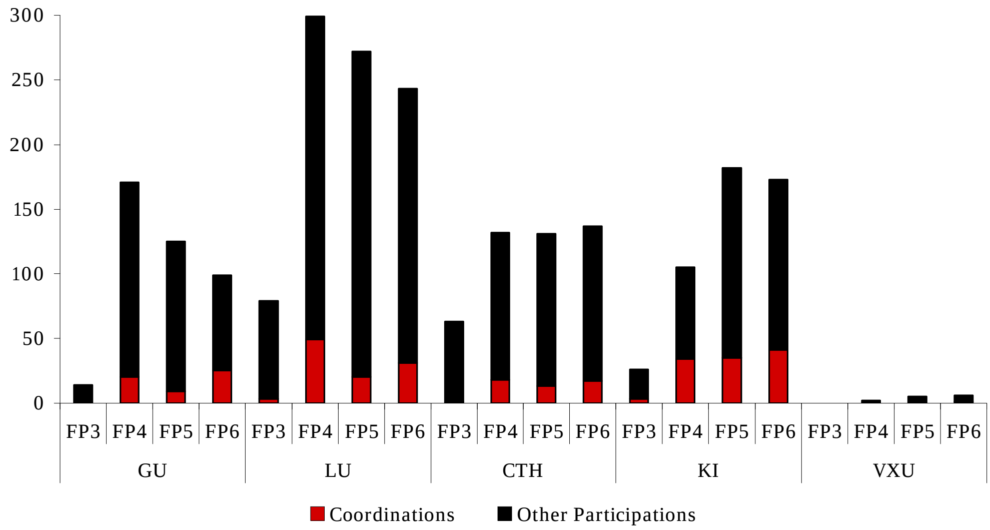


Source: Analysis of HSV data. Note that most but not all of these shares correspond to the FPs

Most of the universities recognised the emerging significance of the FPs as a 'key account' quite some time ago. KI set up a Grants Office function already in 1988, followed by LU and Chalmers at the start of the 1990s, GU in the mid-1990s and VXU in 2007. These appear to be important for researchers to stay abreast with funding opportunities and to cope with the bureaucracy of proposals and financial reporting. As expected, researchers become less and less dependent on their Grants Office as they build up their own FP experience, meaning that established FP participants make less use of them and instead rely on their own experience.

The speed at which the universities were able to start participating in the FPs is quite impressive (Figure 25). After building initial experience in FP3, i.e. between 1991 and 1994, they rapidly ramped up to high levels in FP4. LU and GU seem to have been very enthusiastic in FP4 and pulled back slightly in FP5, while the others grew or remained stable. The drop in numbers between FP5 and FP6 in three of the universities reflects the use of larger projects in FP6, so that fewer participations were necessary in order to sustain the same amount of work – or, as illustrated by Figure 23 and Figure 24, in practice a substantially increased amount of work. Before Sweden joined the EU at the start of 1995, FP entry was rather easy for Swedish participants in that the Swedish state paid for their participations directly. They could be added to FP consortia and bring extra work to the table without costing the others a penny of the FP budget. In these projects, Swedish participants signed contracts with the project consortia or their coordinators (and not with the European Commission), which is the reason why they are not present in the Cordis database. In an interim period (all of 1994), Swedish participation was facilitated by the European Economic Area (EEA) agreement[37], through which Swedish participants were granted the same participation terms as organisations in EU member countries, meaning that funding started coming from the FP. Some of the last FP3 contracts were signed in 1994, i.e. under the EEA agreement. From FP4, when Sweden had joined the EU and become an insider in the FPs, Swedish participation was paid from the FP itself so consortia became more concerned with the balance of costs and benefits in inviting in a Swedish partner.

Figure 25 University participation counts by Framework Programme



Unfortunately, the partner data we have for the period before FP5 are poor, so our analysis of partnerships is confined to FP5 and FP6. We will see, however, that there are also many FP projects with significant industrial influence and therefore that this is a truth with modification.

Figure 26 shows the proportion of the universities' partners in FP5 and FP6 who are higher education institutions (HEIs), research institutes (RIs) and industry (IND), while the 'others' category (hospitals, museums and various other bodies) is omitted. Clearly, the universities cooperate most intensively with other universities and to a lesser extent with research institutes of various kinds (ranging from Max Planck in basic research to applied institutes like TNO, Fraunhofer and the Swedish institute sector), whereas industry represents a very small fraction of the total. While industry's share has grown between FP5 and FP6 we suspect this is an

[37] Through which the EFTA (European Free Trade Association) countries were allowed to participate in EU's single market without joining the EU.

artefact of FP6's larger instruments. The pattern of course varies by field of science and technology (for example, the engineering university Chalmers as well as LU and VXU, probably courtesy of their engineering parts, exhibit a higher degree of industry participation), but the strong message is that Swedish university participation is about membership of the international scientific community and has rather little to do with industrial innovation. We will see, however, that there are also many FP projects with significant industrial influence and therefore that this is a truth with modification.

Figure 26 Swedish university partnering patterns, FP5 and FP6

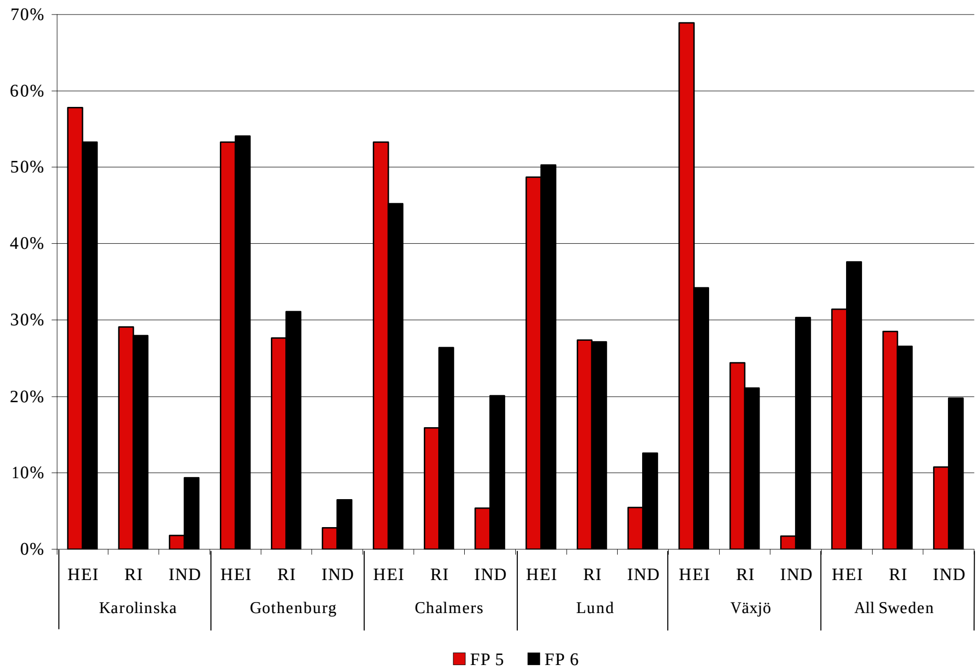


Figure 27 looks at the Top-10 partner countries of the five universities as well as Sweden as a whole. The obviously dominant countries are Sweden, Germany, the UK and France, while the other Nordic countries are relatively unimportant. Sweden's ranking falls between FP5 and FP6 – again, potentially an artefact of the increased size of the consortia in FP6.

Figure 27 Universities' Top-10 partner countries, FP5 and FP6

All Sweden				Chalmers			
FP5	**%**	**FP6**	**%**	**FP5**	**%**	**FP6**	**%**
Sweden	15.3	Germany	14.4	Sweden	24.0	Germany	15.9
Germany	12.5	Sweden	11.8	Germany	14.6	France	12.6
UK	12.1	UK	10.9	UK	10.9	UK	11.8
France	9.2	France	10.0	France	10.8	Sweden	9.5
Italy	7.9	Italy	7.8	Italy	8.8	Italy	7.4
Netherlands	5.9	Spain	5.7	Spain	5.4	Spain	5.7
Spain	5.6	Netherlands	5.3	Netherlands	4.9	Netherlands	4.7
Belgium	3.3	Belgium	3.8	Austria	3.2	Belgium	3.7
Denmark	3.1	Finland	2.8	Belgium	2.5	Switzerland	3.4
Greece	2.6	Switzerland	2.7	Switzerland	2.5	Finland	2.7

Karolinska				Lund			
FP5	**%**	**FP6**	**%**	**FP5**	**%**	**FP6**	**%**
Sweden	14.2	Germany	15.3	Sweden	13.9	Germany	15.4
Germany	12.4	UK	13.2	Germany	13.1	UK	11.9
UK	12.0	Sweden	11.2	UK	12.2	Sweden	10.5
France	10.2	France	9.9	France	10.3	France	10.0
Italy	9.7	Italy	9.4	Spain	6.2	Italy	8.0
Netherlands	6.2	Netherlands	6.3	Netherlands	5.2	Netherlands	5.6
Spain	5.4	Spain	4.8	Denmark	4.0	Spain	5.3
Switzerland	3.2	Belgium	3.8	Belgium	2.8	Switzerland	3.6
Belgium	2.9	Switzerland	3.5	Finland	2.8	Denmark	3.6
Austria	2.1	Finland	2.7	Switzerland	2.7	Belgium	3.0

Gothenburg				Växjö			
FP5	**%**	**FP6**	**%**	**FP5**	**%**	**FP6**	**%**
Sweden	15.6	UK	13.2	Germany	17.6	Sweden	21.1
UK	14.4	Germany	13.1	UK	16.0	Germany	13.2
France	8.8	Sweden	9.3	France	10.1	Greece	10.5
Italy	8.4	France	8.9	Italy	9.2	UK	10.5
Germany	7.3	Italy	7.4	Sweden	7.6	Austria	6.6
Spain	5.6	Netherlands	6.1	Netherlands	6.7	Spain	6.6
Netherlands	5.4	Spain	4.8	Spain	5.0	Finland	5.3
Norway	4.4	Norway	4.2	Austria	4.2	France	3.9
Switzerland	2.8	Denmark	4.1	Belgium	4.2	Italy	3.9
Greece	2.4	Belgium	3.6	Ireland	4.2	Netherlands	3.9

Current policy in all five universities is to encourage increased FP participation. Each has so far followed a ‘bottom-up’ approach, where the university has not had a strategy for FP participation but has encouraged or permitted the individual researchers or their groups themselves to decide whether to apply and in what role. GU is preparing an FP participation strategy at the university level as part of a wider strategy to become more research-intensive, following a period where its focus was more on undergraduate education (cf. Figure 20), but in this it appears to be unique among the five universities. The lack of controls or strategy about applications is quite surprising, in that all five universities say that the 20%[38] overhead paid by the FPs under the so-called ‘additional cost’ model is well below the real overhead. GU, LU and VXU simply accept the lower

[38] In the majority of instruments, 20% is the highest rate of indirect costs (based on all direct costs less subcontracting) allowed by the Commission. However, some instruments have other maxima, e.g. Marie Curie Research Training Networks permit only 10%. Starting FP7, the overhead coverage for universities is gradually improving.

rate of overhead and cross-subsidise FP participation at the central level. Chalmers' central administration tops up the Commission's overhead to 35%, which is what most Swedish research funders accept, but this is still well below actual overhead and leaves departments or faculties to pay for the difference. Both Chalmers and KI, which has no central overhead subsidy, thus expect research groups or departments to cross-subsidise FP projects with other research income. Thus, since neither the FPs nor most Swedish research funders fully reimburse universities for their real costs, every external project successfully won in effect imposes a financial loss on the university. In reality, the insufficient overhead coverage is coped with by each research group or department having a project portfolio, where a given PhD student or group is funded by more than one external project, perhaps topped-up with internal faculty funding (from the government block grant). This practice is explicitly permitted by several of Sweden's main research funders.

3.3 Impacts on the Universities

3.3.1 The universities overall

The universities were in agreement that there was no sense in which the FPs had influenced their overall strategies. Where priorities were set, this was done based on internal processes and judgements, and never with reference to the FPs. In fact, it would be foolish to do so, because the priorities of the FPs are politically set and change frequently: the FPs cannot be relied upon as a 'strategic partner'. This means that large 'omniversities' would be the least vulnerable to dramatic changes in FP priorities since they are more likely to have a researcher qualified to submit a proposal in any given field. However, there have been no such dramatic changes in priorities in FP3–FP6 and since technology, natural science and medicine have remained favoured throughout, it is not surprisingly Chalmers, KI and LU that have reaped the greatest benefits from these FPs (cf. Figure 24). A bibliometric study[39] carried out by the Swedish Research Council as part of this overall study provides no evidence that the priorities of the FPs should have had any influence on the five universities' research priorities.

Of course, despite all the bureaucracy and complexity involved, the FPs are a useful source of funding. The figures above make it clear that while the FPs are not a dominant funder, they are certainly not negligible. The Swedish research and innovation funders have no difficulty in spending their own budgets on what they believe to be high-quality research, so the

[39]Johan Fröberg and Staffan Karlsson, "Possible effects of Swedish participation in EU frame programmes 3-6 on bibliometric measures", 2008.

FPs are not displacing or crowding out good research activities. Hence, one effect of FP funding is to **increase the absolute volume of research** done in the universities. The rectorates are all in favour of increased FP participation for their universities and a couple of interviewees state that they see the FPs as a less arduous way to increase the absolute volume of research (which all five universities aspire to do) than the alternatives, which mainly would be Swedish funding agencies, industry and in the field of medicine US funding agencies.

The fact that the money does not come from a Swedish funder but from the FPs also increases the **diversity** of funding sources. A funding ideal for a number of the more senior people we interviewed was to have a wide range of different research funders with none of them contributing more than perhaps 15% of the funding portfolio. This is a robust strategy because it means that losing support from a single funder will not risk dealing a death blow to the research group. FP funding therefore adds value by adding to the available funding diversity. (This is an implicit critique of the strategy of some of the New Member States, which adopt the FP priorities as their national research priorities. This not only reduces funding diversity in their innovation systems but also leaves the exposed to the regular changes in priorities in the FPs.) We nevertheless interviewed several researchers that have more than half of their funding from the FPs. For a few researchers the FPs have been the final funding recourse that has allowed them to build or sustain their careers in the absence of Swedish funding:

- One researcher who had been reliant on funding from the Swedish EPA lost almost all his external funding in the mid-1990s when the government eliminated the EPA's research budget. For about six years, the FPs became his only source of external income until FORMAS was created in 2001 and began to fund work in his field. Since then, he has gone back to working with only Swedish funding, which he finds easier to obtain and which can be longer term
- Some groups have substantially been built on FP funding. For example, one group in microbiology led by a German professor who moved to Sweden twelve years ago peaked at 25 researchers and is still 20 strong, with 70-80% of its income coming from the FPs
- A research group working on high-temperature superconductors credits the FP with its continued existence. This field has become unfashionable since the 1990s when Swedish funding agencies deemed the 'basic' research issues solved. Most national sources of funding have thus ceased funding projects in this field and research groups in Sweden and in other countries have left the field. The FPs provide one of very few funding sources and is therefore key to the survival of research in this area, which is now orientated towards applied research

issues and implementation previous ‘basic’ research discoveries into new application areas

A number of researchers active in both ‘basic’ and applied research argue that the fact that FP research tends to be mission-orientated means that it makes an especially important contribution to the funding portfolio in Sweden because national sources are strongly biased towards ‘basic’ research.

The role of the FPs as ‘training schools’ has been especially important in Sweden, where post-docs have been (and to a lesser degree continue to be) rare. The Swedish universities mostly staff their FP projects with doctorands, i.e. PhD students. In the earlier days, doctorands would be assigned full-time to an FP project and often ran into trouble with timely delivery of outputs. More recently, participants say that they assign doctorands part time to FP projects and part time to other work, but also that they do an increasing extent use post-docs. This arrangement takes some of the pressure off doctorands and reduces the exposure to delivery problems. In both cases, however, doctorands are exposed both to a more structured way of working than in a purely academic PhD project and to an international network that academics believe increases both learning and mobility. The FPs therefore appear to have changed the character of some PhD training in Sweden: exposing doctorands to more structured project management, allowing them to build international networks early in their careers and exposing them to greater applied problem focus than they would necessarily experience in some Swedish-funded training.

In consortia working with large companies, a number of the interviewed researchers found the process of industrial uptake and exploitation hard to comprehend – it was not clear to them whether uptake happened and, if it did, how that process worked. At the other end of the spectrum, a research group at LU with a very solid FP participation history has produced a phenomenal eight spin-off companies active in the ICT, life science and energy sectors. All these companies clearly trace at least part of their heritage back to FP projects, and in some cases the FP project origin is very direct. Ten years ago, the eight companies had three employees, now they have a hundred employees, and one of the companies has a 45% share of the world market for lithography solutions for manufacturing and replication of advanced micro- and nano-scale structures.

The universities are increasingly under pressure to internationalise – in effect, the university world is globalising around them. The FPs provide an important opportunity to advertise the universities’ brands and to demonstrate that their brands are quality-assured. This opportunity is recognised by the rectorates, but has mainly made it into university strategies in terms of statements that FP participation should increase.

3.3.2 Impacts on researchers

The FP impact literature is full of claims that the FPs increase the quality and quantity of networking among European researchers. Our interviews confirmed that networking is an important aspect, arguable the most important. It was especially important to those entering the FPs – once relationships are established they can be sustained outside as well as inside the FPs, though funding of course always makes such networking easier. Nevertheless, there is unanimous agreement that the networking effects and the inspiration you receive from others to vitalise your own research are the most important and positive effects of participation. Several researchers use large superlatives to describe how much they appreciate the effects of networking; "serendipity results from meetings". Another effect of participation is that the more you participate, the more you get invited into other's proposals. "My network has a life of its own," as one researcher put it. There is consequently a certain degree of direct cascading between projects, meaning that one project leads into another, but it appears more common that this is not the case (partly because the probability of a proposal to the FP is funded is so low). Several researchers argue that early access to others' research results, access to new techniques, personnel exchange and benchmarking within the consortium leads to improved scientific quality in research, provided that you make sure you get involved in high-quality consortia. Several researchers clearly state that you should not go for an FP project for the money; you need to make sure that you gain something scientifically and that the project largely matches the research in which you are already engaged.

Experienced FP participants suggested, in effect, that there can be diminishing networking returns to additional participations. This was supported by stated rules of thumb that suggested one should change the composition of collaboration networks only slowly so that most of the collaborators in a new project had worked together before, knew how to work together and could trust their partners because they had delivered in earlier projects. FP participation was now so common that it no longer had the former effect of marking you out as an unusual researcher, though it still functions as a 'seal of approval'. For example, just as scientists increasingly look to publications as indicators of other scientists' quality, they also use FP participation as a proxy for quality, since to become a member of an FP consortium you have to survive first the judgement of the other consortium members and then the EC's appraisal process with a success rate that is often below 10%.

Changes in networking patterns appear to have been especially important in the life sciences. “The FPs have radically changed our behaviour. Now, European collaboration is often more important than trans-Atlantic. This is a dramatic improvement; we wouldn’t have collaborated with other Europeans without the FPs. You get a whole new feeling for what’s going on in your field in Europe. The FPs have thus definitely contributed to the European Research Area but also to increased quality in European research.”

A few researchers strongly deny that the FPs have in any way influenced their overall research directions – though most say the experience of working in European networks has introduced them to useful ideas, new to them, which have affected more detailed aspects of their research practice. Important parts of the FPs are applied or problem-orientated in nature and a number of researchers said that the applications of their research work thus had been influenced. A chemistry professor said that his decision to work on lipases was a response to an opportunity to join an FP project. A combustion professor said that a similar opportunity meant he had begun to work on large gas turbines in the early 1990s and that he has worked in that field ever since – partly in a series of FP projects, despite the fact that the Swedish company initially inviting him to participate since then has left the field. A professor in bionanotechnology said that an opportunity to join an FP project got his group into a new field earlier than would otherwise have been the case and that they have been able to capitalise on the resulting lead in a cascade of subsequent projects, both inside and outside the FPs.

The mission- or problem-orientation of many FP projects did affect the character of the research. Quite a number of our interviewees said that a benefit of FP participation was that it required interdisciplinarity and that this was a marked contrast to many Swedish-funded projects that tend to be mono-disciplinary (as one would expect from the composition and processes of the Swedish Research Council, which sets the tone for much research funding).

It is important not to regard the FPs as homogenous but to recognise that there are different types of projects and networks. Some are very scientifically driven – and the high proportion of universities and research institutes among the Swedish universities’ partners suggest these may be especially important for the Swedish universities. Here the research community drives the network dynamics. In other cases, the networks are driven by industry. For example, in aeronautics research, aircraft manufacturers and aero engine suppliers effectively choose the university and institute participants so one needs a relationship with at least one key industrial player in order to be included.

A chemist's story

Have the FPs influenced the direction of my work? Yes, a bit. I basically work with the stuff I would have anyway, but I have adapted a bit. As an example, I wouldn't have worked with lipases were it not for FP projects. The opportunity to 'develop' your research is a huge advantage of FP projects and fantastically rewarding.

My network has become more international and so has my partnering, since I've become bolder. I talk to people outside my discipline since projects are interdisciplinary, whereas Swedish projects are more homogenous. The interdisciplinarity and boldness have led to higher scientific quality. Company participation also improves scientific quality, since the large companies participating do so as serious scientific partners. It's clearly more difficult for small companies.

The companies don't tell us if they've patented something, so we don't see the commercial results – if any. The research in our projects is generally basic in nature and the companies are often not interested in working with others close to their applications. But I do know that some of them have commercial products in areas close to our research.

Quite a number of interviewees complained that FP projects were scientifically 'less productive' than 'normal' Swedish projects. To some degree this is a result of the administrative, networking and travel overheads that FP projects entail, diverting effort from research. There is a separate issue with industrially- or problem-orientated FP projects, which have quite demanding but often unpublishable deliverables that are out of alignment with the universities' publications-orientated incentive and promotion systems that effectively penalise work that cannot be published. It seems to us that this is a problem of the universities, not of the FPs.

There appears to be no special 'leverage' of FP funding over national funding or vice versa. Researchers emphasised that, in order to be accepted in an FP consortium, one has to have a demonstrable track record. This is most commonly built up using national money but this is not always the case. What matters is the track record, not the source of the funding. Similarly, a strong track record eases access to domestic funds – generally irrespective of whether that track record is nationally or internationally funded. The aforementioned bibliometric study[40] corroborates the researchers' account that one needs a demonstrable track record in order to qualify for FP funding. The authors of the study find that FP participants at the five universities were "more successful in terms of both citation rates and number of collaborations, already before participating in EU-financed projects. This suggests that one pre-requisite for being successful when applying for EU-funding is to already be an established researcher." The authors further argue that it is conceivable that FP participation may have increased emphasis on collaboration also for researchers not participating in the FPs. This is illustrated in that the general researcher population at the five universities have altered their collaboration pattern more than the FP

[40] Johan Fröberg and Staffan Karlsson, "Possible effects of Swedish participation in EU frame programmes 3-6 on bibliometric measures", 2008.

participants. Moreover, bibliometric analyses[41] indicate that co-publication with a Swedish company used to increase citation rates, but this effect has gradually decreased so as to disappear by the end of the period studied (1990–2006).

It seems, therefore, that the mechanism through which the FPs (and indeed other sources of research funds within Sweden) can influence the de facto strategies of the universities is not by persuading people to change direction but by funding growth in certain research groups and topics. Where the supply of FP money meets the demands of researchers and research topics that fit with the FPs, the FPs can trigger growth that would otherwise not have happened. No one is persuaded by the money to change their minds. But those who want to do what the funders want to fund get the money and grow; those who don't, don't.

3.3.3 Some issues and difficulties

Opinions vary about the degree to which the Swedish community has been able to influence the direction of the FPs. Grants Office managers and university management more generally point to the absence of a coordinated approach to lobby the FPs and therefore a national failure to exert influence on their directions. Many individual researchers argue in the same vein. Others, however, say that it is possible to have an influence at the detailed sub-call level through discussions with Commission Project Officers and by proposing texts to the Commission, usually by invitation. A word of caution may warranted, though, since one researcher pointed out that "many like to exaggerate their contributions to the work programmes; I've heard more than one person claim to have written the same text for the same sub-call".

Another researcher points out that FP projects have resulted in White Papers and roadmaps, which most definitely are read by the Commission and which influence future research directions and the direction of future FPs. While not normally seen as a 'lobbying' process, this kind of work is a rational approach to deciding future strategy that simultaneously creates knowledge about interesting research directions and a group of people committed to those directions. Increased Swedish participation in such activities may be more useful than more self-interested attempts to persuade the Commission to go in a particular direction simply because it happens to suit Swedish interests.

[41] Johan Fröberg and Staffan Karlsson, Note on collaboration with Swedish companies, 2008.

Complaints about Commission bureaucracy are so consistent and well established that there is little point in elaborating upon them here. Our interviewees complained about this without a single exception. More experienced participants complained, too, but also pointed out that once you understand the requirements they are less troublesome than they appear to the newcomer. It is thus in tackling the Commission bureaucracy that the Grants Offices may have their most important role. Many pointed out that their university accounting system was not compatible with the FP's reporting requirements. Given eighteen years of experience with the FPs and the fact that the FP is now one of the universities' biggest customers, it seems reasonable to us to ask: Why not? If the systems really are so incompatible, then a refusal to consider the needs of such a major funder seems a stunning act of arrogance on the part of the universities as well as of managerial negligence in failing to tackle a major source of internal inefficiency.

In our interviews, we heard several claims that the Commission's proposal assessment process was declining in quality. Our interviewees of course all regard themselves as members of the 'A-team' and complained that the Commission is using the 'B-team' for assessment. Most of our scientific interviewees also said that they had not themselves participated in these assessment processes. The minority who had done so said that they found the experience extremely useful because it helped them write better proposals and to understand the inner life of the Commission. Knowing this, the Grants Offices try to encourage researchers to take part, but with limited success and as one scientific interviewee said "the A-team has itself to blame for not participating to a greater extent". Our interviews of course provide no objective evidence about the quality of the EC assessment process, but they do provide an obvious clue about what to do.

Almost all our interviewees liked the STREP instrument, which are the current form of the 'traditional' FP project with a comparatively small consortium. They saw these as manageable and more productive than Networks of Excellence (where there is little or no money for research) or Integrated Projects (which are so big that they fragment into sub-projects and require that a considerably higher proportion of the grant is spent on administration than in STREP projects).

3.4 Impacts of the Framework Programmes on the Universities

The FPs appear to have had an important and positive influence on the Swedish universities but an influence that occurs in a number of rather diffuse ways.

At the highest level of university strategy there is no visible influence at all from the FPs. One reason for this is that the universities have barely had strategies in the past that addressed thematic priorities, so there has been little to no influence. This is beginning to change, but none of the five universities yet takes explicit account of the FPs in determining its strategy. Only one university is in the process of developing an explicit strategy for addressing the FPs, but then likely only in terms of promoting increased participation.

Of course, the universities have de facto thematic strategies, which unfortunately are poorly documented both in their own reports and in official statistics, which collect data about research activities at a level of aggregation too high to be useful for this exercise and with a thematic division that largely appears meaningless to universities, meaning that time series at times become erratic and all but meaningless. It is clear that FP funding has been important in the development of certain individual research groups and departments, and it follows that universities' de facto strategies have been influenced by FP priorities, but systematically documenting this would require many more resources than we have had at our disposal and would involve a great deal of archaeology in an effort to find data at university, faculty, department and group level.

However, it **is** clear that the FPs have over time become a significant source of funding for the universities – not the biggest funder, but everywhere an important source that now accounts for 10.5% of grants sought in competition (or 4.5% of total research income) across the universities studied, second only to the Swedish Research Council (except for VXU). This is **additional** money and represents research activity that would almost certainly not have taken place without the FPs. It is also, for the greater part, high quality and largely mission-orientated research, likely to bring social and economic as well as scientific benefits.

The research community is unanimous in that the biggest impact of the FPs has been to increase the size and scope of its international networks. This has in some cases involved adding a European dimension to previously US-orientated networks; in other cases the industrial dimension has been increased. This increased networking is non-trivial. One aspect is that it enables Swedish researchers to be included in the EU research agenda by placing them inside trust-based research networks. Another is that these networks are 'invisible colleges'[42] in which new research ideas, results and papers circulate ahead of publication giving their members huge advantages

[42] Derek de Solla Price, *Little Science, Big Science,* New York: Columbia University Press, 1963

in scientific competition and access to resources. Those outside invisible colleges often struggle to catch up because they do not know what the latest research questions, debates and results are – and by the time these appear in the form of publications, the community has moved on.

The increased industrial dimension is part of a wider trend and has a corollary in the type of work done, which is more problem-orientated than much Swedish-funded research. As a result, the work of the Swedish research community has become more interdisciplinary than would otherwise have been the case.

The FPs have contributed to funding diversity in the university system. This has a number of implications:

- Certain themes and groups that were not, for various reasons, funded from national sources were able to become established or survive because of the FP funding
- The mission-orientation of FP research has been a needed complement to national research funding sources, which tend to focus on ‘basic’, disciplinary work

The outcome of this increased funding diversity is that the Swedish university research system is more **robust** and diverse than would have been the case without the programme.

FP projects have to a significant extent been staffed by doctorands, so the FP has been a major influence on doctoral education in Sweden, making it more international, building more international networks and exposing doctorands to more structured project management than would otherwise been the case.

Tackling the FPs has also required universities to professionalise their research management, contributing to a wider process of modernisation that includes the use of improved laboratory disciplines, industrial liaison officers, IPR, venture management – and more professional accounting routines.

3.5 Policy Implications

As with any small country, the benefits of involvement and non-involvement are asymmetrical. Were Sweden, for the sake of the argument, to withdraw from the FPs, almost no-one outside Sweden would notice: there are many more good prospective partners than can be funded within the limited resources of the FP. But the effects within Sweden would be devastating. Irrespective of whether Swedish universities participate or not, the FPs play a big role in setting the European R&D agenda. It follows that failing to participate would have a significant **negative impact** on the Swedish research community, tending to marginalise it and exclude it from the evolving invisible colleges. There are therefore negative as well as positive reasons to remain involved at a significant level.

Against the background of the renewed drive towards a European Research Area in 2007, participation has become even more important. In its 2000 incarnation, the ERA was seen as inclusive: everyone could and should be involved. But since the idea of the ERA has gained acceptance beyond the European Commission, its nature has begun to change. In particular it involves the idea of **focusing** – a principle supported by the launch of the European Technology Platforms that aim to focus attention and resources onto a limited number of players. Sweden's traditionally fragmented research infrastructure is poorly positioned in this intended reality. Choices will have to be made about where the Swedish system can assemble enough strength to be a player and where it cannot. This imposes a need for strategy on the universities (and, arguably, the research funders) that takes account of the FPs and of the ERA – as well as dealing with the wider questions of globalisation posed by India and China – and the generation of countries that will follow them into development.

Swedish universities have largely missed their opportunities to influence the directions of the FPs in the past. Similarly, many have missed the learning opportunities and improved competitive advantage that comes from getting experience inside the FP proposal assessment process. There is scope for action both by individual universities and collectively to increase the interaction with the FPs.

More broadly, the growing importance of the FPs and the ERA provide important reasons for continuing to promote the development of university strategies, modernising the universities and their wider links to the rest of society.

4 The Swedish Life Sciences and Health Sector

This report describes the results of the case study on the Swedish participations in the EU Framework Programmes for R&D in the area of Life sciences and health.

Today there are many more diseases than treatments. Just 10,000 of the 30,000 known diseases have treatments available. Greater understanding of disease and the causes of disease are helping to produce better therapies that can more effectively address medical needs. New insights into the biology of disease and more precise understanding of why some people react differently lie at the heart of biotechnology. Life sciences & health contains the promise of more targeted treatments to individual groups of patients as well as providing treatments for diseases that so far have eluded scientists' efforts at curing them. It is also providing new opportunities to meet challenging but common diseases like heart disease, cancer and Alzheimer's as well as rare diseases.

In Sweden, several groundbreaking inventions in life science occurred during the past 50 years. Among them are the pacemaker, the artificial kidney and pioneering drugs like Xylocain, Losec and the first recombinant growth hormone Genotropin.

In the following chapters an overview of the Swedish life science and health sector (including policy) is given (chapter 4.1), followed by a discussion on the dynamics in the sector (chapter 4.3). In chapter 4.4 the Swedish life sciences participation is investigated and reflected against EU calls. Chapter 4.5 introduces the industrial and public research participation in more detail as well as the effects on the branch and knowledge infrastructure. In chapter 4.6 observations and conclusions are summarised.

4.1 Life sciences & health definition

Life sciences and health has been defined in many ways and encompasses several areas. Some people prefer to use the term "biotechnology" where the definition given by the OECD is useful: biotechnology is defined as "…the application of scientific and engineering principles to the processing of materials by biological agents".

Healthcare biotechnology includes pharmaceuticals, vaccines, diagnostics and emerging cell and gene therapies. All these areas result from new discoveries brought about by the sequencing of the human genome, improved knowledge of the way living organisms work and investment in enabling technologies to turn these discoveries into individual benefits and knowledge. Healthcare biotechnology is playing an increasingly important role in treating and curing presently incurable diseases using novel methods of treatment and diagnosis.

Medical technology refers to the diagnostic or therapeutic application of science and technology to improve the management of health conditions. Technologies may encompass any means of identifying the nature of conditions to allow intervention with devices, pharmacological, biological or other methods to increase life span and/or improve the quality of life.

Improving the health and wellbeing of a population requires a continuous stream of new knowledge – knowledge about how our bodies and minds work, about how our genes affect whether we develop certain diseases, about effective treatments and about how best to organise health care. Health research also includes translational and clinical research, which in most cases relies on patient material (data or samples), whether or not organised in large cohorts, biobanks or datasets on biological and molecular material.

Health care biotechnology, medical technology and health care research on biological material are in this case study all part of the life science and health sector.

4.2 Introductory statistics life sciences –setting the scene

After three decades of scientific innovation, development, and convergence, the life science industry has emerged as one of the key industrial sectors. In Sweden, the life sciences are one of the high priority sectors in Swedish industry and innovation policy. Life Sciences could play a fundamental role in securing and developing the Swedish society.

Despite the fact that Sweden only has nine million inhabitants, it is Europe's fourth-largest life science country with the highest number of life science companies per capita in the world[43]. Currently, about 40,000-50,000 people in Sweden are employed in the life science industry. The life science sector accounts for over 20 % of Swedish net export, which equals over 40 billion SEK in export revenues. Life science has grown more rapidly than any other main Swedish industry in the past few years with an annual growth rate of 10 % between 1995 and 2003. It has a strong potential of becoming a new cornerstone in the Swedish economy.

[43] See: www.swedenbio.se

The total number of life science companies active in research and development, product development, consulting or manufacturing within the included business segments of biotechnology, pharmaceuticals and medical technology in Sweden is approximately 620 with a total of almost 34,500 employees. This does not include the companies focusing on marketing and sales. Those companies have over 7,200 employees distributed among about 210 companies. This leads to a total size of the industry amounting to 830 companies and 41,700 employees[44].

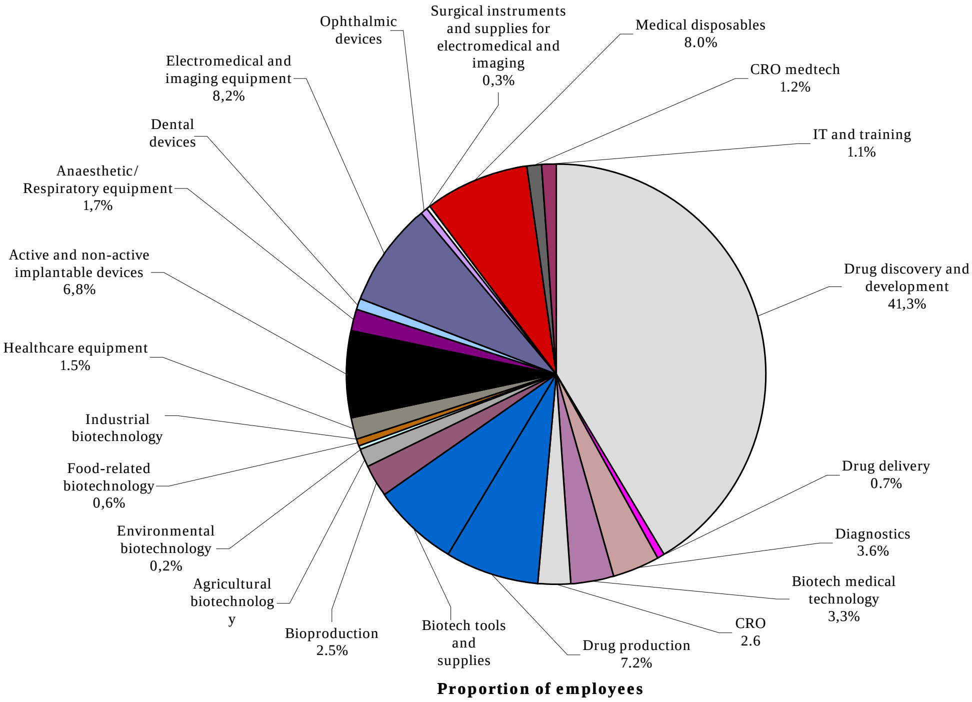
Sweden has a long pharmaceutical tradition and this pharma sector alone (as part of the life science & health sector) employs 19,500 people. Pharmaceutical development is characterised by its R&D intensive, long development processes, which is very capital intensive. The most important sectors of R&D today include drug discovery in metabolic diseases, immunology and neuroscience as well as advanced tools for diagnostics and bioproduction. World-leading pharmaceutical companies such as AstraZeneca have long dominated the Swedish life science arena, however in the past two decades the number of new biotech companies has increased substantially. For example around 10 new companies in the period 89-93, 28 in 1994-98, 50 from 1999-2001, and 30 from 2002-2005, the number of biotech patents is also increasing.

The Swedish life sciences sector also has the following characteristics:

- The Swedish biotech pipeline has 65 projects in clinical trials
- The dominating therapeutic category is diabetes, followed by infectious disease and cancer
- The majority of clinical development projects by Swedish biotech companies are small molecules
- Over 90% of the biotech companies in Sweden have less than 100 employees
- There are three major biotech clusters in Sweden, the Stockholm-Uppsala Bioregion being the largest, followed by Medicon Valley around Malmö-Lund and Medcoast by Gothenburg. Other centres with advanced biotechnology research and high quality companies include Linköping and Umeå.

[44] Biotechnology, pharmaceuticals and medical technology in Sweden 2007 - Cluster profiles, VINNOVA

Figure 28 Swedish life sciences industry employees



About 40% of all 800 companies are involved in drug discovery and development (Figure 28), which have nearly 170 drug candidates in development. Another 30% of the companies focus on medical technology and bio-instruments, such as electro-medical and imaging equipment (8,2%), medical disposables (8%), biotech tools and supplies (6,6%) and active and non–active implantable devices (6,8%). They have currently the most successful products on the market.

Sweden is also renowned for its high-quality clinical trials and extensive biobanks, including the world's largest twin register. It has one of the most research friendly stem cell research legislations in the world. The collaboration between academia and industry is very strong and supports pioneering companies in biotech.

In terms of medical & life sciences research, Karolinska Institute (KI) in Stockholm is one of Europe's largest medical universities. It is a top class institute that is comparable to world famous universities such as the University of Oxford in the UK or the Stanford University in the USA[45]. Karolinska Institute facilitates industrial collaboration and innovation expansion through an umbrella organisation, KI Innovation that offers competences, financing and offices.

[45] From BioScience to New Jobs in Medicon Valley, Medicon Valley Academy, 2004

Lund University has also made special efforts in its three high profile areas: Medicine, Life sciences and Sustainable development. At the Biomedical Center (BMC), located adjacent to the Lund University Hospital, basic research is integrated with clinical research. The goal is to become the leading Faculty in Sweden in medical research and education, as well as one of the leading medical schools in Europe. Efforts are also put into better commercialisation of innovations, as demonstrated by the building of a new Bio-incubator in 2007.

The challenge ahead will be to capture the full potential of Sweden's technical knowledge and combine it to take Swedish life science to the next level in an increasingly competitive international environment.

4.3 Dynamics in the life sciences sector

4.3.1 In academia

Sweden has a long history and tradition of internationally renowned excellence in life sciences. In academia Swedish publications in clinical medicine are the world's most-cited in relation to the population. Industrially, Sweden has demonstrated successful development and commercialisation of both pharmaceutical blockbusters as well as medical devices. However, one of the conclusions of the 2007 European Scoreboard is that Sweden is strong in innovation (inputs), but not in commercialisation (outputs).

The Ministry of Industry Employment and Communication developed a strategy programme on "Pharmaceuticals, Biotechnology and Biomedical Engineering – a part of Innovative Sweden". This strategy programme is the result of a dialogue between the government, industrial organisations, companies, and representatives of universities, trade unions and R&D funders. The following key issues have been identified as ways in which life science research and enterprises can be improved and continue to be internationally competitive:

- Strengthening the dialogue in the life science innovation system and the interaction between industry, health services, university and university colleges as well as the government in order to better cope with international trends, events and initiatives;
- Stimulating clinical research and improving the system for clinical trials;
- Developing a demand driven, quality oriented health service, which readily adopts innovations;
- Organising effective commercialisation of life sciences research;
- Ensuring the provision of skills in the pharmaceuticals, biotechnology and medical technology fields;

- Encourage the cooperation and mobility of personnel between academia and industry.

The Ministry of Education, Research and Culture published a science and research bill in which *Life sciences research* is one of the prioritized areas (in addition to engineering and sustainable development). A budget of 400 MSEK (42 Million Euro) is available for life sciences research. Other priorities in the research bill are securing a good supply of researchers, realising strong research environments, knowledge transfer and valorisation, and infrastructure for research.

No general or specific health research policy (and therefore health research strategy) has been worked out at governmental or advisory body level in Sweden. Objectives on health related themes are developed within universities and to some extent at the research funding organisations. The Research Council (Vetenskapsradet) is funding bottom up research that is selected on the basis of quality. No specific priorities are set except for gene therapy, stem-cell research and ethics in health care.

The creation of VINNOVA in 2001 was the main policy support for biotechnology. VINNOVA is implementing the Industrial strategy programme, and also runs the Brainpower programme together with other funders to integrate R&D into diagnosis and treatment of neurodegenerative diseases. Furthermore, VINNOVA has a number of instruments to stimulate the interaction between academia and industry, such as the Competence centres (from 1995-2005), VINN Excellence centres, Berzelius centres (with VR), VINNVaxt and Institute Excellence Centres. In the period of EU funding that is under investigation, 5 competence centres were in the Biotechnology and Biomedical Technology sector (e.g, Centre for Radiation Therapy at Karolinska and Noninvasive medical measurements, Linkoping). Also 5 of the VINN Excellence centres are in this sector, i.e. the Protein Technology Centre at KTH and the Antidiabetic Food Centre in Lund. The current discussion is about how to be successful in a centre or network: what is a size that works well and how to find strong leaders.

Policy implementation is in principle fragmented and coordination is carried out informally and on an ad-hoc basis at the research funding level. No formal and obligatory fora for coordination exist in the area of research policy and operations, and it is a well-known fact that lack of comprehensive coordination at this level is a weakness of the Swedish system. Despite the fact that a governmental health research policy is lacking, Sweden has an active life science and health industry, which is benefiting from extensive collaboration between academia and industry and health care.

4.3.2 In industry

Worldwide the large international pharmaceutical sector has been subject to major restructurings. Astra and Pharmacia, two of Sweden's big pharmaceutical companies having a large research base in the country, were also involved in these restructurings. Astra merged in 1999 with Zeneca, the British ICI subsidiary, and has kept its R&D headquarters in Sweden. Nowadays, AstraZeneca accounts for 28% of the total number of employees in the life sciences industry. The company is one of the world's leading pharmaceutical companies with products in six fields: oncology, cardiovascular, gastrointestinal, infection, neuroscience and respiratory and inflammation. In Sweden, research is being conducted into respiratory, gastrointestinal and neuroscience in Södertälje, Mölndal and Lund. The largest production unit is Södertälje , but there is also production in Umeå. The head office is located in London, but AstraZeneca's research and development headquarter is in Sweden.

Pharmacia, first merged with Upjohn (USA) in 1995, and subsequently with Amersham (UK) in 1997. In 1999, Pharmacia & Upjohn merged with Monsanto. Most of the remaining research within Pharmacia in Sweden was sold off and a new company, *Biovitrum* was formed in 2001. Eventually, Pharmacia Corporation was taken over by Pfizer in 2003. Since then, Pfizer has diverted most of its activities to other countries and only left a bio production facility in Sweden. The companies created through the sale of Pharmacia's operation have 7,960 employees in the following companies: Biacore, Fresenius Kabi, Biovitrum, Octapharma and Quintiles. Altogether, the former Pharmacia operation has been sold to various owners and now comprises 12 companies.

One of the results of the pharmaceutical mergers was that large numbers of life science experts with a company background came onto the 'market'. Together with the booming amount of venture capital at the turn of the century, it explains the increase in the number of new companies in the period 1999-2001. After the clash of the stock market in 2001, it has become much harder to obtain sufficient venture capital to start a new biotech company, which is also due to the fact that the promises of the life sciences proved harder to realise than expected 10 years earlier.

In the mid-nineties, when the pharmaceutical industry was still fully Swedish, they had (to some extent) an impact on the university research agenda. For example, the pharmaceutical companies were (and still are) represented in the advisory board of the Swedish Science Foundation and were involved in defining the objectives and topics of the biomedical networks that were funded since the mid-nineties. These networks focussed on research topics within the interest of the Swedish pharmaceutical industry such as cardiovascular research, drug development, inflammation, infection and vaccinology, and basic biomedical science like glycobiology and nucleic acids research. An important objective of these networks, apart from the research and the networking goals, has been the training of sufficient researchers with a molecular background that eventually could be employed by the pharmaceutical industry. Despite the mergers and takeovers, and despite the fact that currently molecular techniques are fully automated analysing large numbers of samples, the trained researchers have been largely absorbed by the research labour market, thereby strengthening the Swedish knowledge base in life sciences.

In terms of collaboration between industry and academia in networks and centres it seems that industry is more interested in bilateral collaboration projects. Small companies prefer bilateral collaboration. AstraZeneca, being the only big company could handle larger networks, but did not need them for a long time. However this has been changing. The current pharmaceutical R&D is insufficient to create the volumes needed to defend leading positions, which is a problem for all global pharmaceutical companies. In order to keep up their pipeline they have to closely link to basic –public- R&D, or to small life science companies. Furthermore interdisciplinary approach is important to strengthen pharmaceutical research, e.g integrated research between clinical pharmacology & pharmacy. In order to achieve this, companies can interact with regional players, but as easily go international.

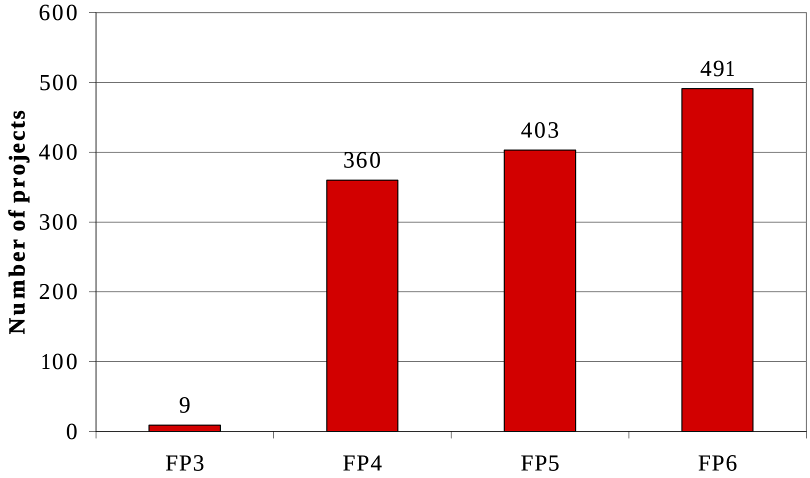
4.4 Swedish participation in EU Framework Programmes

4.4.1 General numbers

All 8394 Swedish participations in the Framework Programmes were characterised in two steps. First, the projects belonging to one of the four case-study areas (ICT, Life sciences, Sustainable energy and Vehicles) were identified (based on project titles) by a senior member of staff at Technopolis with a technical background. Secondly, the life science & health projects were classified by the Technopolis internal expert, according to biomedical disciplines and application of technology (see Appendix A). All the analyses were done manually: the database is over 95% accurate.

From the analysis can be concluded that Swedish universities, institutes and companies participated in 1263 projects in the Life science sector in the European Framework Programmes (FP3-6) (Figure 29). There is a steady increase in the number of participations in FP4, FP5 and FP6. In FP3 only 9 life science participations took place.

Figure 29 Swedish participation in FP in the life sciences & health

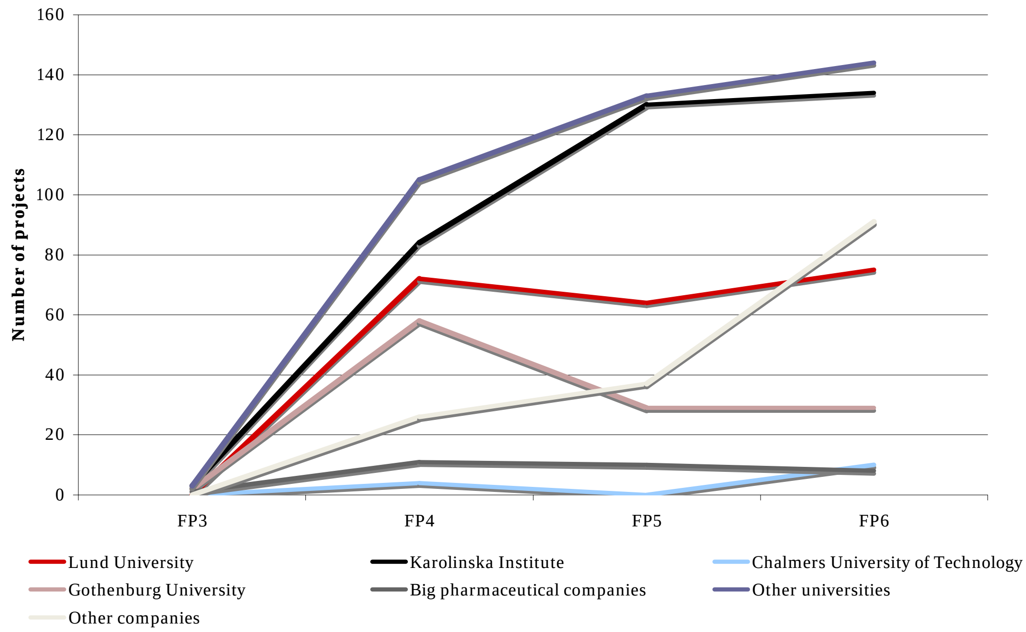


Source: Technopolis analysis

Figure 30 shows that from the 1263 projects, 694 participations are from one of the four universities that are investigated in more detail (Lund University, Karolinska Institute, Chalmers University of Technology and Gothenburg University). A few big pharmaceutical companies (AstraZeneca, Amersham, Biovitrum, Upjohn and Pharmacia) participated in a total of 30 projects. Of the remaining 539 projects, 389 are led by other universities or research institutes and 150 by small life science companies. The total participation of industry is 14.6%, whereas SME participation is 12.2%. Participation of SMEs strongly increased in FP6. There are 113 different SMEs involved in FP participation, indicating that only a few participate in two or more projects.

Figure 30 also shows that Karolinska Institute alone participates as much as all other universities in all Framework Programmes (from 3 projects in FP3 to 134 in FP6). Apart from this, participation of Lund has remained stable over FP4, Fp5 and FP6, whereas participation of Gothenburg University has decreased in time. Chalmers University of Technology isn't very active in life sciences. Overall, KI, Lund, Chalmers and Gothenburg account for 55% of the total amount of life science projects (694 of 1263).

Figure 30 Swedish participation per organisation

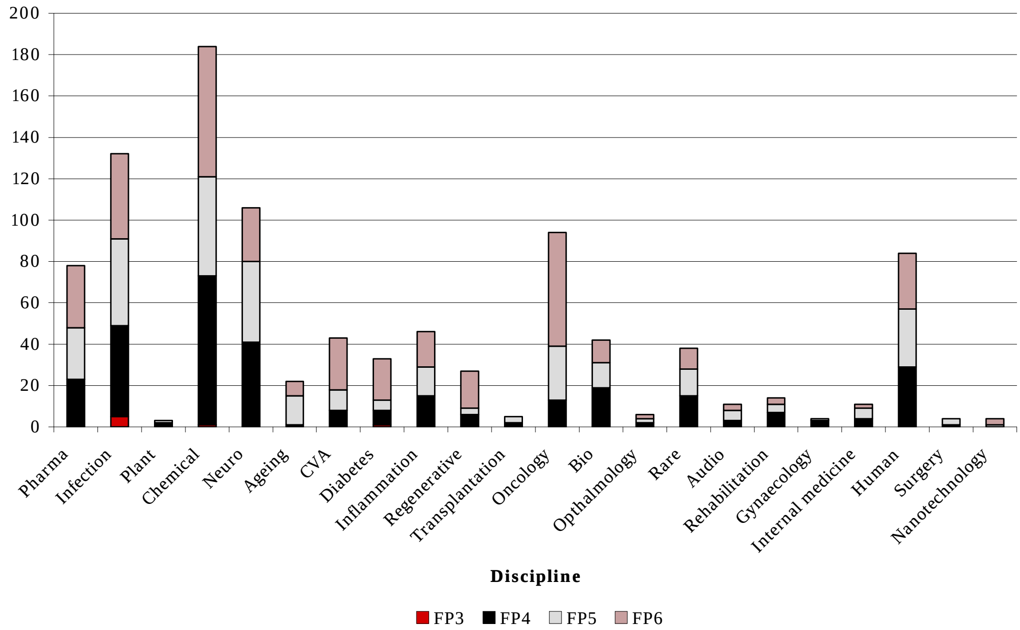


Source: Technopolis analysis

4.4.2 Numbers by discipline and technology

Figure 31 presents (with an accuracy of almost 80%) the distribution of Swedish projects per life science discipline. The five largest disciplines within the Framework Programmes (mainly FP4 to FP6) are 'Chemical' (184 projects), Infectious diseases (132), 'Neuro' (106), Oncology (94) and 'Human' (84). Chemical indicates basic (bio)chemistry research, whereas human indicates research into the whole (ill) human being, not specified. Neuro refers to neurosciences. Pharmaceutical related research takes place in 78 projects. In addition there is a distinction between disciplines that are present in 25 to 40 projects (e.g. Regenerative medicines and Rare diseases) and disciplines that are less present in projects (<10 projects) (e.g. Transplantation). From this division per discipline, it is clear that a large proportion (1/5) of the Swedish FP participations reflect fairly basic research, not relating to any disease mechanism. Disease related research represents 55% of life science research; pharmaceutical plus 'human' research together is about 15%. Over the consecutive Framework Programmes, this distribution remained more or less the same.

Figure 31 Swedish life sciences FP projects by discipline

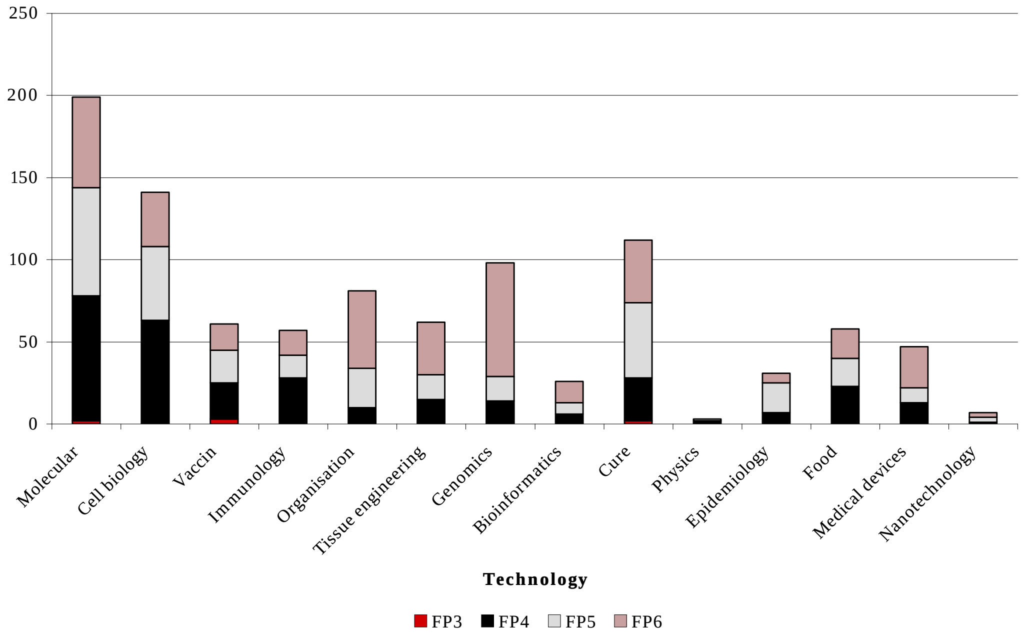


Source: Technopolis analysis. 'Rare' corresponds to 'Rare diseases'

Regarding the distribution of technologies defined for the projects, the following can be concluded (see Figure 32). Molecular (199 projects) and Cell biology (141) are the most prominent technologies, especially as a result of their presence in FP4 and FP5. In FP6 genomics is an upcoming technology (total of 98 projects). Together, these three technologies amount to 45% of all participations, confirming the idea that FP participation offers access to essentially basic research. Note that 'cure' (112 projects) and 'organisation' (81 projects) are relatively well represented. 'Organisation' refers to networks, conferences and workshops and reflects participation in EU networking grants. Cure refers to translational and clinical research, including research into therapy, representing the health research, which amounts to 10% of all participations.

A further breakdown of technologies and disciplines over the consecutive Framework Programmes is presented in Appendix B. Based on these figures, it can be concluded that 'chemical' (19% of all participations) and infectious diseases (13%) are listed in the top-5 of all Framework Programmes. Regarding the technologies, molecular (20% of all participations) and cure (11%) are present in the top-5 of all Framework Programmes. In FP6, there is a strong increase in genomics (coinciding with a decrease in cell biology) and organisation. In the earlier programmes (FP4) food research and vaccine development had a more prominent place.

Figure 32 Swedish life science FP projects by technology



Source: Technopolis analysis

4.4.3 Breakdown of discipline and technology per organization

In this paragraph the main discipline and technology areas of two of the main medical research faculties are presented (Figure 33, Figure 34), as well as those of industry (Figure 35). The main difference between the two most important Swedish knowledge institutes in the life sciences & health, Lund University and Karolinska Insitute (together almost 45% of all participations), is the presence of infectious diseases and pharma within the Karolinska Institute disciplinary top-5 (these two disciplines are absent in the top-5 of Lund University). Inflammation and human are listed in the Lund University top-5 and are absent in the top-5 of Karolinska Institute. The technologies in both the Lund and Karolinska top-5 are the same, but are listed in a different order.

Figure 33 Top-5 disciplines and technologies of Karolinska Institute

Disciplines	Number	Technologies	Number
Infection diseases	57	Molecular	87
Chemicals	53	Cell biology	51
Neuro	46	Cure	45
Oncology	45	Genomics	30
Pharma	21	Organisation	26

Source: Technopolis analysis

Three (infectious diseases, cancer and neuroscience) of Karolinska's priorities[46] are reflected in the top 5, but it is maybe more surprising that the other 5 are not visible at all in EU FP participation. This could be due to EU calls not sufficiently covering these priorities. One could hypothesize that 'pharma' encompasses activities in the area of circulation, metabolism and inflammation. But on the whole, the top 5 disciplines of Karolinska Institute point at a stronger influence of FP calls than of local priorities in Karolinska's participations.

Figure 34 Top-5 disciplines and technologies of Lund University

Disciplines	Number	Technologies	Number
Chemicals	33	Cell biology	32
Neuro	30	Molecular	26
Inflammation	19	Cure	23
Human	16	Genomics	21
Oncology	15	Organisation	19

Source: Technopolis analysis

Almost all Lund's priorities[47] are present in the top 5 (human in experimental medicine; chemical in laboratory medicine), except for the stem cell research. The latter is not so surprising since Swedish legislation on stem cell research is friendlier than European legislation.

Most notably: few of the areas of interest of the competence centres and excellence centres match with Swedish EU discipline or technology, except maybe for the protein technology centre at KTH, suggesting these centres benefit little from European funding.

Breakdown of discipline and technology for industry shows some interesting results. Not surprisingly, Pharma is present in the top 3 of both. In addition, big pharmaceutical industry focuses at vaccine development for infectious diseases and basic biochemistry. In comparison with e.g. AstraZeneca's priority areas (oncology, neuroscience, respiratory, inflammation, gastrointestinal), few of these are addressed in EU projects, suggesting that industry doesn't use EU Framework Programmes very much, but consider it additional. For SME's research into neuroscience and oncology prevails, which could be anticipated as spin offs from universities having strong research in oncology and neurosciences. The medical technology industry does not show off in any of these analyses; the category of medical devices is not significantly present.

[46] Cancer; Circulation and respiration; Endocrinology and metabolism; Infection; Inflammation and immunology; Neuroscience; Movement and reparative medicine; Public and international health; Reproduction, growth and development
[47] Lund Stem Cell Center; Strategic Centre for Clinical Cancer Research; Experimental Medical Science; Clinical Sciences; Laboratory Medicine; Immunotechnology

Figure 35 Discipline and technology in industry

Industry	Discipline	number	Technology	number
Big Pharma top 3 (30 particip.)	Infection	6	Vaccin	6
	Chemical	6	Cellbiology	6
	Pharma	6	molecular	5
SME top 3 (150 partcip.)	Pharma	14	Molecular	33
	Neuro	14	Cellbiology	24
	Onco	14	Cure	20

Source: Technopolis analysis

4.4.4 Concordance and analysis of FP calls

The projects in the different Framework Programmes were also sorted into the respective thematic programmes that they were granted in. As could be expected, the majority of the participations are within the FP4 BIOMED2 (138 projects) and BIOTECH2 (116 projects), FP5 Quality of Life (341 projects) and the FP6 Life Sciences, Genomics and Biotechnology for Health (332 projects) programs. A complete overview for all life science participations is presented in Appendix C. Within the Biomed/Biotech2, QoL and LSGBH programmes, specific focussed calls were defined. Figure 36 shows the concordance between the calls of the consecutive Framework Programmes. From this it is clear that life science & health research in EU context always had a focus on Infectious diseases and rare disease because these would benefit from a European approach rather than the subsidiary level. This explains the high % of infectious disease in the discipline subdivision, and even the rare diseases are noticeably present (see Figure 31). Also genomics, research into e.g cancer and neurosciences has always been present in FP calls. The basic biochemistry at the molecular and cellbiology level was funded through calls like ‘cell factories’, structural biology and applied biotechnology. Remarkably pharmaceutical research was explicitly called for only in FP4 (Biomed2), yet, the pharma discipline is present in the top 5 in all consecutive Swedish FP participations (see Appendix B), reflecting Swedish interest in Pharmaceuticals.

4.4.5 Conclusion

The analysis and comparison with calls strongly suggests that Swedish research participation in the life science and health sector is more influenced by EU calls (see above), than by Swedish priorities (gene therapy and stem cell research), although some of them are overlapping between EU and Swedish priorities (neuroscience). It seems that a bit of steering (in this case by EU FP) is overruling little steering of health research (in Sweden). In other words, it may suggest that the influence of the European research agenda is stronger than vice versa, as reflected by the relatively few EU calls on inflammation and immunology, which is one of the strengths of Swedish research and industry.

Figure 36 Concordance in life sciences calls

BIOTECH 2 (FP4 1994-1998) Cell factories Genome analysis Plant and animal biotechnology Cell communication in neurosciences Immunology and Transdisease Vaccinology Structural Biology Pre-normative Research, Biodiversity and Social Acceptance **BIOMED 2 (FP4 1994-1998)** Pharmaceuticals Research Research on biomedical technology and engineering Brain research Research on diseases with major socio-economic impact: From basic research into clinical practice • Cancer • infectious diseases (AIDS/TB) • cardiovascular disease, • chronic diresease and ageing, • rare diseases, • occupational and environmental Health Human Genome Research Public Health Research, Incl. Health Services Research Research on Biomedical Ethics	**QUALITY OF LIFE AND MANAGEMENT OF LIVING RESOURCES (FP5 1998-2002)** *Key Actions* Food, Nutrition and Health Control of Infectious Diseases The "Cell Factory" Environment and Health Sustainable Agriculture, Fisheries and Forestry The Ageing Population and Disabilities *Generic research activities* Chronic and degenerative diseases, cancer, diabetes, cardiovascular diseases and rare diseases Research into genomes and diseases of genetic origin Neurosciences Public-health and health-services research (including drug-related problems) Research relating to Persons with Disabilities Bioethics Socio-economic Aspects of Life Sciences and Technologies	**LIFE SCIENCES, GENOMICS AND BIO-TECHNOLOGY FOR HEALTH (FP6 2002-2006)** Fundamental Genomics Applied Genomics and Biotechnology Genomic approaches to health and disease • Combating cardiovascular disease, diabetes and rare diseases • Combating resistance to antibiotics and other drugs • Studying the brain and combating diseases of the nervous system • Studying human development and the ageing process Cancer HIV/AIDS, malaria and tuberculosis

4.5 Impact of Swedish participation in EU on the life science & health sector

In this chapter the impacts of the Framework Programme funding on the Swedish Life science & health sector are presented. They result from a series of interviews with university and research institute researchers, big pharmaceutical companies and SMEs in life sciences (Appendix D). University researchers were selected that had either more participations over the years or coordinated EU projects.

The main areas of technological development in life sciences since the early 1990s are the -omics approaches: genomics and high throughput technology in sequencing, micro arrays as well as standardisation of sample collection, humanized monoclonal antibodies in immunology, developments in inflammation, infectious diseases, recombinant vaccines and viruslike particles in vaccinology, gene therapy and stem cells in tissue engineering. However, the most prominent development in life science & health over the years has been the paradigm shift from a ‘reductionist’ approach to a integrated system approach. To a large extent the EC FP have picked up these themes by building collaborations around technological platforms.

4.5.1 Impact on the industrial sector

4.5.1.1 Large pharmaceutical & life science industry

There has never been a real need for EU funding for big pharmaceutical companies, neither in policy nor practically. They had sufficient knowledge in house, or were able to obtain that knowledge in a focused way. In addition, pharmaceutical companies always have difficulties with IP matters. They rather own IP themselves than share it with academia or other companies. Furthermore, the administrative burden was too large for them and for a long time the added value of EU funding was not considered to be sufficient.

So, for Pharmacia and AstraZeneca, EU R&D funding has never been a strategic choice to get involved with, neither did any of the calls affected their internal strategy, research priorities or collaborations. For industry, EU funding only addressed issues that were marginally interesting for them. It has been by and large basic sciences questions, which were only partly relevant for industry. To industry, subsequent EU calls show more of a follower role than the other way round.

This attitude is shown by the fact that AstraZeneca participated in only 25 projects in Sweden over the years 1992-2008. The majority of these 25 projects result from individual contacts where AstraZeneca employees were invited by others to participate. These projects show no general research priorities that connect to Astra's main research areas. Pharmacia was broken down and in Sweden Biovitrum is its largest remaining spin off company (500 employees, largest life science R&D company after Astra Zeneca). Biovitrum got EU projects at the take over of Arexis, but stopped their contribution. They have little experience of their own with European funding, and it isn't very positive so far. Time is an important factor in pharmaceutical R&D and EU funding does not coincide with this prerequisite.

However, times are changing: AstraZeneca new policy aims at 'externalisation' meaning that new breakthroughs are thought to arise from university research and/ or small biotech companies, which big pharma needs to buy in at the right time. This policy is predominant with the other big pharmaceutical companies as well. Externalisation is at the basis of Innovative Medicines Initiative; the EU JTI with a budget of 2 billion euro designed for the needs and wishes of the pharmaceutical industry. AstraZeneca has been actively influencing the EU research agenda for 2006 and it took another year for the formal decision on IMI. IMI is much more tailor made for industry, and has been the result of a growing awareness that industry needs to be involved. Pharmaceutical companies contribute half of the budget to IMI; due to IMI AstraZeneca won't actively apply for FP7 funding.

Biovitrum is changing as well, but is more internally oriented in transforming the company from a small molecule oriented company into a 'biologicals' oriented company. Indeed this process leaves little time for strategic interaction with the academic world, as they have been involved in all aspects important for industrial life sciences R&D such as getting insight as early as possible into medical need, indication, clinical relevance, early clinical work (i.e translational research) and next steps into early design of product development, safety issues, market analysis, business case, competitiveness in specific niche areas and so on. Midsized firms can only be leaders in areas were big pharma is absent.

4.5.1.2 Small life science Industry

The European Framework Programme offers more opportunities than just large research consortia, which provide a way out of the calls. Most SMEs welcomed the opportunities, but the majority of Swedish biotech industry was not open for the funding possibilities.

Swedish SME life science participation in EU FPs is very low. Looking at the pattern of framework funding to Nordic countries, there are major differences. In Norway 3% of the EU funding went to industry, in Sweden it is 15%, of which 12% is SME. By contrast, it is 25% in Denmark and in Denmark the major companies have a substantial part of the funding. This completely different pattern connects to cultural differences.

Whereas many of the companies that do have EU funding value it very much, the other companies suffer from a lack of information on calls and other opportunities for funding, as well as from guidance on how to write a proposal and all other needs to be fulfilled. This kind of support is provided for at universities. The lack of support explains why there is a large number of consultants around offering their services. Therefore, Sweden Bio, the life science branch organisation has set up the SME Life Science Support Office, which is the EU help desk" for Swedish life science SMEs! The aims is to facilitate participation in European funding programmes for Swedish life science SMEs and to increase the knowledge of the possibilities for SMEs to get EU-funding and to increase the Swedish influence on upcoming calls within Life Science.

A difficulty for SMEs specific for participation in FP6 and FP7, is that they don't want to be involved in the big integrated projects. For SME it is more feasible to keep it small and be partner in eg a STREP. Also SMEs participation in large public private consortia relates to problems with IPR issues. While IPR is so important, there is little advice available on this.

Only VINNOVA supplies funding to support IP applications but they cover half of the realistic cost.

On the other hand, a number of SMEs that started after the Pharmacia breakdown, (bringing some experienced senior researchers on the market), does know the way in EU funding. These life science SMEs use EU funding as a source of soft money amounting to almost 50% of their budget. In Sweden the funding for companies is more product driven, whereas there is no national funding to identify new targets. A lot of SMEs are in a stage between research knowledge and product development, for which VC is too risky. Here EU funding comes in to bridge these phases, which can take a considerable time because these SMEs remain within the vicinity of university infrastructure. Participating in an EU-project is an important stamp of approval for an SME, as it is considered a sign of competence. Participation in Framework Programmes could also be a sign of opening up internationally and of transparency.

EU funding is very useful, advantageous and sometimes even indispensable, especially for a true SME. It provides access to all scientific knowledge and technology platforms and collaborations. From there it its easier to start academic collaborations, where an SME is in the front line of its particular research and where you can hear the latest findings. An additional effect of the broader academic collaborations is that it increases serendipity. It is even suggested that SMEs in FP consortia survive to a higher degree than SMEs that are not. In addition, it is suggested that the smaller the SME (<10), the more important FP funding can be. Although a company's strategy does not rely on FP projects EU funding is of clear added value, which these SMEs rather not do without.

In terms of impacts, EU funding has led to more basic research in the company, and sometimes also to shifts into new indication or technology areas. It has increased international collaboration considerably, as well as the nature of collaboration, which is much more by mutual exchange than by outsourcing.

4.5.2 Impact on the public research sector

4.5.2.1 Public university research

Figure 37 Swedish Participants with more than 4 Participations in the Area of 'Red Biotechnology'

Organisation	Total	FP4	FP5	Fp6
Karolinska Institute	101		95	6
Lund University	49	15	12	22
Gothenburg University	38	13	12	13
Chalmers University of Technology	4	2	-	2
Big pharmaceutical companies	-	-	-	-
Other universities	36	-	31	5
Other companies	17	2	10	5
Total	**245**	**32**	**160**	**53**

Source: Technopolis analysis

Figure 37 shows that a significant number of university researchers have participated in more than one EU FP grant. Some researchers even participated in more than 10 projects. In our selection of interviewees, 3 university professors had more than 4 participations.

University grant offices have offered lots of information to raise awareness on EU FPs, and during FP4 and FP5 they offered more and more services for grants applications. The grant offices took care of a gentle education of researchers to listen to the administrator and learned to put together a decent paragraph on project management and implementation. Now most researchers have turned into professional grant writers, and attitudes have changed as well. Most researchers are invited to join a project, 1 in 4 take the initiative themselves. Some people are invited too many times. At KI the advice has been not to compete in one call, especially not as a coordinator. The bureaucracy that comes with European funding is more or less accepted, even though the paperwork is much loathed.

Researchers say they do not want to be in artificial consortia or networks, where at the same time they state that most networks were pre-existing. On the positive side they value the international collaboration very much, in terms of diversity and sustainability. Yet, the demand for bigger consortia in FP6 an FP7 are considered a bridge too far. Like SMEs, university researchers prefer consortia of 6-8 participants.

In almost all cases the focus of the research has not changed because of the European calls. The calls are used where they fit with their own work. On the other hand, it is noticed when a call doesn't fit their work, and they are critical to EU priorities that result from personal interest and lobbying. As a result, one subsequently thinks of action to be undertaken, indicating it does matter.

Researchers reject the importance of the management and valorisation paragraph, but on the whole there is more collaboration with industry (not necessarily Swedish industry). In addition a few of the most successful researchers in terms of number of EU projects, have been involved in their own spin offs. Examples of these spin offs are: Arexis AB (now Redoxis), BioInvent International AB, Alligator Bioscience AB, Symbicom AB and Got A Gene.

The impact of EU projects is also shown by improvement of the excellence and efficacy of research through collaborations and it certainly has improved the international reputation of research groups. At the same time, this is not solely attributable to EU funding as in the most successful research groups, EU funding represents 1/10 to 1/40 of the total research budget of a group. Therefore, one shouldn't overestimate the impact of European funding. The majority of funding comes from research councils and foundations, as wells as from charities.

The general idea is that the Framework Programmes follow the international changes, and in that way are part of the mainstream developments. Sometimes the scale of EU platforms is even shaping the trend: For instance: All clinical samples together are valuable and there is a lot of discussion on standardisation of sampling and measuring. By improving the latter, one gets much more out of community data, which is beneficial for translational research. By working together in a large consortium these issues are being dealt with in practice.

Researchers are not very positive about the networking grants (that are for meetings only); on the other hand, they are said to have some contribution and influence on the networks. But for network building it is more important to do research together. In that sense integrating projects are more interesting.

The ideas on influencing the European research agenda are clear-cut. It is possible to do, by several ways: Through a technology platform, by a high profile coordinator, Swedish contacts at the EC, accessible reports and finally through the European Parliament (albeit very time consuming). At the same time, it is also clear that Sweden is very weak and inefficient at influencing the European research agenda, because there is no common Swedish strategy that is systematically carried out. Since life science & health is very much in the picture, some researchers say it should be addressed at a much higher level by government. It is not sufficient to leave it at the level of research councils or agencies. Instead, a high-level strategy group is needed to make maximum use of European funding opportunities.

4.5.2.2 Research institutes

The main purpose of the research institutes is to support Swedish industry, in order to maintain and increase competences. European Framework Programmes and (international) collaboration are instrumental in keeping up these competences. In Sweden government funding of research institutes is relatively low and has further dropped in recent years, forcing serious reductions in people employed. Therefore, European funding is also regarded as an important instrument to increase research budgets of research institutes. However, European funding needs to be matched and when government funding is so low, matching is getting more difficult. Nevertheless, there is an active strategy at research institutes to double the volume of EU participation, as well as the number of coordinators. For SIK (Institute for Food and Biotechnology), being part of the Swedish technical research institutes, FP funding has been rather successful: At a total number of 90 fte's, they participated in a almost 60 projects, which compared to big pharmaceutical companies like AstraZeneca is quite substantial. Whereas the number of projects is decreasing, the amount of funding is increasing, as currently consortia tend to be bigger. The majority of the successful applications were in the food area. SIK expects it is getting harder to get FP7 funding: it is more difficult to distinguish yourself.

The Swedish food industry is a poor lobbyist; the food Strategic research agenda has not been much reflected in national programmes. In Framework Programmes, the fit isn't always good either; sometimes they participate in projects that are at the edge of their own competences. Especially in food, FPs have been more consumer oriented than technology oriented. With FP7, they expect to get a better fit, which coincides with the European Technology Platform Food for life in which the European Food industry is represented. SIK hasn't really adjusted its strategic agenda to match with EU calls.

The impact of EU research: There is no explicit benefit for successful applicants e.g. in tenure track, but it does help a career indirectly. More generally, EU funding results in new international contacts, and also new Swedish contacts. It has mainly increased industrial participations and with SME's in particular.

4.6 Conclusions

The impacts of the Framework Programmes on the universities have chiefly been at group level. They include the survival of some groups, growth, shifts in focus, an increase in the proportion of problem-orientated research and more interdisciplinary research. General observations are

- EU projects have significantly improved the quality and quantity in international networking and collaboration of the Swedish life science and health sector. In addition, it is beneficial for reputation
- In infectious diseases, public health has been one of the driving forces of the calls, as pandemic outbreaks (like HIV, influenza and bird flu) could severely jeopardize economics. Here there is probably less influence of the usual lobbyist. Also the consecutive calls for rare diseases come from a public health perspective.
- Sweden is losing on its life science and health SME sector: only 113 out of 630 companies know the way to European funding and this is crucial to have substantial funding possibilities up to a critical level to bridge the gap between research and development and between basis research and the clinic.
- In the life science sector pipeline, one loses quite a number of products underway that never hit the market: 50% fails in phase 3 pharmaceutical research, 90% fails phase 1. Swedish funding agencies have unrealistic expectations on the return on investment, expecting a product after three years. In life science & health sector development easily takes 10-15 years; i.e time lines are different in the life sciences
- Technology platforms are crucial instruments to influence the European research agenda. Other influential ways are a very visible coordinator (providing for strong project management results), reports that are easily accessible and also presentation of results in conferences. In addition it is important to get industry support for your research. Eventually, the European Parliament may help out. You have to know how to play the game
- Is the FP a follower or a leader is not so much the question. It is definitely a follower, but who is the leader in the life science & health sector? Not SME's, but big pharmaceutical companies through their branch organisations
- Sweden is not very good at setting central priorities in the life sciences & health sector. As a result they are not as active in lobbying as other countries. When it comes to lobbying VINNOVA is now doing the work. Usually only very urgent last minute priorities come in, like SARS. Otherwise the priority setting is a very slow process that however does work, but is not very transparent. Finland and Germany are very good in lobbying, like the UK, which may explain why the UK and Germany have most projects anyway. Life sciences should be a much higher priority at the national research agenda. The importance of

life science for health care is still heavily under valuated by government. Priorities shouldn't be set by a research council. Life sciences & health need to be represented at the highest level, and there is a need for a strategic group in which all ministries are involved, to set a joint Swedish strategy

- The EU Framework Programmes most likely have mutually affected each other. It is true to say that now there is more knowledge of the EU, and its strategic agenda
- In summary, major impacts are
  - Access to basic research, technology platforms and collaboration with academics is of major strategic importance to SMEs that participate
  - Increasing serendipity through collaboration
  - Bridging the funding gap between research and early stages of development for SMEs
  - Survival of SMEs collaborating in FPs is suggested to be higher
  - Improving international reputation of academic groups
  - Improving excellence and efficacy of research through collaboration (but attribution to FPs is less than 10%)
  - European standardisation and harmonisation of collection, storage and use of large numbers of patient material and datasets, which will improve translational research in the future
- Sweden's one big pharmaceutical company is represented and strongly involved in IMI, the Innovative Medicines Initiative Joint Undertaking, and thereby strategically active in Europe
- However, Swedish lobbying from the universities is ineffective in affecting the direction of the Framework Programme
- SME's continue to under-exploit the Framework Programmes

5 Swedish ICT In the Framework Programmes

5.1 Introduction

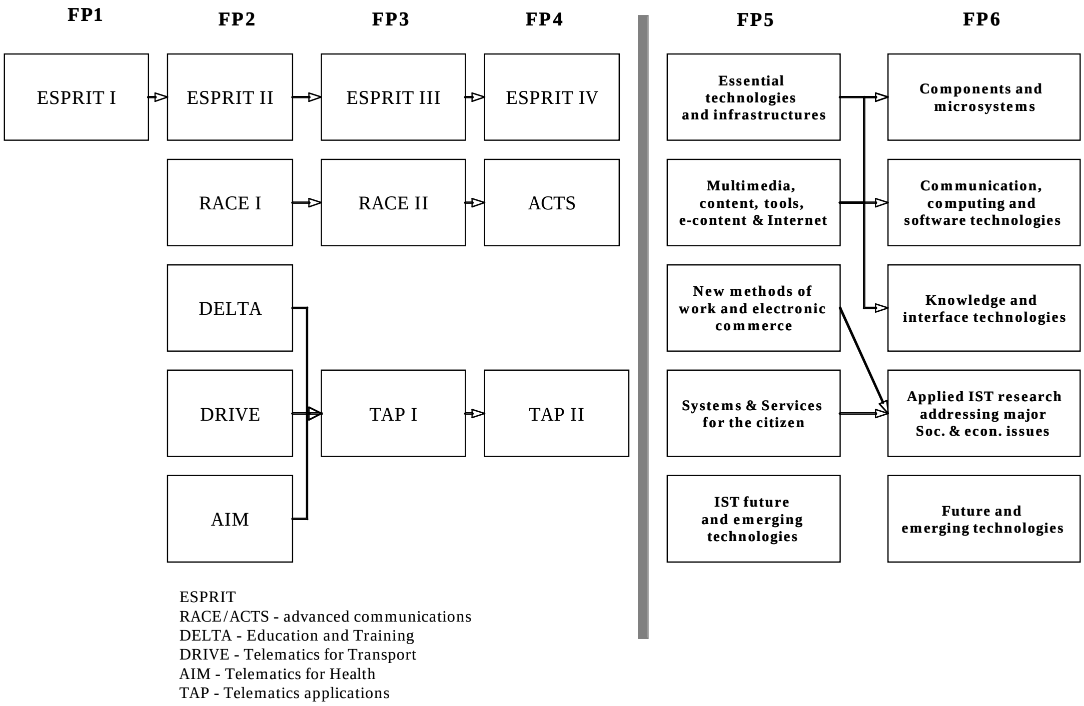
This Chapter focuses on the Information and Communication Technology (ICT) sector and the role European Framework Programmes has played. First, we discuss what the FPs have done in ICT and the overall characteristics of FP participations. Next, we look at the Swedish industrial participation, the role of the public research sector and the role of Swedish actors in the new international Technology Platforms and JTIs. Finally we draw some conclusions about impact and about policy.

5.2 Overall characterisation of FP participation in ICT sector

5.2.1 Evolution of the ICT-oriented programmes in the successive framework programmes

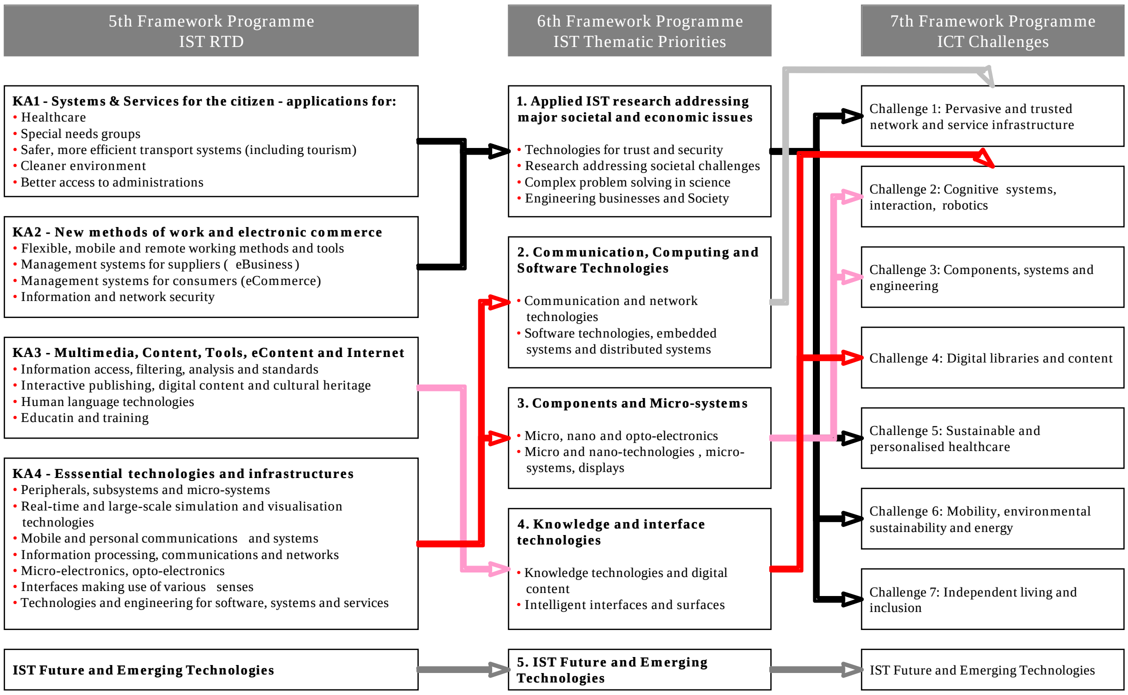
While this study goes back to FP3 the following picture shows the evolution of framework programmes from the very start with the well-known ESPRIT programme. The Second Framework Programme introduced programmes for specific application areas amongst which RACE for telecommunications, which would prove to be very influential for Ericsson (see below). Up to FP4, programmes were operating quite separately from each other and each reaching a specific ICT community. It was in the Fifth Framework Programme that all actions were gathered under the umbrella of Information Society and Technologies (IST) and the attempt was made to address ICT as a horizontal, enabling technology and to link this to different socio-economic areas. In FP6 the emphasis on socio-economic areas became was given less emphasis and interest in specific sectoral needs for strategic industries came to the foreground again.

Figure 38 ICT across FPs 1-6



The following picture shows a more detailed evolution of domains and sub-areas (thematic priorities) of the most recent three Framework Programmes in the area of the Information Society. It shows that the FPs have shifted focus from generic ‘hardware’ to applications in various areas of society and economy.

Figure 39 Evolution of domains and sub-areas in FP Information Society



5.2.2 ICT sub-sectors

The domain of Information, Communication and Telecommunications is not simply one sector but given the broad and enabling character of the technologies involved encompasses many sectors. The ICT Cluster Mapping of the Invest In Sweden Agency (ISA) identifies the core sectors and sub-divisions of those sectors in Sweden:

- Network Infrastructure (with sub categories Wireless Networks, Wireline Networks, Testbeds Network Infrastructure, Backbone Networks, Components and Sub-Systems)
- Operator Systems (with sub-sectors Core Operator Systems, Testbeds Operator Systems, Operator Value Added Services)
- Terminals (with sub-sectors Core Terminal Applications, Terminal Hardware, Testbeds Terminals, Terminal Subsystems & Accessories)
- Applications & Services (with sub-sectors Presentation Applications, Consumer Applications, Testbeds Applications and Services, Interface Applications, Enterprise Mobilisation Applications)
- Operators and Service Providers (with sub-sectors Wireline Operators, Internet Service Providers, Wireless Operators, Internet /IP and Other Operators)
- Third Party Services (with sub-sectors Network Building & Maintenance, Outsourcers, Research and Development and Consulting)

Each of these sub-sectors is again divided into several sub-divisions. Thus, matching the Swedish ICT sector with the Framework Programmes means looking at multiple sub-sectors. However, there is considerable overlap between the sub-sectors and various players have been or are active in more than one field, and/or have shifted emphasis from one sub-sector to another over the years. In addition, universities and research centres have been active in various sub-sectors as well. So in the broad ICT sector there is no ‘clean’ division of labour or R&D communities to be drawn. Ericsson AB is represented in almost all sub-clusters, but most other companies are specialised in one or maybe two clusters.

In relation to the themes of the successive Framework Programmes the two most important sub-clusters would be ‘Network Infrastructure’ and Applications and Services as in these areas most of the R&D activity is taking place. The sub-sector Operator Systems for instance does not contain many R&D intensive Swedish companies.

Overall the participation in the FPs in the ICT sector shows the following characteristics:

- Participation is heavily dominated by universities and research institutes in terms of numbers of participations

- Industrial participation shows a pattern where a small number of large companies (Ericsson AB, Telia (Telia/Sonera), Saab and Volvo) are multiple users. Other companies seem to be participating once or twice, often within one Framework Programme, but there are very few who have participated across several FPs thus over a longer period than 4-5 years
- In the ICT sector there is a large number of ‘other’ organisations that have taken part in FPs. This varies from state research agencies (e.g. Swedish Defence Research Agency, State Road and Transport Research), museums, local and regional governments

There are no data available on the funding that participants have received and companies are not willing to share this information. So little can be said on the financial weight of the FP participation and how much funding went to which type of project. The ICT data provided to us also miss the information on the sub-programmes/work programmes in which the Swedish projects took place so this prevents a statistical analysis by sub-sectors.

5.3 Swedish Participation in the Framework Programmes

5.3.1 The participation of Swedish industry in the Framework Programmes

Industrial participation in the consecutive Framework Programmes can be characterised as follows:

- There are only a small number of companies which have participated in more than one Framework Programme and in three or more projects: Ericsson AB, Telia and later Telia/Sonera. Volvo AB, Saab AB (both automotive and aeronautics related). Other companies include Autoliv Electronics AB (applications for the automotive sector), Biosensor Applications AB, CNET Svenska AB (software house), Silex Microsystems AB, SSPA Sweden (maritime software and management systems), Teracom (telecoms/internet provider), and WirelessCar Sweden
- Most small and medium sized companies take part once or twice, but are not regular users of the FPs over time. According to interviews with intermediaries most SMEs find participation in the FPs a too high burden (long application procedures, administrative requirements) and if they seek public support, would rather use national support schemes than the European programmes
- Apart from Ericsson and Telia in the telecommunication sector, most other companies are connected to one of Sweden’s other strong clusters, e.g. automotive, engineering, the maritime sector. There seems to be

little business sector activity in the combination between the Swedish health sector and IT applications (with the exception of Biosensor Applications AB which has had one FP5 and 2 FP6 projects, but no FP7 project so far), despite a considerable role of Karolinska in this area. There are only a very small number of companies active in the micro-systems and micro-/nano-electronics sector (with the only exception of Silex, a spin-off company of ACREO which has grown considerably in the last years) or software multimedia /development

If we were to demonstrate economic impact this would be most clearly found in the telecommunication area with Ericsson and Telia (Telia/Sonera) as the two main players.

Ericsson's transformation from a minor fixed-line telecommunications equipment supplier to a global player in mobile communications has been documented in detail elsewhere in a VINNOVA study[48]. The company had considerable success in first generation mobile telephony thanks to the creation of the NMT standard by the Nordic PTTs. With support from Swedish national programmes including NMT and IT and a succession of project and programme funding by STU in the late 1970s and through the 1980s, Ericsson was able to master both the components and communications technologies needed to take a lead when second-generation mobile telephony began (with GSM in Europe, rapidly followed by other standards in the Far East and USA). While the European Commission made a key contribution by setting aside the 900MHz band for 2G mobile telephony in 1985, the GSM standard was largely settled in discussions at CEPT and later ETSI by 1987, when RACE – the first telecommunications programme within the FPs – started in 1987. RACE quickly became the natural forum for European efforts in broadband fixed and mobile (ie 3G) telecommunications. Initially, RACE concentrated on the Time Division Multiple Access used in GSM as a basis for the long-run vision of a Universal Mobile Telephone Service (UMTS). In 1992, RACE 2 switched the approach to Code Division Multiple Access in an Ericsson-led project called CODIT. Ericsson regards this and the subsequent FRAMES project as crucial to its continued success in 3G – not only because of the technology developed but also because of the agreement the projects generated in the industry about the road map for 3G mobile telecommunications. At the same time, however, it must be pointed out that from the point where GSM was standardised in the 1990, Ericsson was very actively working in projects on the other world standards, a practice it has extended in the 3G period.

[48] Erik Arnold, Barbara Good and Henrik Segerpalm, *Effects of Research on Swedish Mobile Telephone Developments: The GSM Story*, VA 2008:04, Stockholm: VINNOVA, 2008

While the FPs had important short-term effects in building networks and creating agreement about the technical shape of 3G, the timescale between working on the technology in FP3 and FP4 and products appearing on the market can be very long. Only now that the 3G market is finally growing rapidly are products reflecting some of the technical results of work in RACE and ACTS reaching the market.

The bursting of the 'Internet bubble' and the simultaneous postponement of 3G-infrastructure procurement by most operators early in this decade hit Ericsson hard. One consequence was that it was no longer possible to maintain its sub-scale component operations in Sweden, which in the past had proved a crucial lever in accessing the latest component technologies. The retrenchment that followed means that Ericsson's engagement in the FP now has a much narrower technological base than before, focusing on 'ambient connectivity'. The role of state support in building Ericsson's position has clearly evolved. The support of the Swedish state was crucial for most of the company's first century (fixed telecommunications). Then the crucial support moved first to the Nordic PTTs (1G), the European PTTs and Swedish Telecom (2G) then the FPs, increasingly combined with Ericsson's other international collaborations in 3G, where standardisation has become a truly global game and where a Europe-only approach no longer works. The corollary is that while TeliaSonera maintains a presence in the FPs (often in conjunction with Ericsson and normally working with services-related questions rather than the kind of 'hard' technology issues it previously addressed) it no longer has great importance for Ericsson's development or much of a role in technological development. We can nonetheless conclude that the FPs have played a vital part in securing Ericsson's position in 3G, the likely basis for its recovery from the setback of the early 200s but that these days they must be seen as one block in the global approach needed to succeed in advanced ICT.

Although the FP data are known to be incomplete Ericsson AB (including all Ericsson companies) has participated in over 200 EU projects. [49]

Up to approximately 2003 Ericsson also participated in research projects related to micro-electronics, software design and sub-systems. This was not solely in the ICT programmes (as far back as ESPRIT programme in the 1990s with activities in IC-design, software development, etc) but also in more manufacturing oriented programmes such as Brite-Euram (e.g. micro-systems, IC design and packaging).

[49] A CORDIS search finds 215 projects with Ericsson involvement including older programmes such as ESPRIT, while our VINNOVA data has only 46 Ericsson projects. The large discrepancy can not be explained by the few non-Swedish Ericsson projects in the list

Particularly influential have been the early RACE (1 and 2) and ACTS projects on setting the standards in 3G. Examples of projects that Ericsson considers as important for their current position, are for instance the CODIT project in RACE-2 (1992-1995) and the FRAMES project (1995-1999) in ACTS. The first project led by Ericsson included the major European telecoms operators (including Telia) and hardware manufacturers and developed a testbed for UMTS. The FRAMES project, led by Siemens, was aimed to define, to develop and to evaluate a wideband and efficient multiple access scheme which fulfils the UMTS requirements. Both projects helped to set standards for major requirements for 3G and the use of CDMA instead of TDMA as the interface structure. One the basis of the CODIT results Ericsson decided to build its own testbed in Sweden to develop results further. The first 3G products are still to be expected in the market in the coming years. Whereas the Ericsson led CODIT project did not have other Swedish research partners, the Frames project included both Chalmers and KTH.

Interviewees from public research organisations and other experts have also commented on the diminishing of R&D activities and interests at Ericsson and Telia after the troublesome years around 2002/2003. While Ericsson had a broad spectrum of R&D activities, with the selling of for instance the micro-electronics divisions, research activities in those domains disappeared quickly. Therefore an interest to take part in FP projects or forms partnerships with research centres decreased rapidly. However FP6 data suggest that Ericsson has been a consistent partner for a number of Swedish universities and research centres.

In FP6-IST Ericsson AB projects often included partnerships with Swedish research centres and universities and often with more than one of these centres involved in a project.[50] In the 20 FP-IST projects in which Ericsson AB participated, the projects also included Chalmers (3 collaborations), ACREO (4 collaborations), KTH (8 collaborations), SICS (3 collaborations), and also Lund (3), Karlstads University (2), Uppsala (2) ad Lulea (1). Where Ericsson AB was leading the consortium (4 cases) there was always another Swedish research partner on board. However other Swedish companies were rarely part of the consortium (Telia 6x and ConnectBlue 1x). Very often other Ericsson subsidiaries (Germany, Hungary, Spain, Netherlands) take part or even lead projects, but mostly in combination with the Swedish company.

While Ericsson's interests were technologically much broader in the 1990s, today the company focuses on multi-media applications through various

[50] Based on CORDIS analysis.

devices. The mobile phone is not longer seen as the main device for communications, but it can also include laptops, televisions and other hand held devices. Ericsson has broadened its scope from mobile telecommunication (and all technologies involved) to broadband communication, multimedia technologies, Internet protocols, networks and network security, wireless access, signal processing. Today the company is focusing its European R&D projects on 'Ambient Connectivity' including topics as media delivery, mobility, domain management, multi-access, connectivity control, security and connect provisioning.

The main benefit of participating in FPs for Ericsson is the early sharing of risks, before common standards are set. It helps create a common mind-set and developing more 'open communications technology standards'. The emphasis is on projects, which are in the pre-commercial research and testbed phases and often include the major European competitor firms. The influence of the RACE programmes on setting the GSM standard and the role of Ericsson /Telecoms Sweden in this has been studied in detail in a recent study by Erik Arnold et al.[51] Ericsson's lead in HSPA technology (expected on the market from 2010) has also benefited from FP participation, but its contribution needs to be seen as 'one piece of a larger puzzle'. As Ericsson considers its FP activity as rather 'upstream' a direct link to products and their economic impacts is difficult to make. R&D activities in the late 1980s and early 1990s (development of 3G) were focussed on technologies that only see its real market introduction today and tomorrow. Only on generic topics, such as display and battery technologies, more closer to the market cooperation with competitors in EU projects is feasible. On other domains after the first testbeds each competitor develops its own applications. Ericsson considers projects in which it has taken a leading position (coordinator) as more successful in terms of taking a lead research position compared to its partner companies. The company is selective in choosing these projects in which it takes a lead.

The consecutive Framework Programmes have matched the companies' main challenges quite well, although in the more recent FPs and particularly FP7 the Commission seems to listen better to the needs of the industry, compared to the older programmes where priority themes were set in a top down manner. In this sense the Technology Platforms have worked quite well in setting Strategic Research Agendas that have been translated into the work programmes of FP7.

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[51] Erik Arnold, Barbara Good and Henrik Segerpalm, *Effects of Research on Swedish Mobile Telephone Developments: The GSM Story*, VA 2008:04, Stockholm: VINNOVA, 2008

However, participation in FPs has had very little effect on the skilled human resources within Ericsson. Although the financial impact of the FPs is not made public, it is considered to be not large enough to have made a quantitative impact on the number of researchers employed by the company. In addition, Ericsson stresses that European collaborative research is only a small part of the international R&D activities: Ericsson takes part in collaborative R&D projects in the US, China (over 800 projects), Korea and Japan.

Some interviewees have commented on the importance of the close relationship between Swedish Telecom and Ericsson in jointly developing testbeds for new generations of mobile communications. With the breaking up of this ‘natural partnership’ after privatization of Swedish Telecoms and the subsequent merger of Telia and Sonera, this trusted partnership for testing new technologies changed character. However looking at the most recent FP6-IST projects where TeliaSonera AB has participated (in total 13 projects), six of these were in partnership with Ericsson AB. Typically TeliaSonera AB takes part in large FP6 projects involving many European telecoms actors, it never takes the lead in a EU research project and in almost half of the project the company teams up with Ericsson AB. The research topics include network architectures, wireless technologies, internet interfaces and network access technologies. Despite the difficulties in the telecoms sector and the merger with Sonera its European R&D activities have not decreased, as the company had a similar level of projects in FP5.

As afore mentioned there are very few smaller companies that have participated in the Framework Programmes more than once. One of the smaller companies interviewed was active in Framework Programme 5 and 6 in software development and particular middleware technology for service-oriented architectures. The company has ties with universities, as the founder and staff originated from a Stockholm research centre (SISU) and an FP4 project in Telematics lay at the basis of the founding of this company. It was due to their background as researchers that they were contacted by European partners who wanted to include the company in an FP5 project. The company would in EU projects typically focus on prototyping software applications in interactive network architectures, while more academic partners do longer term research. While at first the focus was on e-learning, later participation shifted attention to mobile software applications. The first project on e-learning led to many new insights and knowledge, prototyping of applications, and international networks, but in the end there was little commercial benefit in the e-learning segment of the market. The knowledge of that project could be used as a basis for a follow-up EU project, which shifted attention to mobile use of middleware technology. The two EU projects fitted very much into a long-term development strategy of the company, of building up competences in certain areas and discovering which areas were not interesting to pursue. EU funding as a way to contribute directly to product development was considered by the companies' director to be unrealistic. As an advantage of EU-projects as against to national funding was the transparency of the proposal evaluation and the feedback given on proposals, even if they failed. The downside from the small company perspective is the cash flow problem it creates due to late payment.

It was considered difficult to obtain national funding for software R&D as it is considered too close to the market by Swedish agencies. EU funding represents about a third of the companies' development and 100% of its longer-term research. While the EU projects are just 'a piece of the puzzle' the company could hire more R&D staff thanks to the EU projects. Currently the company is the 'technical co-ordinator' of an Integrated Project still running under FP6.

5.3.2 The participation of the public research sector

Although this study focuses on a number of universities in Sweden in the area of ICT we need to also include the non-university sector (ACREO AB and SICS) and KTH to have a complete picture on the influence of the Framework Programmes. Public sector research and the universities have a large majority of the FP participations. Their role goes back to before Sweden entered the European Union in 1995.

The following figure shows the development of participation from the major research actors in successive FPs. Lund, Chalmers and particularly KTH form the main core of IST related research in Sweden. All three show a considerable increase in participation in FP6. Lund's participation is from a wide range of scientific domains including mathematics, robotics, physics, engineering and telecommunications. Chalmers' domains participating in ICT projects involves micro-electronics, robotics, telecommunications (particularly wireless), physics, engineering and health management departments. The strongest research actor is by far KTH with involvement of numerical analysis and computer sciences, physics, speech technology, electronics, micro-electronics, engineering and the department for user centred IT applications. Even more so than with industry participation, for public research participation it is difficult to point out very specific pockets or niches with typical Swedish strengths, as the domains and topics seem to be widely spread, albeit with a considerable bulk of telecoms and robotics related research activities.

Our interviews with various research leaders from various universities and research centres suggest that there are three typical groups of public research departments /centres:

- A group where participating in EU projects is an essential element of their R&D work and strategy as well as an important source of research income. These tend to be:
  - In areas where Swedish national funding is of low priority (nano-electronics, software development)
  - In applied (industrial) research and even development
- A group where EU projects are a relative important ‘piece of the puzzle’ and these tend to be:
  - Those where basic funding is at ‘medium’ level and
  - International collaboration is necessary to gain visibility within the own institutions
- A group where EU funding is just an additional pot of funding. These tend to be:
  - In more academic fields
  - In areas where national funding is more generous

Collaboration with industry in FP projects is limited to collaboration with the larger companies (notably Ericsson) and hardly involves Swedish SMEs or high-technology start-ups. The Europractice projects in which ACREO plays a leading role is the exception to this and allows SMEs to use research facilities (clean rooms, IC prototyping facilities etc) for prototyping and demonstration projects. Thus national research centres and universities cannot be used by Swedish SMEs to ‘piggy back’ into the Framework Programmes.

The **benefits and impacts** of taking part in FP differ between these three groups but general impacts for research departments are

- Increased international partnerships and greater international visibility (and credibility as future EU partner). Partnerships with foreign universities / research centres are created and maintained on a project-by-project basis rather than through strategic alliances. We have not heard any strong evidence suggesting that lasting partnerships with foreign companies have resulted from EU projects, rather the tendency is still that companies bring their national research partners along.
- International co-publications have increased due to EU research projects
- In case of the third and second group EU participation has formed a leverage for additional funding. For some groups EU funding is more than a third of their annual research budget and dependency on the Framework Programme for maintaining research staff is high.

- Recognition of a department within the own university has increased due to successes in obtaining EU funding and the international visibility that has resulted from this.
- The scientific impact is difficult to establish in such broad thematic fields but the reported increase of international co-publications will most likely have had a positive impact on scientific citations. Interviewees state that EU participation has brought them scientific and technological advancement and additional expertise that they would not have achieved without the projects. They see this as one building block in their portfolio of research activities.

However on other topics the influence or impacts were small to modest

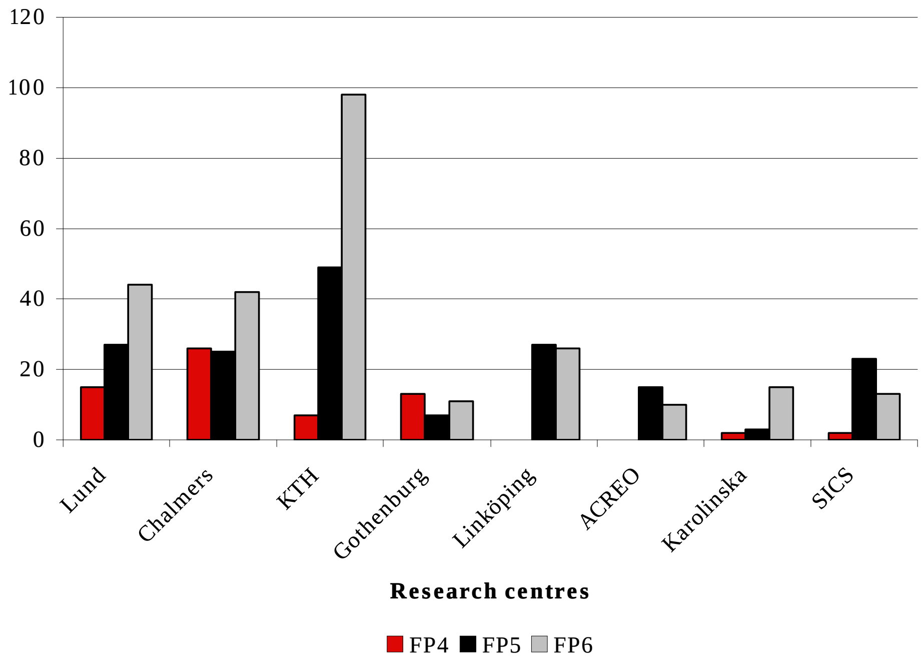
- There is little indication that EU thematic priorities changed Swedish research agendas: participants seek clearly if work programmes match their own existing research lines and use EU projects as one piece in the puzzle to develop a particular research domain
- Apart from departments that have a high EU funding dependency the impact on the human resources of public research in Sweden is indirect by adding to overall funding flows. Few professors that we have spoken made use of Marie Curie Fellowships or similar EU schemes to attract foreign researchers, nor has EU participation led to recruitment of researchers from partner institutions in any significant way
- We have not found significant evidence that EU projects has provided the universities with patents and licences for which they received considerable revenues or which led to the creation of start-ups

There are a number of **bottlenecks** to EU participation that professors and research managers reported on frequently

- Participation in FPs needs co-funding and over the years the ability to find this co-funding has influenced the possibilities to enter into new EU projects. Several research departments noted that the low amount of ‘free money’ or basic funding and the fluctuations of this funding over the last decade, have made a big difference in terms of ability to engage into FP projects. Particularly the research centres engaged in applied research have reported on this as a major issue;
- As in all sectors and countries the huge administrative burden of leading EU projects prevents researchers from taking a coordinating role even though the relative impact and benefits are potentially larger. Particularly with the Integrated Projects introduced in FP6 the willingness to lead consortia has dropped drastically. Interviewees report that this coordination costs at some periods in the past decade were supported by VINNOVA but the policy on this has fluctuated. Interviewees would see the benefits of reinstalling this type of support (top-up subsidy for project management and proposal coordination);

- Most universities are not well equipped to support the project leaders with administrative and project management resources. Chalmers seems to be the exception to this rule.

Figure 40 ICT participation by selected Swedish research performers



5.4 Role of Swedish players in international platforms (European Technology Platforms, Joint Technology Initiatives)

There are a number of important European Fora in the ICT area where key players are present. The question is whether Swedish players are also active on these platforms which have become important vehicles to shape the work programmes for the 7th Framework Programme. One should thus expect that being a key player in these fora helps to put forward the Swedish research interests.

The European Technology Platforms, an initiative initiated by the European Commission to enhance the development of European Strategic Research Agendas , has a number of important ICT related platforms:

- Artemis (for Embedded Systems); Artemis has two Swedish players in the Steering Board: ABB and Ericsson, but not in the Executive Board. In the subsequent Joint Technology Initiative (Artemis IA) which will receive ample funding from member states and the European Commission, neither companies were involved as founders or key actors

- eMobility (for mobile and wireless communications); Ericsson AB is playing a leading role in eMobility in the Steering Board and the Executive Group
- NEM (Networked and Electronic Media); Ericsson AB is a member of the Steering Board but not in the Executive Committee
- ENIAC for micro- and nano-electronics. Ericsson AB is a member of the Forum of Stakeholders. In the subsequent Joint Technology Initiative, Ericsson is not one of the founders nor corporate members. Acreo is one of the active members of the JTI as only Swedish actor. There are no Swedish members in the Scientific Advisory Committee
- EPoSS European Technology Platform on Smart Systems Integration; There are no Swedish players in this platform

Although it is difficult to picture direct causalities, the active participation of Ericsson in consecutive Framework Programmes has definitely contributed to their role in some of these Technology Platforms. However the company has chosen to focus on eMobility which the company considers as its key domain for the future and thus the other ICT domains do not have strong Swedish influences.

For industrial research we must however also take into account the Eureka programmes which can be much more interesting for companies as it concerns applied collaborative research. Funding levels are however dependent on national programmes and rules. The main Eureka Strategic Initiatives (Clusters) in the ICT field are

- CATRENE (Cluster for Application and Technology Research in Europe on NanoElectronics with a budget of €3 billion) and successor of MEDEA and MEDEA+. No Swedish partners are involved
- Euripides (merger of former PIDEA and Eurimus) on smart systems (budget €1.2 billion). There are no Swedish industrial partners on board, but Acreo is member as scientific partner
- ITEA 2 (advanced pre-competitive R&D in software for Software-intensive Systems and Services) with a budget of €3 billion. There are no Swedish companies on the Board or founding members
- Celtic (Telecommunications) with budget of €1 billion; Ericsson is strongly involved in CELTIC and is member of the core group. There is no Scientific Advisory Group in this cluster

Overall we could conclude that

- Today the presence of Swedish industrial and research partners in the main European strategic programming bodies is limited and restricted to Ericsson's core area of expertise: wireless and broadband telecommunications. The ICT domains of micro- and nano-electronics, smart systems, software development do not have any Swedish industrial representation

- Despite the strong participation of the Swedish universities in the Framework Programmes none of these universities takes part in the more industry oriented strategic initiatives, unlike for instance German, French, Finnish, Spanish, Belgian Dutch and Irish public research actors. ACREO as non-university research institute is the exception to this Swedish pattern. Individual professors could possibly be involved in Scientific advisory committees or individual research projects (EUREKA) but as institutions Swedish research organisations and universities are quite invisible. This confirms the previous findings that there is a gap between the university interests and the industry interests in type of FP research projects and joint participation of Swedish public and private partners in projects is limited
- This means that Sweden is hardly represented at those fora that are influential in defining the research agendas of tomorrow

5.5 Overall Observations and Conclusions in the ICT Area

As a general conclusion participation in the ICT domains of the Framework Programmes has had several positive effects:

- Given the enabling character of ICT the economic impacts are dispersed over various sectors and multiple single actors. The main area where a significant influence can be demonstrated of EU (and other international) programmes is in the telecommunications area and particularly in the wireless networks and related technologies. Here the beneficiaries of the economic impacts are mainly Ericsson and to a smaller degree Telia who have been major users of consecutive FPs. However these companies have not created or taken along a cluster of suppliers or other specialised companies to join the EU projects. Ericsson has developed collaboration networks with a number of Swedish universities and research centres in particular Chalmers, Lund, SICS, ACREO and KTH although not only through EU channels but mainly using national subsidy channels
- There are a very small number of smaller companies that have participated more than once in FPs. These are R&D intensive firms for whom the international networking, the knowledge building have shown substantial contributions to the longer-term development and positioning of the firm. EU projects are for them one ‘piece of the puzzle’ that helps build up competences. A direct link from an EU project to discrete products is less easy to establish
- EU participation has increased the international visibility and activity of research partners in public sector research. While it has not drastically changed Swedish research agendas, through cross-fertilisation and knowledge sharing scientific and technological progress and impact have had a positive boost according to interviewees. Long-term

bibliometric research in specific domains would be able to substantiate this with harder empirical evidence

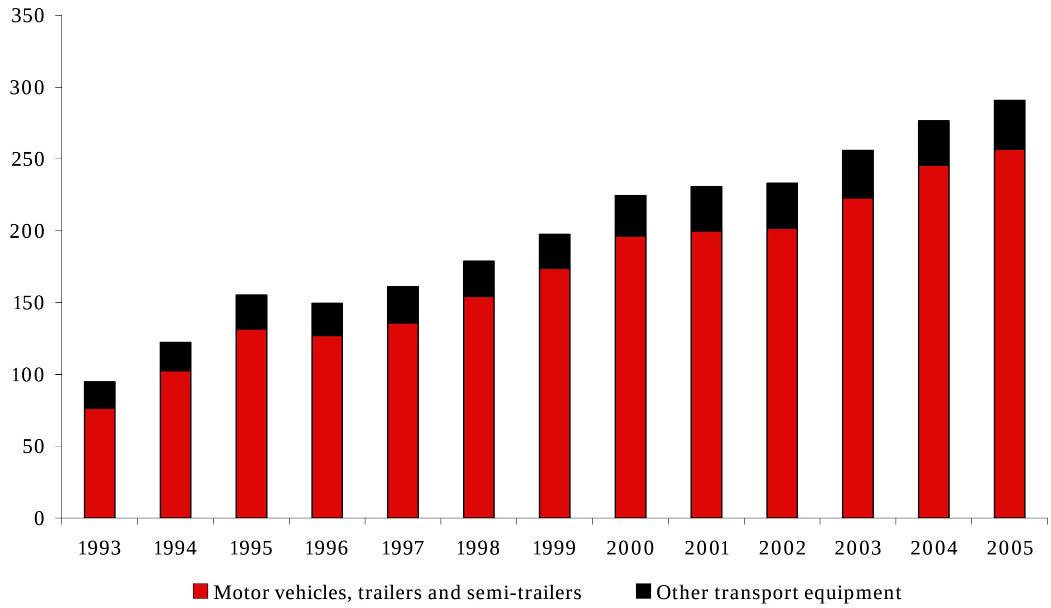
- With the exception of the telecoms area and in application areas such as automotive, industry-academia collaboration is weakly developed and universities are mostly interested in the more fundamental parts of the Framework Programmes
- The agendas of European research are today set in International Fora such as European Technology Platforms, Joint Technology Initiatives and EUREKA clusters. Swedens' position on these fora seems to have eroded, mainly because Sweden has hardly any industrial partners that take an active role in this (see previous paragraph) and research centres and universities are not present in most of the scientific advisory boards. Influence on strategic research agendas thus mainly takes place through the policy route. Today with larger emphasis on demand led research programming that will not be sufficient to have a decisive voice. Sweden could do more in supporting the few medium sized firms to take up more strategic roles

6 The Vehicles Industry

6.1 The Industry in Sweden

The vehicles industry is a major component of the Swedish economy. As the production data from the national accounts suggest (Figure 41), road vehicles dominate. Marine vessels and aircraft comprise the upper parts of the bars in the Figure. Most of our attention in this chapter focuses on road vehicles though we also touch upon aspects of aerospace and rail.

Figure 41 Swedish vehicles industry production at current prices (BSEK)



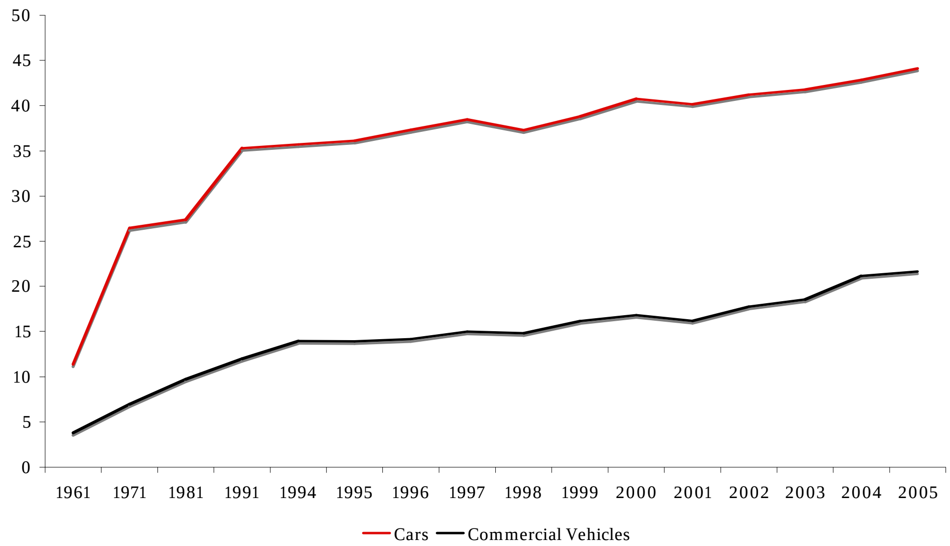
Source: SCB

Road vehicles are a massive global industry. Figure 42 (beware the changes in scale on the horizontal axis) shows the development of the world's production of road vehicles since 1961 to a total of 66 million in 2005. The commercial vehicles figures include light commercial vehicles, SUVs etc. Sweden's production of commercial vehicles is focused on the heavy (more than 16 tonnes) segment, which is only a small part of the commercial vehicles curve shown below. Global vehicles production was about 60m units in 2006 and – even if there are changes in the mix of large and small vehicles – the number of units continues to grow.

The Swedish shares of production are very small (Figure 43), hovering at about one percent in cars and half to three quarters of a percent in commercial vehicles until 1999, then falling – though the decline in commercial vehicle (CV) production is an artefact of classification: from

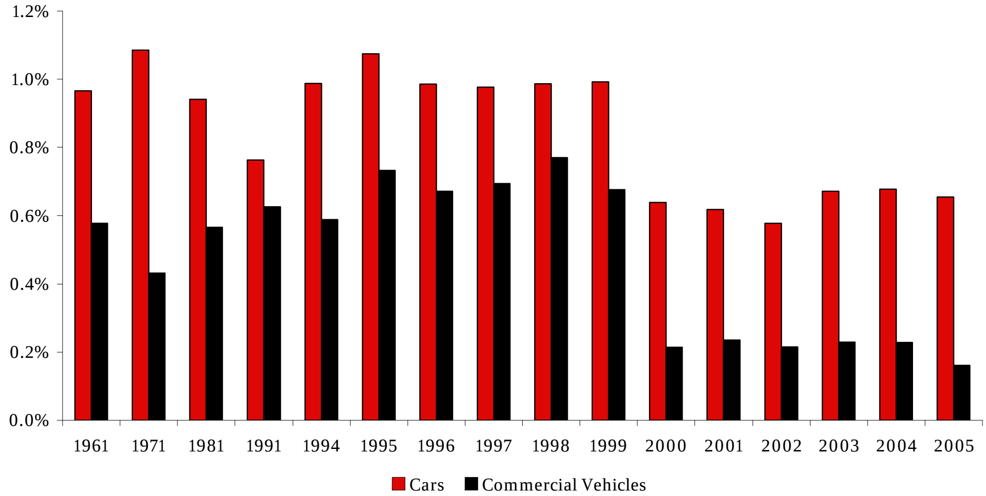
2002 the country of final assembly, not manufacture, is the basis for classification. Sweden is 21st in the global ranking of vehicle producing countries (Figure 44). Swedish vehicles manufacturers (VMs) also have plant outside Sweden, so their collective market share is about twice that shown in the production statistics. Figure 45 shows the development of Swedish manufacturers' overall production (not just that in Sweden). The area of growth is in Volvo Truck's heavy commercial vehicle business, largely driven by the acquisitions of the operations of Renault and Mack.

Figure 42 World production of cars and commercial vehicles, 1961-2005 (millions)



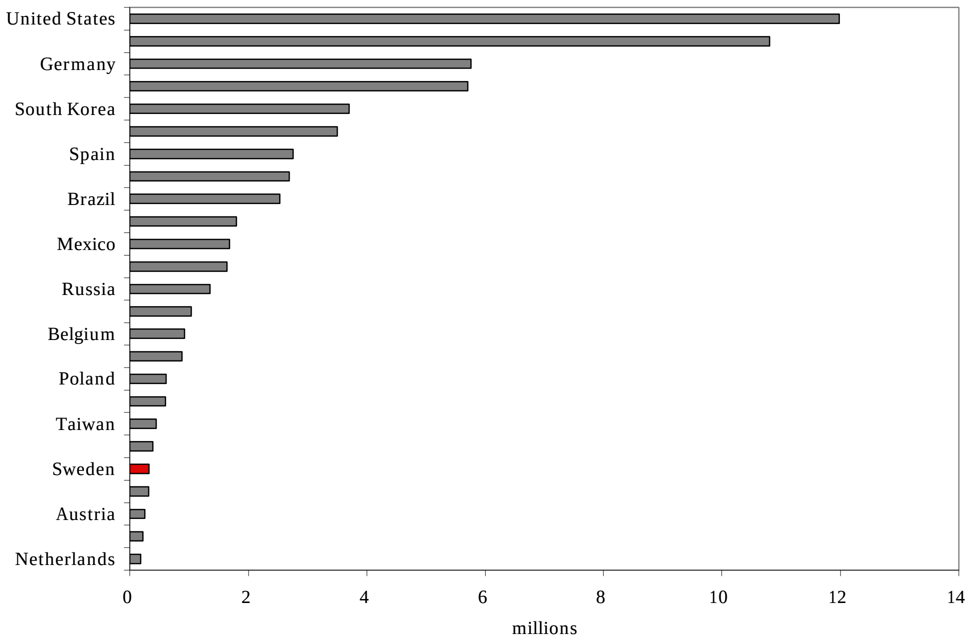
Source: Wards Motor Vehicle Facts and Figures 2006, Southfield, MI accessed at the US Department of Transportation web site

Figure 43 Swedish share of global car and CV production



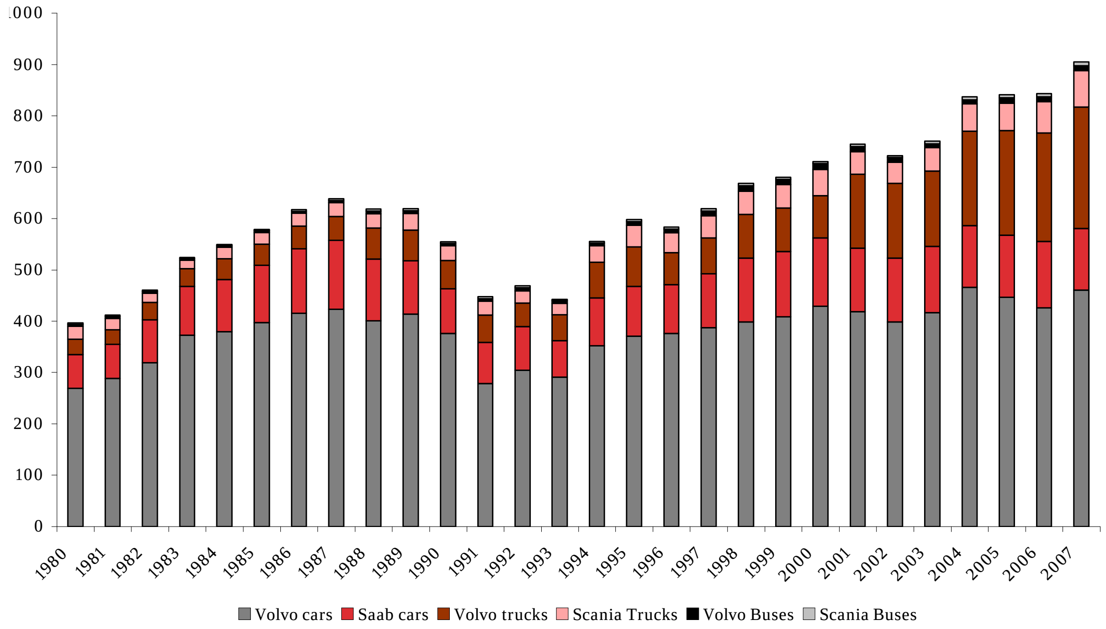
Source: Wards Motor Vehicle Facts and Figures 2006, Southfield, MI accessed at the US Department of Transportation web site

Figure 44 World road vehicles production, 2005



Source: Wards Motor Vehicle Facts and Figures 2006, Southfield, MI accessed at the US Department of Transportation web site

Figure 45 Overall production of road vehicles by Swedish manufacturers



Source: Bil Sweden. Volvo Truck includes Mack and Renault from 2001 and Nissan Diesel from 2007

The automotive industry has huge economic significance for Sweden. About 140,000 people (one fifth of the manufacturing labour force) work in the industry: some 67,500 for the vehicle manufacturers and the rest for component manufacturers[52]. Road vehicles and components provide 15% of Sweden's exports. Around 85% of passenger cars and 95% of trucks made in Sweden are exported. However, compared with larger vehicles-producing countries, the domestic supply of components is modest – only about 35% of the bought-in value of components comes from Sweden. The rest is imported, so the industry makes quite a big contribution to imports as well.

Sweden has had four substantial road vehicles makers during the period covered by this study.

- Volvo AB (trucks, buses and also heavy construction machinery, which is not discussed here)
- Volvo Car, which Volvo sold to Ford in 1999
- Scania (trucks and buses), which was part of the Saab group from 1969 when Saab bought Scania-Vabis and until 1995 when Scania was de-merged to become a separate company. The European Commission vetoed Volvo's take-over bid for Scania in 1999, as a result of which

[52] *The Automotive Industry – an Integral Part of Innovative Sweden*, Stockholm: Ministry of Industry, Employment and Communications, 2005

Volkswagen bought almost half the company and has since increased its holding to more than two thirds

- Saab Automobile. General Motors bought 51% of Saab's car division in 1990 and the balance in 2000. From 2008, however, production of Saab cars is being transferred to GM's Rüsselsheim factory in Germany, leaving Saab to produce powertrains and short-series vehicles for GM

Volvo Car has been making about 400,000 vehicles a year recently, and Saab Automobile somewhat under half of this. Both divisions are 'premier' brands within their US parents' portfolios and are therefore exposed in the current market shift towards smaller and more fuel-efficient vehicles. Together, their global market share is well under 1% of passenger cars. However, in the heavy (over 16 tonnes) truck segment, Volvo and Scania together have about a 20% world market share – though less than a fifth of this is actually produced in Sweden.

There are three other companies making road vehicles in Sweden. The Italian Pininfarina company has a small plant in Uddevalla making specialist and short series models, including for Volvo. Koenigsegg produces about 30 high-end sports cars per year. Hägglunds (now part of the BAe Systems group) makes fighting vehicles in Örnskjoldsvik.

Upstream, the Swedish components industry contains a handful of nationally owned large firms – Autoliv, SKF, Haldex and SSAB (steel) – but most of the industry comprises small Swedish firms or production plant owned by multinational component makers.

In the aggregate, the Swedish transport industries (including air and marine craft) performed BSEK 15.8 of R&D in 2005: 20% of BERD as a whole. Of this, the state funded 10.7%, compared with a national average across all industries of 4%. Ten years earlier, the state was funding 15% of the transportation industries' R&D. Some 11,490 people worked in transportation industry R&D in 2005, compared with 8,714 in 1995.[53] The high share of state funding is partly a function of military spending (primarily on aerospace) and the fact that Sweden invests substantially in national R&D programmes for the vehicles industry.

PwC argues[54] that, especially since the enlargement of the EU beyond fifteen member states, Sweden's labour cost disadvantages compared with alternative production locations in Europe have worsened while the Swedish taxation regime is more onerous that that in other vehicles-producing

[53] Statistics from SCB

[54] PwC Automotive Institute, Automotive industry investment and location drivers: Focus on Sweden, Pricewaterhousecoopers, 2005

countries. While Sweden's labour costs are lower than those in Germany, production scale and the attractiveness of both the large automotive market and the supply industry in Germany with its associated large labour market can outweigh this. The Swedish automotive industry is therefore squeezed between low-cost producers on the one hand and larger, established producing countries on the other.

Swedish industrial policy has been to support the vehicles industry via a range of measures. Since 2004, these have included the so-called Trollhättan package of research, training and transport infrastructure support aiming to increase the attractiveness to GM of keeping the Saab Automobile factory in Sweden open.

In 2005, the government made an attempt to coordinate measures for the automotive industry, which was one of the major branches in focus in the Innovative Sweden programme, through an agreement between the government and the industry. R&D support for the industry was a key plank in the strategy, which nonetheless largely described existing actions and policies rather than adding much that was new. In fact, the Swedish state has had R&D funding agreements in place with the automotive and aircraft industries since 1994. In the early 1990s, the objective of the Vehicles Research Programme (FFP) was to increase the Swedish vehicles industry's competitiveness in the market through increased cooperation with the university system and the resulting increased supply of research-trained manpower. The changes in ownership since that time mean that more decisions in the VMs are made outside Sweden, there is a greater degree of technological specialisation within the multinational VMs. Hence the extent to which Swedish VMs themselves design entire vehicles has diminished. Especially since the turn of the century, the FFP and other forms of R&D support to the automotive industry have increasingly been about strengthening the Swedish VMs' positions in the **internal** competition to be allocated R&D and production tasks within the multinationals. Lübeck argues[55] that this implies R&D support needs increasingly to be tailored to the individual companies and their role in the international division of labour rather than being uniform or based on a 'level playing field' notion.

National R&D funding relevant to vehicles comes from a number of sources. During the 1990s, the Swedish Transport and Communications Research Board (KFB) funded work on policy and sustainable fuels. The Swedish National Board for Industrial and Technological Development (NUTEK) was responsible for funding research on industrial innovation and

[55] Lennart Lübeck, Förslag till Forskningsprogram 2009-2013 för en svensk fordonsindustri med hållbar inriktning, available at www.pff.nu

during the second half of the 1990s it also contained the energy agency function, which has a long tradition of funding R&D on fuels and energy production. From 1998, the Swedish Energy Agency (STEM) acquired the responsibility for energy R&D while in 2001 KFB and the industrial innovation part of NUTEK were merged into today's Swedish Agency for Innovation Systems (VINNOVA).

In parallel to these agencies' efforts, the Programme Board for Automotive Research (PFF) has run programmes based on agreements between the state and the vehicles industry since 1994. The Vehicle Research Programme ran from 1994. The state contributed 30 MSEK per year in funding at Swedish universities, matched by industry's own efforts. State funding rose to 50 MSEK per year in 2006-8. From 2000 to date PFF also ran the Green Car programme, contributing about MSEK 500 (30% of the total budget) over the period. In both programmes, the industry itself together with government agencies (in committee) decided what to fund and the emphasis was more on medium-term developments, typically incremental improvements to petrol and diesel engines rather than longer-term work on more radical changes (such as hybrid drive lines or fuel cells) – though the first part of the Green Car programme contains some work in these areas. Longer-term engines research has been funded at universities by the Energy Agency. Two newer programmes have since been funded under the PFF umbrella: the EMFO Emissions Research Programme (2002-8. With the state paying two thirds of the budget, which turned out to be a little over MSEK 140) and the Intelligent Vehicle Safety Systems (IVSS) programme (2003-2008, where the state pays MSEK 370 of the total MSEK 640 cost). In these last two programmes, proposals are peer reviewed and approved by state agencies: VINNOVA; the Swedish National Roads Administration (SNRA), the Energy Agency; the Environmental Protection Agency (SNV); and the Invest in Sweden Agency. In combination, PFF and the agencies' 'business as usual' programmes provide a long list of automotive-relevant programmes also spanning production technologies, vehicle telematics, vehicle deign, road vehicle energy systems and alternative fuels.

The other major source of national funding for vehicles research is the Competence Centres programme launched in 1995 and its VINN Excellence Centres continuation at VINNOVA. Key competence centres funded since 1995 by NUTEK and then STEM are

- Competence Centre for Combustion Processes, Lund, which tends to focus somewhat on turbines
- Competence Centre for Catalysis, Chalmers
- Combustion Engine Research Centre, Chalmers, which is more orientated to reciprocating engines

In 2006, the Centre for ECO2 Vehicle Design was set up at KTH and the Wingqvist Lab for Efficient Product Realisation at Chalmers, both with significant vehicle industry participation. The SAFER 'supercompetence centre' at Chalmers has been started in the same period with state support mainly from VINNOVA, to work with industry on active and passive safety.

It is extremely difficult to identify and count the various kinds of R&D support different countries provide for their domestic automotive industries, not least because the range of relevant technologies is so wide. In earlier work[56] for PFF, we have nonetheless attempted some comparisons among a number of car-producing countries. These suggest that Sweden stands out as spending much more than other countries per head of population and per unit of GDP, in response to the need to provide the kind of rich support, which larger countries can more easily offer. Normalised for employment in the automotive industry, however, Sweden is within the same range as its major competitors, so Sweden's apparently high investment in fact simply corresponds to its industrial specialisation in the automotive industry. The fact that the Swedish vehicle makers collectively produce a low volume of cars and trucks means that subsidy per unit produced is high. (Note, however, the very high value of the trucks produced.) Compared with vehicles R&D overall, Sweden's subsidy level is similar to that of the major vehicles-producing countries.

This implies a connection between the R&D and the subsidy. Our discussions with Swedish and foreign VMs about the way they select research projects and make location decisions suggests that

- The subsidy helps improve the quality and relevance of the knowledge infrastructure and of human capital production
- This is further enhanced by research relationships between the knowledge infrastructure and the VMs, who effectively focus the universities' and institutes' attention on research problems relevant to their own needs
- As a result the position of VM research and production facilities is improved, whether as part of company-internal competition, competition in external markets, or both
- There is not a linear relationship, however, between R&D subsidy and some other variable. The amount of subsidy provided seems to depend on the logic of each country's situation. There is no evident marginal calculus that allows the 'right' amount of subsidy to be calculated

[56]Erik Armold, John Wormald, Edward Kithcin, Anne-Cécile Ollivier, *A Survey of State Funding for Vehicles R&D in Selected Countries*, report to PFF, Brighton: Technopolis, 2007

This combination of offensive and defensive roles for the knowledge infrastructure in supporting nationally based vehicles manufacturers makes it difficult to avoid funding vehicles-relevant research activities. This is not the only way to interpret the data, but it is certainly an interpretation that is consistent with what the companies themselves say.

6.2 Technological Change in Vehicles

Despite the massive engineering and technological effort put into R&D by the industry as a whole, the research agenda has been shifting only slowly since the early 1990s. In practice, despite the huge R&D investment, this is an industry that does little research and a lot of development. Figure 46 gives a partial impression of the division within the Swedish industry. Even here, the implicit definition of ‘research’ is broad.

Figure 46 Technical and total personnel among Swedish vehicles and component makers, 2006

	Research	Development	Product Design	Manufacturing Engineering	Total Technical Staff	Total Employees
Saab (GM)	111	539	389	129	1168	6103
Volvo PV (Ford)	253	1780	1110	680	3823	19844
Scania	310	930	170	415	1825	12147
Volvo (Truck)					2712	23596
Total VMs	**674**	**3249**	**1669**	**1224**	**9528**	**61690**
(%)	**2%**	**9%**	**4%**	**3%**	**15%**	**100%**
FKG - min	280	1600	1800	800	4500	54631
FKG - max	320	1900	2200	1000	5500	
FKG	**1%**	**3%**	**4%**	**2%**	**9%**	**100%**

Source: Modified from Addendi, Nationella och regionala klusterprofiler. Företag inom fordonsindustrin i Sverige, rapport 2007:05, Stockholm: VINNOVA, 2007

The drivers of technical change in the industry have broadly been

- Environment
- Fuel efficiency and oil dependence
- Safety
- Mobility in the crowded driving environment
- Economics of manufacturing

In a number of areas, these drivers are reflected in regulation and legislation.

The environment issues have changed through the period. In the early 1990s, the major concern was with so-called 'harmful emissions' such as Nitrous Oxidess (NOx) and Poly-Aromatic Hydrocarbons (PAHs). The use of catalytic converters, in which Sweden played an internationally leading role, and better (electronic) engine management systems brought these emissions down. They also helped stop dead the development of methanol as a biofuel in Sweden because methanol poisons the catalysts used in exhaust after-treatment[57]. The 'cold start' problem – that engines optimised to minimise emissions at their working temperature are very dirty before they are warm – was tackled through better catalysis. (In Sweden, the KCK competence centre played a key role in the late 1990s and early 2000s.) The

[57] While methanol is the easiest biofuel to produce from forest feedstocks (where Sweden has a natural advantage and where feedstocks to not have alternative uses as food), it is also very corrosive, damaging engines and exhaust systems alike

main remaining ‘harmful emission’ is micro-particles of carbon from diesel engines, which are believed to cause cancer.

However, as the ‘harmful emissions’ were eliminated, concern about the greenhouse effect grew, so that ‘emissions’ in the vehicles industry increasingly equates to ‘CO2’ and therefore to improved fuel efficiency. The fuel efficiency trajectory was given a boost by the oil price shock of 1973 (see the Chapter on sustainable energy) and the growing expectations that oil would become both scare and expensive. Especially in Europe, where high fuel taxes exacerbated the effects of oil price rises, one of the industry’s concerns has therefore been to reduce vehicle weight by using lighter and stronger materials by designing structures that were both strong and light.

One clear candidate for weight reduction was the engine: a huge lump of cast iron with various holes and moving parts attached. Pelle Gillbrand, known as the ‘father of the Saab turbo’ successfully revived the idea that pumping air into the engine produced a massive increase in power in exchange for only a small increase in weight[58] and allowed ‘downsizing’ of the engine. The Saab 99 turbo was introduced already in 1977. But as the fear of high oil prices and the worries about oil dependence faded through the 1980s and 1990s, so charging was increasingly used to increase engine power rather than reduce engine weight. However, downsizing has now come back onto the agenda as a way to reduce CO2 emissions.

More efficient combustion is a way to increase fuel efficiency and reduce most emissions (especially CO2) and has been a major concern of all engine builders. Despite continued interest in alternative ‘lean burn’ engine cycles, the industry has largely continued to develop the Otto (petrol) and Diesel engines. European companies have focused especially on Diesels, developing clean and efficient ‘second generation’ engines for cars as well as trucks. Diesel is especially interesting in Sweden not only because of its greater simplicity and potential for fuel efficiency but also because Sweden focuses on heavier vehicles where Diesel is advantageous and because Diesel engines can more easily be adapted for ethanol and other biofuels. One result of this trajectory is that Saab Automobile has responsibility within the GM group for charging technologies and ethanol (E95) engines.

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[58] As early as the 1920s and 1930s ‘superchargers’ were fitted to some engines, using revolutions from the engine crank to drive an air pump. Turbochargers drive the pump by putting a small turbine in the exhaust gases. Both technologies need high-precision parts revolving at very high speeds. Much of the industry has preferred to increase the number of inlet valves per cylinder from two to four, achieving a similar effect using more established technology

More radical approaches to fuel efficiency and the need to move away from oil as a fuel involve changing the ‘driveline’: the engine and transmission that together convert fuel into power to the wheels. The ‘hybrid’ approach (already brought to market in Toyota’s Prius car) uses a small reciprocating engine to charge a battery, which then powers an electric motor. This gives higher efficiency for city driving but is inefficient for long distances and higher speeds, where clean Diesel seems to have the greatest potential. However, this is likely to be an intermediate step to using fuel cells (probably burning hydrogen or biofuels like ethanol) to charge the battery. Like the rest of Europe, Sweden came late to research into these technologies and devoted limited effort until this century. They are especially difficult for the Swedish VMs to tackle because they challenge their established Diesel competence, require new knowledge and production capabilities and will eventually need to be phased in slowly to the product range. They pose a fundamental challenge to the industry more generally. The engine is the heart of a road vehicle and is (together with styling) one of the aspects of the product that manufacturers have kept in-house. If components like batteries, electric motors and fuel cells made by other industries become central product characteristics, the heart is ripped out of the vehicles industry and the basis of competition will change dramatically.

While the new drivelines depend upon lighter battery technologies with less use of expensive or dangerous metals (lead, cadmium, nickel, etc), there is little evidence of much research or progress in the vehicles industry since the spurt of interest in electric cars that was prompted by the oil price shock. Battery technology limitations meant that their short range limited them to specialist applications and in part prompted the idea of putting an engine on board to charge the battery.

Sweden has led the way in safety research for road vehicles, partly prompted by the SNRA’s ‘zero vision’ on eliminating road deaths. Elsewhere in Europe, the policy and regulatory focus on safety strengthened during the 1990s, creating advantages for Swedish manufacturers who had focused earlier on safety questions. During the 1980s and 1990s, the main focus was on ‘passive safety’: understanding the dynamics of the human body in a crash, modifying vehicle designs and using restraints like seat belts and head rests to reduce injuries such as whiplash. Increasingly sophisticated crash dummies and modelling systems have been important here. Swedish passive safety research has been strong and crucial to the success of Autoliv and Volvo Car. In the 1990s, interest in ‘active safety’ grew: namely, finding ways to make the vehicle intervene in a crash, for example using airbags. Increasingly, industry is interesting in integrating active and passive safety, for example by using on-board electronics to detect an imminent crash and apply the brakes. Safety research also extends to improved human-machine interaction (HMI) and infrastructure design.

Another major driver for research has been increased crowding on the roads resulting in traffic jams, delays and accidents, which have been tackled through Road Transport Informatics (RTI) or Intelligent Highway Vehicle Systems (IVHS) or Intelligent Transport Systems (ITS). These involve the use of electronics to allow the vehicle to communicate with the infrastructure and provide information to the driver. The commonest form of ITS today is probably the in-car navigation and traffic information system. Others include fleet management systems, parking sensors and collision avoidance systems. The industry started making significant efforts in this area during the 1980s. Volvo and SNRA had a prototype route guidance and traffic information system working in Gothenburg at the end of the decade as part of the EUREKA Prometheus project. Market growth in the area happened when mobile telecommunications infrastructure became ubiquitous and electronic components so cheap that is was feasible to build massively complex mobile electronic devices at low cost. With these conditions in place, there has been growth – but the vehicles industry has also rather lost control of the developments it started. Work continues to find ways to use ITS in order to add services to vehicles, much as a growing part of R&D for mobile telephones these days is about how to use them as services platforms.

The huge increase in the amount of electronics in vehicles raises an issue of knowledge and control similar to the challenge posed by new types of driveline. Traditionally, vehicles manufacturers have had limited skills in electrical and electronic components, relying on their suppliers in these areas. Although these skills are increasingly central to the industry, for example in areas like engine management systems, and the prospect of interconnecting electrical and electronic systems across the whole vehicle means that standards are needed. As a result, there is an important strand of research to develop and support alternative standards. ERTICO, in particular, has put a lot of effort into supporting industry-wide standards to allow component interoperability and to prevent component makers like Bosch from imposing de facto standards and acquiring a Microsoft-like grip on their customers.

Manufacturing process improvement is not very prominent as a research topic except in the steady increase of modelling in many aspects of vehicles design. There is nonetheless a large amount of incremental applied research and engineering that is of relevance to the industry but also to other parts of the engineering industry.

From the perspective of the VMs (EUCAR), the major research agendas are

- Energy compatibility
- Energy consumption
- Safety
- Intelligent Transport Systems
- Mobility
- Vehicle qualities
- Industrial competitiveness[59]

The European Road Transport Advisory Council (ERTRAC) that organises all parts of the research community, including the transport ministries, offers a wider agenda that takes in the infrastructure as well as the vehicles.

1. Mobility of people
2. Transport of goods
3. Accident prevention
4. Accident pact mitigation
5. Road transport system security
6. Reduced greenhouse gas emissions and more efficient energy use
7. Environment – including impact on communities and natural habitats
8. Time to market and implementation
9. Flexible production systems
10. Lifetime resource use[60]

Figure 47 is a somewhat impressionistic overview of the relative weight given by vehicles-producing countries to different technical areas, based on state funding programmes in the first half of this decade. It reflects the later entry of Europe into new drivelines, the reduced interest in batteries and other trends discussed above.

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[59] EUCAR Master Plan 2000, Brussels: EUCAR, 2000
[60] European Road Transport Research Advisory Council,

Figure 47 Government automotive activity by technology area

Technology Areas	Australia	Canada	France	Germany	Italy	Japan	Norway	UK	USA	Sweden
Powertrain - Fuel Cells	High	High	Medium	High		High	High	Low	High	Low
Powertrain - Hybrid	High	High	High	Low	Medium	Medium	Medium	Medium	High	High
Batteries		Medium				High			High	
Hydrogen Infrastructure	High	Medium	Low	High		High	High	Low	High	
Bio-Fuels	High	Medium	Medium	Medium		High	Medium	Medium	High	High
Environmental Pollution	High		High	High	High	High	High	Medium	High	High
Sustainable Emissions	High	High	High	High	High	High	High	High	High	High
Safety	Medium	Medium	High	High	Medium	High	High	High	High	High
Human/Vehicle Interaction			Medium	Medium	Medium	High		High	High	Medium
Control Systems, Advanced Control	Medium	Medium	Medium	High	Medium	High		Medium	High	Medium
Materials, Structures and Related Processes	High	High	Medium	High	Medium	High	High	Medium	High	Medium
Manufacturing	Medium	Medium		Medium		High	Medium		High	Medium
LCA and Recycling						High		Medium	Medium	

Level of priority:

High
Medium
Low

6.3 The Framework Programmes and Vehicles Technology

The vehicles research agenda in the Framework Programme is not so much a driver of what the industry does but a result of what it wants to do – or what the industry in combination with relevant ministries in the member states can negotiate. The European road vehicles industry is not only oligopolistic but has a well established tradition of coordination through the European Automotive Manufacturers' Association ACEA, in which the US Ford and General Motors companies are prominent players. Its EUCAR offshoot was set up in 1994 specifically in order to lobby the European Commission on research for the automotive industry and as a vehicle for its members to organise collaborative projects with EU subsidy.

The European Road Transport Research Advisory Council (EARTRAC) brings together the European-owned vehicles manufacturers, the EU trade associations, member-state ministries and the European Commission to discuss and establish visions and roadmaps for European automotive R&D. A further forum for coordination is ERTICO – the European Road Transport Telematics Implementation Co-ordination Organisation – comprises industry, ministries, infrastructure organisations and users of Intelligent Transport Systems (ITS) and provides a forum for coordinating ITS policies, databases and standards.

In the aerospace area, the Advisory Council for Aeronautics Research in Europe (ACARE) is the most influential body informing the content of the FPs. The European Rail Research Advisory Council (ERRAC) aims to play a similar role in railways.

Curiously, the history of significant involvement by the vehicles industry in the FPs actually starts with the EUREKA Prometheus project, which was originally started on the initiative of Daimler-Benz in 1986. A definition phase followed in 1987 and research ran from 1989 to 1994. Swedish Telecom and STU funded Swedish participation via the national industrial IT R&D programme, IT4. Swedish participants were: Saab-Scania; Volvo; Swedish Telecom; Chalmers; KTH; the University in Linköping; the Institute of Microelectronics (IM); the Swedish Institute of Computer Science (SICS) and the national transport laboratory VTI. Prometheus was itself a major programme with a total budget of over MSEK 600m per year, of which the Swedish share was about 5%. It comprised research projects and ten 'Common European Demonstrators'. These substantially defined the research agenda in RTI/IVHS up to the present time. Route guidance products such as the UK Trafficmaster appeared as early as 1991, based in part on Prometheus work. Volvo has fleet management products that have roots in the Prometheus work. Other parts of the agenda such as cooperative driving (where cars would form high-speed, automatically controlled convoys on motorways) are still a long way from practice.

Figure 48 Swedish participation in Prometheus CEDs

Common European Demonstrators	Saab-Scania	Volvo group	Swedish Telecom	SNRA
1. Vision Enhancement	√	√		
2. Proper Vehicle Operation	√			
3. Collision Avoidance		√		
4. Cooperative Driving	√			
5. Autonomous Intelligent Cruise Control	√	√		
6. Emergency Systems				
7. Commercial Fleet Management		√	√	
8. Test Sites for Traffic Management				√
9. Dual Mode Route Guidance	√	√		
10. Travel Information Services	√	√		

Source: Prometheus Central Office

The DRIVE programme in FP2 duplicated much of this activity but was nonetheless attractive because, not being an industry initiative, it was able to get greater participation from the public authorities. Thus, Prometheus focused more on in-vehicle technologies while DRIVE put more emphasis on the infrastructure. Among the Swedish participants, the biggest industrial benefits seem to have gone to Volvo, because it was the only company with a central research department able to act as a strong counterpart to the academic researchers[61].

Three major strands are visible in the FPs that are relevant to the automotive industry (Figure 49) One follows the RTI/IVHS/ITS trajectory that started in Prometheus. A second is a changing mix of activities focused on engineering production that at some times is specifically focused on road vehicles but at others is more generic. The third is a stream of energy research dealing with new and alternative vehicle fuels.

Figure 49 Vehicles-orientated parts of the Framework Programmes

	RTI/ITS	Vehicle Engineering	Energy and Fuels
FP2	[Prometheus] DRIVE	BRITE/EURAM	JOULE
FP3	Telematics • DRIVE2	BRTITE/EURAM II	JOULE2
FP4	Telematics • Telematics for Transport	BRITE/EURAM III • Materials and Technologies for Product Innovation • Technologies for Means of Transport	JOULE
FP5	IST • Systems and Services for Transport & Tourism	GROWTH • Key actions (products, mobility, transport, aeronautics) • RTD (materials and their technologies; steel)	Sustainable Development • Sustainable Energy Systems
FP6	InfoSoc • IST • Applied Research • eSafety	SUSTDEV • Sustainable surface transport	SUSTDEV • Long-term impact

6.4 Swedish Participation in Vehicles Projects

Our definition of 'vehicles' takes in the building of vehicles for all modes of transport and necessary interactions between vehicles and their infrastructure – for example, railway and traffic signalling, in-car traffic information services, air traffic control. It does not include the building of physical infrastructure such as roads or harbours.

Figure 50 shows the number of projects with Swedish participation divided by mode of transport. Clearly, the dominant interest is in road followed by aircraft. The decline in the overall number of projects between FP5 and FP6 is probably caused by the increased average project size in FP6.

[61] Erik Arnold and Ken Guy, *Evaluation of the IT4 Programme,* Final Report, Stockholm: IT Delegationen, 1992

Figure 50 projects with Swedish participation by mode and FP

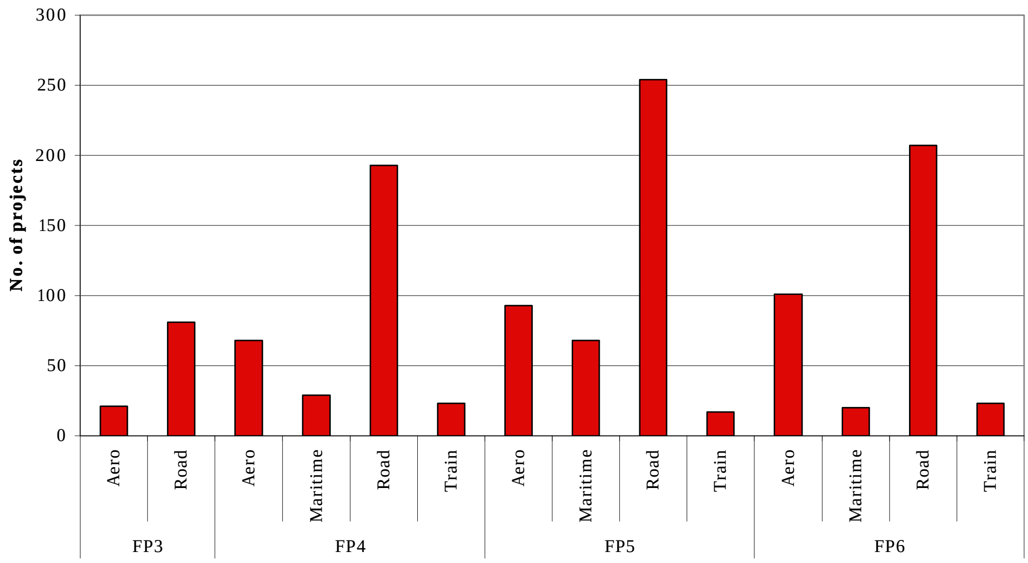
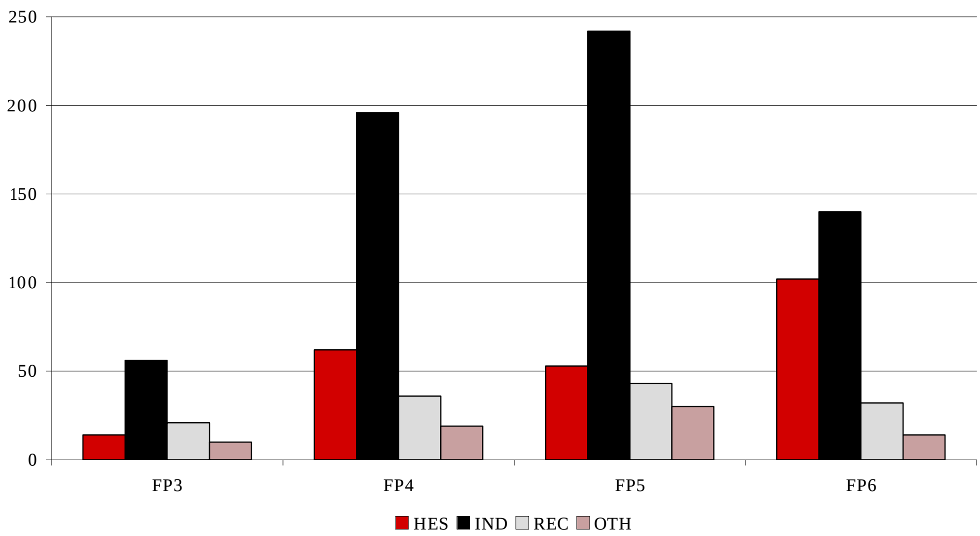


Figure 51 shows that it is industry not the universities that dominates Swedish participation in vehicles projects. This reinforces the impression that in this engineering-dominated part of the FPs it is industry not academia that has set the agenda. However, the share of participation by the Higher Education Sector (HES) has increased in FP6 at the same time as the number of industrial participations has dropped dramatically. This may partly reflect the fall-out from increased foreign ownership of former parts of the Swedish vehicles industry and also the narrowing of focus from vehicles and infrastructure in general in FP5 towards sustainable development in FP6 (Figure 49). Participation by the research institutes (REC) and state authorities (OTH) has also declined in absolute terms between FP5 and FP6.

Figure 51 Swedish participants in vehicle projects by category



Unfortunately we do not have access to partnership data for FP3. However, the profile of the Swedish participants' partners shows some different patterns in FP4-6 (Figure 52). Partner numbers do not change much between FP5 and FP6 – essentially because the larger project sizes and the greater numbers of partners per project in FP6 compensate for the reduced number of Swedish participations. The share of partners in the university sector rises between FP5 and FP6, suggesting that the role of academia is increasing outside as well as inside Sweden. The role of partner industry and research institutes does not decline. Foreign industry and institutes do not seem to go through the same retrenchment as the Swedes: perhaps because globalisation has not been hitting the vehicle manufacturers in the same way and because institutes outside Sweden institutes are more robust and play a different role. In Germany and the Netherlands, for example, the kind of combustion research done at Lund or Chalmers is done in institutes rather than universities. Because there are trends working in opposite directions, it is hard to give a completely authoritative interpretation of these changes but it is equally hard to avoid an impression that the Swedish industry and institutes are to some degree being marginalised within the FP. While in the medium term, Swedish universities can ride the trend to more university participation in the FPs, in the longer term their vehicles-relevant expertise depends upon their having a continuing relationship with a robust Swedish vehicles industry. If the industry stagnates then not only does the flow of ideas, problems and resources to the Swedish universities go away but so also does the raison d'être for the parts of the university system that have for years lived in symbiosis with the vehicles industries.

Figure 52 Swedish vehicle participants' partners by organisation type

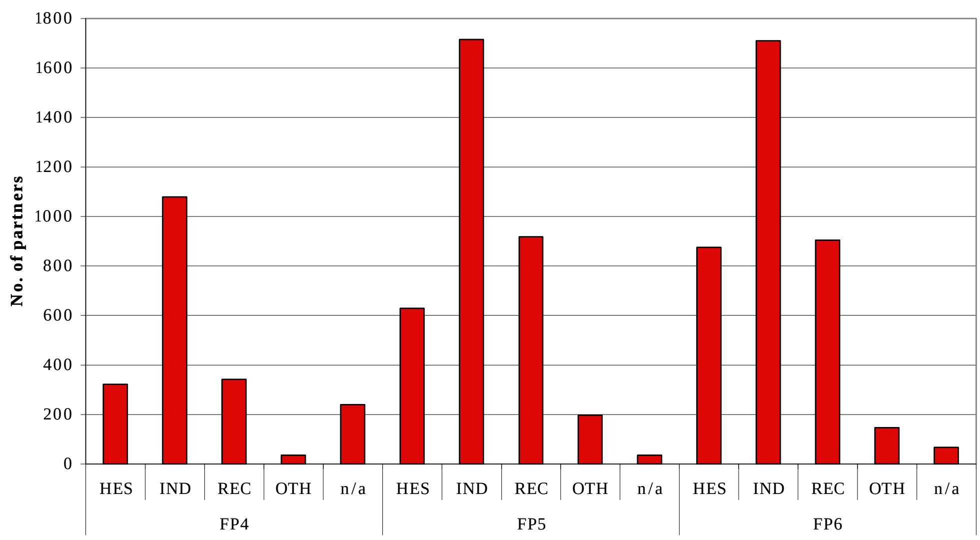


Figure 53 lets us look at Swedish institute participation in more detail. By far the biggest participant is defence, where we have avoided the institutional complexity of various reorganisations over the years by simply adding the three institutes involved together. Almost all their work is on aerospace, in support of Swedish defence. The SICOMP composites institute (now part of SWEREA) also experienced growth between FP5 and FP6. This, too, is driven by aerospace.

Figure 53 Research institutes' participations in vehicles projects, FP3-6

	FP3	FP4	FP5	FP6	sum
FFA/FOA/FFI	7	16	15	22	60
VTI	4	8	9	12	33
SICOMP/IFP	2	1	2	8	13
TFK	4	2	4		10
IVF	1	4	4		9
IVL		1	4	1	6
I Metall		2			2
SICS	2				2
SP			2		2
YKI			2		2
Keraminstitutet	1				1
SWECAST		1			1
Viktoria Institute		1			1
ACREO			1		1
Socialdata Institut			1		1
Maritime Institute			1		1
Meterological Institute			1		1
Corrosion Institute			1		1
Interactive Institute				1	1
Totals	**21**	**36**	**47**	**44**	**148**

VTI, the state road and transport research institute, is the only one of the institutes more active in the road vehicles area that continues to make a strong contribution to the FPs. In contrast, the production engineering institute (IVF), the industry-owned transport research institute TFK and the environment institute IVL all falter at the start of FP6. The spotty involvement of other industry-orientated institutes stops at the same time as the focus of the FP shifts from **making** road vehicles to longer-term concern with their environmental effects and how to manage them.

The university participation data show two trends. First, there is an obvious consolidation at the major universities of technology. CTH is the traditional partner of the road vehicles industry. KTH has historically been more interested in aircraft structures as well as functioning as the university node for the vehicles industry in East Sweden, especially Scania, but has been increasingly its road vehicles strengths in the last few years. Both CHT and KTH also have strong links to the railway industry. Lund (LTH) is especially strong in combustion, especially in turbines. These three universities are the backbone of academic support to the road vehicles and aircraft industries (Figure 54).

Figure 54 Universities' participations in vehicles projects, FP3-6

	FP3	FP4	FP5	FP6	Sum
CTH	3	25	14	28	70
KTH	3	11	14	29	57
LTH	4	11	15	15	45
LiU	2	2	3	7	14
LTU	1	2		6	9
UU	1	3		4	8
GU		2	3		5
HiSkovde		2		2	4
Högskolan Väst				4	4
UU		1	2		3
HiDalarna		3			3
Ingenjörshögskolan i Jönköping				2	2
UMU			1		1
SU			1		1
Växjö Universitet				1	1
Blekinge TH				1	1
Högskolan I Borås				1	1
Högskolan I Malmö				1	1
Totals	**14**	**62**	**53**	**101**	**230**

Linköping is a fairly new university and while its FP vehicles participation has been growing it is fragmented across many topics and Linköping has not displaced the old links between Saab aircraft and KTH.

The rest of Figure 54 reflects the growth of the (largely regional) system of new colleges and universities in a very fragmented pattern. In the context of the globalisation trends that threaten the Swedish vehicles complex and the need to build critical masses of excellent research and higher education capability in order to survive international competition, we can ask whether this fragmentation is useful.

The universities with a strong natural science orientation, like Stockholm and Uppsala, do not figure in these FP Vehicles participations. Both facts underscore the engineering and applied science focus of work in the vehicles area.

In all (depending on how you count), about 180 Swedish-based companies have participated in Vehicles FP3-6 in Sweden. Figure 55 shows those, which have participated at least twice. They are a mixture of component/materials providers, systems manufacturers (in which category we place the VMs), technology developers/consultants and users, together representing the vehicles supply chain.

The rail sector is small, with Bombardier (inheritor of the ASEA rail legacy) and Swederail. There is also a modest sea cluster: Kockums; SSPS, Stena Line, TTS Ships Equipment, ACAB, Göteborg Port. The aerospace cluster is bigger, together accounting for about a fifth of the participations listed: Saab; Volvo Aero; KaMeWa (whose participation stops after the take-over by Rolls-Royce).

Figure 55 Companies with two or more vehicles FP participations FP3-6

	FP3	FP4	FP5	FP6	Sum
A2 ACOUSTICS AB			1	1	2
ABB AB	1	4	2		7
ACAB Acoustic Control Laboratories AB		1	1		2
ACL Group			1	1	2
Akzo Nobel Surface Chemistry AB		1		1	2
Anderstorps Gummiindustri AB		2			2
APC Composit			1	1	2
Autoliv			1	1	2
Ah Sweden			1	2	3
Bombardier (ex-ASEA, Daimler) Signal		2	3	1	6
Box Modul		1	1		2
Catella Generics AB	2	2	3		7
Celsiustech AB	1	2			3
CSM Materialteknik			2	1	3
CTT Systems			2		2
Daros Piston Rings			2	1	3
ENEA Embedded Technology				2	2
Ericsson		8	5		13
Flowtech International Ab		2	1	1	4
Gatesace			1	3	4
Göteborg Port		1	2	1	4
Hamworthy KSE			2		2
HBH Consultants		2			2
Höganäs AB		1	3		4
Inexa Profil		1	1		2
Kamewa/Rolls-Royce		4	3		7
Kapsch Trafficom				2	2
Kockums		8	3	1	12
Logistikcentrum Väst		1	1	1	3
Mecel		2	1	3	6
Motortestcenter MTC			3		3
Peek Traffic AB	2				2
Prosolvia Clarus AB			5		
SAAB and Scania excl Automobile	**11**	**35**	**23**	**9**	**78**
Saab	10	29	19	9	67
Saab/Scania CV / Bus	1	6	4		11
Saab automobile (GM)	2		4		6
Sandvik	1		1		2
Skanska			2	2	4
SSPA Maritime Consulting			18	5	23
Stena Line		2	2	1	5
Stridsberg Powertrain				2	2

	FP3	FP4	FP5	FP6	Sum
Swederail		2			2
Sydkraft (now EON)		1	2	1	4
Telia/Telelogic/Teliasonera	3	1	1		5
Teracom			3		3
TRANSEK AB		2	4	1	7
Trelleborg			1	1	2
Tribon Solutions			7		7
Trivector Traffic			3	2	5
TTS Ships Equipment			2	1	3
Ultralux AB		3			3
VBB (SWECO) VIAK AB			2		2
VOLVO AB excl. Car	**24**	**56**	**66**	**41**	**187**
Volvo AB/TU	15	40	39	27	121
Volvo Aero	8	9	13	12	42
Volvo Construction Eqpt			1		1
Volvo IT			2		2
Volvo Penta		2	2		4
Volvo Powertrain			1	1	2
Volvo Truck	1	3	8	1	13
Volvo Wheel Loaders		2			2
Volvo Car/Ford	3	9	21	2	35
Wirelesscar Sweden				2	2
Sum	**50**	**156**	**214**	**94**	**509**

Largest is the road vehicle and infrastructure cluster. One group of companies has its roots in the ITS work going back to Prometheus: Celsiustech; Peek Traffic; Kapsch Trafficom; Trivector traffic; Wireless Car; a small part of the Saab participation (through the former Combitech cubsidiary; Logistikcentrum Väst; Ericsson, and TRANSEK and others working on economics and planning. The now defunct Ultralux company was involved in exploiting the Prometheus work on adding ultraviolet to headlights and using reflective coatings on road markings to increase driver visibility – a 'quick hit' component intended to generate early results from a programme that was otherwise very long term. The effect was that headlight technology generally got better through diffusion of the idea of brighter, wider-spectrum lights but the authorities were reluctant to paint reflective strips everywhere once they realised this would make people drive faster at night, not more safely. From there, Ultralux moved into passive safety modelling.

The other group of road vehicle companies clusters around the vehicles: components firms; materials companies; technology specialists like MTC and Mecel in engine management and control; Catella Generics working largely on batteries; and of course the VMs themselves, whose participation outstrips that of the others by an order of magnitude. The major participant is Volvo AB, especially through Volvo TU (the corporate research department idiosyncratically named ‘technical development’ and in recent years transformed into Vtek to serve Volvo AB, Volvo Car and other external companies). We show Volvo Car separately. Its participation has faltered since the Ford takeover but has potential to make a come-back now that Ford has discovered the strengths and weaknesses of its development department, Vtek and the Göteborg knowledge infrastructure. Saab Automobile (GM) is in contrast much less involved in the FPs with GM mainly participating in them via Opel in Germany. The main road vehicles participation from the Saab group has been via the now-separate Scania truck and bus operation. In fairness, we should point out that both Saab Automobile and Scania are much more involved in national programmes and competence centres than might be inferred from their rather slight involvement in the FPs.

The public authorities are the remaining group of Vehicles FP participants (Figure 56). The biggest participant is the national roads administration, which played an especially important role in the early ITS work through Prometheus and DRIVE. In some respects, as early ITS technologies have started to mature it has handed the relay baton on to Göteborg (which was a demonstrator city for navigation and traffic information in Prometheus and DRIVE) and to Stockholm City, which has a long tradition of piloting and demonstrating new approaches to transport planning, public transport, safety and environment. Some of its and Göteborg’s congestion charging and planning expertise derives from FP participation. Other cities and local authorities have followed, largely with public transport initiatives.

Figure 56 Public authorities' participations in vehicles FP projects, FP3-6

	FP3	FP4	FP5	FP6	Sum
SNRA	10	3	3	3	19
City of Stockholm / SL		1	10	3	14
Banverket - Rail Administration		5	2	4	11
SJ SwedishRailways		6	1		7
City of Göteborg		1	2	1	4
Civil Aviation Authority			1	1	2
Energy Agency			2		2
Maritime Administration		1	1		2
VINNOVA			2		2
City of Malmö		1		1	2
Environmental Health Office			1		1
Sweden's Radio		1			1
Rescue Services Agency				1	1
City of Gävle			1		1
Gotlands Kommun			1		1
Huddinge Kommun			1		1
Swedish Association of Local Authorities			1		1
Växjö Kommun			1		1
Totals	**10**	**19**	**30**	**14**	**73**

There is a separate strand of participation in railways, where the Banverket rail infrastructure agency continues to work with the FPs but the former monopoly train operator SJ has faded from the R&D picture under the commercial pressures of competition – a story familiar from the increased marketisation of infrastructure companies everywhere (and one that could have been avoided through simple devices such as the imposition of a research levy on the industry).

6.5 Effects of Framework Participation on the Swedish Vehicles Cluster

In this section we look in some detail at the role of the FPs for selected industrial companies and university groups. Our coverage of the industry is not complete but is sufficient to get a fairly good picture of the type of impacts the FPs provide. On the university side, we have picked out four research groups at Chalmers with strong links to the vehicles industries and explored the role of the FPs in their development.

6.5.1 Industry

As our earlier discussion of the industrial dynamics of the Swedish vehicles industries indicated, the effects of globalisation on the industry are considerable. As competition and technological change move towards the global level, so it is increasingly difficult for a very small economy like Sweden to maintain its position. The fact that the vehicles industry actually comprises a number of overlapping industrial knowledge systems associated with the different modes of transport means that across the whole system as well as within the different mode systems there are some interdependencies. Some of the obvious ones are that the systems builders need component makers, research performers and educators who operate at critical mass and who are capable of keeping up with the quality and efficiency norms of global competition. Thus, for example, it hurts Volvo Car if Saab Automobile stops building cars in Sweden.   The sense that this interdependence is important seems to be re-emerging in the industry. Rather famously, a quarter of a century back the major Swedish engineering companies (Volvo, Saab, ASEA etc) consciously played leading roles in introducing new technologies, which would then trickle up the supply chain. This role has long been abandoned but it is interesting to note that Vtec now (with subsidy from the PFF) operates a small office whose mission is to help involve other companies than Volvo as partners in FP projects.

6.5.1.1 Volvo AB

Through its Vtek central research laboratory, Volvo AB is Sweden's strongest industrial FP participant and because of its crucial position in the concern and the industry, Vtek is a significant national resource. It has close and important relations with groups in the Swedish knowledge infrastructure – but these are rarely reflected in common FP project participation. Rather, these links are separately maintained.

Vtek was originally the in-house research function of the Volvo group: Volvo TU. When Volvo sold its Car division to Ford, a significant part of the department's work risked being transferred to Ford's laboratories elsewhere in the world. So Volvo AB also turned the research function into a distinct organisation, offering to work not only for the Volvo Group but also for Volvo Car (Ford) and for other organisations outside the Volvo sphere. This has been an extraordinarily successful strategy. Volvo TU employed about 150 people in 1990 and had grown to 200 by the end of the decade, when Ford took over Volvo Car. Vtec continues to work for Volvo Car, the group and others and grew to 425 by 2007. Currently, it gets 10-20% of its income from the Volvo group in basic funding and wins about the same again in public funds from national and international R&D funders. The remaining 60-70% is contracted from various strategic business units of the Volvo group, Volvo Car and (to a limited extent) external companies. Vtec argues that the discipline of contracting with the SBUs not only keeps its work relevant but also ensures results are communicated and exploited – overcoming the gap many large firms experience between their central R&D function and the operating divisions. Fiat's corporate research function is about the same size and operates in the same way. General Motors' corporate research function has shrunk from about 1500 people to 400 or so between 1990 and the present. Vtec is key to Volvo and the Swedish industry 'punching above its weight' in automotive R&D. While the SBUs do have their own R&D functions, Vtec's longer-term horizon means that it is the main link to the FPs. (The exception within the group is Volvo Aero – whose technological problems overlap to a more limited extent with the group than is the case among the land-based vehicle producers in Volvo. We return to them below.)

The fact that Vtec has both a research focus and sufficient scale means that it can provide a 15-20 year perspective on technology to the Volvo group. As a result, the group has a portfolio of technologies in the pipeline that cover not only short- but also long-term needs. Thus, in contrast to the widespread lurch in the industry away from fuel efficiency work in the latter 1990s and early 2000s (when oil was for a long time unexpectedly and unsustainably cheap) that also affected Volvo Car under Ford's ownership, Vtec has been able to maintain focus on this area. Similarly, it was able to sustain a level of fuel cell and alternative driveline activity through a period when those close to market were sceptical of the need for these technologies. Since in Vtec's funding model most of the money comes from the SBUs, whose interests are naturally short to medium term, Vtec tends to use national R&D and FP money to fund such longer-term activities. In general FP funding is not only more attractive than national money or Eureka money (because it covers a higher proportion of Vtec's costs) but it provides a continuity that is lacking in large parts of the business world. Lacking this long-term view and funding, the other Swedish VMs are exposed to a much more erratic flow of technology and capabilities and are less able to take a strategic view of where to focus technological effort.

At the general level, Vtec gets a number of benefits from participating in FP projects

- Intelligence about competitors' capabilities
- Bigger networks of technology partners and suppliers, whose capabilities are known
- A way to develop Volvo engineers and researchers, exposing them to international practice and giving them international networks before (often) moving them into the SBUs, transferring their higher level of knowledge into places where it influences product and process design
- Most of Sweden's national R&D subsidy programmes involve money being spent at universities. The FPs are attractive because they also fund companies to do R&D that is 'additional' to what they otherwise could have afforded

Given the large scale of Vtec's FP participation, we cannot attempt an exhaustive account. However, there are several very clear themes that have been developed or strengthened on the basis of FP participation. Neither Vtec nor we would claim that the FPs are the **only** contributing factor but these activity streams are successively turning into products, many of which allow Volvo to maintain its market position as well as to contributing t wider social goals such as reduced emissions.

While European countries generally have been slow to start research on hybrid drivelines and fuel cells compared with the Japanese and US efforts, the FPs maintained a modest level of effort through the 1990s and an increased one since the turn of the Millennium. Figure 57 confirms that the effort was limited in the early 1990s but that it grew so that the effort from FP5 onwards was considerable – at a time when oil was very cheap but when there was growing anxiety about global warming.

Figure 57 Volvo AB FP participations for alternative drivelines

FP	Acronym	Title
FP3		European hybrid technology development approaching efficient zero emission
		Traction batteries for electric and hybrid vehicles
FP4		Bench test and evaluate traction energy storage systems for electric and hybrid electric vehicles "Phase III"
	EIHP	European integrated hydrogen project
		Car autothermal process reactor initiative
		Lithium-carbon-liquid electrolyte battery system for electric vehicles: battery module and system development project
	LIBERAL	Lithium Battery Evaluation and Research - Accelerated Life test direction (LIBERAL)
FP5	AMFC	Advanced Methanol Fuel Cells for Vehicle Propulsion (AMFC)
	ASTOR	Assessment and testing of advanced energy storage systems for propulsion and other electrical systems in passenger cars.
	FUEVA (PHASE II)	European Fuel Cell Vehicles validation Phase II
	EIHP2	European Integrated Hydrogen Project - Phase II (EIHP2)
	FUERO	Fuel Cell Systems And Components General Reasearch For Vehicle Applications ('FUERO')
	ELMAS	New High Efficiency Electric Machines Solutions For Mild Hybrid Applications ('ELMAS')
	PROFUEL	On-Board Gasoline Processor For Fuel Cell Vehicle Application ('PROFUEL')
		Thematic network on fuel cells and their applications for electric & hybrid vehicles (ELEDRIVE)
FP6	HYICE	Optimisation of hydrogen powered internal combustion engines (HYICE)
	HYSYS	Fuel Cell Hybrid Vehicle System Component Development
	NICE	New Integrated Combustion System for future Passenger Car Engines (NICE)
	RENEW	Renewable fuels for advanced powertrains (RENEW)
	HARMONH Y	Harmonisation of Standards and Regulations for a sustainable Hydrogen and Fuel Cell Technology
	STORHY	Hydrogen Storage Systems for Automotive Application (STORHY)
	HYSAFE	Safety of Hydrogen as an Energy Carrier (HYSAFE)
	FURIM	Further Improvement and System Integration of High Temperature Polymer Electrolyte Membrane Fuel Cells (FURIM)
	HYTRAN	Hydrogen and Fuel Cell Technologies for Road Transport (HYTRAN)
	ROADS2HY COM	Research Coordination, assessment, deployment and support to HyCOM
	PEMTOOL	Development of novel, efficient and validated software-based tools for PEM fuel cell component and stack designers (PEMTOOL)

The effort did not only allow Vtec to build and maintain capability but also to contribute to the early standardisation efforts that are needed in order to make sure incompatibilities do not slow down the development and deployment of hybrid and fuel cell technologies. These efforts have contributed to Volvo’s ability to launch a hybrid bus at the 2008 Hannover fair and it is widely known that the company will launch a truck in 2009 that uses a hydrogen-burning fuel cell in its driveline. Only by developing and maintaining such log-term capabilities is it possible to catch up with and move towards the front of world product developments in this way.

Volvo has been involved in FP R&D in combustion since 1985 (FP1, when a joint project with a researcher at Imperial College allowed the firm to access know-how about how to model (cold) gas flows within engines). First results of the project were incorporated in engine designs launched in 1990. It has taken much of the past 20 years to develop this understanding to the point where it is possible to model hot gas flows and to link them to combustion chemistry. A result is that Volvo and a handful of other vehicles makers can – using a combination of commercially available software and confidential knowledge and experience generated in the Framework Programme since FP1 – can predict the emission characteristics of engine design by simulation, rather than by building and testing in the old manner. At the same time, the cumulated experience of projects inside and outside the FPs has improved their understanding of combustion processes, again feeding into engine design.

Volvo has also pursued complementary work on exhaust after-treatment in the FPs since the start of the 1990s. The first wave of catalysis work was aimed at petrol engines but the FPs have also provided an opportunity to work with alternative concepts for diesels. A combination of work in the FPs and with the KCK competence centre at Chalmers has gone a long way towards solving the NOx problem. Volvo lost some momentum in this area when Ford bought Volvo Car and a lot of catalysis work moved to Ford Dearborn but it was able to rebuild both through its own efforts and with the support of the strong network of technology and commercial partners built up during FP5 projects, in particular. **Fel! Hittar inte referenskälla.** shows the sequence of combustion modelling and after-treatment projects in which Volvo has participated, illustrating the long-term commitment required to succeed in this area. Vtek credits these projects – together of course with its own efforts and national projects – for its comparative strength in combustion and after-treatment, especially for diesel engines. The linkage to Chalmers' competences is a key ingredient and has supported both the competitive strength of Volvo and influenced investment decisions by Volvo Car (Ford)[62].

[62] Erik Arnold, John Clark and Sophie Bussillet, *Impacts of the Swedish Competence Centres Programme 1995-2003*, VA2004:03, Stockholm, VINNOVA: 204

Figure 58 Volvo combustion and catalysis participations, FP3-6

FP3	Integrated development on engine assessment on environment friendly fuel efficient combustion technology	
	Nitrogen oxide removal	
FP4		Diesel engine simulations aiming to reduce emission levels
	LES ENGINES	Large eddy simulations of stratified charge engines
	ECONOX II	Gas sensors and associated signal processing for automotive exhaustpipe
	ZODIAC	Optical diagnostics for industrial applications in combustion
FP5	MINNOX	Minimisation Of NOx Emissions (MINNOX)
	AMMONORE	Advanced nanostructured metal/metal-oxo/matrix catalysts for redox processes. Application for NOx reduction to nitrogen.
	PARTICULATES	CHARACTERISARION OF EXHAUST PARTICULATE EMISSIONS FROM ROAD VEHICLES
	KnowNox	Development of continuous catalytic NOx reduction for Lean Burn Cars
	D-LEVEL	Diesel-Low Emission Levels by Engine Modelling
	G-LEVEL	Gasoline Direct Injection---Low Emission Levels by Engine Modelling
	Hy-SPACE	HeavY duty diesel whole SPACE combustion
	REPART	Improved removal of particulate contaminants from surfaces to increase functionality and appearance of products (REPART)
	I-LEVEL	Injector flows - Low Emission Levels by Engine Modelling (I-LEVELS)
	ARTEMIS	ACOUSTIC RESEARCH ON TURBOCHARGED ENGINE MODELLING OF EXHAUST AND INLET SYSTEMS (ARTEMIS)
	ATECS	Advanced Truck Engine Control System
	FUNIT	FUTURE UNIT INJECTOR TECHNOLOGIES (FUNIT)
	LOTUS	Low Temperature active urea based selective catalytic reduction of NOx (LOTUS)
FP6	ECO-ENGINES	Energy COnversion in ENGINES (ECO-ENGINES)
	GREEN	Green Heavy Duty Engine

The effort on combustion and catalysis is complemented by a series of vehicle weight reduction projects such as FP3's Low Weight Vehicle project, FP4's FLOAT Action for low weight automotive technologies, FP5's HYDROTUBE, which aimed to reduce CO2 emissions by finding ways to substitute tubes for solid structures in the vehicle and FP6's SLC project on production technologies for light-weight structures. These projects tend to produce rather diffuse effects: they increase participants' understanding of possibilities and are likely to influence design and manufacturing engineering but are inherently not visible because they do not lead to evidently new or changed products.

Passive safety has had its own trajectory, with a specialised research community that in Sweden has had spectacular successes in areas like whiplash injuries, where research results have triggered new designs at Autoliv, Volvo and elsewhere that have reduced injuries[63]. Passive safety relies heavily on understanding biomechanics and designing vehicles and

[63] Knut Sandber Eriksen, Arild Hervik, Arild Steen, Rune Elvik and Rolf Hagman, *Effektanakys av Nackskadeforskningen vid Chalmers*, VA 2004:7, Stockholm: VINNOVA, 2004

restraints around the biomechanical effects of crashes on the human body. Other kinds of safety work relate to road design (an area where the VMs are little involved), electronic connections between vehicles and the infrastructure (hazard warning, emergency calls) and using sensors and intelligent electronics to intervene before or during a cash to avoid or reduce adverse effects. These agendas have tended to merge as industry feels passive safety has begun to approach its limits. Notably, Volvo has not participated in passive safety FP projects in recent years while the safety group at Chalmers has continued work in the area.

Figure 59 follows Volvo's participations in the passive safety trajectory, with themes becoming increasingly active over time. Crash dummies have been key instrumentalities for extending and implementing understanding of biomechanics as well as satisfying regulatory requirements for crash testing. The four FP6 active safety projects were designed by EUCAR with strong input from Volvo and share a common demonstrator. They therefore allow Volvo to increase the amount of funding and work devoted to longer-term safety issues, compared with what would have been possible to finance internally. The link to the demonstrator means the companies involved have to face the challenges of advanced engineering, forcing them to find out whether research results are practicable and applicable. This link accelerates the link between research and practical application.

As well as helping it maintain its leading position on safety research, the FP participation has led to a stream of job applications from people in partner organisations wanting to work for Vtec. Other parts of the company do not experience similar pressure of applications but in this case the FPs help increase the supply of relevant manpower, owing to Volvo's capabilities and reputation in safety. Vtec's capabilities here also underlie Volvo Car's responsibilities for safety research within the Ford group.

Figure 59 Volvo safety FP participations

FP	Acronym	Title
FP3		Dummy modelling for car crash simulation (Car)
FP4	HUMOS	Human model for safety
	SID2000	Side Impact Dummy Enhancements for Improved Occupant Protection for the Year 2000 and Beyond
	SIDECAR	Simulation of dummy and its environment for car crash
FP5	HASTE	Human machine interface And Traffic Safety in Europe
	VC-COMPAT	Improvement of Vehicle Crash Compatibility through the Development of Crash Test procedures
	CHAMELEON	Pre-Crash Application All Around the Vehicle
	RadarNet	Multifunctional Automotive Radar Network
FP6	PREVENT	Preventive and Active Safety Applications contribute to the road safety goals on European roads. They help drivers to avoid accidents, by sensing nature and significance of imminent dangers, while
	AIDE	Adaptive Integrated Driver-vehicle Interface
	EASIS	Electronic Architecture and System Engineering for Integrated Safety Systems
	GST	Global System for Telematics enabling On-line Safety Services

The move from passive to active safety causes a convergence between the biomechanicians and systems people. Active and infrastructural safety work are long-standing parts of the ITS research agenda dating back to Prometheus, and Volvo's participation since the time of Prometheus has been a source of multiple innovations. Figure 60 looks beyond the FPs to take a (partial) look at some of the other key international projects involved. This is an area where there are standards battles and where industry tends to favour EUREKA or even self-financed cooperations as fora for agreeing very specific standards close to implementation. (The FP provides a place to do technical exploration about potential future norms and standards rather than always being very operational.)

Figure 60 Volvo participation in FP and selected other ITS projects

Programme	Acronym	Title
Prometheus	CED 3	Collision avoidance
	CED 5	Autonomous Intelligent Cruise Control
	CED 7	Commercial fleet management
	CED 9	Dual mode route guidance
	CED 10	Travel info services
FP3	MICRO MOBILE	
		Travel and transport information services
FP4		Development of Criteria and Standards for Vehicle Compatibility
	AWARE	Anti-collision warning-avoidance radar equipment
		Vehicle Automation - Driver responsibility, provider liability, legal and institutional consequences
FP5	VERTE C	Vehicle, Road, Tyre and Electronic Control Systems Interaction: Increasing vehicle active safety by means of a fully integrated model for behaviour prediction in potentially dangerous situations
	PUSSE E	Paradigm Unifying System Specification Environments for proven Electronic design
	3GT	3rd Generation Telematics

Programme	Acronym	Title
	ITSWAP	Intelligent Transport Services over Wireless Application Protocol
	E-MERGE	Pan-European Harmonisation of Vehicle Emergency call Service Chain
	RELY	Integrating Satellite DAB, terrestrial cellular technology and EGNOS capabilities to demonstrate real-time wireless navigation and fleet-management services
FP6	SISTER	Satcomms in Support of Transport on European Roads
	RCI	Road Charging Interoperability Pilot Project
	HEAVY ROUTE	Intelligent Route Guidance of Heavy Vehicles
	CVIS	Co-operative Vehicle-Infrastructure Systems
	SAFESPOT	Cooperative systems for road safety "Smart Vehicles on Smart Roads"
	ATESST	Advancing Traffic Efficiency and Safety through Software Technology
	FRICTION	On-board measurement of friction and road slipperiness to enhance the performance of integrated and cooperative safety systems
	SMMART	System for Mobile Maintenance Accessible in Real Time
ITEA	EAST-EEA	Embedded Electronic Vehicle Architecture
Industry	AUTOSAR	Automotive Open Systems Architecture

Figure 60 reminds us that Prometheus was the key European starting point for collaborative ITS research and traces Volvo participation through to FP6 and other current or recent projects. CED 10 Travel Information Services was carried on in the FP2/3 DRIVE programmes on travel and transport information services – reinforced by projects in mobile communications (FP3 MICROMOBILE and FP5 3rd Generation Telematics and the ITSWAP project that explored the use of the Wireless Applications Protocol for ITS. It leads on to 3GT in FP5 and GST and CVIS in FP6.

This line of research and demonstration built the basis for Volvo to launch its Dynaguide navigation and traffic information system in 1996. For a time this was a way for Volvo Car to differentiate its products, but a separate supply chain has since evolved for digital maps, traffic information and SatNav devices that can be retrofitted to vehicles, bringing scale and distribution advantages that the VMs have not been able to match. Volvo has been more successful with Dynafleet and other products that build on the work of CED 7 Commercial fleet management and address the narrower, professional market of truck fleet owners. Here, too, there is a history of relevant participations in FP projects, culminating in the FP6 HEAVYROUTE project. In 2000 Volvo span off Wireless Car to offer transport telematics products and services – having apparently learnt the lesson that a VM cannot readily operate such an activity if it is tied to its own vehicles and production volumes. Other new businesses like Kapsch, Q-fee and Efcon are building new business models in these areas.

The multi-functional nature of ITS means that projects cannot necessarily exclusively be allocated to one or another applications area. There is strong overlap between safety and information systems, for example. Some of the ITS work provides increasingly sophisticated platforms onto which services can be built. Maintenance, traffic information and emergency call services are among these. Here too, services like 'Volvo on call' have been launched that are based on FP research.

The Autonomous Intelligent Cruise Control and Collision Avoidance strands started in Prometheus still continue in active safety research. Early spin-outs into product include parking sensors. The difficulty (and legal liabilities – also explored in the FP) associated with building vehicle systems that cooperate or over-rule the driver is very large but Volvo expect these strands also to generate product innovations in the next few years.

ITS is not the only aspect of the vehicle where electronics is increasingly important. Electronic engine management, traction control, the need to control power steering and so on push the industry towards 'drive by wire' (again, something that was tried in Prometheus, though Saab not Volvo was involved on the Swedish side) and a need for comprehensive and open standards for electrical and electronic architectures and components for vehicles. The FP6 EASIS Electronic Architecture and System Engineering for Integrated Safety Systems project played a role in defining some of the needed standards. The industry has pursued such standards more widely through the EUREKA ITEA cluster, notably the EAST-EEA project to define an electronic architecture for vehicles and more widely through the industry-run AUTOSAR Automotive Open Systems Architecture project. Without such standards, powerful components makers can effectively hold the industry to ransom and leave smaller VMs especially vulnerable. The FP work that led into the emerging AUTOSARS standard therefore plays an important role in enabling continued innovation and sustaining the position of small manufacturers like the Swedish ones.

However, standardisation does not work everywhere. For example, neither the FP nor other European action has resulted in an interoperable standard for collecting road tolls. This imposes unnecessary costs on drivers and impedes the development of globally viable capital equipment companies in Europe.

If we sum up the effects of the FPs at Volvo AB, they are large

- They have made a key monetary contribution to the survival of the research function in Volvo AB and therefore the Swedish road vehicles industry as a whole
- They have enabled Volvo/Vtec to take a longer-term perspective in parts of its research, empowering it to provide not only short-medium term

technologies to the Volvo group but also to implement longer-term strategies to build future capabilities

- At times, this has involved sustaining technologies with a long-term future but for which there has been limited short-term operational interest within the group such as alternative drivelines
- A long series of product innovations – some successful, some not – can be traced back to Volvo's FP participation
- FP participation, especially through EUCAR, has allowed Volvo to 'punch above its weight' in helping set the FP agenda
- The FPs have helped sustain key Volvo technological strengths, notably in combustion, catalysis and safety/ITS
- They have extended Volvo's international technology and business partnerships (both with research institutions and industry) and maintained its position as an 'insider' in the European industry

But these effects are also contingent upon Volvo's own actions, national support and its relations with strong research capabilities in the Swedish knowledge infrastructure. They cannot be attributed to the FPs alone. The length of the lobbying process through EUCAR means that short-term issues cannot efficiently be levered through the FPs. They are better tackled in-house or with support from the national programmes, which can be more flexible.

6.5.1.2 Volvo Car

While there are some overlaps between the project participations of Volvo Car and Volvo TU/Vtec (such as the FP3 crash dummy work and HYDROTUBE), it is striking that most of Volvo car's participations are more process- and short-term orientated – which is what would be expected of an SBU's participation as distinct from that of the research department. The other striking fact is that the participation tails off following the acquisition by Ford (Figure 61).

The impacts of Volvo Car's participation have been improved process knowledge and design understanding. Some of the projects – for example, the VCR variable compression ratio project – have also provided insight into longer-term opportunities. From the perspective of an operating company with short-medium term interests, the presence of large numbers of competitors is often undesirable. For these purposes, national programmes and bilateral relationships – with Ford R&D in the USA or Germany or with the local Swedish knowledge infrastructure – are often more appropriate. Large, multi-competitor projects are interesting, however, when they build common resources that competitors can separately exploit. A current idea in the industry is to establish a Field Operational Test project – hopefully under the FP – that will create a large database of experience of driver behaviour, providing a useful resource for everyone.

Now, after some years of experience of Ford ownership, there is growing interest at Volvo Car in selectively returning to the FPs, especially in support of Volvo Car's relative strengths in the Ford group in safety and aspects of combustion. The company's relationship with Vtek means that it can access longer-term project results indirectly, as it did under Volvo ownership and it also has access through Ford Germany, which is in EUCAR. Caption

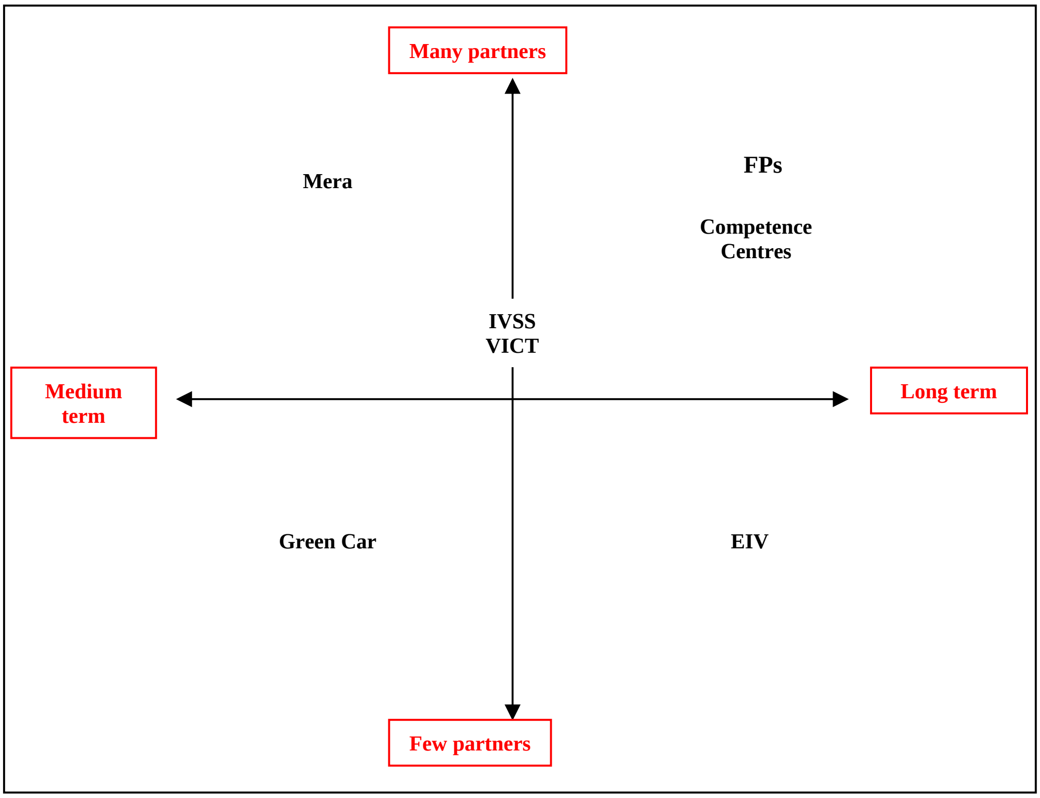
Figure 62 shows how the company perceives the roles of national and international automotive programmes. The FPs and the National Competence Centres are useful for long term topics that can be shared with many partners. VINNOVA's Mera production engineering programme is medium term but interesting because the issues tackled are of common interest: it does not hurt Volvo Car if other companies also benefit. In other areas such as the Green Car projects, which are more focused on obtaining specific competitive advantages, fewer partners can be tolerated. Rationally, therefore, companies will use different programmes for different purposes. It is reasonable to expect SBUs to be more interested in the South West quadrant and research laboratories to focus more on the North East - but with variations by theme.

Figure 61 Selected Volvo car vehicles FP participations

FP3		Development of split film co-knitted thermoplastic composites
		Dummy modelling for car crash simulation
		Refrigeration and automotive climate systems under environmental aspects
FP4		Eco efficient treatment of elv with emphasis on plastics
		Vehicle model based diagnosis
		Low Cost Press Tooling
	SI_GYRO	Silicon surface micromachined gyroscope for mass-market applications
	ZINCPASSIVATION	SUBSTITUTION OF ENVIRONMENTALLY HARMFUL CHROMATES FOR PASSIVATION OF ZINC PLATED PARTS WITH MOLYBDATE PHOSPHATE
	MULTIDOC	Multilingual document processing
FP5	3D - STRUCTURES	Lighter and Safer Automotive 3D-Structures at Low Investments through the Development of the Innovative Double Sheets Hydroforming Technology
	3DS	Digital Die Design System
	HYDROSHEET	Sheet Hydroforming for the Automotive Industry
	COMUNICAR	COmmunication Multimedia UNit Inside CAR
	EMF	Electromagnetic Forming of tube and sheet metal for automotive parts (EMF)
	PSIM	Participative Simulation environment for Integral Manufacturing enterprise renewal
	HUMOS2	HUman MOdel for Safety Two
	INLASMA	Improving Laser Welding in Automated Manufacturing
	PROBATT	Advanced Processes and Technologies for Cost Effective Highly Efficient Batteries for Fuel Saving Cars
	EUCLIDE	Enhanced human machine interface for on vehicle integrated driving support systems (EUCLIDE)
	LIRECAR	Light and Recyclable Car (LIRECAR)
	HYDROTUBE	Reduction of CO2-impact by weight reduction achieved by bending and hydroforming of steel and aluminium tubular parts for body and chassis applications.
	TECABS	Technologies for Carbon Fibre Reinforced Modular Automotive Structures
	RemoWeld	Highly Efficient & Flexible Remote Welding Systems for Advanced Welded Structures
	BRAKE	Distributed Automotive Safety System
	AFFORHD	Alternative Fuel For Heavy Duty (AFFORHD)
	VCR	Variable Compression Ratio for CO2-Reduction of Gasoline Engine (VCR)
	Mg-engine	Light Weight Engine Construction through Extended and Sustainable Use of Mg-alloys (Mg-Engine)
	LOCUST	Life-like object detection for collision avoidance using spatio-temporal image processing
	LTD - BAMS	Assessing long term durability of bonded automotive metallic structures (LTD-BAMS)
	MANIAC	Innovative methodology in quality assessment of coatings (MANIAC)
FP6	ATESST	Advancing Traffic Efficiency and Safety through Software Technology
	PREVENT	Preventive and Active Safety Applications contribute to the road safety goals on European roads. They help drivers to avoid accidents, by sensing nature and significance of imminent dangers, while

Caption

Figure 62 Vehicle Manufacturer Perspective on Roles of Automotive Programmes



Source: Sten Sjöström, Volvo Car

6.5.1.3 Saab Automobile

Saab was an important participant in Prometheus but its car division was 51% sold to General Motors at the start of FP3, hence the company on the one hand had access to GM's global R&D resources and on the other needed to find and compete for a place within the company's internal division of labour.

Lacking the large research resources of Volvo in Sweden and the mission to provide a rounded portfolio of short-, medium and long-term opportunities, Saab Automobile's R&D division's FP participation was limited from the start. GM's presence in Sweden comprises not only Saab Automobile but also part of GM Powertrain, building on Saab's capabilities in combustion, emissions and charging and therefore downsizing. In recent times, the Trollhättan operation has also had global responsibility for E95 (ethanol) engines. Saab/Powertrain's participation in the FPs faltered, made a recovery in FP5 in projects on biofuels, emissions, production and safety but then fell away again in FP6. By FP7, the company had begun to support its presence in Sweden with FP participation in two projects associated with charging and combustion. In practice, participation in national projects has been more important in order to maintain a medium-term edge in the internal competition within GM. Close links with Göteborg Competence Centres has been an important support to both Automobile and Powertrain, with GM in the USA also making use of the KCK centre.

GM does of course participate in the FP through Opel in Germany and Vauxhall in the UK, and some ideas from the Swedish operation are reflected in projects formally run from these locations. However, by not being involved in the long chain of combustion projects that were so important to Volvo TU/Vtec from the outset, it would now struggle to gain admission to the relevant networks. Being outside the European research networks also means Saab Automobile's perspective on technology and on others' capabilities is filtered through the USA. As a result, the position of the company is less robust that it would have been had it participated more significantly.

In this concentrated industry working to a demanding technological agenda, it is clear that there are not only benefits to being in the Framework Programme, there are also costs to being out.

6.5.1.4 Volvo Aero

While Volvo Aero – formerly Flygmotor – is part of the Volvo group, its different technical interests mean that it does a greater proportion of its R&D within the SBU, though there is still cooperation with Vtec. We can largely think of its FP participation, therefore, as if it were a free-standing company.

Volvo Aero formerly made entire aircraft engines, including various designs licensed from Rolls-Royce for use in Swedish fighter aircraft. However, the costs and technological demands that have forced increasing concentration in the industry have mean this is no longer a viable business strategy and the company now produces engine components for companies like Rolls-Royce and GE, which design and integrate (but in practice no longer produce all the components for) whole engines.

Early FP participations focused on what were then core technologies including combustion and ceramics but also areas such as composites and other materials for component construction. Since FP5, the time when the company shifted focus from whole engines to components, the projects are increasingly concerned with technologies for individual engine components and, occasionally, engine integration and test beds.

Moving to become a components business rather than an engines business has changed the meaning of the FPs for Volvo Aero. Now, the networking involved has a much higher value, since the company's strategy is to network with engine designers and integrators. Responsibility for FP participation has correspondingly shifted from the technical function to marketing. The EEFAE Environmentally Friendly Aircraft Engine project was key to this strange of strategy, providing a platform in which the company could build relationships but at the same time stake a claim to leadership in selected engine components. Crucially, it enabled Volvo Aero to extend its relationship with Rolls-Royce from military to commercial engines, with one result being that it has components flying on the new Airbus A380 double-decker wide body aircraft. A series of subsequent projects have provided ways to cement and extend these relationships and to become a partner in the Clean Sky JTI in FP7. This will establish a common test bed that should in turn bring significant technological and competitive advantages to its participants.

Volvo Aero makes use of the national Aircraft Technology programme (analogous to FFP), competence centres and more routine funding instruments, which it sees as vital to maintaining its technological competences and to doing shorter-term technological development. The key impact of the FP is that is has enabled the company to make the transition from whole engine production to an advantaged position in engine components and thereby to sidestep the economic logic that has been reducing the number of engine integrators over time. Its continuing commitment to advanced research and to cooperations like the FP is necessary in order to maintain its position in high-value components that are co-designed with other component makers and the engine integrators.

6.5.1.5 Combustion Engine Group at Chalmers

The Combustion group within the Department of Applied Mechanics at Chalmers has roots that go back to the 1940s. It currently comprises some ten faculty, fifteen doctorands and supporting technicians. It hosts the CERC competence centre in combustion engine technology and is one of the key sources of research-trained combustion engineers for the Göteborg vehicles cluster. During FP5, the group had four parallel FP projects, together accounting for about 20% of its income. Today, the FP provides about 6-7% of research income.

Chalmers sets great story by FP participation and contributes to project overheads in order to make this more feasible. From the group perspective the projects are nonetheless loss making and have to be cross-subsidised from other sources. The key research questions in the 1990s involved improving combustion models but the more recent focus on CO2 reduction means the FP work has become more applied and – from the university perspective – less interesting. This explains the declining importance of the FPs for the group. For the most part, however, FP projects have fallen within the broad research agenda of the group so their effects have been to increase the number of PhDs educated, publications and other research results rather than to alter their character. International visibility, networking and co-publication have increased. The working links with companies in the Göteborg area have further been reinforced but were already very close. Overall, the effects on the group have been a welcome portion of 'more of the same'.

6.5.1.6 Railway Mechanics at Chalmers

Formerly, when the state railways SJ and the ASEA company functioned as a 'development pair', Sweden boasted an independent railway equipment industry able to provide a rather complete set of equipment to the national railways. National railway markets were somewhat independent of each other and differences in standards hampered inter-operability. (Notoriously, for example, because of voltage differences the Paris-Amsterdam 'express' used to need three separate engines: one for each segment of its journey.) As in telecommunications, liberalisation and privatisation have reduced the ability of the infrastructure companies to do research and promoted concentration among equipment suppliers leading to increased standardisation, interoperability and economies of scale. The major facilities for railway equipment production in Sweden have moved from ASEA (ABB) to Daimler-Benz and on to Bombardier so that Sweden now produces sub-systems and certain train models rather than a complete range of equipment. Sweden's 'sector principle' – that sectoral agencies have responsibility for maintaining knowledge and research capacity to meet their own needs – means that the state's Banverket infrastructure agency runs a research programme in support of its needs.

Railway mechanics research began at Chalmers in 1987 and is currently carried out within the CHARMEC Competence Centre hosted by the Department of Applied Mechanics. The centre has strong, collaborative relationships with the railways and equipment manufacturers. NUTEK strongly encouraged the group to join the FPs and it was very successful in winning 5 projects in the mid-1990s. Today, they are in two projects and in the last three years the FP has provided a little under 20% of the group's research income.

The railway industry in Europe has had cooperations on standards and technology for many decades, but these have primarily been talking-shops rather than involving joint research. The internationalisation of the industry not only increases the need for standards but also the opportunities to increase performance. For example, increased scale and more intense competitive requirements for equipment performance (higher speeds, higher axle loads, less noise, fewer emissions – for example of particles) means that more aspects of designs have to be optimised. Sub-disciplines are being combined: for example, the old tradition of handling railway dynamics and deterioration research separately no longer works well enough and the researchers have to work with a combined analysis of dynamic train–track interaction and subsequent deterioration. As a result, the research front is international and in Europe a failure to participate in the FPs amounts to a decision not to do serious research.

The long lead times and administrative requirements of the FP are frustrating and the fact that the FP does not provide full cost coverage means that it cannot be the only element of the group's funding mix. Strong national funding is the foundation needed for international participation. The time-limited nature of FP funding means that the university manages risk by hiring contract researchers to do the bulk of the work. These include doctorands, but the nature of the work means they have to mix work on FP projects with other activities in order to incorporate enough fundamental research to satisfy the PhD requirements.

The effects of FP participation have been in one-way fundamental: it keeps the group in the 'game' and certainly the levels of international collaboration would have been much lower without it. These would have been bilateral rather than multilateral. About 75% of the group's international co-publications come from FP projects. Continued industrial funding of the group suggests that the mix of national and FP money also helps keep the group in a position of supporting Sweden-based industry: equipment makers as well as operators. The fundamental topics addressed in the FP work are ones the group would in any case have wanted to address, so there is no effect on the research direction and the use of contract researchers means that here is only a temporary effect on the group's size. But in an internationalising field it is clear that FP participation is one of a number of preconditions for this research group to play a useful role in research and education in the Swedish system.

6.5.1.7 SAFER

SAFER is a new research centre at Chalmers, funded by VINNOVA, the university and industry – in effect a large competence centre that has been created outside the national competence centres programme. It builds on the university's tradition of work on biomechanics and passive safety research to take a more holistic view of safety from risk reduction through active and passive safety. A key challenge for the centre is to shift its skills and focus more towards active safety.

Per Lövsund's group, which formed the initial core of SAFER, has a long history of FP participation going back to FP3 and a close relation with Volvo's passive safety projects during the period. The FP network projects have been especially important as ways to reinforce existing international relationships and generate successful proposals for collaborative work. The main effects of FP participation have been to increase the scale of the research rather than its direction. The group believes that it has been part of the community that effectively defined the research agenda in passive safety so there is a circularity in looking for ‘effects; of the FPs on research directions. More doctorands and senior researchers have been exposed to international research and able to develop international networks than would otherwise have been the case. Publication patterns are primarily driven by the needs of the doctorands, who do most of the work, so about 90% of publications are in peer-reviewed journals irrespective of the source of funding. The FP work has increased the degree of co-publication.

In the absence of FP funding, the research group would have been smaller and its focus would probably have been a little more on fundamental research in biomechanics. The opportunities to influence industrial practice and ultimately safety would correspondingly have been a little smaller.

6.5.1.8 Product and Production Development: Winqvist Lab

The core competence of this group is tolerancing and robust design and it hosts the Wingqvist Lab, a VINNOVA-funded competence centre. Both have very close links to Volvo SBUs in the tolerancing field. This is an issue of acute importance in design for manufacture but one that is not explored much in corporate research functions.

The group’s tolerancing capabilities were established using national funding and the level of industrial interest is sufficiently high that it has been possible to exploit the group’s capabilities through software and bilateral relationships. They have only once been involved in an FP project and see no attraction in seeking more FP money since they already have more work than they need. More broadly, they see little opportunity in the FP for the kind of production engineering questions with which they work. Further, there are very few groups elsewhere that tackle the same sort of research questions as this one and they are fierce competitors so the opportunities for collaboration are also limited.

6.6 Conclusions

The Framework Programmes have a very significant effect on the industrial sustainability and development of Swedish vehicles industries and their knowledge systems. This effect is possible because of the context of national research strength and funding, which have functions complementary to those of the FP. Sweden invests quite substantial sums of money in such national programmes but the level of spending is in proportion with what other vehicles-producing countries invest.

The Swedish road vehicles makers – especially the two US-owned car producers – are very small players in a global industry whose specialised technological competence is one of the keys to their survival. They exist in long-standing partnerships with local universities that support their specialisations through research and the training of engineers and research-capable manpower. These relationships help sustain the industrial capabilities that are essential to the VMs' survival in international competition – competition that takes place not only in the external markets but also inside the multinationals where different parts of the company compete to be allocated R&D and production tasks. Long-term R&D capability in the industry exists primarily at Volvo Vtec, which functions ad a research department not only for Volvo AB but to a degree for Volvo Car and others external companies. The health of Vtec is critical to the industry as a whole. Given the dependence of the Swedish VMs on common labour markets, components manufacturers and knowledge the system of vehicles production is interdependent and there is a strong national interest in maintaining the size and capabilities of the cluster. This is not only for reasons of competitiveness but because the loss of parts of the system could cause the whole to fall below critical mass. Broadly, for the Swedish vehicles industry the FPs are a source of funding for longer-term research questions while the national R&D supports address short- medium-term issues more critical to short term competitiveness where it is not desirable to involve a large number of competitors in projects. In other terms, the FPs address the areas of research where market failures are highest.

If we sum up the effects of the FPs at Volvo AB, they are large

- They have made a key monetary contribution to the survival of the research function in Volvo AB and therefore the Swedish road vehicles industry as a whole
- They have enabled Volvo/Vtec to take a longer-term perspective in parts of its research, empowering it to provide not only short-medium term technologies to the Volvo group but also to implement longer-term strategies to build future capabilities
- At times, this has involved sustaining technologies with a long-term future but for which there has been limited short-term operational interest within the group such as alternative drivelines
- A long series of product innovations – some successful, some not – can be traced back to Volvo's FP participation
- FP participation, especially through EUCAR, has allowed Volvo to 'punch above its weight' in helping set the FP agenda
- The FPs have helped sustain key Volvo technological strengths, notably in combustion, catalysis and safety/ITS

- They have extended Volvo's international technology and business partnerships (both with research institutions and industry) and maintained its position as an 'insider' in the European industry

These effects are also contingent upon Volvo's own actions, national support and its relations with strong research capabilities in the Swedish knowledge infrastructure.

The strong players in the Swedish scene – both in industry and the universities – have participated in a series of FP projects over many years. This means they have good intelligence about the capabilities and activities of both partners and competitors and have roles to play in technological development. As Saab Automobile has discovered, those who are unable to join or who drop out of these networks get left behind, becoming increasingly unattractive cooperation partners for the incumbents. So there are not only benefits of joining in FP projects; there are also costs of staying out. This is particularly the case in vehicles, which is an increasingly concentrated industry that itself tends to define the FP research agenda. The FP does not 'lead' but reflects a consensus on what the important research questions and interesting technologies are.

The FPs are also crucial to other parts of the vehicles industry. In particular, Volvo Aero's success as a jet engine components maker depends not only upon the technological competences it hones internally and in the FPs but also on the relationships it forges there with engine designers/integrators and with complementary producers of engine components. The FP keeps university railways research in Sweden in touch with the research frontier and the European railway research community, so that it is able to support both the national authorities and Sweden-based industry.

For the university groups involved consistently, FP funding does not mean a change of direction but money that lets them increase their scale of operations and networks that keep them involved with the leading research questions in their fields. These support their abilities to remain in the established national partnerships with their industrial counterparts.

Leaving the FP is hardly an option for Sweden or for other member states. The vehicles industry example, however, is one where the benefits of involvement are large and the disbenefits of disengagement would also be large. This is a case where industry is mature, concentrated and organised to express its needs. The Framework Programme is well adapted to such situations – and, indeed, the encouragement of Technology Platforms JTIs and Article 169 arrangements in FP7 underlines this fact.

National level policy implications include

- A need to continue to support FP participation as far as possible
- Defining national R&D policies that complement the FPs rather than imitate them. FP funding is not a substitute for national funding
- Policies that tend to concentrate research capabilities so that they develop the mass and quality needed to participate in the FPs
- Engagement in the ‘lobbying’ processes through which industry influences the course of the FPs
- Given the importance of individual companies and research groups in this concentrated set of industries, tailoring national R&D support policy to specific needs rather than setting the kind of ‘level playing field’ rules that make sense in fragmented areas

7 Sustainable Energy

This Chapter describes the results of the case study on Swedish participation in the EU Framework Programmes for R&D in the area of Sustainable Energy.

The domain ‘sustainable energy’ for this evaluation includes R&D projects related to

- Non-carbon energy sources (hydro (incl. wave energy), wind, solar)
- Short cycle carbon sources (biomass)
- Technologies that may play a role in a non-CO2 energy society (hydrogen, fuel cells, CO2 capture and storage, electricity grid, etc.)
- Other (mainly policy projects)

In the following sections, first a sketch of the Swedish sustainable energy sector (including energy policy) is given, followed by a discussion of the dynamics in the sector. Then the Swedish energy research expenditure since 1974 is compared with international expenditure based on IEA (International Energy Agency) R&D statistics. Section 4 gives an overview of Swedish participation in the various framework programmes. In Section 5 we draw conclusions about the impact of the FPs.

7.1 The Swedish sustainable energy sector

The most important energy sources in Sweden are hydropower and nuclear energy. In 2006, total electricity supply was 157.861 GWh: 38.8% hydropower; 41.2% nuclear power[64]. Since the mid 1990s the production of nuclear power (peaking in 2004 at 75.000 GWh) and hydropower (peaking in 2001 at 78.418 GWh) has more or less remained stable.

Bioenergy is also very important in Sweden. Wood and wood waste provided 32.6% of all carbon-based energy in Sweden (424.706 TJ in 2007)[65], partly used for electricity production, but mostly for heat generation. Since the 1980’s, especially the use of wood fuels for district heating has increased[66]. Wind is the another renewable energy source of some importance, (0.6% wind power), which has slowly but steadily increased over the years.

[64] Statistics Sweden
[65] Energiförsöjningen fjärde kvartalet samt aren 2006 och 2007, Energimyndigheten och Statiska centralbyran
[66] IEA Task31 Country report Sweden 2008

If we look at the Swedish sustainable energy sector four types of actors can be distinguished

- Research actors: universities (and to some extent research institutes)
- Energy producers
- Other users of sustainable energy systems and components
- Producers of sustainable energy systems and components

The *research actors* in the sustainable energy system are mainly located in the universities. There is not one single university centre for the whole area of sustainable energy. KTH, Chalmers and Lund cover a broader range of areas (with some size in the area of biomass). Some of the other universities have more specialised groups in one area like the Ångstrom solar centre and the wave energy group at Uppsala University or the dye-sensitized solar cells group at KTH.

Biomass research is also performed in research institutes (e.g. SP-Swedish National Testing and Research Institute and Skogforsk-Forestry Research Institute of Sweden). Sustainable energy research outside the biomass area in the research institutes is limited since the Aeronautical Research Institute of Sweden (FFA) was merged and stopped its activities in the wind energy area.

The *energy production sector* in Sweden is dominated by large utility companies like Vattenfall, Fortum and Sydkraft (now EON Sweden). A small part of the research of these companies is (since 1993) coordinated by Elforsk AB, a virtual organisation.

Local communities with their own district heating systems (largely based on biomass) are also of importance. Furthermore the forest industry (e.g. paper industries SCA, Stora Enso) generates its own heat and power by burning its biomass waste.

Other *users of sustainable energy systems and components* are industrial companies like Volvo (interested in using more sustainable energy sources for their cars, e.g. fuel cells) and local communities promoting the use of sustainable energy (e.g. Växjö).

There is no single sector of *producers of sustainable energy systems and components*, but each source of sustainable energy has its own players who do not interact very much with companies using other sources of sustainable energy.

Within this group the equipment suppliers in the biomass sector are the largest because of the long bio-energy tradition in Sweden. Important players include Alstom Power, ABB, TPS (combustion technology), Turbec (micro turbines) and SEKAB (bio fuels).

The solar energy sector consists of Sunstrip (a leading European manufacturer of absorbers for solar heating, approx. 20 employees), a couple of smaller collector manufacturers, 5 photovoltaic-module manufacturers (rather low-tech companies, mainly integrated with (foreign) suppliers of silicon-solar cells), and two very innovative cell manufacturers (Solibro AB (research in Sweden, production in Germany) and Midsummer (starting production in Sweden in 2008)). Overall it was estimated that 400 people were working in the PV community in Sweden in 2006.[67]

Sweden does not have a domestic wind turbine industry, however there is assembly of Finnish WinWind wind turbines (at Dynawind, a subsidiary of Morphic) and tower production for Enercon. Furthermore Sweden has a strong component industry with a.o. ABB (cable, generators, power electronics), SKF (bearings, control equipment) and ESAB (welding equipment). Project developers (developing wind parks) include, apart from the utilities companies like Vattenfall, Vindkompaniet (which is participating in FP projects).

Hydroelectric power is dominated by Alstom Power (who supplied turbines for the Three Gorges Dam in China) and ABB (supplying subsystems).

In the area of fuel cells there are three manufacturers: Volvo, Cell Impact (also a Morphic subsidiary) and Cellkraft, in addition to some component manufacturers.

There is also some small Swedish involvement in wave energy (Seabased AB - in the development stage) and Sweden has the largest number of heat pumps installed in the world for use of geothermal energy.

7.2 Dynamics of the sustainable energy sector

The availability of hydropower and nuclear power (since the 1960s) started to reduce the dependency of Sweden on imported coal and oil and led in the 1970s to low policy need for other sources of (sustainable) energy, reducing the market potential for these energy sources. The 1980 referendum to close nuclear power generation led to renewed attention to sustainable energy sources (although the first nuclear reactor was actually closed only in 1999). Climate change became a major driver for sustainable energy policy from 1990 onwards. Energy taxes were lowered, while CO2-taxes were

[67] National Survey Report of PV power Applications in Sweden, Ulf Malm&Lars Stolt, Uppsala University, May 2007

increased with the consequence that fossil energy became more expensive compared with sustainable energy. The next step in terms of policy was the start of a green energy certificate trading scheme in 2003, increasing the amount of (new) sustainable energy that has to be provided to consumers every year. All these policy initiatives focused on promoting renewable energy in the most cost efficient way, including competition between different sources of renewable energy and culminated in the 2006 decision to become the first oil-free economy by 2020.

As a result of these policy dynamics, sustainable energy (apart from hydro-electric power) started to grow. The greatest growth was in biomass, the most cost efficient source of renewable energy in the Swedish situation. In the 1990s the use of biomass in Sweden increased by 44%[68]. The availability of wood waste from the forest industries, combined with the tax on fossil fuels, led to application of this renewable energy source to cover the energy needs of the industry and in district heating systems. CHP (Combined Heat and Power generation) became more and more important. EU targets on sustainable energy per country also gave wind energy a boost, especially offshore in wind parks. However wind-energy is still rather marginal compared to hydropower or biomass.

The industrial landscape of renewable energy was as a consequence also rather dynamic. The large utility companies were influenced by the liberalisation of the energy market. Sydkraft and Fortum privatised (and became parts of international companies) and Vattenfall, although still government owned, was further distanced from the government. This led in some cases to a diminished and refocused position towards their renewable energy research in Sweden. The utility company research had always been a defensive: they wanted hands-on experience with new technologies to see how these technologies could influence their markets. This experience could now also be obtained abroad.

In the area of biomass the dynamics were also very intensive. Forest industries, municipally owned CHP plants and various equipment manufacturers (including Alstom and ABB) have played more prominent roles in developing Sweden’s position in commercial use of renewable energy sources.

ABB and Alstom also played a role in hydropower (and nuclear power): Alstom as a manufacturer of power plant and turbines and ABB mainly in electric systems.

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[68] Biomass and Swedish energy policy, Bengt Johansson, Lund University, 2001

The dynamics in the sector are most strongly visible with the small players.

- The wind turbine manufacturers (e.g. Nordic Windpower) were not able to establish a domestic industry, and in the case of Nordic, moved to the US
- Solibro's solar cell production was partly financed by Sydkraft under pressure from the Swedish government to create a Swedish solar cell manufacturer, but could only establish production facilities in Germany together with Q-cells
- The PV module manufacturers face hard competition from Asian competitors and can only survive through their direct access to solar cells from their sister companies
- SEKAB, Sunstrip and Morphic are all still rather small companies and the start-ups like Midsummer, Cellkraft and Seabased are still very small and/or in a pre-production phase

7.3 Swedish energy research in an international context

The IEA R&D statistics[69],[70] show that the total Swedish expenditure on energy R&D for the period 1974-2006 was €3.5 bln (Figure 63). 33% was spent on energy efficiency and 26% on sustainable energy.

[69] Accessible by way of http://www.iea.org/Textbase/stats/index.asp
[70] The IEA database on energy R&D has it's limitations, esp. with respect to new areas of energy research, but is the best that is available, see for a discussion Energy R&D statistics in the European Research Area, EUR21453, EU DG Research, 2005

Figure 63 Swedish energy research 1974-2006 (M€)

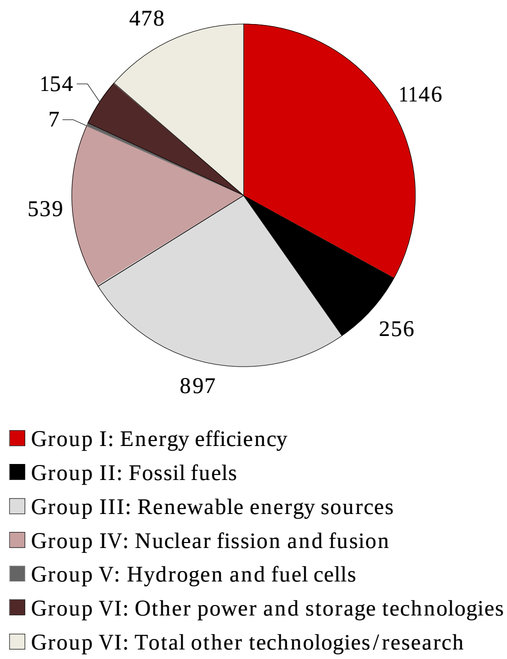
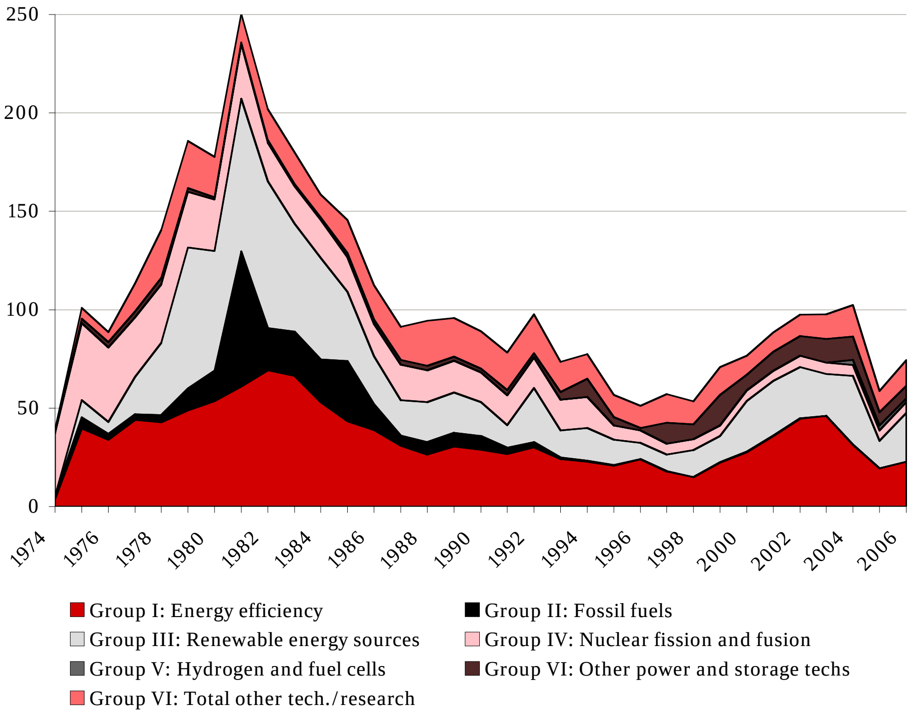


Figure 64 shows the expenditure per research topic over the years in M€.

Total Swedish energy research increased significantly after the energy crises in the 1970s, peaking in 1981, and then rapidly declining in the 1980s, rising again only after the year 2000.

Figure 64 Swedish energy research 1974-2006



During the years 1974-2006 Sweden performed 0.88% of all IEA research and followed the trend of the IEA countries. Sweden is however more extreme in its fluctuations in Energy R&D expenditure. In 1981-1983 (when energy research in the IEA was already twice as high as at present) Sweden was responsible for 1.26% of all IEA R&D and in 1995-1999 (when energy research in the IEA was low, at 90% of its present value) Sweden was responsible for only 0.60% of energy R&D in the IEA.

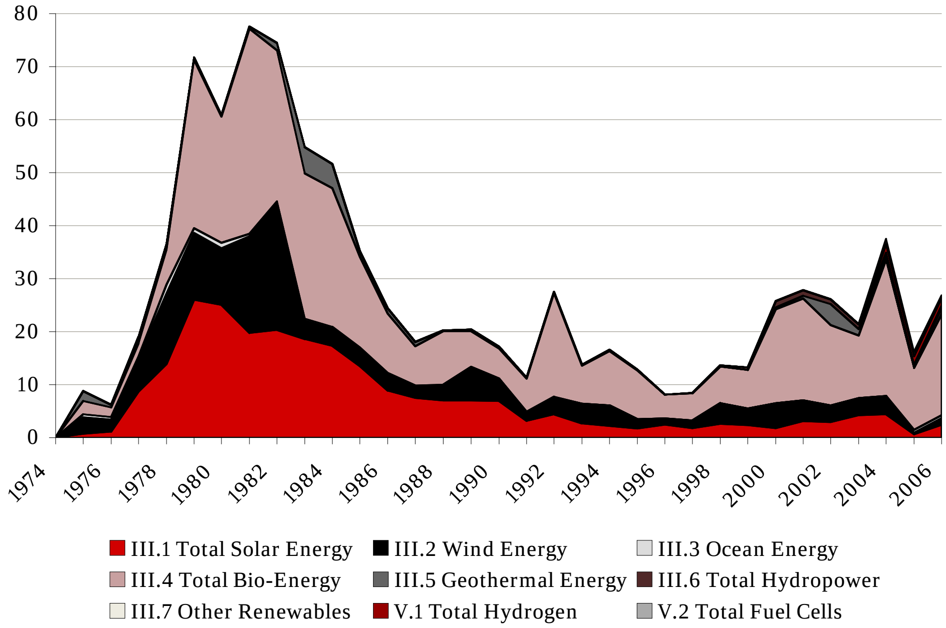
The figure also shows that fossil fuel research was an issue only in the years 1980-1990, and that nuclear research was cut back by some 40% after the 1980, and again by more than 60% after 1994. Other power and storage technologies have been growing since 1990. (Statistics for Hydrogen and fuel cell research are only available since 2003).

Sweden has spent significantly more than the IEA average on energy conservation (3.31% of all IEA research in this area has been done in Sweden since 1974) and sustainable energy (2.67%). Significantly less than average has been spent on nuclear energy (0.24% of all IEA research in this area) and on fossil fuel research (0.50%).

Figure 65 looks specifically at sustainable energy research in Sweden. Biomass research has remained the most important sustainable energy research topic in Sweden since the 1970s (50% of total renewable energy research). Solar energy and wind research were significant areas (27%; 18% respectively), but their importance has decreased in the last few years.

The decrease in solar energy research is mainly related to a decrease in R&D spending on solar heating & cooling (inc. daylighting), that dropped from a maximum of €25m in 1979 to zero in 2006. Research on solar PV showed a gradual increase from 1996, peaking in 2004 (at €3.5m). Geothermal and ocean energy research have been generally small.

Figure 65 Sustainable energy R&D in Sweden 1974-2006 (M€)



There is a surprisingly small amount of R&D in the area of hydropower. The IEA figures state that (after long years of negligible spending) the investments since 2000 were around €1m per year (€1.1m in 2006). The Elforsk research programme however claims to have spent 58m SEK (some €6 m) alone.

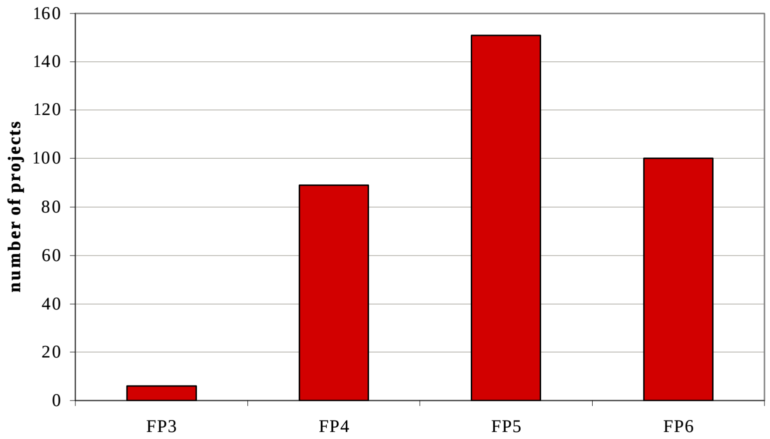
According to the IEA database there was no research on CO2 capture and storage (contrary to Swedish FP participation, see below).

7.4 Swedish FP participation in the area 'Sustainable Energy'

7.4.1 Overall participation

To our knowledge, Swedish universities, institutes and companies participated in 346 projects in the area of Sustainable Energies in the European Framework Programmes (FP3-6, Figure 66). The development of the number of projects with Swedish participation in the area of sustainable energy in the Frame Programmes is more or less in line with the development in specific budgets for sustainable energy in the FP's: a strong increase from FP3-FP5, and then a serious decrease in FP6.

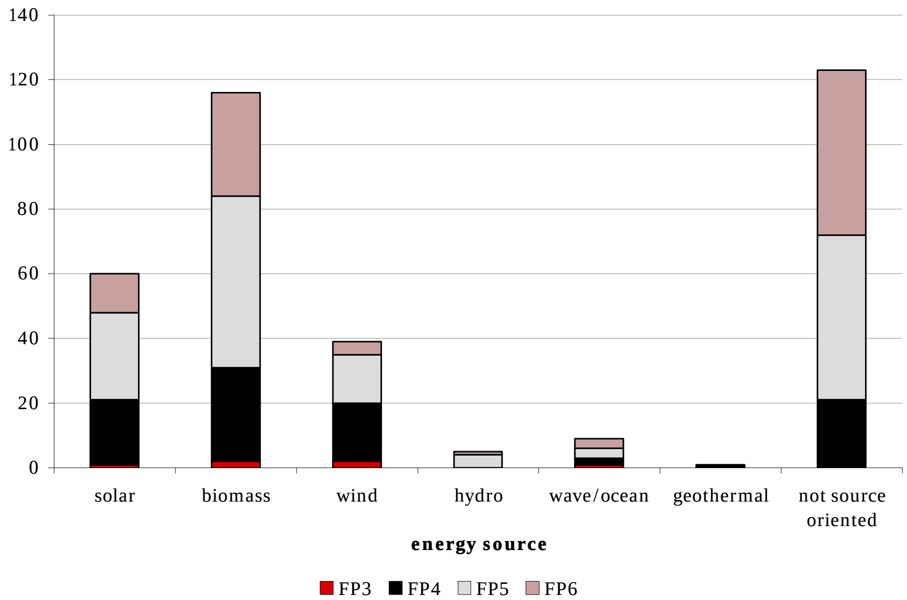
Figure 66 Number of projects with Swedish participation in FP area Sustainable Energy



Source: Technopolis analysis

Figure 67 shows the distribution of Swedish projects per source of energy. The largest group comprises of the 'not source oriented' projects. These include general policy projects and projects aiming at applying sustainable energy without specifying the source of energy (e.g.. sustainable energy development projects in cities; hydrogen and fuel cell projects, etc.).

Figure 67 Swedish projects by source of energy



Source: Technopolis analysis

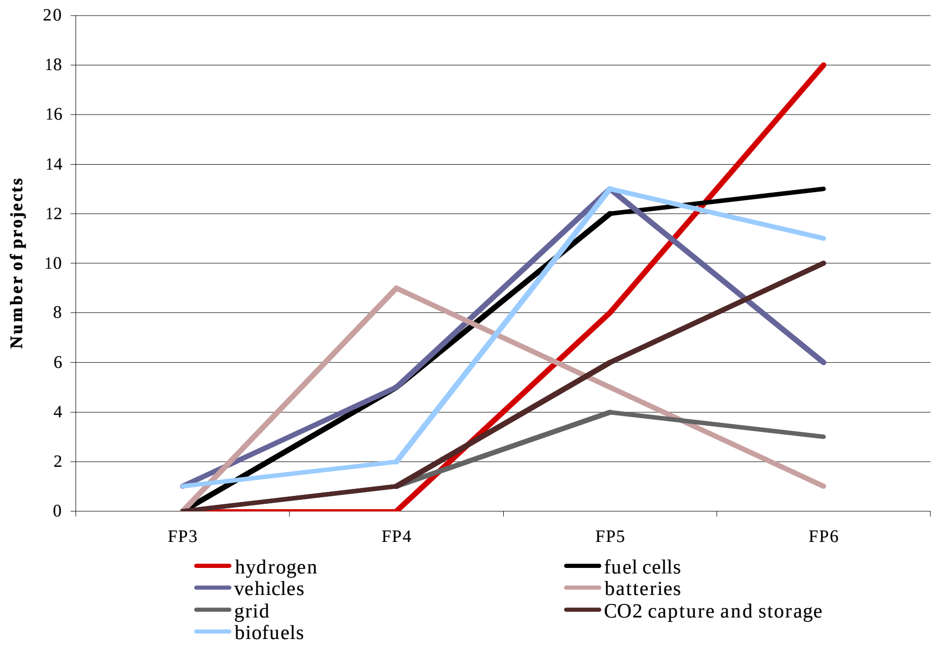
Among the remaining projects the largest group (50%) is related to biomass (mainly thermal processes; some biological projects and increasingly liquid bio fuels), 26% is in the area of solar energy and 17% related to wind energy. There is only a very small number of projects on hydro electric power, wave/ocean energy and geothermal energy.

This distribution is completely in line with the budget distribution of Swedish Energy research according to IEA statistics (see above) and the distribution of the projects in the Swedish Long Range Energy Research programme[71].

Figure 68 shows the number of Swedish projects in the FP programmes in some application areas. 'Hot issues' in recent years are hydrogen, fuel cells, (liquid) bio fuels and CO2 capture and storage, and to a lesser extent projects with respect to the electricity grid and decentralised electricity production. The number of projects in the areas of batteries and vehicles decreased. Battery research seems to have been replaced by fuel cell research; and fuel cell research shifted later on from mobile to stationary applications. These are not only Swedish developments; the trends are noticeable elsewhere as well. The IEA database only has figures on these emerging research topics since 2003 for some countries. These show a large growth in these topics from then on. The relative participation of Sweden in this area seems rather low, but this may partly be attributed to the low absolute figures and the inaccuracy of the data.

[71] Evaluation of the Swedish Long Range Energy research Programme, 1998-2004, Final Report, Technopolis, 2003

Figure 68 Swedish FP projects in sustainable energy by application



Source: Technopolis analysis

The total number of Swedish participations in the 346 sustainable energy projects was 527. This means that on average 1.5 Swedish partners were participating in each project with Swedish participation. In almost half of the Swedish participations there is only one Swedish partner, and in some 20% there are two partners. The limited number of projects with larger Swedish participation accounts for the remaining participations. No clear cooperation pattern could be discovered. Many projects include university-industry cooperations (within Sweden), but there are also industry-industry links within Sweden within the projects (as well as other combinations of Swedish partners).

The number of Swedish participations per project is highest for biomass (average: 1.7), maybe a reflection of the strong Swedish position in this area and/or the small size of university groups.

If we look to the number of Swedish participants per project in specific technology or application areas the extent of cooperation in the area of vehicles is high (on average 2.12 Swedish participants per project with Swedish participation). Other areas with a relatively large number of Swedish participants are hydrogen (1.7) and grid and related technologies (1.6). The high cooperation in these areas may however be caused by the facts that these are all relative new areas that increased in importance in the last FPs (which also included new instruments like NoEs and IPs, aiming at larger groups of participants. Our dataset was not sufficiently detailed for determining this).

7.4.2 Swedish Participation per sustainable energy sub-area

7.4.2.1 Solar energy

Swedish participations in FP3-6 focus on solar PV: 46 project participations, against 27 in the area of thermal solar energy. This is contrary to the IEA statistics where thermal solar energy has been far the most importance topic (budget wise) until 2000-2002. Possibly much of the budget for thermal solar energy R&D has gone into applications research in Sweden in order to obtain a fast reduction in energy consumption in the 1980s. PV was then (and is to a certain extent) still more embryonic. Furthermore, PV-research is an international research field of high tech nature and therefore available budgets in FP-calls were higher. Swedish participations in FP projects come both from the private sector (some 45%) as well as from the public sector - mainly (40%) universities.

Participants with more than 2 participations are given in Figure 69.

Figure 69 Most important Swedish participants in FP solar energy research

	PV/Th/other	FP3	FP4	FP5	FP6
CIT Management AB	Th			3	
Scanarc Plasma Technologies AB	PV			3	2
Sunstrip AB	Th			3	
SP Swedish National Testing and Research Institute	Th, oth		1	1	2
Dalarna University	Th		1		2
Kungliga Tekniska Hoegskolan	PV, Th		2	2	1
Uppsala University	PV, oth		6	5	2

Source: Technopolis analysis

The leading university in this area in Sweden (based on FP participation) is clearly Uppsala University. Most of the projects are from the Ångstrom solar centre there. This centre is also participating in the JTI/TP in the solar cells area now. The FP projects were essential for the solar centre because there was no other financing in the beginning. Solibro AB was a spin-off from the solar centre, and the FP research was therefore an essential (but not sufficient) element in setting up Solibro.

Midsummer (the other PV-cell manufacturer in Sweden) has participated in one FP project, which forms the basis for existence. Nobody in Sweden believed in its technological approach, and therefore it could get no funding. The FP project raised its first significant budget, and opened up ways to venture capital (and national projects).

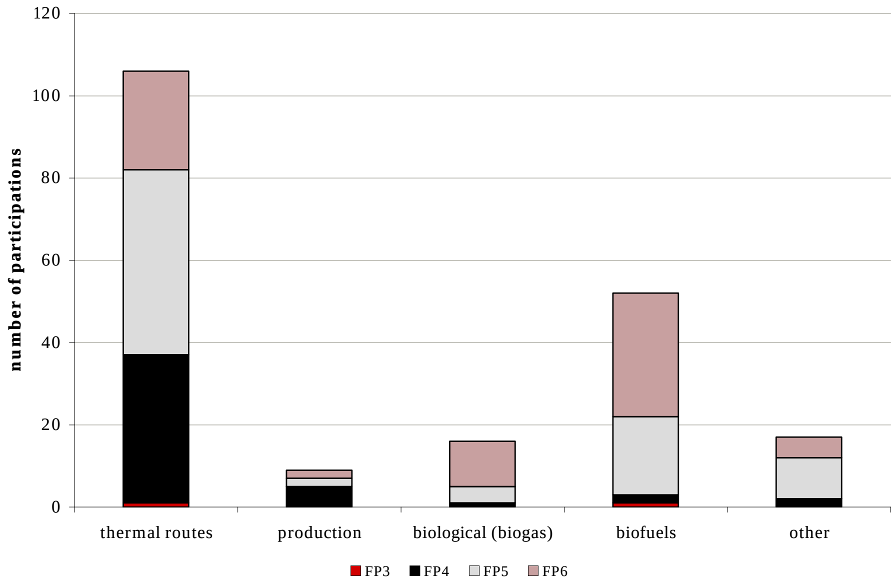
Scanarc Plasma Technologies AB is the only company with more than 3 participations. They are mainly involved in projects on (plasma) process for the production of solar grade silicon.

Sunstrip (the leading European manufacturer of absorbers for solar heating) has 3 FP participations. These cooperation projects are mainly with Spanish partners and seem to focus on market application. Sunstrip's core technologies were developed outside the FP with Uppsala University and SAPA (an aluminium manufacturer from Sweden).

7.4.2.2 Biomass

There are 200 Swedish participations in the waste and biomass area. In line with the instruments of the FPs (promoting larger consortia) the number of Swedish participants in these projects increased from 1.5 (FP4 and 5) to 2.25 (FP6).

Figure 70 Swedish participation in FP biomass research



Source: Technopolis analysis

As can be seen in Figure 70 thermal routes for biomass utilisation form the largest focus of attention of Swedish participants, but the relative importance of this topic has decreased since FP4. Bio fuels (for transport) is growing in importance. Production of biomass (cultivation) has received little attention in recent years.

Companies are the leading Swedish group in FP participations with 50% of participations, but there is also a strong university presence (approx. 30% of participations). This distribution has been rather stable throughout the FPs.

Chalmers University is the only party in this area involved in all Framework Programmes since FP3, however this concerns various different groups. Kungliga Tekniska Högskolan is the university with the largest number of participations. Lund University is the university with the largest number of recent participations. Overall the participation seems as scattered over the different groups as is the Swedish university research system.

The most important Swedish participants in FPs the area of biomass research are given in Figure 71.

Figure 71 Swedish participants with more than 3 participations in FP biomass research (number of participations)

	FP3	FP4	FP5	FP6
Alstom Power Sweden AB			5	
Energidalen I Sollefteaa AB		1	2	
Svalõf Weibull Ab		3		
TPS Termiska Processer AB		9	6	2
Turbec AB			1	3
Vattenfall AB		5	5	3
City of Stockholm			3	2
Swedish Energy Agency			1	2
Bioalcohol Fuel Foundation			2	2
Chalmers University of Technology	2	3	2	1
Kungliga Tekniska Högskolan		6	7	5
Lulea University of Technology		3		1
Lund University			6	8
Sveriges Lantbruksuniversitet		2	3	4
Umeaa University		1	2	1

Central players on the private side are Vattenfall AB and TPS Termiska Processer AB. Vattenfall has researched and demonstrated various (co)combustion technologies for electricity generation.

TPS was a 1992 spinout from Studsvik AB, a nuclear R&D company. At its formation, TPS was owned by a consortium, comprising its own personnel and Swedish energy companies. FP projects were important for the growth of TPS from 40 to 50 persons[72]. Then the company transformed from being an R&D company towards development/engineering, and later also manufacturing. At present it is owned by a Swedish Investment Group.

Alstom has mainly worked on turbine R&D in the Framework Programmes.

The bioalcohol fuel foundation (with SEKAB as prominent member) has participated in projects on ligno-cellulosic ethanol, on bio ethanol for sustainable transport (with 9 Swedish partners), on/ETBE in Italy and China and in Latin America Thematic Network on Bio energy.

[72] TPS web site, 22-07-2008

7.4.2.3 Wind energy

There are 51 Swedish participations related to wind energy. These participations are more or less equally divided over the various groups of players in the Research and Innovation system (universities; institutes and government; companies), with the companies leading with 41% of participations.

The largest number of participations in the wind energy area were by the former Aeronautical Research Institute of Sweden (FFA). They were responsible for 22% of all Swedish participations, and participate in 30% of wind projects with Swedish participation. Most (8) of these participations date from FP4. In FP6 there is no participation from FFA. Since the integration of FFA into the Swedish Defence Research Institute, interest in wind energy seems to have disappeared.

Other important participants are T.G. Teknikgruppen AB (5 participations; 4 in FP4; 1 in FP6; a consultancy firm specialising in wind energy); Chalmers University (4: 2 in FP3; 2 in FP4); Kungliga Tekniska Högskolan (4: 2 in FP4; 1 in FP5; 1 in FP6); The Swedish Defence Research Institute (3 in FP5); Nordic Windpower AB (3: 1 in FP4; 2 in FP5) and Vindkompaniet (I Hemse) AB (3: 1 in FP4; 2 in FP5).

Nordic went bankrupt and is now American based and owned. Vindkompaniet is developing wind parks all over Sweden, but is not manufacturing wind turbines. Suppliers like SKF and energy companies like E.ON have participated only in one FP project

The limited industry that Sweden has in wind energy seems therefore not much based on FP results.

7.4.2.4 Wave energy

There are 11 Swedish participations (in 9 projects) in the area of Wave/Ocean Energy. Overall half of these participations are related to (training) networks and coordinated actions. The other half are research participations. Seven of the wave/ocean energy participations come from universities (mainly Chalmers University, recently also Uppsala University). Companies participate in 4 projects ABB AB (FP6), Veterankraft AB (FP5) and ITT Flygt Products AB (FP4)). Overall the activity in this area is quite marginal. The only activity with Swedish involvement that at this moment might lead to commercial exploitation is Seabased, a spin-off from Uppsala University. This is, however not an FP related development, although Uppsala University is participating in CA-OE, the Coordinated Action on Ocean Energy in FP6.

7.4.2.5 Hydropower and other sources of energy

Hydropower research is more or less absent in FP research: only 5 projects with Swedish participation: 4 in FP5 (KTH, Sveriges Energieföereningars Riksorganisation, Ericsson, Cargo&Kraft Turbin AB) and one in FP6 (All Motion Technology AB). The IEA database shows no Swedish research in this area from 1974 until 1994, and only after 2000 significant amounts (approx. €800.000/year). As has been stated above the Elforsk research programme has spent 58m SEK (some €6m) in 2006 alone on SVC a new Swedish Hydropower Centre in order to maintain and improve the available knowledge in this area in Sweden. The main industrial player in Sweden, Alstom Hydropower is however not visible in the FP.

In the area of geothermal energy there has only been one project, in FP4, by Chalmers University.

7.4.2.6 Fuel cells and hydrogen

Participations in the area of fuel cells start in FP4 (5 Swedish participations), and increase rapidly in FP5 (16) and FP6 (21), caused by the increasing budgets for this topic in the FPs. Universities and companies each account for approximately 50% of participations. There have been no institutes active in this area in the Framework Programmes.

Hydrogen research is only present in FP5 (15 Swedish participations) and FP6 (30). Companies are responsible for 53% of participations, universities for 31% and institutes and government bodies each for 6%.

The number of parties active in FP fuel cell research is rather limited. 10 companies and 5 universities (and 1 government organisation) account for all 42 participations. Dominant within the universities is the Kungliga Tekniska Höegskolan (KTH) with 12 participations. Among the companies Volvo AB is most active with 9 participations. Sydkraft AB has 3 participations, and has obtained a leading role in the FP7 Fuel cell Technology Platform, and is therefore able to influence the European Research agenda in this area (to a certain extent). The long term presence of Sydkraft has led to an influential position for Sydkraft in Europe in this area. With the take-over of Sydkraft by Eon, the former Sydkraft (now Eon Sweden) remained responsible for following up this line of development for the whole Eon group (and not Eon Germany). However, the reasons for Eon/Sydkraft to follow up this line of research are rather defensive: they don't want to miss out when this gets big. Since Eon is an end-user not an equipment manufacturer it is doubtful that the predominant economic effect will be in Sweden.

Quite a number of companies active in fuel cell research are also active in the biomass research in FP5.

In the area of hydrogen the University of Stockholm is leading with their 4 research participations in projects on hydrogen storage technologies. Uppsala (3 projects) and Lund (1) are active in biological hydrogen production. Lund also has two more system oriented hydrogen projects. Volvo AB is here in the lead as well from the company side: these are in general different projects than the fuel cell projects above, although they are obviously related.

7.4.2.7 CO_2 capture and sequestration

Although no research in this area was identified by IEA, Swedish researchers are actively participating in FP research: 17 projects with Swedish participation have started in this area with 21 Swedish participations (1 in FP4; 9 in FP5 and 11 in FP6). As in other European countries power companies have taken the lead, in the Swedish case Vattenfall, with 9 participations. In its cooperation Vattenfall is only once cooperating with a Swedish partner, Chalmers University (ENCAP project FP6).

There are two FP5 projects with Alstom participating, both focusing on a CO2-free power plant. All other participations are from universities (Lund 3, KTH 3, Chalmers 3 and Uppsala 1).

7.5 Observations/conclusions

7.5.1 Relative importance of FP financing in the sustainable energy area

Financial figures on budgets related to FP participation at project level were not available to the project team. With Swedish participation in 346 FP projects in the area of sustainable energy and an estimate of €200-300.000/project the Swedish return of the FP may have been around €70-100m over the FP4-FP6 period (1995-present), or approximately €5-7m per year. Compared to the IEA figures on sustainable energy R&D (for this period on average €20m/year) this is a significant amount.[73]

For the university groups participating in the FPs, this participation has often been quite important. One respondent claims that at times 50% of all research of the group was funded by the FP. More common seem FP-contributions of around 20%. This means that the FP financing has contributed significantly to the size of Swedish university research activities in the area of sustainable energy.

[73] Björn Telenius (Swedish Enterprise and Energy Ministry) estimated in 2004 a much lower contribution of FP to Swedish sustainable energy research (10%, e-mail of 29-9-2008)

7.5.2 Topical Focus of FP research in comparison with Swedish national research

In terms of research subject/source of energy the Swedish participation in research in the FP is in a striking way similar to research in the Swedish Long Range Energy Research programme and the overall IEA figures on sustainable energy research in Sweden: 50% biomass research, 25% solar energy research (though in FP more focused on PV), 20% wind energy and 5-10% other. The question arises whether this is a deliberate strategy (which means that Swedish national policy was leading) or whether this is caused by the (more or less independently defined) topics of the FPs and the orientation of Swedish industry.

Professors interviewed state that the themes in the FP had only limited effect on their own choice of research topic. Of course they were influenced by international research results and discussions but basically they were following their own interest, and using the FP when their own interests were in line with the FP goals.

This conclusion seems also valid with respect to small companies: entrepreneurs don't take huge risks in starting an FP project when these projects are not completely in line with their business strategy.

For larger companies there may also be more defensive reasons for participating in FP-projects (in order to be involved in research that may influence in business). In these cases the topics of the FP may have had some strategic influence.

Swedish R&D policy was focusing on biomass, solar energy and wind power, while Sweden's energy policy had a clear focus on hydropower in the 50s, on nuclear power in the 1970s and on biomass in the 1990s (and on energy conservation!). Wind became also interesting from an energy policy point of view only after 2000. Swedish successes are those supported by energy policy and not those supported by R&D policy alone: The focus areas wind and solar energy that received quite a significant amount of R&D subsidies but were not supported by energy or industrial policy have not had much effect on industry.

7.5.3 Effects of sustainable energy FP research

7.5.3.1 Knowledge effects

Positive effects on the knowledge position are often reported in evaluations of research programmes, and were also reported during most of our interviews (not all: there have been interviews where no real progress of scientific knowledge was reported). The (by estimate, see above 7.5.1) €70-100m FP money spent on sustainable energy research in Sweden (which means approx. 100 additional researchers each year for 10 years) should be no exception to this finding. Quite a lot of this budget must have been spent in universities (they are responsible for 40-50% of FP participations in this area, and are quite often the partner doing most of the research).

7.5.3.2 Size effects

Not many Swedish university research groups have had a major role in multiple successive FP projects. The small average size of research groups in Swedish universities and the effort it takes to submit a FP proposal may be (partly) the cause of that. The effect of FP research on the size of groups must therefore have been limited for those groups not participating. As is stated above for groups participating the percentage of FP funding seems to have been 15-20%, with occasional peaks where this proportion may have risen as high as 50%.

Overall the Swedish university research system in sustainable energy seems rather fragmented and many groups are (on their own) below the critical mass for international excellence. The university orientation is by technology, not according to application. Cooperation between different groups in the same university in adjacent areas could help in this respect but is not always regarded as the natural thing to do (e.g. in one interview we asked whether there was cooperation between the PhDs of two groups working on related applications within the same department, and were told there was none because ‘we are physicists and they are chemists’).

7.5.3.3 Economic effects

As this chapter makes clear, only very limited direct economic effects are visible from the FP research in Sweden on sustainable energy.

In the biomass area there may have been some effect, but this could not be confirmed in interviews (and the effect of national programmes may have been larger). The most complete picture was obtained in the solar energy area. For the two (at present) small solar PV cell-producers the FP role has been crucial (but not sufficient), and a small number of other companies report some influence of the FP. In the interviews outside the solar energy area economic effects were considered absent or very indirect, and many Swedish companies that play an international role in some sub-area have not participated in FP research very heavily.

7.5.3.4 Network effects

International network effects are mentioned in the interviews as the most important effect of the FP, in the form of networks with other organisations, but also with other people (who may move from organisation to organisation). Without FP participation the networks would have been smaller and not so intensive.

Networks have also positive effects on the performance of research groups and companies: there is better knowledge of trends, easier access to new knowledge, more cooperation opportunities (and co-publication opportunities), more influence on research agendas. For example, the role of Sydkraft/E.ON/Grontmij on fuel cell and hydrogen research in FP7 should not be underestimated and may not have been exploited to the full by the Swedish fuel cell community. See also the role of the Ångstrom centre in the international PV community. In some cases such as Sunstrip AB, market access has been a key impact.

The effects of FP on participation on national networks was not clear from this study: although there was intra Swedish cooperation in more than 50% of all FP projects with a Swedish partner no clear cooperation pattern could be discovered. Many projects include university-industry cooperations within Sweden, but there are also industry-industry links within Sweden within the projects as well as other combinations of Swedish partners.

7.5.3.5 Other effects

FP research also has some other effects. In the first place FP projects are prestigious, especially for coordinators. FP projects also have effects on the opportunities to attract people, such as researchers for universities. FP creates additional positions in Sweden and additional competences to the researchers participating in the projects. They can influence research strategy bottom-up, on the basis of individual choices of professors or create differential advantage and growth for groups working in areas that the FPs prioritise. Business strategy may also be affected. Power companies seem to participate in FP projects because they want to know (hands-on) about new developments that can affect their business.

Effects on Swedish Policy from FP projects seem limited. Some regional and local authorities (e.g. Växjö, Malmö, Stockholm) participated in FP projects to support their local policies to make their city/region sustainable (these have not been interviewed). Direct policy effects are not evident at national level.

7.5.4 Does the FP set the research funding agenda?

From the interviews it becomes clear that in some cases, especially when starting up a new business or new research line, FP financing was important. Later on in the technology life cycle Swedish subsidies and other means of financing become more important and are easier (e.g. from an administrative point of view) than FP financing.

This suggests, that at least to some extent, the Swedish national subsidy providers in the area of sustainable energy are rather conservative, with more attention for track-record and ‘proven’ technologies and research lines than focus on originality and new business opportunities.

7.5.5 Comparison of FP and national instruments

The FP is considered prestigious, interesting and a lot of bureaucratic work. The application procedure is considered professional and forces you to think about your strategy. It takes however a long time before you know whether you are successful. The FP is better placed to realise the scale (and expertise) to solve large complex problems and does draw on a larger pool of researchers. Coordinating a project is a lot of work but brings you more benefits and opportunities to influence research (though not as much as when you do the research yourself). Language may cause some problems in FP projects.

Thematic national programmes are considered to be an easier way to get research money, but the procedures in these programmes are also very long, and agencies tend to have the wish to put competitors in projects with each other (which does not work, especially when one is small and the other is big). Focus is too much on university research: this is OK when the research question requires fundamental research, but universities should not perform the research when the research question is applied.

The project oriented national subsidies (e.g. from STEM, esp. for SME’s) are considered very useful and user friendly.

7.5.6 Research instruments versus market pull mechanisms

The German case of the Erneubahre Energie Gesetz (EEG), providing long term secured high prices for ‘green power’, has shown that (creation of) market pull mechanisms is a very effective way of not only to increase the sustainability of the energy supply, but also to contribute to the development of a significant (local) sustainable energy industry (wind and solar).

In Sweden the policy with respect to biomass has to some extent worked this way as well[74]: the change in the energy tax from energy to (partial) CO2 basis has promoted the use of biomass for district heating (and CHP). The incentive was however not high enough to promote wind energy and solar energy because electricity prices in Sweden are low, and consequently these technologies were not implemented on large scale in Sweden and no related industries developed. From another point of view Sweden has given priority to achieving large volumes of cost efficient new renewable energy. The downside of that is that market interest in the more expensive

[74] see 1.2

technologies is modest. Market effects of subsidies and development will be more visible in the most expensive technologies.

The question is also why the effect on the biomass energy systems industry in Sweden was smaller then the effect on the wind energy and solar energy industry in Germany.

Could it be that the recipe of market stimulation for creation of an industry only works in embryonic areas (which combustion technology is not: rather mature technology and many suppliers all over the world) with large possible and vast expanding markets (which biomass is not as much as solar and wind energy)? In this case bio fuels (with third generation technology: conversion of bio waste), fuel cells, CO2 capture and storage and grid technologies (for de-central power supply systems with a strong position of ABB) are the right topics for the future to focus on (although every country is thinking along the same lines). There may even be opportunities left for solar technology (this is still rather embryonic technology). Market creation and not just R&D funding must however play a role in all these areas.

7.5.7 Other technology push options

The technological position of Sweden in the area of hydroelectric power seems excellent (with some competition from e.g. Kvaerner from Norway) and market opportunities good (but not huge). Most of the national hydropower stations are now 40-50 years old and face large maintenance and/or reconstruction in the near future. The SVC (backed up by Elforsk) seems to be inspired by these opportunities/necessities and may be sufficient.

Furthermore ocean energy might be interesting (especially where this does not depend on large tidal differences (there the Portuguese and Scottish coast offer far better opportunities, and the national British programme on tidal and wave energy is leading)). The technology basis is however rather small in Sweden.

8 Conclusions and Policy Implications

Our analysis suggests the impacts of the Framework Programmes in Sweden have been mixed – sometimes very positive; at other times quite minimal – and that features of the Swedish innovation and research system mean that Sweden has under-exploited its opportunities in the Programmes.

The Framework Programmes started as industry policy and have to a degree gradually mutated into research policy – certainly as far as Sweden is concerned (though the trend is also more general) – owing to the increasing dominance of the university and institute sectors. We view with some alarm the small number – at most 5 – of major Swedish companies that have found enough value in the FPs to be consistently involved in them over a long period of time but recognise that this reflects not only on the FP but on the process of globalisation that is forcing Sweden to find a different and probably more niched role in future industrial organisation.

The FPs contain a wide range of activities that include

- Fundamental research
- Industry-driven research and innovation
- Standardisation and pre-normalisation (in areas where this could not be done at the national level)
- Road mapping and other activities that help the vision of technological communities to converge on agreed trajectories
- Developing human capital and increasing its mobility

It follows that there will be no single 'answer' about the effects of the FPs but that they will have different effects in different contexts.

8.1 Universities

In the university context, the FPs have added quite a substantial amount of money to external research income. In so far as research (and education) are good things, then these are good things that should broadly lead to increased social and economic welfare. This funding is **additional** to national funding; we have not found suggestions that national funding has been reduced to compensate. And Sweden's excellent performance in bringing money home from the FPs means the bargain for Sweden has been a good one: she takes out more than she puts in and most of that additional money goes to the universities.

There is evidence that the additional money complements national resources, though it does so in a range of different ways. In some places, it allows more applied and innovation-orientated work to be done by companies as well as academics. It allows some themes that are overlooked or otherwise difficult to fund at the national level nonetheless to be funded. Perhaps the most interesting thing is that by adding **diversity** to a system that some of our interviewees saw as overly focused on basic research the FP funding adds robustness to the Swedish system as a whole.

The FPs have clearly added size and scope to researchers' networks, probably increasing quality and including them in more international 'invisible colleges' that make them 'insiders' in groups of researchers working at or near the leading edge in their fields. The practice of staffing FP projects largely with doctorands ensures that they play an important role in doctoral education and also exposes those doctorands to the international partnerships of the FPs, with beneficial effects on their educational, research and career prospects.

Swedish universities essentially obtain these benefits because they can apply bottom-up for project funding, largely unconstrained by any strategic considerations of the FPs, national programmes or their own universities – even though winning FP projects can bring a financial penalty to those universities by not covering the full economic cost of the projects.

However, the fact that the universities largely lack thematic strategies for their own operations and consistently lack strategies for handling the FPs is an important missed opportunity to use FP resources systematically to promote the development of critical masses and therefore to combat the fragmentation in the university system. This fragmentation puts it at risk, both in terms of the general need for critical mass and specialisation in an increasingly globalised university system (and, indeed, in support of the knowledge and manpower needs of key parts of Swedish industry) but also the specific need to specialise in the context of the focusing of resources that is intended within the future ERA.

8.2 Industry

The FPs have had rather different impacts in the four industries/technologies we studied.

The FPs have also added considerable resources to the Swedish university research effort in life sciences and health. These are areas of pre-existing strength in which Swedish research is highly competitive and Swedish institutions – notably Karolinska – have seized the opportunities provided to widen their thematic research areas in areas prioritised by the FPs. The nature of intellectual property in the industry means that large pharma barely participates in the FPs. The small amount of industrial participation largely involves SMEs, which can derive considerable support from the programmes. This is a science-driven industry, so the focus on basic research is nonetheless the right one, with industry deriving benefits through bilateral relations with the universities inside and outside the FPs. The lack of an explicit Swedish strategy for life sciences and health research means that use of the FPs has to be opportunistic. Sweden has little influence over the FP agenda because it is not clear or agreed how Sweden would like that agenda to change. The comparative absence of major Swedish industry from the emerging IMI JTI in the area will ensure that Swedish strategic influence continues to be small.

Swedish ICT participation is dominated by universities and research institutes and has – together with national programmes – supported the need to increase the research and education areas in ICT significantly over the past 20 years or so. FP funding has broadened the research base by supporting some areas of research that were hard to fund from national resources. Numbers of large and small firms have obtained short-term support from the FPs. Ericsson and Teliasonera are the major companies that have worked with the FPs at some scale and over a long period. Teliasonera's importance as a source of technology and market power has been declining since liberalisation. However, Ericsson's participations in the FP have enabled it to build strong positions in 3G mobile technologies through influencing standards and key choices of technological direction. Innovations derived from participation in FP3 are still being implemented and others from later work are in the pipeline. In this area where Sweden had already established significant industrial power, the FPs have been a powerful lever on national industrial and technological competitiveness.

In contrast with the other industries studied, vehicles participations are more industry- than university-dominated and the work of the projects is generally more applied. Important aspects of the continuing strength of Swedish positions in the industry build on long-term alliances with Swedish universities in areas like combustion, catalysis and safety. These alliances have been brought into FP participation, extending the scale of national efforts but also building new links to foreign institutions. FP money has been one of the factors enabling the industry in general, and Volvo in particular, to maintain the high level of technological capabilities that have so far protected vehicles design and production activities in Sweden, which from a scale logic are anomalous. This industry is very explicit in internally agreeing and then telling the Commission what should be put into the FP strategy via organisations such as EUCAR. As a result, the FPs address longer-term issues of relevance to industry. The complementary combination of national and FP programmes has been instrumental in the survival of the Swedish road vehicles industry in its current form and is – from a Swedish perspective – a major success.

In sustainable energy, the FPs have served to increase the amount of university research in a pattern that reproduces the pattern of national effort. The additional spending is not sufficient to overcome the fragmentation of research within the higher education sector, which essentially uses FP money to do 'more of the same' – although with the added benefits that arise from international networking. The major energy equipment suppliers have tackled the limited modifications to traditional equipment needed for thermal biofuels but are not involved in the major new potential sustainables. With neither the incumbent companies nor the state stepping up to shoulder the innovation risks, that burden falls to a number of small companies – several of them supported bottom-up through the Framework Programme. However, neither Swedish policy nor the FP seems to be able to move beyond conventional R&D policy to develop the kind of consistent industry, energy and taxation policies, developmental procurement or demonstration measures likely to be needed to accelerate the shift to sustainables – let along to seize the opportunity to establish industrial advantage in sustainable technologies. In the past, major leaps in energy technology have involved the state as a major customer and risk-taker with new technology and it is not clear that the needed rapid transition to new energy sources can be obtained without a similar type of intervention that goes well beyond the current mandate of the Framework Programmes.

8.3 Conclusions

The study suggests that the FPs have had some important impacts in Sweden and that some of the areas of limited impact result from a lack of strategic direction from the Swedish side. Figure 72 is a very crude summary of findings.

The FPs have had limited strategic impact because there are not many strategies to impact. This is a vicious circle: in the absence of national strategy, it is difficult to articulate how the FPs' strategies should change in order to serve the national interest. Partly as a result of this, the FPs' ambition to structure' research in Sweden has not been realised at all. The FP resources have added a little scale but not changed the structure of the higher education and research sector – and certainly not helped address the long-standing problem of fragmentation. In principle the FP resources could be used to support restructuring, but only in the presence of national strategies.

Figure 72 Impacts in summary

Impacts	Universities	Sustainable Energy	Life Sciences	ICT	Vehicles
Research strategy	X	X	?	X	?
Structuring research	X	X	X	X	X
Scale of research	√	√	√	√	√
Quality	√	√	?	√	√
Addressing EU questions	?	X	√	√	√
Convergence/visioning	X	X	X	√	√
Industrial innovation	√	√	√	√	√

√ = Yes. X = No

It appears likely that the FPs have had a positive influence on research quality.

The FP has in certain cases enabled issues that should according to the subsidiarity principle be tackled from the EU level to be addressed in part through work in Sweden. Where there are strong industrial lobbies or groupings, it has helped generate agreement about technical directions and influenced standards – and this has been very beneficial for major Swedish companies. It has more broadly supported industrial innovation in both small and large firms.

Perhaps the most striking thing about this analysis is that it points to circularities. Where there is a national strategy or an industry strategy, the FPs can be recruited to this cause. The openness of the FPs to strategic ideas means that where there are powerful lobby groups, their ideas are likely to be adopted, and the vehicles industry example shows that this can have very positive industrial effects. (Of course, lobby groups can also degenerate into cartels.) The FP is much less good at dealing with unpredictable or SME-dominated sectors. It cannot tackle areas like sustainable energy very well, where it is not clear who its discussion counterpart is and where seems necessary to go beyond the existing rules and functions of the FP in order to effect the industrial change that is urgently required.

While the FPs have tended (with varying degrees of success) to conserve existing strong industrial structures (vehicles) and even to build on success (telecommunications) they have had no visible industrial effects in the science-based life sciences and health industries. They have not significantly been able to encourage the needed industrial risk-taking in sustainable energy, where the established players are largely leaving the risks to the little firms, presumably hoping to pick up some of the pieces once the smoke clears and it is obvious who the winners are. It is reasonable to ask whether – in the absence of ‘joined up’ research, energy, demonstration and investment policies for sustainable energy at either the Swedish or the European level – this is the best way to promote the rapid and large-scale change needed in our collective energy basis in order to tackle climate change. The state probably needs to step in and take over more of the innovation risks, as it did in past times of radical change in energy sources.

The shift from the earlier and rather diffuse objective of 'European Added Value' in the form of networking, cohesion and scale to building the European Research Area that took place in FP6 should have quite profound implications for the Swedish knowledge infrastructure. This is a small country on the periphery of Europe with no real research strategy and a notoriously fragmented research community that undoubtedly will need further to specialise in order to survive. Some specialisation within the more applied areas of research is happening as a function of industrial relationships and needs. In more fundamental research, national instruments are only just beginning to appear that promote specialisation and scale. We have seen that the effect of the FPs in the universities is – with some modest exceptions – to magnify national efforts and strategies. In the absence of such strategies (formal or de facto), it is hard for the FPs to ad value in their present form. European-level, redistributive instruments such as centres of excellence and competence centres would probably be needed in order to overcome such national constraints on the FPs' mission to restructure research within the ERA.

The Framework Programme's origins lie in bringing together the Round Table major computing and electronics companies in Europe in the early 1980s and agreeing with them what needed to be done in R&D support and other areas of industry policy. (Both Volvo and Ericsson were involved at this stage, even though Sweden was not yet a member of the European Communities.) It still works best in discussion with the powerful existing players. The upside of this is the ability to direct effort to areas that appear the most relevant. The downside is lock-in and our sector examples show the relative powerlessness of the FPs in the face of radical changes in technology and industry structure that disconnect the EC policymakers from lobbying by well-defined industrial constituencies.

From the Swedish perspective, the most urgent policy implications of this analysis are

- An acute need to develop strategies for thematic and institutional concentration in the ERA
- A need to communicate about strategy and needs to the Commission and with the research and industrial communities
- A requirement to support increased Swedish participation in the Technology Platforms and other new structures such as the JTIs – not

least because it is not clear that the FPs will continue in their present form

- A need to maintain a fully independent set of national strategies and programmes tuned to national needs but more deliberately to consider how to use the complementary resources available from the FPs. A slavish reproduction of the FP priorities is in the interests neither of Sweden nor of Europe
- A need to find policy mechanisms that can compensate or substitute for the Framework Programme's weakness as an instrument to tackle fragmented SME- and technology-based industries
- A need for new mechanisms that can go beyond R&D support to tackle some of the key innovation risks in radical technological change in areas like energy and climate change, where there is not necessarily time available to wait for a market solution to emerge but where risk-sharing between equipment supply and major users is a requirement for transition

Appendix A University of Gothenburg

A.1. Introduction

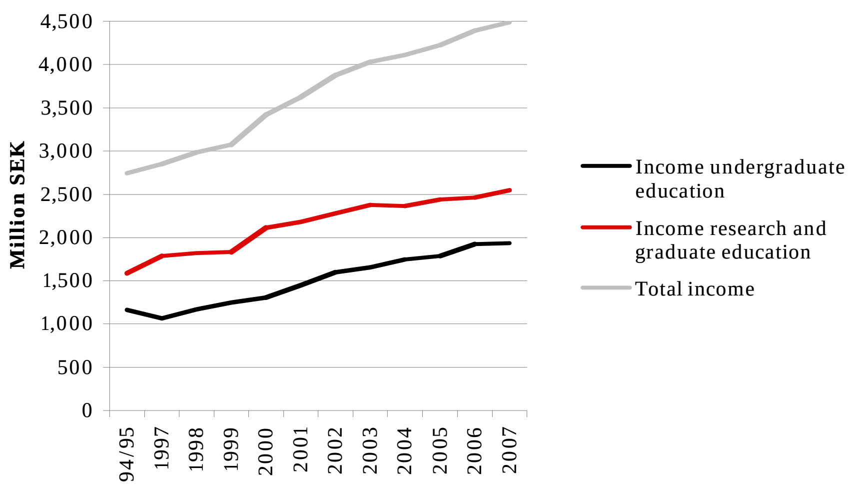
In 1891 the predecessor of the University of Gothenburg (Göteborgs Universitet (GU)), Gothenburg University College, was founded based on private donations, initially operating with seven professors and twenty-one students, four of whom were females. In 1907, the University College acquired the same status as the existing established Swedish universities (in Uppsala and Lund) and in 1954 the Medical College in Gothenburg, founded in 1949, was merged with the Gothenburg University College, thus formally forming GU. Over the years additional previously independent colleges have been incorporated into GU; most recently the College of Health. Today GU offers the most comprehensive range of courses and degree programmes of any university in Sweden. The university comprises 57 departments organised into nine faculties:

- Science
- Arts
- Social sciences
- Education
- Fine applied and performing arts
- IT-University
- School of Business, Economics and Law
- Education and Research Board for Teacher Training
- Sahlgrenska Academy (pharmacy, medicine, odontology, and health care sciences)

The university board is the university's highest decision-making body. According to the Higher Education Act, the board shall conduct "supervision over all the university's affairs, and is responsible that its duties are fulfilled". Seven of the 14 board members, including the chairman, at present Carl Bennet, are appointed by the government to represent general interests. In addition, the vice-chancellor, three lecturers and three students are ordinary board members. Representatives for the employees – three union representatives – have the right to be present and to express opinions at board meetings. Vice-chancellor since 2006 is Pam Fredman.

Over the past decade, GU’s income for undergraduate[75] education has increased by 82%, while its income for research and graduate education has increased by 43%, see Figure 73. In the same timeframe, the number of undergraduate students has increased by 16%, whereas the number of graduate students has *de*creased by 19%, see Figure 74 and Figure 75. In the period 2000–2007, research staff has increased by 17%, see Figure 75. Obviously, costs have increased considerably faster than income. Over the entire 1990–2007 timeframe shown in Figure 74, the number of undergraduate students has increased by 70%. GU’s research intensity (here defined as the proportion of research and graduate education income in total income illustrated in Figure 73) has decreased from 63% in 1997 to 57% in 2007.

Figure 73 Income development



Source: HSV

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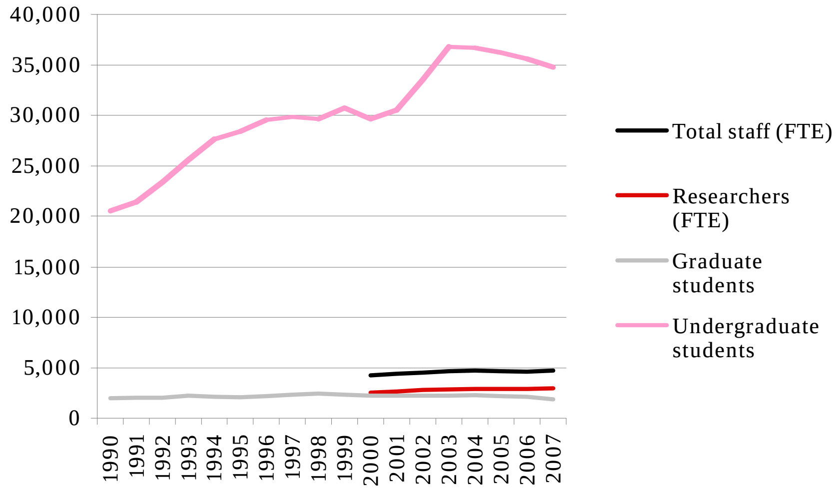
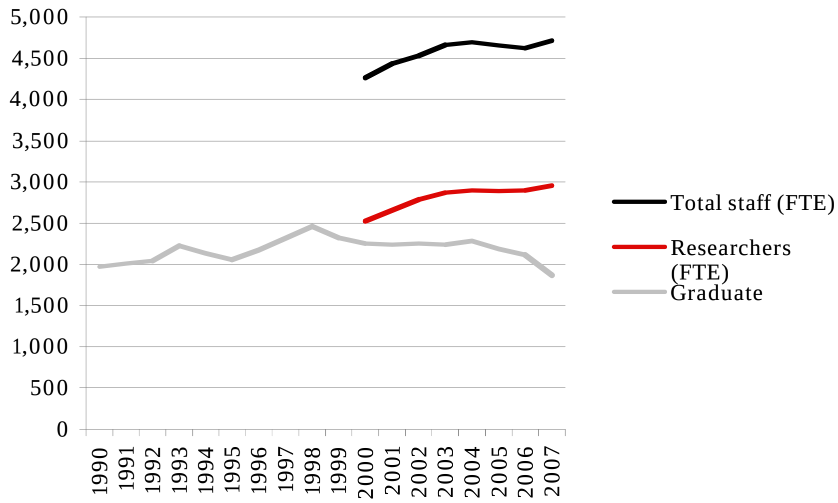
[75] Prior to adopting the education structure of the Bologna process in 2007, Sweden had a two-tier educational structure at university level that differed from most other countries. For the purposes of the case studies in this report, the two levels are referred to as “undergraduate” and “graduate”, resulting in a master’s and doctor’s degrees, respectively. It should be noted that this division constitutes a simplification.

Figure 74 Development of employees (full-time equivalents (FTEs)) and students (individuals)



Source: GU annual reports, Statistics Sweden and HSV

Figure 75 Development of employees and graduate students (data of Figure 74 excluding undergraduate students)



GU annual reports, Statistics Sweden and HSV

The number of undergraduate students from GU studying abroad for at least one semester has increased slightly over the last decade – from 467 in 1997 to 511 in 2007. The number of foreign students spending at least one semester at GU has almost doubled during the same time period– from 430 in 1997 to 830 in 2007.

According to Webometrics' ranking from January 2008, GU is in position 172 on the global list of universities. On the ranking list produced by

Shanghai Jiao Tong University, GU is in the 203–304 bracket globally and in the 81–123 bracket in Europe. The Times Higher Education Supplement does not list GU in any category.

A.2. Strategy development

Previously, GU's strategy was documented in the strategic documents "Vision" from 1997 and "Göteborgs universitet 2010" from 2004. The treatises in these two policy documents remain at a very general level and few concrete prioritisations are thus defined. One reason for this is that the faculties are quite independent of each other courtesy of the university being the result of repeated acquisitions, another that departments traditionally formulate their own strategies.

GU's website mentions that in December 2005, the university board decided that GU's strategic documents needed revision, since they were lacking in content, structure and comprehensiveness. For this reason, GU's governing documents are being revised in the course of 2007–2008. However, also the 2007–2010 strategic plan from 2006, which GU management considers as the first true unified university strategy, lacks concrete priorities. The lack of specific prioritisations was also spelled out in GU's internal news magazine (GU Journalen 5-07) as part of the preparatory work behind the 2009–2012 Research and education strategy, which was requested by the Swedish government.

According to university management, strategic thinking in terms of research prioritisations was partly driven by the 2005 research policy bill, in which the government launched an initiative to fund internationally competitive centres of excellence in all scientific fields for up to ten-years. These Linné grant calls led to intense activity to determine where GU could consider itself internationally competitive. While GU only received one Linné grant in the first call (and one in the second, announced in June 2008), the internal prioritisation process itself was valuable and has markedly changed strategic thinking within the university. While individual researchers probably already knew to what extent they were internationally competitive, neither faculties nor university management had a strategic view of this, with the exceptions of the Faculty of Science and Sahlgrenska Academy. In the latter case, a previous funding opportunity in the field of functional genomics by the Wallenberg Foundations forced the (then) medical faculty to think strategically already in the end of the 1990s. This resulted in a successful proposal together with Chalmers University of Technology (Chalmers) and Lund University (LU) and a substantial joint five-year grant for the SWEGENE project.

The 2009–2012 Research and education strategy defines five profile areas and eight priority areas. The profile areas are:

- Health
- Culture
- Environment
- Democracy and social development
- Knowledge formation and learning

Within these wide profile areas, priority research areas are specified on the basis of three criteria. The area should be:

- Of high academic quality and be embedded in a research environment where advanced research is being conducted (preferably also where disciplines meet)
- Unique to GU or at least be an area where the university is strong nationally or internationally
- Of social relevance

The eight priority research areas thus defined are:

1 Patient-centred research on heart and vascular disease including obesity, biomaterial and vaccine
2 Learning
3 Language technology
4 Democracy and opinion
5 Marine ecology
6 Cultural heritage
7 Globalization
8 Culture and health

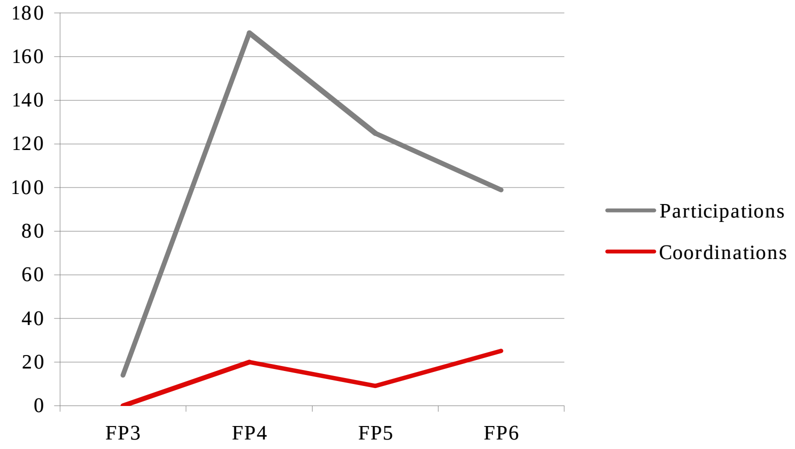
Within areas 1–4, GU already has a long tradition and documented excellence, whereas areas 5–8 are seen as emerging areas within which GU has significant potential to become internationally competitive. It is noteworthy that in April 2008, the Swedish government announced that it will fund a centre for marine research at GU, i.e. in area 5, setting aside SEK10 million (€1.1m) p.a. Within the centre, GU will collaborate with the universities in Stockholm, Umeå and Kalmar.

A.3. FP participation

Figure 76 illustrates that GU's FP participation was modest in FP3, but increased dramatically by FP4 (an extraordinary twelvefold increase). During FP4 and FP5, GU was a rather infrequent coordinator, but in FP6 it has become the most frequent coordinator (relatively speaking) of the five

Swedish universities studied herein, coordinating every fourth project. In FP3, most Swedish participations were formalised through a contract with each project consortium or its coordinator and funding was provided by Swedish government agencies. This changed on January 1, 1994 (towards the end of FP3), when Swedish participants through the European Economic Area agreement[76] were granted the same participation terms as organisations in EU member countries. A year later Sweden joined the EU.

Figure 76 Number of participations and coordinated projects per Framework Programme



Source: Cordis[77].

GU's Research services function (hereinafter referred to as grants office (GO)) was set up in the mid-1990s and found its form towards the end of the 1990s when FP5 started. Another important driver for its formation was university management's observation that most other established Swedish universities already had a GO; GU was thus rather late in this respect. The GO now has a staff of four working with EU funding and one working with major national proposals; in addition, one of the university's lawyers is engaged in EU-related matters. The GO lacks a formalised overall strategy, but supports researchers with:

- Newsletters
- Website
- Workshops on how to write a successful proposal
- Department-internal information meetings

[76] Through which the EFTA (European Free Trade Association) countries were allowed to participate in EU's single market without joining the EU.
[77] Cordis data has been complemented with information from VINNOVA and GU's grants office. Data on coordinated projects is known to be incomplete for FP3–FP5.

- Basic assistance with proposals, including budgets and forms (compulsory)
- Proposal review (carried out by external consultant)
- Supply of legal documents to the Commission
- Contract negotiations
- Review of consortium agreements (compulsory)
- Department-internal project start meeting with researchers and administrators
- Review of financial statements (compulsory)
- Help-desk function

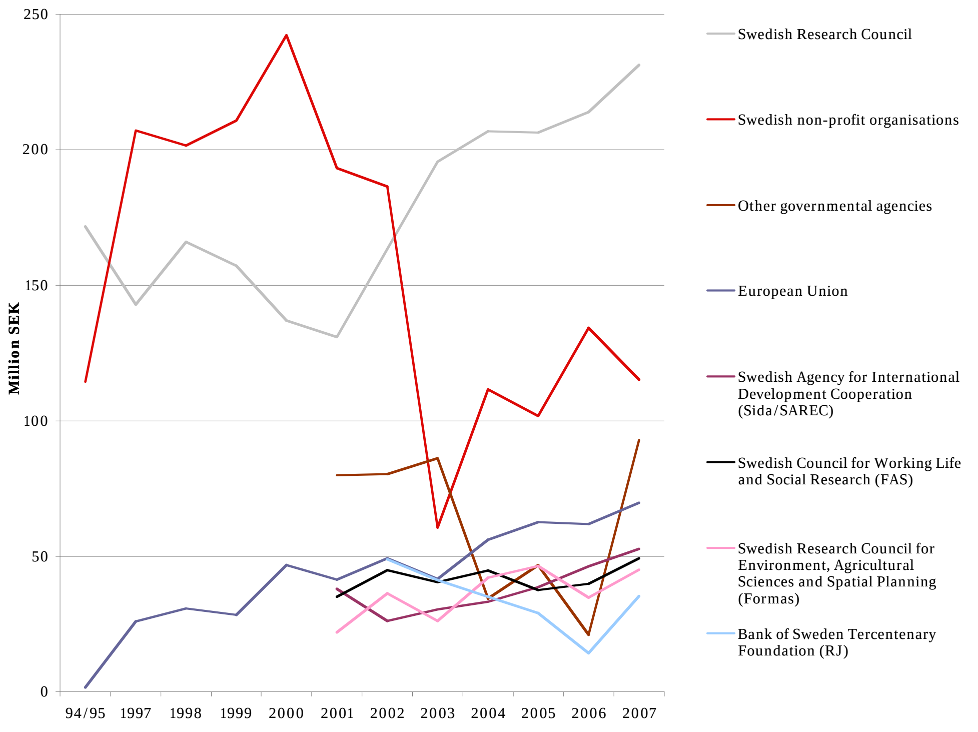
Moreover, per decree from the vice-chancellor, faculties financially support FP projects by not charging a larger overhead than received from the European Commission, meaning that they do not suffer from the insufficient overhead coverage common at many other Swedish universities. While researchers are highly satisfied with the services of the GO ("One of the best things with belonging to GU is the grants office!"), they all agree that the university could and should do much more to encourage FP participation. It is speculated that strategic planning and sound financial incentive structures (such as the ones that LU practices) could lead to dramatically increased FP participation.

As indicated by Figure 73 and by the previous observation that GU's research intensity has decreased notably in the past decade (to 57% in 2007, which is quite low among the established universities in Sweden), GU has in the past placed a strong focus on undergraduate education. In contrast, the present vice-chancellor has clearly declared that GU is to grow stronger as a research university and the finance director has stated that the FPs offer the best prospects to increase research income. In addition, both university management and researchers are said to anticipate top-down strategic measures following recent FP-related strategic processes and the fact that the vice-chancellor now has a research-funding advisor tasked with developing an FP participation strategy. So far, GU's FP projects have resulted from bottom-up initiatives and the university has not assessed the opportunities the FPs offer from a strategic perspective. To amend this situation, GU management would like the GO to support deans and heads of department in more proactive work. One such initiative is that the GO recently arranged a field trip with the vice-chancellor, the pro-vice-chancellors and the deans to the European Commission's DG Research. The GO is now trying to capitalise on the internal interest thus created and to funnel it into concrete action.

A.3.1. Effects on university

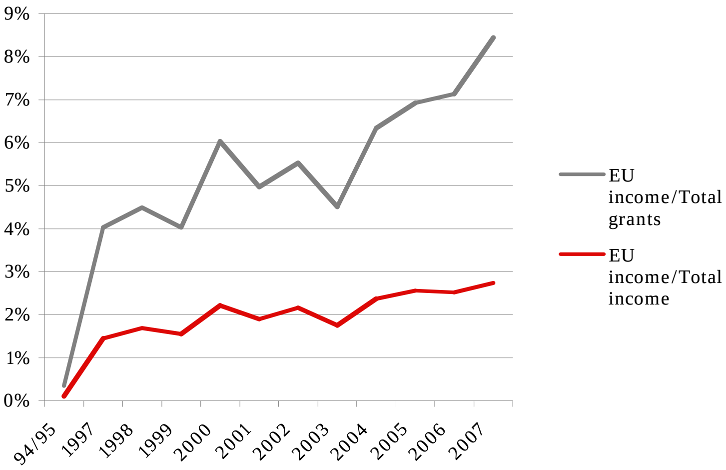
Since 2002 GU has increased its dependency on government grants for research and graduate education (or reduced its dependency on grants sought in competition); the proportion of grants sought in competition in total funding for research and graduate education (i.e. including government grants and commissioned research), which was 32% in 1997, peaked at 39% in 2002 and has since gradually decreased to 36% in 2007. Figure 77 illustrates that research income from the EU (75% of which in 2007 originated from the FPs) has increased rapidly, from an insignificant level in 1994/1995 to now being the second largest source of grants (see caption to Figure 77 for explanation). The strong increase in EU funding is both due to the dramatic increase in number of participations in FP4 and to the significantly larger average projects in FP6. Figure 78 illustrates the rapidly increasing relative importance of funding from the EU; regardless of which ratio is seen as the most relevant, it is obvious that EU funding has become a very important source of income for GU.

Figure 77 Grants for research and graduate education sought in competition. Only eight largest sources of income in 2007 shown in figure. The categories "Swedish non-profit organisations" and "Other governmental agencies" are composites of several funding sources, meaning that the EU is the second largest source of grants; however, in 2007 only 75% of EU income originated from the FPs



Source: HSV

Figure 78 Ratio of EU income to research and graduate education grants sought in competition, and total income for research and graduate education (i.e. including government grants and commissioned research), respectively



Source: Analysis of HSV data

GU management notes that in general the FPs' call topics have not matched GU's research areas very well in the past, with the notable exceptions of the Faculty of Science and Sahlgrenska Academy; in this respect, FP7 is an improvement. Although GU has clearly benefited from the FPs, there appears to be no indication that the FPs should have influenced the university's overall research priorities, particularly since past FPs have not matched its research direction particularly well. Nonetheless, management points out that FP funding is particularly important since it is "dynamic funding" (as opposed to "static funding" that must go to wages, rent, infrastructure etc.) and thus provides an instrument to realise GU's strategic research priorities. The marginal effects of such additional funding may be critical for the individual researcher. There is no arguing that participation in the FPs have benefited GU's collaboration network, but it is suggested that the main effects are in terms of intensity and plurality, rather than in the collaboration pattern as such.

A.3.2. Effects on individual researchers and research groups

While most faculties have formalised strategies, few departments do. Whether or not there is a formalised strategy, there is often a strategic direction to research. As an example, the Faculty of Science (which does not have a formalised research strategy) has identified ten "research platforms" to promote collaborative, interdisciplinary programmes both within the Faculty and with external partners. These have been selected for strategic financial support from the Faculty following an internal competition and international peer review. Several platforms involve collaboration with Sahlgrenska Academy and Chalmers. At department level, detailed research areas are ultimately determined by individual researcher's interests and available funding opportunities.

All interviewees agree that FP participation is strategically important, but motives appear to vary depending on the extent of dependency on FP funding. At one extreme, a researcher in the medical field with marginal dependency on FP funding sees the FPs as the enabling mechanism for inter-European collaboration. "The FPs have changed collaboration patterns dramatically, since we would not now have collaborated with Europeans were it not for the FPs. Previously, there was no incentive to collaborate with Europeans and the only way in which a researcher in life sciences could be seen, was through an American mirror; your reputation was created through your image on the US scene." At the other extreme, there are researchers that almost entirely have built their research groups with FP funding, either during a limited time period when no domestic funding at all was available, or more or less permanently. One of these researchers points out that "after a few successful proposals and a couple of sessions as proposal reviewer for the Commission, you begin to understand the process, meaning that your proposal success rate becomes acceptable". Other than funding, strategic values of FP project participation include network building, getting access to other's knowledge, enhancing one's international reputation and expertise, and dissemination of research results.

Among the few disadvantages mentioned regarding FP participation are incomplete cost coverage, that it is difficult to build a research group with relatively short projects and that there is a significant risk of having your research ideas stolen in the consortium and proposal formation phases (ideas presented to failed consortia or unsuccessful proposals that have later been realised by one of the previous would-be partners).

The leveraging effect of being a recipient of FP funding when applying for domestic grants ranges from weakly positive to decidedly negative. The latter refers to a proposal rejected by the Swedish Research Council on the explicit grounds that the applicant had so much FP funding that he did not need any funding from the Council. There is a leveraging effect also in the opposite direction, but it is indirect; you do not qualify for participation in an FP project unless you have already built a research base, but the source of the funding used to build this base is in this context irrelevant. There is a certain degree of cascading between FP projects (one project leading to another), but it is equally common that there is no such effect.

Interviewees agree that their FP participation has not had any significant influence on the direction of their own research. The researchers have of course been inspired by collaboration partners, but effects on the direction of their research have been marginal. On the other hand, two of the researchers interviewed have for a period of a few years or throughout their research career been unable to secure any significant domestic funding, meaning that they would not have been able to pursue their set research direction without FP funding. Researchers agree that FP participation clearly has had positive effects on their collaboration networks and made them considerably more international and interdisciplinary. The FPs have definitely contributed to building the ERA, but has also increased quality of European research. Nevertheless, collaboration on the European scene typically requires European funding; "collaboration is always easier if you have joint funding".

The interviewees who have coordinated FP projects consider coordination valuable and a good learning process, but argue that the value may not be in proportion to the time invested, unless you have access to highly qualified administrative support infrastructure. Such infrastructure must be next-door; the GO is too far away. An important lesson is that if you set out to coordinate a project, you should make sure you build your consortium around partners you know well and only allow a minority of newcomers that truly add a critical competence. You should also ensure that all partners get to do what they want to do and are good at; artificial constellations are difficult to manage.

Researchers clearly favour smaller projects of the STREP type, since they are more manageable and flexible, and provide better value for money than large projects. Scientific production is also the highest in projects of the STREP type and may be higher than in single-partner projects since partners split work and merge expertise. The backside of being coordinator is that it takes so much time that it reduces scientific productivity. In good projects, publications may become much more solid, more interdisciplinary and more insightful through co-publication and the projects' interdisciplinary nature. Previously, interviewees used PhD students in projects, but are now more likely to use post-docs due to them being more flexible and better at delivering on time.

With only one exception, interviewees cannot point to any effects on project partners from industry, supposedly since their research is at the basic end of the spectrum. The exception is the Swedish company SBL Vaccine, which markets a cholera vaccine that was initially developed within an FP4 project and subsequently refined in NIH-funded projects. It is pointed out that dissemination of basic research results (whether from FP projects or not) is slow and complex, so expectations should be modest and patience great. Although companies participating in FP projects, as well as companies that do not but have some form of ongoing affiliation with the department, directly or indirectly get access to the department's expertise, but since industry is usually tight-lipped about what research results they use and for what purpose, it is oftentimes difficult for researchers to know if and how their work is exploited.

One researcher relates that the European Commission’s project officers are usually open-minded and ask for ideas and also welcome unsolicited input. If you play your cards right, you may thus influence priorities in upcoming work programmes and call texts. Another researcher describes how he successfully influenced an upcoming call text through Swedish committee representatives.

A.4. References

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University income statistics from The Swedish National Agency for Higher Education (www.hsv.se)

University personnel statistics from GU annual reports, Statistics Sweden (www.scb.se) and The Swedish National Agency for Higher Education (www.hsv.se)

Appendix B Lund University

B.1. Introduction

Lund University (LU), founded in 1666, is the second oldest university in Sweden (after Uppsala). The purpose of establishing a university in Lund was to strengthen Sweden's grip on the newly conquered territories in the south (now southern Sweden), which until then had been under Danish rule. Initially, the university had four faculties; theology, law, medicine and philosophy. In 1852 the Swedish government took over financial responsibility for the university and in the 1880s, women were admitted as students.

With its 37 000 students, LU is now the largest university in Scandinavia. Outside the city of Lund, where most of the university is located, there are also campuses in the neighbouring cities of Malmö, Helsingborg and Ljungbyhed. LU has eight faculties:

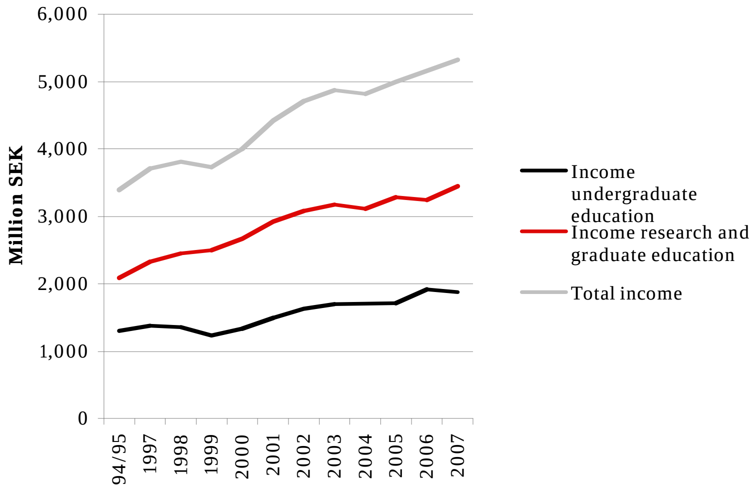
- Natural sciences
- Law
- Social sciences
- Economics and management
- Medicine
- Engineering
- Humanities and theology
- Performing arts

The faculties of Medicine, Natural Sciences and Engineering are of approximately equal size, each making up around a quarter of the university.

The supreme decision-making body is the university board consisting of 15 members, of which eight, including the chairman Allan Larsson, are appointed by the Swedish government. The remaining board members are vice-chancellor present Göran Bexell and three representatives each of staff and students.

Over the past decade, LU' income for undergraduate[78] education has increased by 36%, while its income for research and graduate education has increased by 48%, see Figure 79. In the same timeframe, the number of undergraduate students has decreased by 4% and the number of graduate students by 21%, while research staff has increased by 7%, see Figure 80 and Figure 81. Obviously, costs have increased considerably faster than income in the beginning of the century. Over the entire 1990–2007 timeframe shown in Figure 80, the number of undergraduate students has increased by 28%. LU's research intensity (here defined as the proportion of research and graduate education income in total income illustrated in Figure 79) increased rapidly towards the end of the 1990s and peaked at 67% in 1999; since then it has been in gradual decline and is currently at 65%.

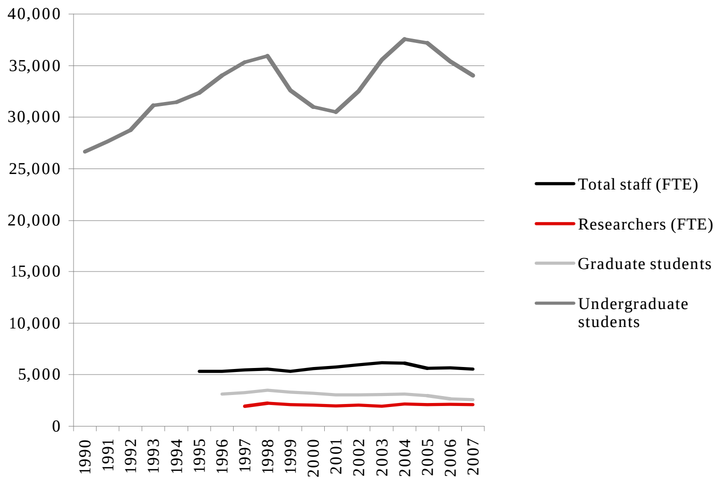
Figure 79 Income development



Sourec: HSV

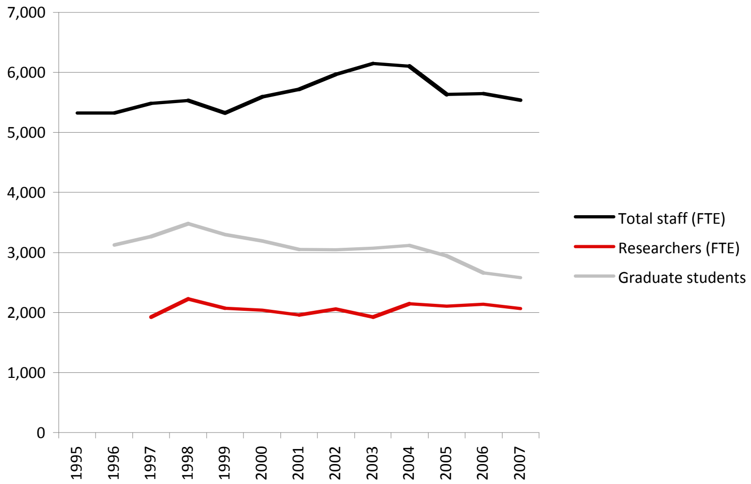
[78] Prior to adopting the education structure of the Bologna process in 2007, Sweden had a two-tier educational structure at university level that differed from most other countries. For the purposes of the case studies in this report, the two levels are referred to as "undergraduate" and "graduate", resulting in a master's and doctor's degrees, respectively. It should be noted that this division into two levels and degree structure constitute simplifications.

Figure 80 Development of employees (full-time equivalents (FTEs)) and students (individuals)



Source: LU web site and HSV

Figure 81 Development of employees and graduate students (data of Figure 80 excluding undergraduate students)



Source: LU web site and HSV

An important feature of LU's international cooperation is the university's location in the very south of Sweden, close to Copenhagen. When the bridge connecting Sweden and Denmark was opened in 2000, the entire region experienced a strong push for integration, which also affected the universities of the Öresund region. The ensuing enhanced possibilities for cooperation between research institutions in the region is well reflected in all strategy documents. The concept of the Öresund University encompasses all 12 universities in the region, while research cooperation takes place within the framework of Öresund Science Region, wherein several research platforms have been launched:

- Öresund IT
- Öresund Food Network
- Öresund Environment Academy
- Öresund Logistics
- Medicon Valley Alliance (associated member)

LU is the sole Swedish member of Universitas 21, which is an organisation for leading universities worldwide. Cooperation also takes place within the League of European Research Universities (LERU), which from Sweden also comprises Karolinska Institutet (KI). Other forums wherein LU is a partner are the Utrecht network, the Santander network and Nordlys (a Scandinavian network mainly engaged in student exchange).

A striking feature of different strategy documents are the numerous plans for promoting education in English at LU. More classes are to be offered in English, but there are also plans to improve the level of English among the teaching staff. Such plans are definitely not unique for LU, but the documents leave no doubt that in this case the plans are more profound and far-reaching than for many other universities and, for instance, international perspectives are to be integrated in all aspects of education. Furthermore, recruitment of international top researchers is high on the agenda. One strategy for increased internationalisation is to develop joint programmes with universities outside Sweden, thus allowing the students to obtain joint degrees. Already a 1995 strategy document sets the target that 20% of students should spend at least some time abroad. The total number of LU students studying abroad has, however, remained stable at just below 1 000 for a decade. However, the number of foreign students at LU has more than doubled in the same period – from 800 in 1997 to 1 700 in 2007.

LU is represented at Fudan University in China through the Nordic Centre, while LU's engineering students now have the opportunity to study one semester in China. There is also increased cooperation with countries in the Middle East and South Asia.

Webometrics' ranking of universities places LU in position 111 worldwide, position 26 in Europe and fourth place in Sweden. The Times Higher Education Supplement places LU in position 106 worldwide and in second place in Sweden; LU is not on the list of the top 50 engineering universities worldwide (but then again, no Swedish university is).

B.2. Strategy development

LU considers its good reputation its main asset. Nevertheless, a common theme in the policy documents from the mid-1990s and onwards is the concern for losing ground, at least internationally. As expressed in many documents, this concern is not limited to LU, but to Swedish research in general. Moreover, the structure of domestic research funding is also a cause for concern, because it is said to have a tendency to promote applied research with short-term gains or topics "in fashion" at the expense of long-term basic research.

The most ambitious of the policy documents is the 2003 Research strategy in which concrete goals are listed. Areas of strength in sciences, technology and medicine are:

- The laser facility (optics, medical technology, molecular spectroscopy)
- The Nanometric consortium (electronics, photonics, biophysics, and various interdisciplinary topics)
- Systems technology and applied mathematics (information technology, automatic control and telecommunication technology)
- Sustainable process engineering and production (which includes the Swedish Center for Bioseparation (CBioSep))
- Food and biotechnology
- Energy conversion
- Centre for geobiosphere sciences (geology, ecosystems dynamics)
- Ecology
- Sense biology (the communication of humans and animals with their environment – from molecules to ecology)
- High-energy physics
- Surface and colloid research (physical chemistry, theoretical chemistry, biochemistry and analytical chemistry)
- Stem cell research
- Diabetes
- Blood and defence (haematology)
- Inflammation
- SWEGENE, which is a cooperation between LU, Chalmers and University of Gothenburg (GU) on research on genomics. Especially biotechnology and biomacromolecules are mentioned as LU strengths

New intra-university broad focal areas are medicines and drugs, which include both medical chemistry and future medical technologies and life sciences; the latter aiming at strengthening cross-departmental cooperation. The 2009–2012 Research and education strategy adds more areas, including health and ageing, complex systems, climate–environment–energy–

economy and advanced materials research. This expansion of focal areas partly stems from the positive experiences from the first set of areas pointed out, but is also an effect of LU in 2006 being awarded eight ten-year (domestic) Linné grants to excellent research environments, corresponding to a striking 40% of the total budget for the call[79]:

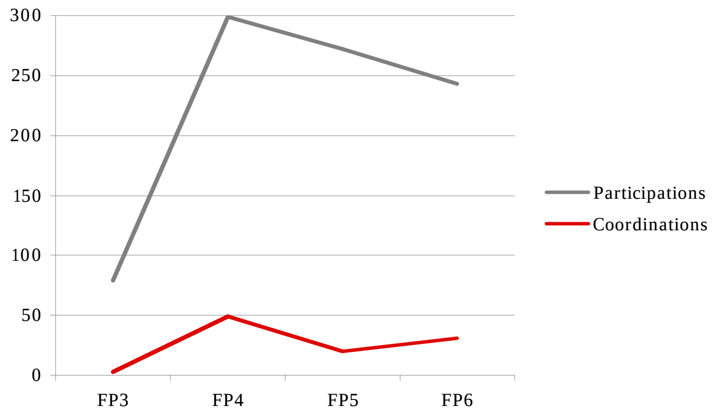
- Centre for Economic Demography (CED)
- Dissection of the genetic and metabolic complexity of diabetes and its complications
- Exploring and Controlling the States of Matter with Light–Multidisciplinary Laser Spectroscopy
- Hemato-Linné to understand healthy and unhealthy blood formation
- Innovation, Entrepreneurship and Knowledge Creation: Dynamics in Globalising Learning Economies
- Nanoscience and Quantum Engineering
- Neuronanoscience Research Centre–A cross-disciplinary research and technological platform combining neuroscience, nano- and microtechnology and biotechnology
- Organizing Molecular Matter

B.3. FP participation

Figure 82 illustrates that LU was a rather well-established participant already in FP3 and its participation nearly quadrupled in FP4. In FP3, most Swedish participations were formalised through a contract with each project consortium or its coordinator and funding was provided by Swedish government agencies. This changed on January 1, 1994 (towards the end of FP3), when Swedish participants through the European Economic Area agreement[80] were granted the same participation terms as organisations in EU member countries. A year later Sweden joined the EU.

[79]LU was awarded six additional Linné grants in the second call announced in June 2008.
[80] Through which the EFTA (European Free Trade Association) countries were allowed to participate in EU's single market without joining the EU.

Figure 82 Number of participations and coordinated projects per Framework Programme



Source: Cordis[81]

LU's "research services" function (hereinafter referred to as grants office (GO)) was set up already in the beginning of the 1990s and was at the time limited to FP funding. In 1999, the mandate was extended to also include major national proposals wherein the university is the formal applicant. At the start of FP6, the GO received additional resources and now has a staff of 6.5 FTEs. The GO has an elaborate and structured system to guide a researcher through the administrative aspects of a proposal. The GO supports researchers with:

- Dissemination of call information, including seminars
- Budgeting, filling in forms and review of proposals
- Contract negotiations
- Consortium agreements
- Kick-off meetings
- Help-desk function

It is pointed out that the GO is only one part of a larger support system. The GO collaborates closely with LU's legal unit, which supports researchers with legal advice, as well as with its internal revenue service, which issues audit certificates.

LU's Faculty of Engineering, which is the most frequently participating faculty, has a closer relationship to the GO than the other faculties. For a number of years it has bought more elaborate services from the GO than

[81] Cordis data has been complemented with information from VINNOVA and LU's grants office. Data on coordinated projects is known to be incomplete for FP3–FP5.

provided to other faculties. A similar, but less extensive, relationship exists with the Faculty of Medicine.

The university has its own structured financial support system for would-be project coordinators who may receive a planning grant for the proposal phase and, if the proposal is successful, the LU coordinator may receive an annual grant to cover costs of coordination not covered by the FP grant. Moreover, the university also organises courses to train project administrators. Although LU is the most frequent Swedish FP participant, it is noteworthy that the share of projects that LU researchers coordinate is the second lowest among the five universities studied herein (12.8% in FP6 for LU; only Chalmers has a lower ratio at 12.4%), considering the aforementioned elaborate coordinator support scheme. In addition, departments are not charged an overhead cost greater than the overhead provided for in the FP grant, meaning that LU departments do not suffer from the insufficient overhead coverage that departments at many other Swedish universities do.

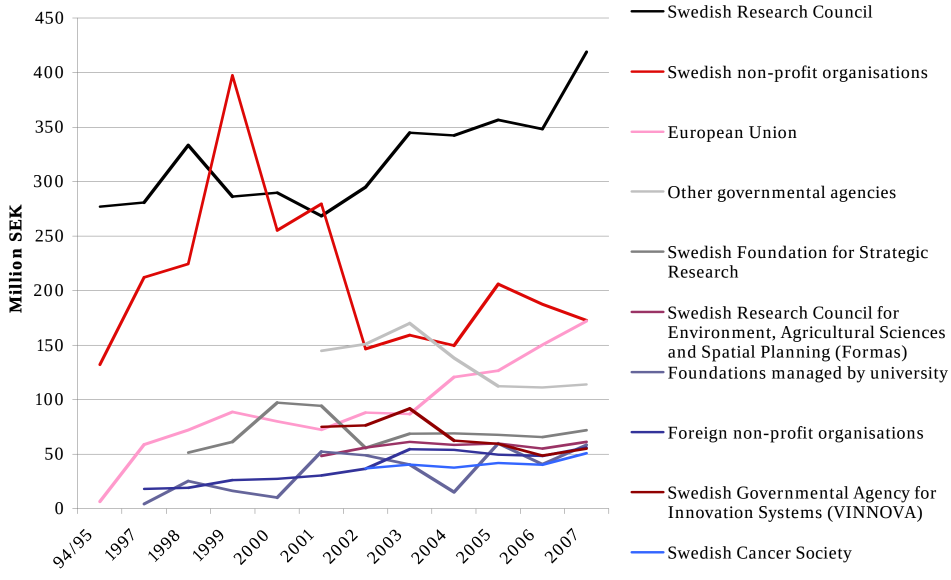
LU management stresses that the university strives for increased research-intensity, improved international contacts and enhanced multidisciplinarity, which are all potentially achievable within FP projects. Moreover, proposal competition and in-project benchmarking enhances quality, since FP projects provide benchmarking with the best research groups in Europe. LU management sees it as its role to provide encouragement from the university in terms of strategies, financial support and the GO, but realises that researchers are under great time pressure and can always use more assistance with proposals. So far, all LU's FP projects have resulted from bottom-up initiatives and the university has not assessed the opportunities the FPs offer from a strategic perspective, nor has it matched these opportunities with LU's strengths. For example, how could the Marie Curie instruments strategically be used to increase the number of foreign students at LU? LU management argues that in some cases, a top-down initiative with coordinated LU action could possibly be a good idea. On the same note, some form of national coordination and lobbying would likely also be beneficial. LU management laments that it has not yet had any programme to encourage its researchers to participate as FP evaluators. Nor has it exploited and disseminated the experiences from the ones that spontaneously have participated as evaluators.

The GO argues that it already has a full-service offer as far as the FPs are concerned, so any expansion of its services would more likely be in the direction of other funding sources rather than in the FP field. Overall, LU's more frequent FP participators are quite content with the support provided by the GU, but they also argue that they have become so experienced FP participators that their need for support may not be representative of the average LU researcher.

B.3.1. Effects on university

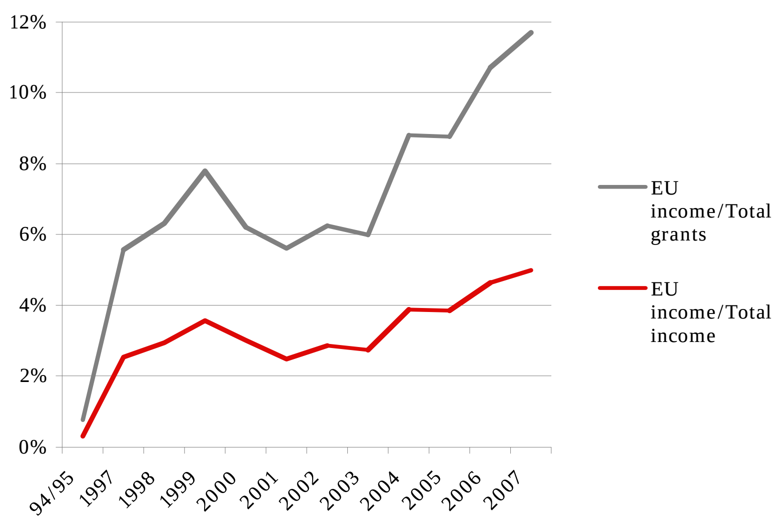
Interestingly, since 2000 LU has increased its dependency on government grants for research and graduate education (or reduced its dependency on grants sought in competition); the proportion of grants sought in competition in total funding for research and graduate education (i.e. including government grants and commissioned research), which was 45% in 1997, peaked at 48% in 2000 and has since gradually decreased to 43% in 2007. Figure 83 illustrates that research income from the EU (for LU more or less synonymous with FP funding) has increased rapidly, from an insignificant level in 1994/1995 to now being the second largest source of grants. The strong increase in EU funding is both due to the dramatic increase in number of participations in FP4 and to the significantly larger average projects in FP6. Fifure 84 illustrates the rapidly increasing relative importance of funding from the EU; regardless of which ratio is seen as the most relevant, it is obvious that EU funding has become a very important source of income for LU. Despite this rapid increase in importance, LU management sees no reason for concern regarding over-dependency on university level, but there may be a risk of local over-dependency on FP funding for individual research groups. It is pointed out that the co-funding requirement (partly due to the insufficient overhead coverage) drains resources from other fields, but on the other hand, this applies also to some domestic grants. For example, the Linné grants have even stricter co-funding requirements than FP projects, since they require that the university uses the government block grant for co-funding. Nevertheless, LU management would like to see grants for research and graduate education sought in competition increase and the FPs are considered a less arduous way to achieve this than the alternatives

Figure 83 Grants for research and graduate education sought in competition. Only ten largest sources of income in 2007 shown in figure. The category "Swedish non-profit organisations" is a composite of several funding sources, meaning that the EU is the second largest source of grants



Source: HSV

Figure 84 Ratio of EU income to research and graduate education grants sought in competition, and total income for research and graduate education (i.e. including government grants and commissioned research), respectively



Source: Analysis of HSV data

LU management notes that the FPs' predetermined call topics are not a limitation for LU on an overall level, since LU's subject scope is so broad that there is always a researcher that is qualified to apply to any given call; for the individual researcher, the situation of course may be very different.

LU has clearly benefited from the FPs, but there are different accounts as to whether the FPs have influenced LU's overall research priorities. Some argue that the structuring effects are not strong enough, particularly considering that LU is so all encompassing in terms of disciplines that that any call fits some researcher, whereas others tentatively suggests that there may after all have been a slight influence in strategic priorities.

There is no arguing that participation in the FPs have extended LU's collaboration network, but is suggested that the main effects are in terms of intensity and plurality, rather than in the collaboration pattern as such. Within FP6, LU has around 4 000 partners (duplicates not eliminated) distributed on the following organisation types:

- Industry: 18%
- Universities: 46%
- Research institutes: 24%
- Others: 12%

FP participation enhances quality in general and of graduate education in particular, since project work is mainly performed by graduate students, who benefit from increased international exposure allowing them to build their own networks. When graduate students' views on internationalisation changes, so does – with time – the university's. LU has just seen the first graduations from the nano-engineering undergraduate (MSc) programme that was set up several years ago; past FP projects in related fields have certainly had a positive influence on this programme.

LU joined the League of European Research Universities (LERU) some 3–4 years ago and this has proven an effective way to exert influence. Lobbying has also taken place through the Region of Skåne. LU's management has in the past responded to national policy documents as well as to Green and White Papers of the European Commission, but recognises that it could and should take a much more proactive approach in attempting to influence contents of future work programmes and call texts. "From Swedes working for the Commission, we've been told that Sweden is much less visible than other nations in Brussels. We ought to be more active, particularly in development of new work programmes, but we don't quite know how.

B.3.2. Effects on individual researchers and research groups

Just as at other universities, it is the odd department that has a formalised strategy. It is pointed out that it is hard to have a visionary strategy in an opportunity-driven organisation like a university, where the only all-encompassing strategy may be to make sure to exploit the opportunities, mainly in terms of funding, that arise. Ultimately, detailed research areas are thus determined by individual researcher's interests and available funding opportunities. Having said that, many departments and divisions nevertheless appear to have a highly strategic approach to their operations and it is argued that the strategic direction is developed at division level. In one case, division management is said to carry out elaborate strategic discussions to manage and develop its research direction through addressing questions such as "Where do we have blind spots?" and "How should we ensure we do not become so diversified that we lose focus?". When a new FP work programme is available, usually well before it is officially published, the division goes through it to identify strategic opportunities and to divide proposal work between senior researchers. Another division mentions the strategic thinking behind applying for a large-scale facility project to open up its own laboratory facilities to others; this has, as planned, led to a more extensive collaboration network and enhanced reputation for the division.

All interviewees consider participation in FP projects as strategically important, but one argues that participation used to be more valuable in the early days when there was a uniqueness to FP participation, while another states that the marginal benefit of yet another participation is getting smaller. Collaboration with excellent groups, networking, international visibility for both organisation and individual, as well as funding are among the more frequently mentioned benefits of participation. Participation in projects with industry seems particularly appreciated and such mission-oriented and multidisciplinary projects are said to provide a good counterbalance to more fundamentally oriented projects funded by for example the Swedish Research Council and the Swedish Foundation for Strategic Research. Moreover, even in mission-oriented projects, fundamental scientific problems need to be solved. In many cases, it is the companies that coordinate projects and they select the academic partners they want to work with, so participation becomes a form of quality seal. It is further emphasised that wide and frequent FP participation results in an opportunity to influence future WPs, thus making participation extremely important from a strategic perspective. There is a formidable competition in proposal evaluation and this enhances quality, although there is some concern about the quality of the Commission's evaluation process, which some see as being in decline.

A prominent disadvantage of FP participation is the level of bureaucracy, which for a division with many FP projects can become a serious burden that sets a limit to participation. This problem is made worse by the fact that LU's accounting system is not compatible with the Commission's reporting requirements for Marie Curie projects. Another factor limiting an organisation's participation is the incomplete coverage of indirect costs, which requires substantial complementary funding (despite LU's internal subsidy in terms of indirect costs). On the other hand, one interviewee points out that coverage of direct costs is more generous in FP projects than with grants from most domestic sources. It is hypothesised that the political compromises supposedly involved in work programme development occasionally results is "impossible" call texts, meaning that requirements are contradictory and counterproductive. The rigidity of projects is another problem, that leads to proposers becoming very careful and conservative with formulation of deliverables and where some use the tactic to already have carried out part of the work beforehand (so that you know you can deliver). As a consequence of this, as well as the incomplete cost coverage, it is important that FP projects fit within the organisation's core research activities. Despite up to 30% of their groups' total research income coming from the FPs, no interviewee sees their level of dependency as a reason for concern from a vulnerability point of view.

The leveraging effect of being a recipient of FP funding when applying for domestic grants is claimed to be small to non-existent. However, one researcher mentions that his strong European network was singled out as a strength in an evaluation report from the Swedish Research Council. Another researcher relates that the Swedish Foundation for Strategic Research probably would not have invited him to submit a proposal for a major centre grant had he not already had a strong track record and a research infrastructure that partly has been built with FP funding. The leveraging effect the opposite direction is strong, but nevertheless indirect; you do not qualify for participation in an FP project unless you have already built a research base, usually with domestic funding. There is a certain degree of cascading between projects (one project leading to another), but it is more common that there is no such effect.

Interviewees agree that their FP participation has influenced the direction of their research to some extent, but that it is usually a matter of new fields of application rather than new fields of research. However, FP projects provide an opportunity for your research to evolve through external influences and this is seen as tremendously valuable and rewarding. One researcher states that his FP participation has made him bolder and made him address broader topics than he previously did. Another researcher argues that the thematic priorities of the FPs probably influence you more than you realise and goes on to suggest that the most notable effect may be that the Swedish Foundation for Strategic Research obviously has been influenced by FP priorities. The researchers agree that FP participation has clearly affected their collaboration patterns and made them considerably more international in both academia and industry, but also more interdisciplinary. While Swedish projects tend to be rather mono-disciplinary, FP projects are much more interdisciplinary and this has lasting effects on both participants' research and on their collaboration patterns.

All interviewed researchers have coordinated FP projects and consider coordination valuable and a good learning process. It is no simple matter to coordinate a large project and it requires good and firm leadership. "Being coordinator is both a responsibility and a mandate; if you want to be successful you must really coordinate your projects and not let partners do what they want."

There is no doubt that researchers prefer smaller projects of the STREP type, since they are more manageable and collaboration becomes close and genuine. In most cases, Integrated Projects (IP) are just too large and are rarely closely coordinated, so there is limited collaboration in practice. Since Networks of Excellence (NoE) projects usually do not have a significant research component, enthusiasm and efficiency are low. There are, however, rare exceptions. One researcher describes an IP that is an exceptionally good graduate school in which students get exposure to a lot of new techniques and get trained into new research leaders. In short, they are said to get the kind of experiences that otherwise usually requires a couple of post-doc assignments. The same researcher tells of an NoE that also has been a very good and ambitious graduate school with courses for both graduate students and their advisors. Moreover, this NoE is said to have resulted in 30 new FP projects. The accounts of Marie Curie projects (mainly Research Training Networks (RTN), but also Early Stage Research Training (EST)) are mixed. RTNs are said to be good (although financial reporting is a nightmare), but in both RTNs and ESTs projects easily become isolated from each other, which is detrimental to the development of the candidate. The experience of the large-scale facility instrument is limited, but very positive in terms of both networking effects and the low level of bureaucracy involved.

Scientific production is the highest in projects of the STREP type and may in some cases actually be much higher than in domestic projects, since there is a greater degree of co-publication when the consortium is small, effective and tight. Industry-led projects are more likely to result in deliverable reports than in scientific publications, so in this respect they are less efficient and thus not ideal for graduate students. One researcher relates that they used to have graduate students working full-time in FP projects, but gradually realised that this not ideal, both from the perspective of publication difficulties and due to the risk of students being crushed by demands for deliverables. For this reason, they now try to involve graduate students part-time in an FP project and the rest of the time in another project, to provide students with some flexibility and leeway.

By and large, the interviewees have a solid history of participation in industry-led or at least application-oriented FP projects, which clearly shows in the effects mentioned. In some cases, researchers take recurring industry participation and recurring invitations to participate in industry-led FP projects as indications that their own work is of industrial relevance and that it is likely to be exploited by industry. In other cases, such as with the Swedish energy sector, the industry dialogue is more direct and constantly ongoing, but industry's time perspective is so long that no concrete results are yet visible. In either case, industry is rather tight-lipped about what research results they use and for what purpose, so it is oftentimes difficult for researchers to know how their work is exploited. For the very same reason, it is difficult to know where a multinational company exploits a given research result. At the other end of the spectrum, a research group with a very solid FP participation history has produced a phenomenal eight spin-off companies active in the ICT, life science and energy sectors. All these companies clearly trace at least part of their heritage back to FP projects, and in some cases the FP project origin is very direct. Ten years ago, the eight companies had three employees, now they have a hundred employees, and one of the companies has a 45% share of the world market for lithography solutions for manufacturing and replication of advanced micro- and nano-scale structures.

One researcher describes that FP projects have resulted in White Papers and roadmaps, which most definitely are read by the Commission. Active and broad FP participation means you are invited to all kinds of events and expert groups and this gives you an opportunity to exert influence. Another researcher relates how he participated in "importing" the converging technologies concept from the United States to Europe and this effort had great impact on subsequent work programmes. Researchers have also contributed call texts, but are unsure of the real effects of their own efforts and argue that some individuals like to exaggerate their influence; as one researcher puts it: "I've heard more than one person claim to have written the same text for the same sub-call."

B.4. References

Lund University in the future – visions and strategies (Lunds universitet inför framtiden – visioner och strategier), 1995

Lund University strategic plan 2002–2006

Lund University strategic plan 2007–2011

Lund University research strategy, 2003

Lund University research and education strategy 2009–2012

Policy for internationalisation at Lund University 2008–2011

Lund University annual reports

www.lu.se

FP participation data from Cordis, complemented with data from VINNOVA and LU's GO

University income statistics from the website of The Swedish National Agency for Higher Education (www.hsv.se)

University personnel statistics from LU annual reports

Appendix C Chalmers University of Technology

C.1. Introduction

The history of Chalmers dates back to 1829, when the director of the Swedish East-India Company, William Chalmers, donated the financial means required for the establishment of an “industry school” in Gothenburg. In the beginning, the school employed three teachers and had ten students. Over the years, Chalmers was gradually incorporated into the Swedish publically funded system of higher education. In 1994, the government established an independent foundation, the Chalmers University of Technology Foundation, which in turn set up the limited company Chalmers tekniska högskola AB. This development provided increased freedom for Chalmers in developing its educational programmes and research. Despite initial scepticism regarding this for Swedish conditions rather unique arrangement (there are only three universities independent of the Swedish government), the change of governance appears to have been smooth. As a consequence of this change, Chalmers is led by a board appointed by the Chalmers University of Technology Foundation, whose board is the supreme decision-making body that appoints the university board, decides on discharge from liability and manages the Foundation’s capital. The university board, in turn, is responsible for overall planning, coordination and follow-up of the university’s activities, while the president, who reports to the university board, is responsible for operative management. Chairman of the university board is Sven Eckerstein, while Karin Markides serves as president and CEO since 2006.

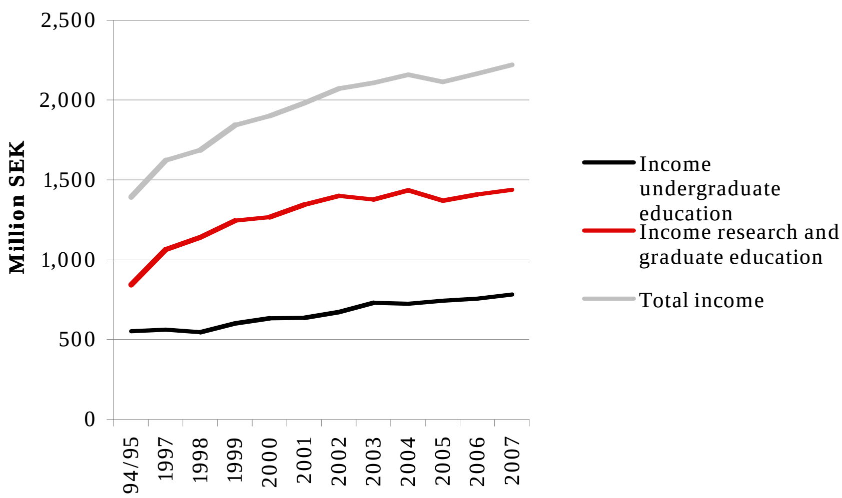
Chalmers is an engineering university with 17 departments, which have the overall responsibility for research and education. However, much of the cutting-edge research takes place in centres, which are products of inter-departmental cooperation, and the following listing of the present centres thus provides a good overview of Chalmers’ research:

- Antenna Systems Excellence Centre, CHASE
- Centre for Combustion Science and Technology, CECOST
- Centre for Competence and Knowledge Building in Higher Education, CKK
- Centre for Co-ordinated Energy Research, CEC
- Centre for Environment and Sustainability, GMV
- Centre for High-Speed Technology, CHACH (national centre)

- Centre for Intellectual Property, CIP
- Centre for Language and Communications
- Centre for Microwave Antenna Systems, CHARMANT
- Centre for Process Design and Control, Chemical Process Engineering
- Chalmers Biocentre
- Combustion Engine Research Centre, CERC (national centre)
- Competence Centre for Catalysis, KCK (national centre)
- Competence Centre for High Temperature Corrosion, HTC (national centre)
- Competence Centre in Environmental Assessment of Product and Material Systems, CPM (national centre)
- Competence Centre in Railway Mechanics, CHARMEC (national centre)
- Consortium Gas Turbine Centre, GTC (national centre)
- Centre for Built Environment in Western Sweden
- Facilities Management
- Forum for Risk Investigation and Soil Treatment, FRIST
- Gothenburg Mathematical Modelling Centre, GMMC
- Competence Centre Infrastructure
- Construction Centre
- Lighthouse - Maritime Competence Centre
- Linnaeus Centre on Engineered Quantum Systems
- Material Analysis at Chalmers, MACH
- Metal Cutting Research and Development Centre, MCR
- Multiphase Flow
- Onsala Space Observatory
- Plastics for a Sustainable Society, PLUS
- ProDesign
- ProViking
- R&D, Innovations and Dynamics of Economies, RIDE
- SAFER, The National Vehicle and Traffic Safety Centre at Chalmers
- Scientific Centre of Non-Destructive Testing, SCeNDT
- Soundscape – Support to Health
- Stochastic Centre
- Supramolecular Biomaterials Structure Dynamics and Properties
- Swedish Hybrid Vehicle Centre
- Swedish Microsystem Integration Technology Centre, SMIT Centre
- Wingqvist Laboratory

Over the past decade, Chalmers' income for undergraduate[82] education has increased by 40%, while its income for research and graduate education has increased by 35%, see Figure 85. In the same timeframe, the number of undergraduate students has increased by 16%, while the number of graduate students has *de*creased by 5% and the number of researchers and teachers likewise has decreased by 1%, see Figure 86 Obviously, costs have increased considerably faster than income and in the beginning of the century Chalmers was making a loss, which explains the reduction in personnel and to some extent graduate students illustrated in the figure. Over the entire 1990–2007 timeframe shown in Figure 86, the number of undergraduate students has increased by 72%, the number of graduate students by 14% and the number of researchers and teachers by 56%. Chalmers research intensity (here defined as the ratio between income for research and graduate education and total income illustrated in Figure 85) is currently at 65%, but is in gradual decline from a peak of 68% in 2001.

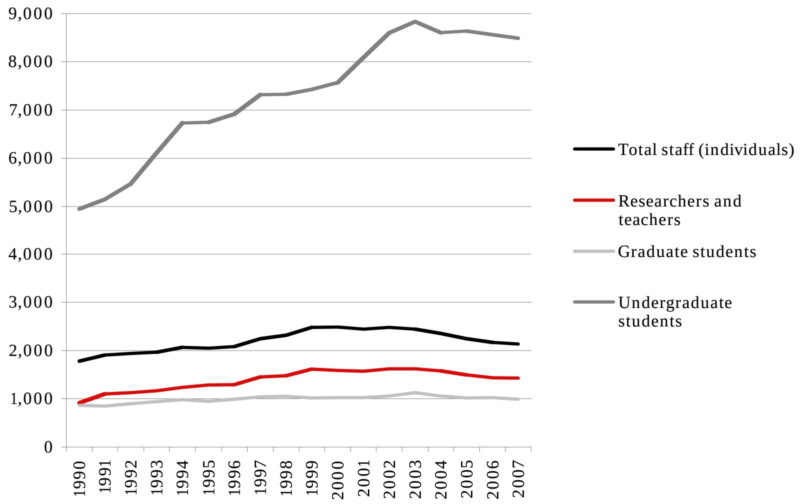
Figure 85 Income development



Source: HSV

[82] Prior to adopting the education structure of the Bologna process in 2007, Sweden had a two-tier educational structure at university level that differed from most other countries. For the purposes of the case studies in this report, the two levels are referred to as "undergraduate" and "graduate", resulting in a master's and doctor's degrees, respectively. It should be noted that this division into two levels and degree structure constitute simplifications.

Figure 86 Development of number of employees and students



Source: Chalmers annual reports

Chalmers is engaged in several initiatives to enhance its degree of internationalisation, including:

- The Alliance for Global Sustainability together with Massachusetts Institute of Technology (MIT), Boston, USA, Swiss Federal Institute of Technology (ETH), Zurich, Switzerland, and University of Tokyo, Japan
- Representation in China, established together with Karolinska Institutet (KI) and the Royal Institute of Technology (KTH) in Stockholm
- The outreach collaboration framework project Molecular Frontiers, established together with Massachusetts Institute of Technology, Cambridge, MA, USA, and Stanford University, Palo Alto, CA, USA, which is expected to enhance research and education

In order to accommodate international exchange in undergraduate education, the number of courses taught in English is to be increased. Within Sweden, close cooperation with Sahlgrenska Academy (the medical faculty of Göteborg University (GU)) is expected to enhance research in biotechnology, while cooperation with industry has been a priority for a long time.

The number of Chalmers' undergraduate students spending some time abroad is small. In spring of 2007, a total of 164 students were studying abroad; in 2003 the corresponding figure was 146. The 2007 annual report laments that there is no real competition among Chalmers' students to go abroad through exchange programmes since there are so few applicants, but the report does not elaborate on any reasons for this. In the period 2003–2007, the number of foreign students at Chalmers has oscillated somewhat and was almost 1 300 in autumn of 2007.

According to Webometrics' university ranking from January 2008, Chalmers is in position 153 among universities in the world, whereas Shanghai Jiao Tong University places Chalmers in the 203–304 bracket worldwide and in the 81–123 bracket in Europe. The Times Higher Education Supplement from 2007 lists Chalmers in position 197 globally in the category encompassing all universities, but Chalmers is not on the list of the top 50 engineering universities worldwide (but then again, no Swedish university is).

C.2. Strategy development

Chalmers' planning instruments have a three-tier structure. At the core of strategic planning lie the annual plans of the departments, in which operational goals are set out. Based on these plans, an overall plan for the coordination of policy is developed at university level. A long-term approach is taken in the strategic plan, which is also important for development of the Chalmers culture and image. The most recent comprehensive strategic plan dates back to 2004. A new plan is forthcoming in 2008, but is not yet available.

Chalmers' Strategic Plan 2000 emphasises that it is difficult to foresee new research areas, especially because they tend to emerge at the crossroads between traditional disciplines. It is noteworthy that the role of social sciences and humanities is highlighted, which may indicate an orientation towards increased multi- and interdisciplinarity. Moreover, the traditional distinction between basic and applied research is expected to gradually lose its relevance. For these reasons, *inter alia*, the prioritised research areas are defined in rather broad terms in the Strategic Plan 2000. Four such broad research areas are identified as having a significant potential, namely biotechnology, microtechnology, environmental science and information technology. These areas share the characteristics that they have an impact on society as a whole and on industry in particular, while at the same time allowing for basic research at the scientific frontier. In order to narrow down these broad areas, a list of concrete developmental foci has been established, which, judging from the wording of the Strategic Plan 2000, probably should not be seen as being all encompassing:

- The Department of Microtechnology and Nanoscience (MC2) formed in 2003 by strong research groups from three different departments
- The Department of Signals and Systems comprising information theory, communication systems signals as well as digital imaging systems and analysis
- Biotechnology, which combines medicine and technology
- Sustainable society, including transport systems, resources and energy, lifecycle analysis and processing science

Whether or not they have a direct connection to the aforementioned prioritised research areas, the Strategic Plan 2000 lists microelectronics and material science, mechanical engineering, solid mechanics, civil engineering, acoustics, chemical engineering, electrical engineering and computer science as particularly strong individual disciplines. In some disciplines, including chemistry, physics, mathematics, computer science and geology, Chalmers cooperates closely with GU to enhance critical mass and to ensure a high scientific standard in research.

The document Chalmers strategies 2004–2007 states that Chalmers is to be “a leading engineering university with a strong foundation in natural sciences, mathematics and architecture”, but provides no prioritisations in terms of research areas. Instead, the document emphasises concentration of resources to internationally competitive research areas, critical mass, collaboration with others (primarily GU) and interdisciplinarity. It even states that support for under-critical research areas should be discontinued, unless they have the potential to be strengthened or are of great importance for other research areas, so as to favour the strongest research areas.

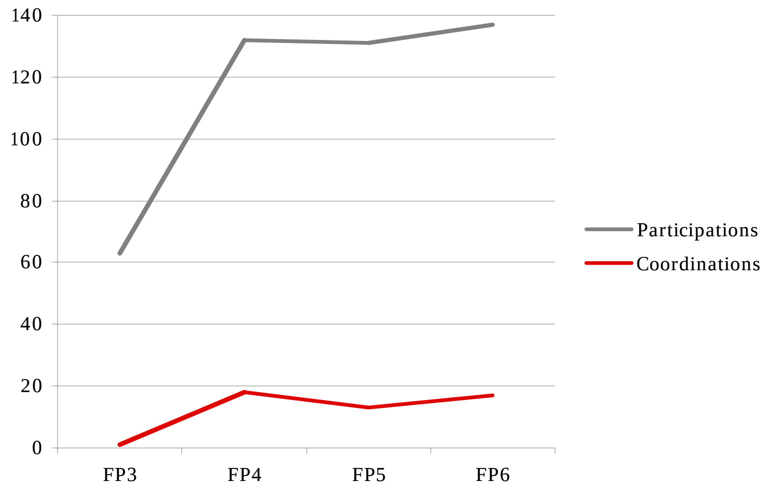
Sustainable development is a core value at Chalmers. This development is reflected in the fact that it is repeatedly highlighted in more recent strategic documents. In this context, sustainable development refers to education and research aiming at satisfying both short- and long-term needs of society by applying a lifecycle perspective. As evidence of this policy’s success, Chalmers was in 2006 named “UN Habitat University” and was granted a UNESCO professorship in sustainable development. At present, Chalmers’ hosts five graduate schools and five MSc programmes within the field of sustainable development.

C.3. FP participation

Figure 87 illustrates that Chalmers was a well-established participant already in FP3. In FP3, most Swedish participations were formalised through a contract with each project consortium or its coordinator and funding was provided by Swedish government agencies. This changed on January 1, 1994 (towards the end of FP3), when Swedish participants through the European Economic Area agreement[83] were granted the same participation terms as organisations in EU member countries. A year later Sweden joined the EU.

[83] Through which the EFTA (European Free Trade Association) countries were allowed to participate in EU’s single market without joining the EU.

Figure 87 Number of participations and coordinated projects per Framework Programme



Source: Cordis[84]

Chalmers' FP participation history started towards the very end of the 1980s and it was soon realised that the FPs were a potentially important source of funding for the university. The recognition that participation in the FPs required skills and insights that few researchers then possessed, led to the appointment of an "EU coordinator" in 1990. This function has never consisted of more than two persons and for the last 6–7 years, the present EU coordinator who started in 1994, has been working on his own. Despite working alone, the advent of ICT tools, mainly e-mail and pdf versions of work programmes etc., has meant that he is able to provide a whole lot more extensive services to researchers than he used to. He also points out that so far the interest in coordinating projects is limited at Chalmers[85], which reduces the need for support. Although he feels that most of the time he manages to respond to demand, he is well aware that certain other universities' grants offices offer broader services than he does. However, when comparing with grants offices of other universities, it should be noted that some of them have a broader mandate than Chalmers' EU coordinator, who only works with FP funding, meaning that direct comparison may lead to incorrect conclusions. Chalmers for example has a separate function dealing with major national proposals where the university is the formal applicant.

[84]Cordis data has been complemented with information from VINNOVA and Chalmers' EU coordinator. Data on coordinated projects is known to be incomplete for FP3–FP5.
[85]Chalmers coordinates 12.4% of projects in FP6, which is the lowest proportion among the five universities studied herein and a figure that has not varied much since FP4 (cf. Figure 76).

The EU coordinator supports researchers with:

- Selectively disseminated call information via e-mail (there is an individual interest profile for each researcher)
- Assistance with proposals, mainly in terms of budgeting and filling in forms
- Contract negotiations
- Consortium agreements

The EU coordinator arranges internal courses on demand, typically twice a year, both for potential proposers and for department administrators. For consortium agreement reviews, the EU coordinator used to interface with GU's lawyers from whom Chalmers bought legal services. However, since November 2007, Chalmers again has its own lawyer, who spends about half of her time scrutinising and negotiating consortium agreements. Regular financial reporting in ongoing FP projects is the responsibility of each department, but the EU coordinator provides advice as required.

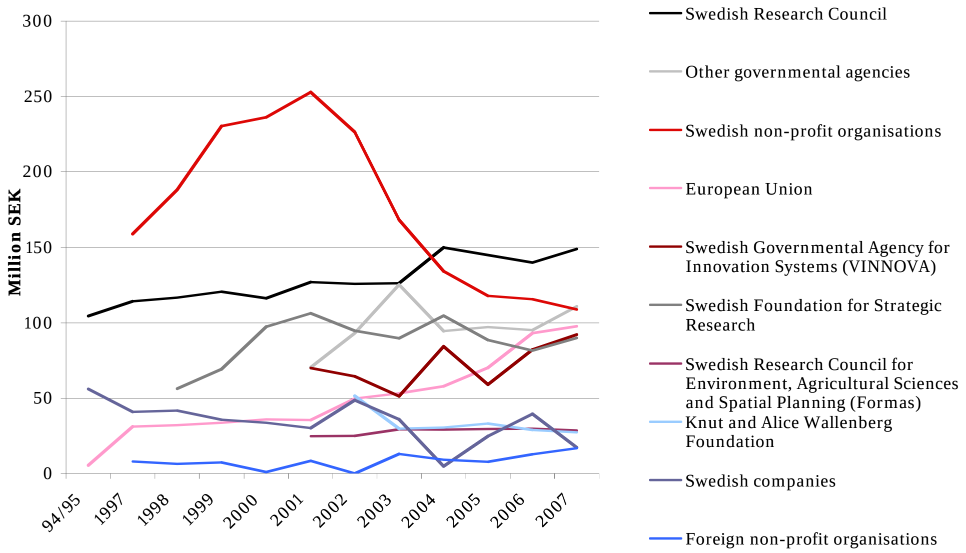
Chalmers management is in the process of discussing a range of possible future support measures to facilitate further increased FP participation. On the one hand, such measures have their origin in that Chalmers has an ambition to increase both its overall research resources and its degree of internationalisation, and on the other hand in the observation that Chalmers' potential for increased FP funding is virtually "unlimited", as opposed to most domestic funding sources where Chalmers already receives as great a proportion as is politically correct. It is recognised that any substantial increase in FP funding will require proactive action from Chalmers management, including expanded support for applicants. For this reason, Chalmers management closely follows an initiative by two Chalmers departments to see if their initiative might serve as model for the entire university. The two departments currently employ an experienced consultant half-time to help write and improve proposals. He partly acts as ghost writer and partly as general FP advisor. The explicit goal is a greater number of proposals and an improved success rate. Another specific action under consideration is to hire recently retired professors as coaches for young researchers, although this would not only apply to teaching them how to navigate the FPs. Chalmers management would also like to see more of its researchers participating as proposal evaluators for the Commission and in development of technology platforms and strategic research agendas etc., but does not quite know how to convince busy researchers to invest the time to do so.

Despite the perceived need to increase its support to would-be FP proposers, Chalmers' top FP participators appear quite content with the support provided by the EU coordinator. However, they also hypothesise that they by now are so experienced FP participators and that they work in departments with qualified FP participation infrastructure that their need for assistance may not be representative of the average Chalmers “customer”. Moreover, the university’s central administration supports departments with indirect costs so that each project receives 35% overhead, i.e. on par with the level provided by most Swedish funding agencies.

C.3.1. Effects on university

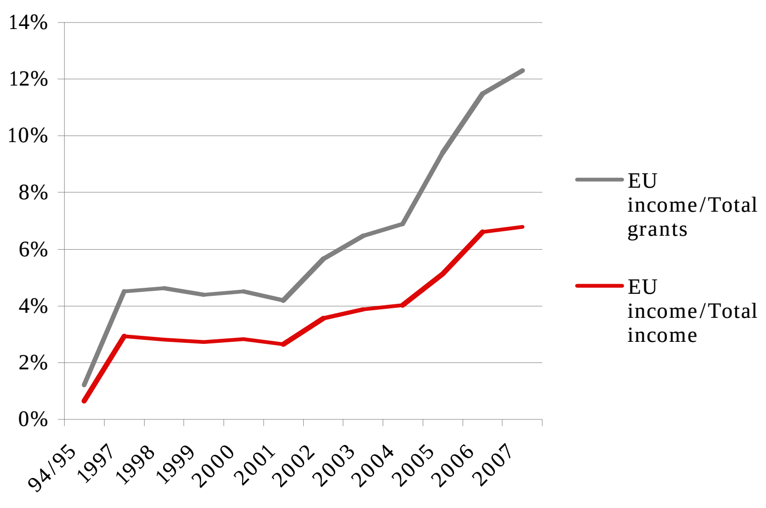
Interestingly, in contrast to many other Swedish universities, Chalmers has over the last decade reduced its dependency on grants for research and graduate education sought in competition (or increased its dependency on government grants); the ratio of grants sought in competition to total funding for research and graduate education (i.e. including government grants and commissioned research) has gradually decreased from 65% in 1997 to 55% in 2007. Nevertheless, research grants from the EU has increased rapidly, from a very low level in 1994/1995 to now being the second largest source of grants, cf. Figure 88. The strong increase in EU funding (which for Chalmers is close to synonymous with FP funding) is both due to the increase in number of participations in FP4 and to a lesser degree in FP5, as well as to the significantly larger average projects in FP6 (approximately 65% larger in terms of Chalmers budget than in FP5). Figure 89 illustrates the rapidly increasing relative importance of funding from the EU; regardless of which ratio is seen as the most relevant, it is obvious that EU funding has become an important source of income for Chalmers. Despite this rapid increase in importance, there is at least for now no reason for concern regarding over-dependency on university level; EU funding is in practice another funding source in the natural funding mix of Chalmers. However, there may be a risk of local over-dependency within certain research groups. The maximum overhead accepted by the Commission (20% for most instruments in past FPs) is indeed a problem (despite Chalmers’ central administration “topping up” project budgets to 35% overhead, as previously mentioned), since real overheads are substantially larger. This means that a mix of research funding from different sources is required, preferably at group or department level, to make ends meet.

Figure 88 Grants for research and graduate education sought in competition. Only ten largest sources of income in 2007 shown in figure. The categories "Swedish non-profit organisations" and "Other governmental agencies" are composites of several funding sources, meaning that the EU is the second largest source of grants



Source: HSV

Figure 89 Ratio of EU income to research and graduate education grants sought in competition, and total income for research and graduate education (i.e. including government grants and commissioned research), respectively



Source: Analysis of HSV data

As obvious from the figures above, FP funding is indisputably of large and growing importance to Chalmers. Moreover, if Chalmers management manages to facilitate a further increase in participation, the FPs are likely to become even more important for the university. However, it is argued that FP projects are just means to an end, namely to:

- Acquire new knowledge
- Build networks
- Enhance internationalisation and strengthen the Chalmers trademark
- Enhance industrial relevance in research
- Increase competitiveness, since participation is a matter of “selection of the fittest”

There is no arguing that the FPs have benign effects on Chalmers’ development, but there appears to be no evidence that the FPs should have had any structuring effect on Chalmers’ research agenda. In any case, other funding agencies making larger and more concentrated investments, such as the Swedish Foundation for Strategic Research and the Swedish Governmental Agency for Innovation Systems (VINNOVA), would be more likely to have a structuring effect, and it is argued that not even in such cases is there any effect on an overall university level. In terms of the collaboration network, the pattern is said to have become more international and considerably wider. FP participation adds vitality to and enhances quality of graduate education, since project work is mainly performed by graduate students, who benefit from increased international exposure allowing them to build their own networks. Moreover, most graduate students teach undergraduate courses, and their research thus naturally spills over into these.

Chalmers’ management has in the past responded in public consultations of the European Commission, but recognises that it could and should take a more proactive approach in attempting to influence contents of future work programmes. Different options are under discussion and one of them is the aforementioned intention to encourage more of its researchers to participate as proposal evaluators and in development of technology platforms.

C.3.2. Effects on individual researchers and research groups

Although departments are not required to have formalised strategies, some departments have formal research strategies. There are examples of both long-standing traditions of such strategies and more recent initiatives brought on for example by professors retiring. However, the more common situation is that group leaders and departments formulate informal strategies around their own competences and available funding opportunities. Some departments also have funding strategies, which inevitably tend to promote FP funding as an important source of funding. One department is in the process of developing an FP participation strategy to exploit the valuable intellectual capital created through years of substantial FP participation; the strategy will have the following core elements:

- Educate and inform personnel

- A manual to determine whether to participate in a proposal or not and, if yes, to what extent (since ill-fitting project may become a liability)
- Whether to aspire to have FP projects with participants from more than one division of the department and under what circumstances that might be an advantage
- How to share and disseminate experiences of past projects to newcomers to the FPs, particularly when it comes to administrative matters

Also other departments strive to encourage young researchers to go for FP projects, even as coordinators. Senior researchers are said to have a responsibility to bring up the next generation of researchers in an "FP spirit". Young researchers learn early on that once a year you apply to the Swedish Research Council, and this consequently becomes a natural thing. There is no equivalent tradition for the FPs and of course the lack of annual call pattern makes it more of a challenge. However, it is pointed out that ultimately the initiative to participate in an FP proposal rests with the individual researcher, although the head of department and colleagues provide support. A head of department sees it as his role to ensure that the department offers the necessary infrastructure in terms of qualified and experienced administration, experienced and helpful research colleagues, good contacts with Chalmers' EU coordinator, access to an external, part-time FP consultant (during a trial period) and last but not least an encouraging atmosphere. One researcher mentions that it is obvious that some professors have made the FPs into a survival strategy in the face of dwindling government grants.

Among the incentives for participating in the first FP project are money, curiosity, the novelty of FPs (referring to the early FPs) and direct invitations from consortia. It is interesting to note that while the initial motivations luring researchers into the FPs vary, the recurring incentives tend to converge. There is unanimous agreement that the networking effects and the inspiration you receive from others to vitalise your own research are the most important and positive effects of participation. Several researchers use large superlatives to describe how much they appreciate the effects of networking; "serendipity results from meetings". Another effect of participation is that the more you participate, the more you get invited into other's proposals. "My network has a life of its own," as one researcher put it. There is consequently a certain degree of direct cascading between projects, meaning that one project leads into another, but it appears more common that this is not the case. S everal researchers argue that early access to others' research results, access to new techniques, personnel exchange and benchmarking within the consortium lead to improved scientific quality in research, provided partners that you make sure you get involved in high-quality consortia. More than one researcher clearly states that you should not go for an FP project for the money; you need to make sure that you gain something scientifically and that the project largely matches the research you are already engaged in. On the same note, never ever try to build up a new research field based on FP funding only; FP funding should be seen as marginal funding. The last two statements partly have their origin in the fact that FP funding does not fully cover the costs; a mix of funding from different sources is a requirement.

The competitive element in proposal evaluation enhances scientific quality, assuming the process is fair. One interviewee argues that the evaluation quality has increased with time, while another that evaluation quality has decreased significantly and goes on to say that the European Commission has a serious credibility problem that it urgently needs to tackle. One interviewee further brings up the account that the Commission employs “a B team to evaluate an A team”, but goes on to say that the A team has itself to blame, since it too seldom takes the time to participate in evaluations.

The leveraging effect of being a recipient of FP funding when applying for domestic grants is said to be small to non-existent; one researcher even argues that it may be a liability to have significant FP funding when applying to the Swedish Research Council. In contrast, having solid funding, whether domestic or not, is most certainly an advantage when applying to the FPs, since track record and facilities count for so much in evaluations.

The majority of interviewees agree that FP participation definitely has had obvious effects on the direction of their research, although they at the same time specify that this influence is within the general limits of their field. Collaboration in a consortium by necessity means that you get involved in tasks and areas you would not otherwise have delved into. One researcher mentions that he got into a futuristic new field sooner than he otherwise would have, another that the FPs allow him to pursue a research area for which there is no domestic funding available. It is evident that the external influences affecting their research direction is much appreciated. The researchers obviously value the projects’ networking effects immensely, and they agree that the FPs have resulted in considerably more extensive and deeper European networks and also collaboration between disciplines.

All interviewees have coordinated FP projects and see it both as a good investment and a good learning process. You get the opportunity to determine the research direction and select the partners, both the individual and the organisation get credit and recognition meaning you get invited to participate in others’ proposals, and you get an insight into how the Commission works, which may be used to your advantage. The learning threshold of being a coordinator is painful, but when you have done it once, it is not that bad. For coordination of larger projects, it is clearly a necessity to hire someone to help with administration and instead concentrate on scientific management.

In terms of experiences of different instruments, it is striking that many researchers are not aware of what instrument a given project is. The ones that do, clearly favour projects of the STREP type, since they are manageable and permit good-quality research. Although accounts differ significantly, the odd Network of Excellence has also proved very valuable and has provided resources for research. One recipient of an infrastructure grant explains that it has been a very good marketing and networking tool for him and his department and praises the simple administrative procedures of this instrument.

Researchers see limited evidence of industrial exploitation of FP project results. There are some accounts of increased industrial understanding and new measurement techniques, as well as some references to university spin-offs, but more common are tales of unsuccessful industry participation, absence of relevant industry in Europe, or Swedish life-science companies being uninterested in participating in FP projects.

Not surprisingly, Chalmers' more experienced FP participators appear well versed in how to influence content of FP work programmes. Two interviewees describe how they, courtesy of their international recognition, were invited by the Commission to contribute texts for upcoming calls and that their contributions were used more or less intact. In one case this led to a successful proposal in that very sub-priority, while in the other case the proposal did not pass minimum thresholds despite naturally being spot on in terms of contents and allegedly being submitted by an excellent consortium. Other means of influencing research agendas that in turn tend to influence upcoming FP work programmes are participation in development of Strategic Research Agendas and JTIs and this avenue has been explored by two interviewees.

C.4. References

Overall activity plan 2007

Chalmers strategies 2004–2007

Chalmers strategic plan 2000

Chalmers annual reports, 1998–2007

FP participation data from CORDIS, complemented with data from VINNOVA and Chalmers' EU coordinator

University income statistics from the website of The Swedish National Agency for Higher Education (www.hsv.se)

University personnel statistics from Chalmers annual reports

Appendix D Karolinska Institutet

D.1. Introduction

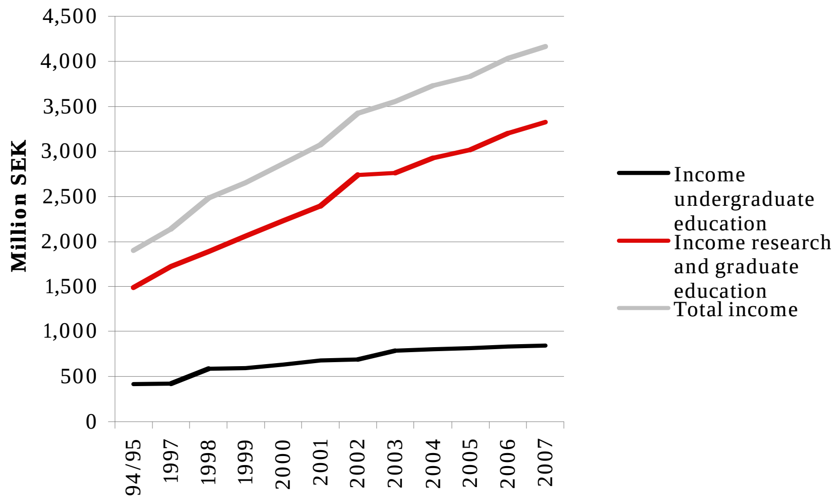
Karolinska Institutet (KI), soon 200 years of age, is the leading Swedish medical university. Located in Stockholm, KI was founded for the sole purpose of improving the education of physicians, especially in light of the needs caused by the unsuccessful war against Russia in 1808–1809. The vision of the founders, including the renowned chemist Jöns Jacob Berzelius, was the establishment of a future medical university, i.e. very much like KI today; KI was awarded university status in 1861. In 1895, Alfred Nobel appointed KI to pick the winner of the Nobel Prize in Physiology or Medicine. At present, KI's share of Swedish medical research is approximately 45%.

In accordance with Swedish tradition, KI is a publicly owned university and at the same time a government body, thus sharing several similarities with other bodies in public administration. The supreme body of KI is the Board, presently consisting of nineteen members, including representatives of students' and employees' organisations; six of the members are appointed by the Swedish government. Other candidates to the Board are nominated by an Election Committee consisting of all individuals employed half-time or more by KI. At present, the Board is chaired by Susanne Eberstein, representing the Swedish government. Vice-chancellor Harriet Wallberg-Henriksson is a member *ex officio*.

Over the past decade, KI's income for undergraduate[86] education has doubled, while its income for research and graduate education has increased by 93%, see Figure 90 In the same timeframe, the number of undergraduate students has increased by 85%, the number of graduate students by 86% and the total number of employees by 41%, see Figure 91. As illustrated by Figure 90, KI is very much a research university with a research intensity (here defined as the proportion of research and graduate education in total income illustrated in Figure 90) of 80% in 2007; this ratio was 80% also back in 1997 and has gradually recovered from a low point of 76% in 1998.

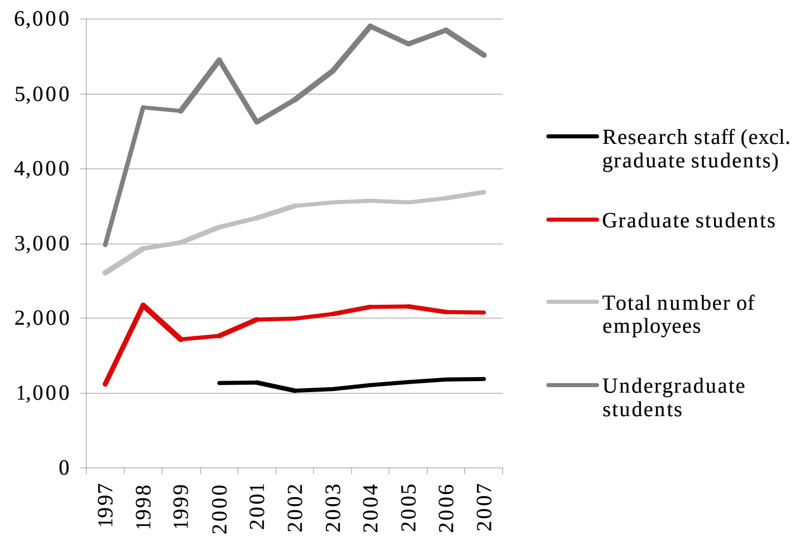
[86] Prior to adopting the education structure of the Bologna process in 2007, Sweden had a two-tier educational structure at university level that differed from most other countries. For the purposes of the case studies in this report, the two levels are referred to as "undergraduate" and "graduate", resulting in a master's and doctor's degrees, respectively. It should be noted that this division into two levels and degree structure constitute simplifications.

Figure 90 Income development



Source: HSV

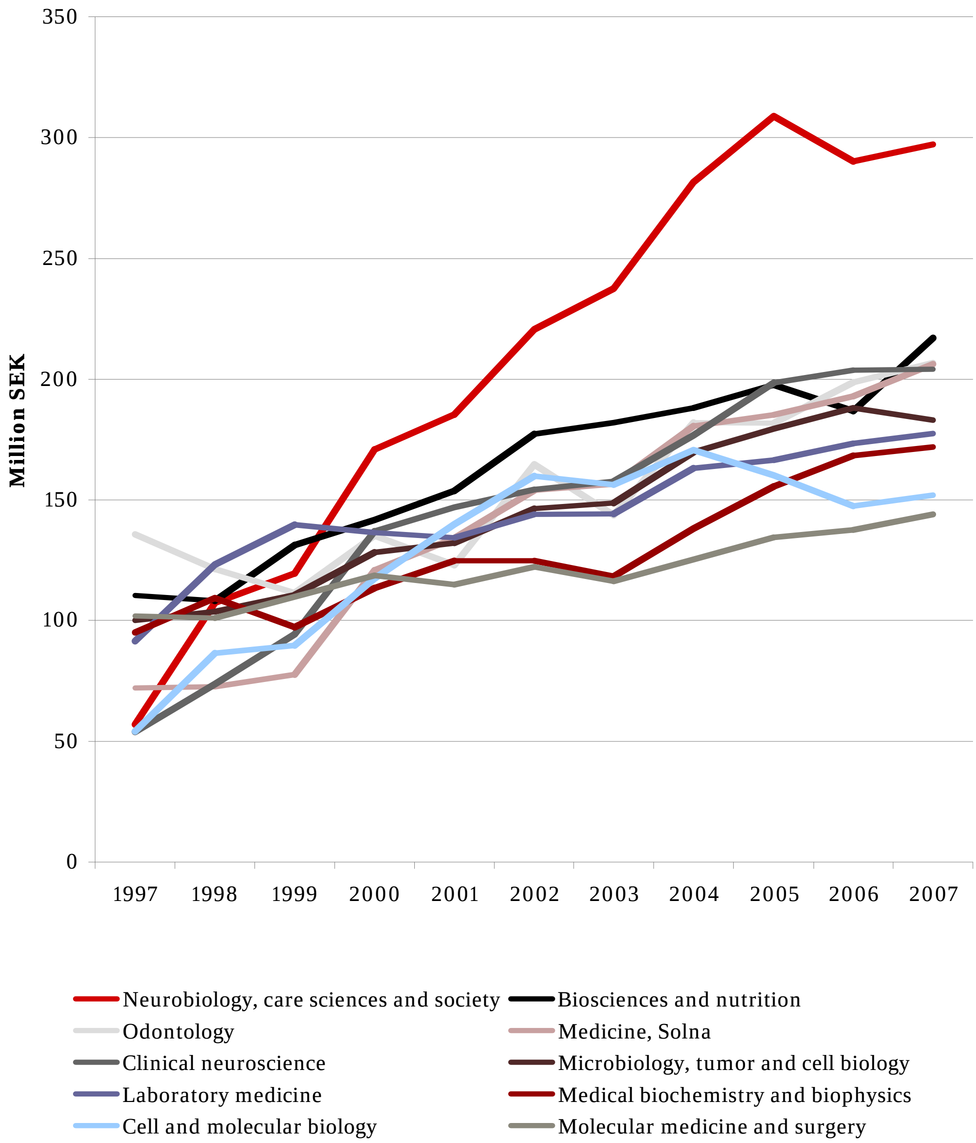
Figure 91 Development of number of employees and students



KI annual reports

Given the strong income development apparent from Figure 90, it comes as no surprise that all departments have grown in the last decade; the one growing the least grew by 31% and the one growing the most by almost 550%. The income development of the ten largest departments (of 22) in 2007 is illustrated in Figure 92.

Figure 92 Development of income for the ten departments that had the largest income in 2007



Source: KI department annual accounts

KI aims at being a world-leader in research, prominent in medical pedagogy, an attractive partner in the international researchers' community and a European leader in the application of research results. Much of the research at KI is carried out at research centres, which are focused concentrations in certain research areas. The centres have flexible organisations and are limited in time. A common characteristic is that centres consist of research teams sharing equipment and premises. According to the guidelines set by the Board of research, a research centre may be established by KI's Board, KI's president, the Board of research or the Board of education. At present the following centres are active:

- Aging Research Centre, ARC
- Cancer Centre Karolinska, CCK
- Centre for Health Equity Studies, CHESS
- Centre for Allergy Research, CFA
- Centre for Antiviral Therapy, CAT
- Centre for Biosciences, CB
- Gene Therapy Centre
- Centre for Gender Medicine
- Health Informatics Centre (HIC) together with Stockholm County Council
- Swedish National Centre for research in Sports
- Centre for Infectious Medicine, CIM
- Centre for Molecular Medicine, CMM
- Centre for Oral Biology, COB
- Research Centre for Radiation Therapy
- The Centre for Technology in Medicine and Health, CTMH, together with Royal Institute of Technology (KTH) and Stockholm City Council
- Centre for Trauma Research
- Centre for Cognition, Understanding & Learning, CUL
- Centre for Violence Prevention
- The Centre for Health Care Science
- The Centre for Hearing and Communication Research
- Karolinska Institutet Physical Activity Research Centre, KI-PARC
- Medical Case Centre, MCC
- Medical Management Centrum, MMC
- Osher Centre for Integrative Medicine, OCIM
- Stockholm Bioinformatics Centre, SBC
- Stockholm Brain Institute, SBI
- Strategic research centre for studies of Integrative Recognition in the Immune System, IRIS
- Structural Genomics Consortium, SGC
- Swedish Brain Power

Internationalisation on all levels is an explicit goal in KI's strategic plan from 2005. Figures for undergraduate student exchange between 2003 and 2007 show a greater number of foreign students coming to KI than KI students going abroad; the figure for the former group is consistently above 200, while the figure for the latter remains below 200. There is a programme for improving the level of English among the teaching staff at KI in order to better accommodate exchange students. At present there are some 80 international agreements for cooperation in both research and education. Cooperation agreements have to add value to KI and be implementable, and should enhance the mobility of students and researchers. Also the possibility for doctoral students to earn a joint degree (i.e. from two universities, one of which is KI) is highlighted. The agreements can broadly be divided into two groups, namely those made with other leading medical universities and those where KI disseminates knowledge abroad. In cooperation with Chalmers University of Technology, Göteborg, and Royal Institute of Technology (KTH), Stockholm, representation offices have been opened in China and Singapore, which reflects the increasing interest in cooperation with South-East Asia. Another indicator of international cooperation is the degree of foreign participation in KI's publications; in 2007, this percentage was 55, up from below 50 percent in 2000.

Webometrics' ranking of higher education places KI in position 418 globally and in position 183 in Europe, while, according to Shanghai Jiao Tong University's ranking, KI is number 53 in the world and number 11 in Europe. The Times Higher Education Supplement places KI as number 24 in the world in life sciences and biomedicine.

D.2. Strategy development

The most conspicuous goal in the current strategy is to become the leading medical university in Europe. This goal should be seen against the backdrop of an explicitly stated fear of losing ground against other medical universities in the World, which is also reflected in the international rankings mentioned above. Furthermore, KI is perceived as an important part of the economic development of the Stockholm region (and ultimately of the entire country), which calls for closer cooperation with other universities, and in particular KTH. A successful KI is thus expected to have beneficial effects on the regional and national innovation systems.

According to the 2001–2004 research strategy, particular attention was to be paid to the research areas of odontology, health care research and bioinformatics. It is worthwhile noticing that health care has a strong flavour of social sciences while bioinformatics gains from new innovations in information technology. Here an inclination towards inter- or multidisciplinary science is clearly present. In the 2005–2008 research strategy, the priority areas have increased to seven: epidemiology, the functioning of the brain and psychic health, infections, oral health, structural genomics, systems medicine and health care. Placing emphasis on a limited number of research areas is motivated by the need to achieve and maintain critical mass in research.

Concerning epidemiology, the need to collect data from large population groups in order to identify causes for numerous diseases is stressed. This has been the fastest growing field at KI and it is further enhanced by changes in Swedish legislation allowing for co-ordination of public health registers. Brain research has remained a priority of KI throughout its existence. Research on infections has its background in the growing concern for the spread of infectious diseases. Another priority area is systems medicine, the aim of which is to shorten the time span between discovery and clinical implementation, which, by and large, implies closer connection between research and application in hospitals, i.e. translational research. The overall strategy document KI-05 adds focus on health and diseases caused by lifestyles and heritage to the priority areas, thereby further emphasising KI's broad inter- or multidisciplinary approach to medical science. An apparent trend reflected in development plans (KI--93, KI-99 and KI-05) may be summarised as an increasing awareness and concern for the role of KI in a globalised world. While KI-93 focuses almost entirely on internal changes (such as enhancing the role of departments), the undertone of KI-05 is characterised by an awareness of increasing international competition.

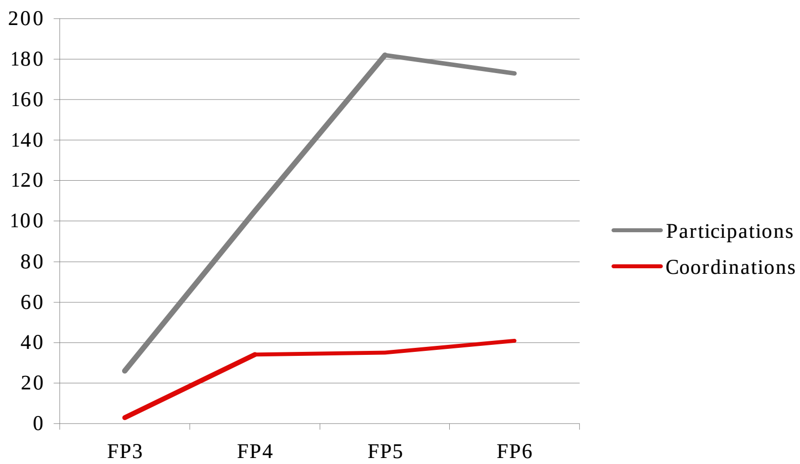
The 2009–2012 research and education strategy is less explicit on research priorities than previous documents and the previously mentioned prioritised research areas are merely reiterated. In essence, a tendency towards increased interaction with other spheres, both in science and society, can be traced in strategic documents. The 2009–2012 strategy reiterates the overall goals previously mentioned: the creation of centres of excellence, being excellent in medical pedagogy, being an attractive partner in international research cooperation, interacting with health care, being a European leader in applying research results, and creating research infrastructure. Although cooperation within the EU is given high priority, it can be noted that cooperation with North American universities is mentioned prior to cooperation within the EU. This observation also applies to the 2006 strategy for internationalisation of research. On the other hand, the latter document is more specific on European cooperation, stating that KI participates in two European university networks, namely EUROLIFE consisting of seven universities, and League of European Research Universities (LERU) consisting of 20 universities. These networks are important in enhancing cooperation between universities.

Education at all levels is given high priority in all strategy documents. Recruitment of the most suited graduate and postgraduate students is regarded as being put at risk because of insufficient financial means. The solution suggested is focusing on graduate schools and the creation of more post-doc positions.

D.3. FP participation

In contrast to many other well-established Swedish universities, KI was a relatively late entrant in the FPs and was not involved in any great number of projects until FP4, see Figure 93. Although KI may have woken up somewhat late, it has caught up with a vengeance. In fact, KI is now the most frequently participating university in Europe in the life science/health priority of the FPs, far ahead of number 2. KI stands out among the universities subject to the present case studies in that KI researchers, from FP3 and onwards, are significantly more prone to coordinate projects; in FP6, every fourth project KI participates in is coordinated by a KI researcher (a level equalled by researchers at GU, who, however, were less likely to coordinate projects in previous FPs than their colleagues at KI).

Figure 93 Number of participations and coordinated projects per framework programme



Source: Cordis[87]

When FP5 was in preparation, KI management realised that the programme was a potentially important funding opportunity for its researchers. In light of KI's modest participation in FP3 and FP4, KI management recognised that some form of qualified support would be needed if KI were to be more successful in FP5. At about the same time as FP5 was launched in 1988, an EU participation support function consisting of two persons was consequently established. KI also joined the EUROLIFE network of European universities in life science, which aims to "collaborate within the research and training opportunities offered through the European Commission's Framework Programmes".

[87] Cordis data has been complemented with information from VINNOVA and KI's grants office. Data on coordinated projects is known to be incomplete for FP3–FP5.

Encouraged by its successful participation record in FP5 and realising that proposal competition was continuously getting fiercer, the EU participation support function was further reinforced in time for the launch of FP6 in 2002. The function was then renamed Grants Office (GO) and during the course of FP6, the GO has grown to its present seven employees. However, the GO's mandate is now considerably wider than EU funding; two persons essentially work full time with various aspects of EU funding advice, one with US funding (mainly National Institutes of Health (NIH)) and one with Nordic (including Swedish) funding. Moreover, two GO employees provide operative administrative support to several KI coordinators of FP6 projects and are also funded by these projects. The GO further makes use of legal expertise from KI's legal department, which frequently buys additional legal services from firms. The GO focuses of pre-award issues, such as:

- Informing and dissemination of FP funding opportunities through lunch meetings, seminars etc.
- Providing advice regarding administrative aspects of budgets and proposals
- Help-desk function
- Science-writing function
- Lobbying to influence contents of FP work programmes

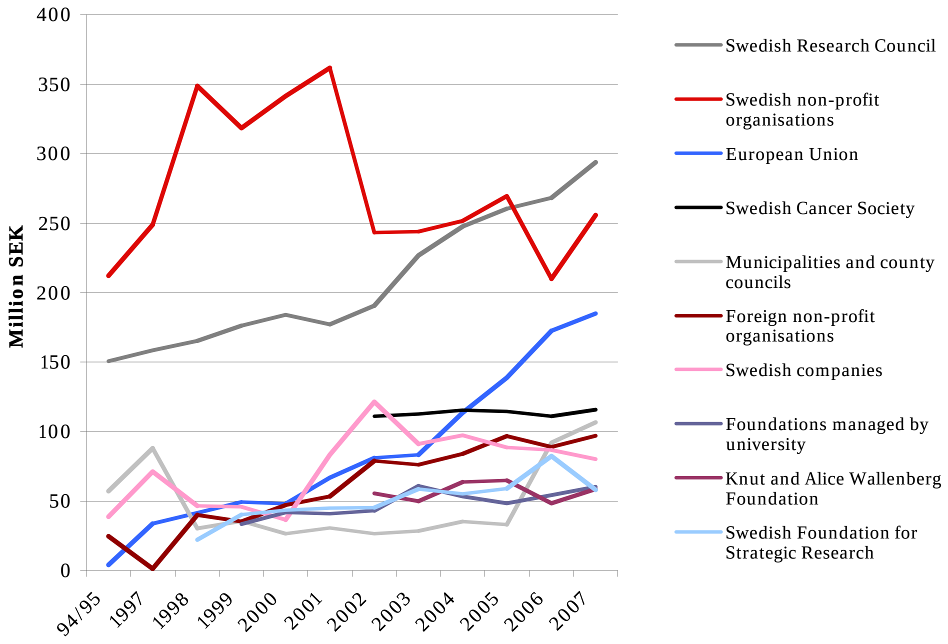
In contrast, post-award issues such as administrative reporting from partners to coordinators usually takes place without the GO's help, but with help from KI's central financial unit. The GO has had visitors from both Sweden and abroad wanting to learn how to effectively support researchers in matters regarding research funding.

There appears to be a limited need for explicit incentives to encourage researchers to exploit the opportunities offered by the FPs. In fact, the researchers' situation is such that all possible funding opportunities are exploited without the need for additional encouragement.

D.3.1. Effects on university

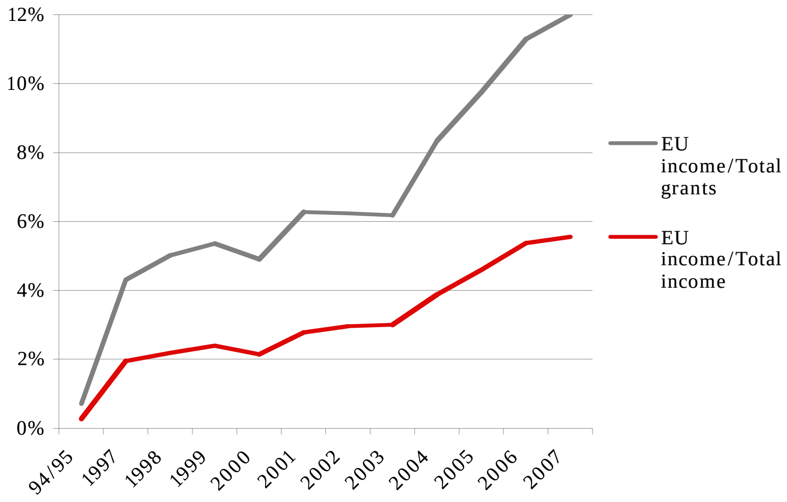
As all Swedish universities, KI has over the last two decades or so experienced a rather painful transition from generous government block grants to becoming increasingly dependent on grants for research and graduate education sought in competition; the proportion of grants sought in competition in total funding for research and graduate education (i.e. including government grants and commissioned research) gradually increases and was 46% in 2007, up from 38% in 1994/1995. Over the past decade, research income from the EU has increased dramatically, from insignificant levels in 1994/1995 to now being the second largest source of grants, *cf.* Figure 94 The strong increase in EU funding is both connected to the sharp increase in number of participations in FP5 and to the notably larger projects in FP6. It is noteworthy that the EU funding data in the figures is not identical to income from the FPs, since approximately 4–5% of EU income is from the public health programme of EU's DG SANCO (GO estimate), but the trend is nevertheless clear. Figure 95 illustrates the rapidly increasing relative importance of funding from the EU; regardless of which ratio is seen as the most relevant, it is obvious that EU funding has become an important source of income for KI. Despite this rapid increase in importance, there is at least for now no reason for concern regarding over-dependency; EU funding is in practice another funding source in the natural funding mix of KI. The maximum overhead accepted by the Commission (20% for most instruments in past FPs) is indeed a problem, since real overheads are considerably larger, but this issue dealt with within each department. This means that a mix of research funding from different sources is required, preferably at group or department level, to make ends meet.

Figure 94 Grants for research and graduate education sought in competition. Only ten largest sources of income in 2007 shown in figure. Apparent drop in "Swedish non-profit organisations" in 2002 is due to several funding sources (notably "Swedish Cancer Society" and "Knut and Alice Wallenberg Foundation" in figure) being reported separately starting 2002. Largest single funding source among the more than 170 in "Swedish non-profit organisations" contributes SEK32 million in 2007, meaning that the EU is the second largest source of grants



Source: HSV and KI controller

Figure 95 Ratio of EU income to research and graduate education grants sought in competition, and total income for research and graduate education (i.e. including government grants and commissioned research), respectively



Source: Analysis of HSV data

There is no doubt that EU funding is of significant importance to KI, but interviewees agree that far more important are the European networks maintained and extended. However, there are few indications that KI's collaboration pattern should have been notably affected by the FPs. KI was already very active internationally before getting seriously involved in the FPs, but the emphasis was then more of North America. The FPs have emphasised European collaboration and have led to increased intensity in KI's intra-European collaboration, but are said to have had little effect on the collaboration patterns as such.

There is also scant evidence that the FPs should have influenced KI's research agenda. On the one hand, large directed funding opportunities, regardless of origin of the funds, may clearly benefit research groups that are already competitive by providing them with additional resources that may be of such magnitude that they are obvious also at university level. Such examples at KI include inflammation and asthma research, which have benefited from concentration of domestic funding onto these areas. On the other hand, most of KI's research has matched the FPs' priorities quite well anyway. Roughly half of KI's projects are in the life science/health priority, whereas the remainder are distributed over the other priorities. It is argued that life science/health cuts across almost all fields, so there is no strong incentive for KI researchers to adapt to FP priorities.

When the European Commission started setting aside 15% of the budget to participation of SMEs in FP6, participation of SMEs in the life science sector increased notably. Most of these companies are based in Stockholm and several of them within the auspices of Karolinska Institutet Holding AB.

It seems clear that the FPs have had notable benign effects of graduate education, since it is common that PhD students work in the projects and they thus get a chance to get international exposure and to develop their own networks. Particularly Marie Curie projects are valuable in promoting both young researchers' career development and international mobility and networking.

KI strives to influence the contents and priorities of upcoming work programmes through several venues. One of them is through EUROLIFE and LERU, another is through key KI representatives, such as the Vice-chancellor, participating in different high-level expert groups and equivalent forums. Another way to influence developments is through national programme committee representatives, scientific officers etc. Moreover, KI has participated in the development of the JTI Innovative Medicines Initiative (IMI), partly through participation in the FP6 project INNOMED. IMI, which was launched in April 2008, is in turn expected to influence the contents of future health work programmes. Despite such efforts, KI management recognises that the university can always do more to influence upcoming work programmes.

D.3.2. Effects on individual researchers and research groups

There is no requirement for individual departments to have their own formal research strategies and it is the rare department that does. The normal situation is that group leaders formulate their own informal strategies with a certain opportunistic trait depending on available funding opportunities. Researchers are entrepreneurs who are experts at exploiting the funding opportunities available. The FPs are one element of a "survival strategy" now that the dependency on external grants for research is so large.

The funding opportunity aside, curiosity and access to new knowledge appear to have been the initial incentives for participation. Compared to the alternatives, the FPs also offer the possibility of relatively long and relatively large grants at a time when the chances of receiving large domestic grants are diminishing. The message is mixed regarding any leveraging effects of FP grants. On the one hand, all agree that any substantial grant that is well used will enhance the recipient's CV and personal competitiveness, meaning that he/she will be more likely to come out on top in a future proposal evaluation. A specific example is that one researcher deliberately planned to use a major FP7 grant (assuming he were to be successful) as explicit leverage in applying for substantial grants from US Army and NIH. The €12m FP7 proposal, of which he is coordinator, was granted and the plan for using it as leverage has subsequently been launched.

KI's top FP participators argue that in their respective fields, competition is fierce and that this enhances proposal and consequently research quality. Their dependency on FP funding is substantial, which is certainly an element of risk exposure, particularly since the FPs do not provide a guaranteed continuity in funding opportunity, since priorities are politically set and may differ between FPs. Given this strong dependency, it is clear that FP funding has affected these KI participators' research in terms of scope.

Some argue that their participation in the FPs have had no effect whatsoever on the direction of their own research, while others testify that contacts and collaboration with others provide continued inspiration to their research, which is thus vitalised and perhaps somewhat redirected, but stress that this is not a matter of involuntary change. "You learn the most unexpected things [in FP projects]!" All seem to agree that the FPs do not result in any total change of track in terms of research area. There is a similar unanimous agreement that the value of the collaborative element in FP projects is the greatest benefit of participation and references to the ERA come easy. Once again, the argument is that the collaboration pattern is not affected, but the intensity of collaboration is. There is a certain degree of cascading between projects, meaning that one FP project leads to another, but it appears equally common that there is no such effect.

The will to take on the arduous responsibility of project coordination may be decisive in there being a proposal in the first place; most would-be co-proposers are unwilling to even consider it. On the other hand, it is argued that coordination is not as bad as it is made out to be, provided you have capable administrative co-workers. There is also a degree of routine to coordination, with a tolerable marginal effect once you have learnt the trade. The key is to be careful in picking consortium partners and to only permit the odd new and unknown partner into the consortium. Smaller projects (of the STREP type) are considered to be considerably better value for money than larger projects and they result in much more genuine collaboration. Thus, the lesson is to stay away from large projects, unless the research task at hand really demands it. Even though smaller projects supposedly are better value for money, researchers argue that in general FP projects provide less scientific output than projects with funding from other sources. This is largely due to the excessive level of bureaucracy FP projects require and researchers exemplify with other, much more efficient alternative funding sources, such as the NIH, with less taxing bureaucracy. And, as one researcher puts it, "the worst thing is that the extra red tape has no effect on reducing corruption and unintended use of public funds; the ones who really want to exploit the system can always find ways around it anyway.”

Researchers appear highly content with the services offered by the GO, but the more experienced FP participants stress that they usually make do with their own experiences and that the main target group of the GO is likely less experienced FP participants.

The researchers interviewed argue that research results from their own FP projects have been put to use in both the ICT and life science sectors in Sweden, but that effects are indirect and commercial exploitation by industry may be a long way off.

The more experienced FP participators seem to know how to influence contents of future work programmes. This is achieved both through formal routes, where the Commission invites senior researchers to participate in for example expert groups, and through informal means, including socialising with scientific and occasionally project officers while in Brussels.

D.4. References

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KI-99 development plan

KI-05 development plan

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KI department annual accounts, 2007

FP participation data from CORDIS, complemented with data from VINNOVA and KI’s GO

University income statistics from the website of The Swedish National Agency for Higher Education (www.hsv.se)

University personnel statistics from KI annual reports

Appendix E Växjö University

E.1. Introduction

Växjö University (VXU) belongs to a group of universities established during a period of rapid expansion of the Swedish higher education system. Originally established in 1967 as a branch to Lund University, it became an independent university college in 1977 and was granted university status in 1999. A particularly rapid phase of expansion took place in the 1990s and up to 2003. VXU now has far-reaching plans for a merger with the University of Kalmar (HIK), with the purpose of concentrating resources. This process is estimated to result in the new Linné University effective January 1, 2010.

Traditionally, VXU has been dominated by humanities and social sciences, but it has gradually increased activities in natural sciences and technology. VXU has two faculties (Mathematics, natural sciences and technology, and Humanities and social sciences) harbouring seven schools (departments):

- Humanities
- Social sciences
- Health sciences and social work
- Education
- Management and economics
- Mathematics and systems engineering
- Technology and design

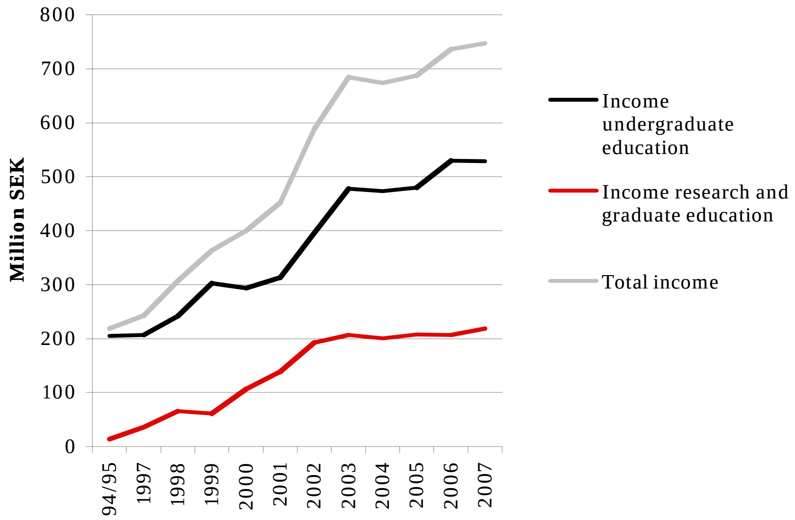
The supreme decision-making body of VXU is the university board with 15 members, of whom eight are appointed by the Swedish government, including the chairman of the board, at present Mats Bergquist. Three members each represent staff and students. The present Vice-chancellor is Johan Sterte.

Over the past decade, VXU's income for undergraduate[88] education has increased by 156%, while its income for research and graduate education has increased by a phenomenal 506%, see Figure 96. In the same timeframe, the number of undergraduate students has increased by 62% and research

[88] Prior to adopting the education structure of the Bologna process in 2007, Sweden had a two-tier educational structure at university level that differed from most other countries. For the purposes of the case studies in this report, the two levels are referred to as "undergraduate" and "graduate", resulting in a master's and doctor's degrees, respectively. It should be noted that this division constitutes a simplification.

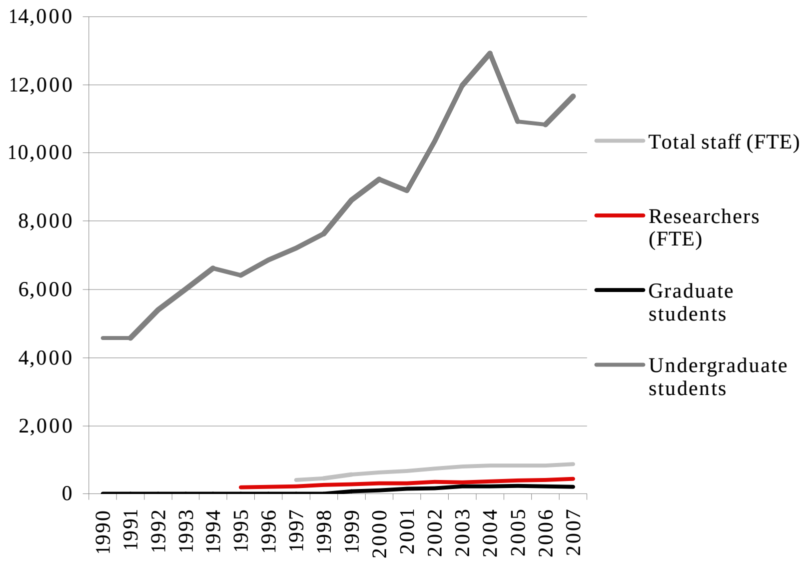
staff by 108%; the first graduate students were employed in 1999 and the number has since grown rapidly, see Figure 97 and Figure 98. Over the entire 1990–2007 timeframe shown in Figure 97, the number of undergraduate students has increased by 155%. Obviously, costs have nevertheless increased considerably faster than income. VXU's research intensity (here defined as the proportion of research and graduate education in total income illustrated in Figure 96) increased rapidly towards the end of the 1990s and peaked at 33% in 2002 fuelled by rapidly increasing direct government grants; since then it has slowly declined and is currently at 29%, which is considerably lower than for Sweden's established universities; VXU obviously has a strong emphasis on undergraduate education.

Figure 96 Income development



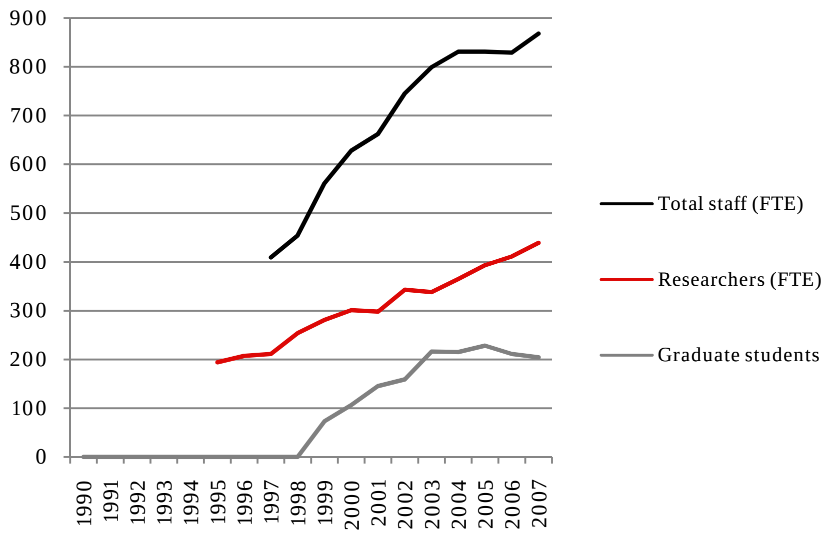
Source: HSV

Figure 97 Development of employees (full-time equivalents (FTEs)) and students (individuals)



Source: VXU annual report 2007 and SCB

Figure 98 Development of employees and graduate students (data of Figure 97 excluding undergraduate students)



Source: VXU annual report 2007 and SCB

The number of foreign students enrolled at VXU has increased from 299 in 1997 to 803 in 2006/2007, or just below 7% of all students, which is a little below the Swedish average. The number of students from VXU going abroad is less than 300 and the number has not changed much over the last decade.

According to Webometrics’ ranking of world universities, VXU is in position 1 112 globally and in position 452 in Europe. VXU is neither listed by The Times Supplement of Higher Education nor by Shanghai Jiao Tong University.

E.2. Strategy development

When VXU received university status in 1999, the 1999 Research strategy was developed emphasising the necessity to focus on a limited number (5–6) of research areas. University management consequently allocated some 25–30% of faculty funding to six prioritised research areas for four years, with a possibility of another four years pending a mid-term review. The 2005–2008 Development plan lists these six prioritised research areas, as well as four additional ones mainly funded by external funding. At the mid-term evaluation in 2004–2005, support for three of the original six prioritised research areas was discontinued. At present, VXU’s prioritised research areas are the following, which together receive 20% of the university’s faculty funding:

- Labour market, migration and ethnic relations
- Entrepreneurship
- Forum for inter-media studies
- Research in professions
- Welfare systems and democracy research
- Mathematical modelling and systems collaboration
- Wood and energy technology

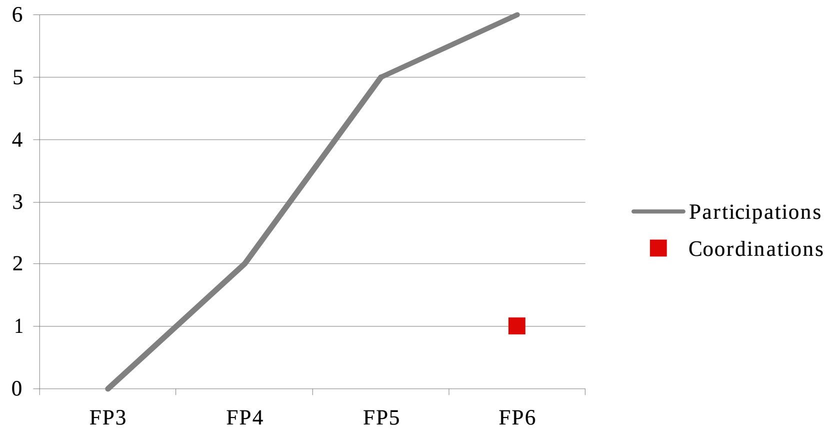
The first two areas are now on their eighth and final year of funding. Within the Faculty of mathematics, natural sciences and technology, encompassing the last two areas in the above list, allocation of the faculty funding is predetermined. Within the Faculty of humanities and social sciences, encompassing the remaining three areas, allocation has been determined through internal calls where proposals have been externally peer reviewed. These areas receive funding for four years, pending a successful mid-term review. An important point is that university support for prioritised research areas is limited in time; the intention of the support is that it should fund research environments long enough for them to become sustainable on their own.

The 2009–2012 Research and education strategy requested by the Swedish government emphases that, although the technology-related research is important, VXU’s research emphasis is on the humanities and social sciences. The strategy also states that VXU should carry out research of regional relevance.

E.3. FP participation

Figure 99 clearly illustrates that VXU is a newcomer to the FPs. While the relative increase in number of participations is rapid, absolute numbers obviously remain quite modest. VXU coordinates the FP6 integrated project CHRISGAS.

Figure 99 Number of participations and coordinated projects per Framework Programme



Source: Cordis[89]

The decision to set up a grants office (GO) was taken as recently as autumn of 2007, although limited advisory activities then had been ongoing for some time. The current personnel comprises six part-timers borrowed from other parts of the administration and in total probably amounts to less than two FTEs. In anticipation of the 2010 merger with HIK, the two GOs are developed in collaboration. VXU's GO lacks formal structure, but strives to:

- Increase the number of proposals
- Increase the types of proposals
- Increase awareness among researchers on the opportunities of the FPs

The GO provides support through:

- Dissemination of call information (not only regarding the FPs)
- Budgeting, filling in forms and review of proposals
- Contract negotiations
- Consortium agreements
- Operative support with financial reporting and revisions

[89] Cordis data has been complemented with information from VINNOVA and VXU's grants office.

- Lobbying

It is pointed out that the network of Swedish university GO directors is valuable, particularly for a small and young university such as VXU. VXU is said to have reaped tremendous benefits from this network, particularly for the CHRISGAS proposal. The network, which brings universities closer together, has also made it possible for VXU to use the services of the University of Gothenburg's lawyers while its own lawyer is on parental leave.

VXU management sees FP participation as strategically important and the GO is thus seen as strategic investment, but at present no additional initiatives are foreseen. "We have already invested significantly and now need to ensure that returns are in proportion to the investment. As an example, getting the coordinatorship in the CHRISGAS project amounted to a substantial investment."

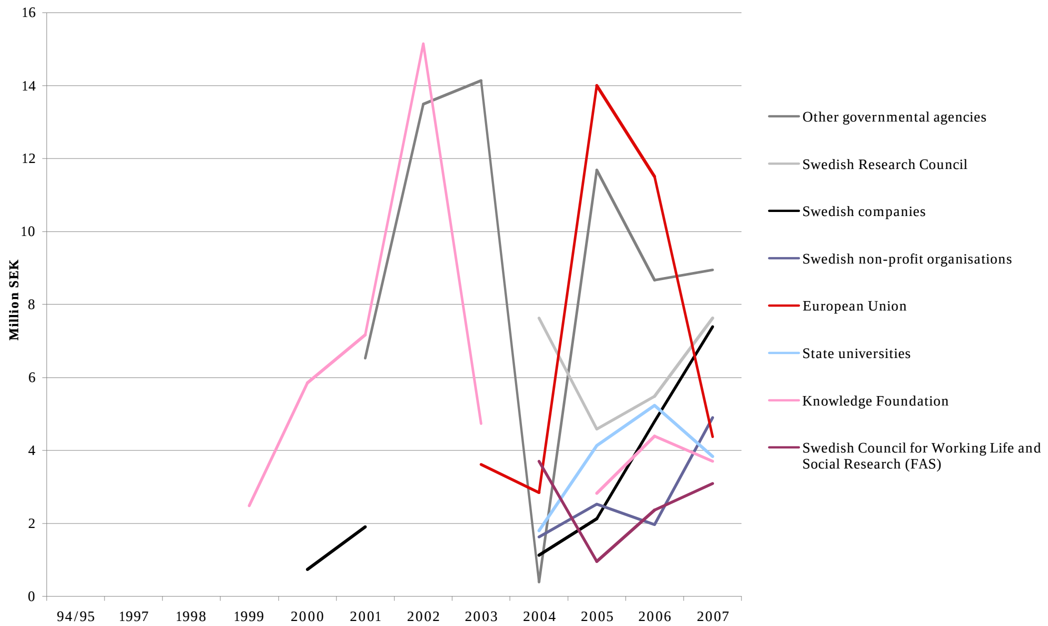
Departments are not charged an overhead cost greater than the overhead provided for in the FP grant, meaning that VXU departments do not suffer from the insufficient overhead coverage that departments at many other Swedish universities do.

E.3.1. Effects on university

Over the last decade, VXU has decreased its dependency on government grants for research and graduate education (or increased its dependency on grants sought in competition); the proportion of grants sought in competition in total funding for research and graduate education (i.e. including government grants and commissioned research) has gradually increased from 3% in 1997 to 25% in 2007. VXU management admits that the university's degree of external funding still is too low and that it ought to increase, partly with means from the FPs. It is hypothesised that one reason for the relatively low degree of grants sought in competition may have its origin in the generous government grants for research following VXU being granted university status and that this may have led to some researchers becoming accustomed to this, meaning they are less liable to write proposals for external grants.

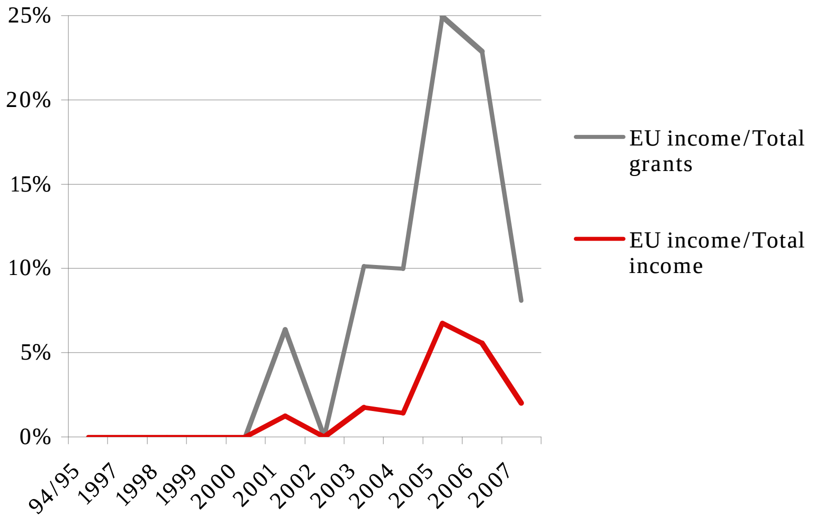
As illustrated by Figure 100 grants sought in competition are small since projects are few and fluctuations between years are therefore huge, but VXU management sees limited problems in dealing with such fluctuations as long as the dependency on grants sought in competition remains small. The income from the EU (70% of which in 2007 originated from the FPs) is made up of a small number of projects and the 2004–2005 peak is largely attributable to the start of the CHRISGAS project. Figure 101 illustrates the relative importance of funding from the EU, but the fluctuations make drawing of any conclusions difficult. Nevertheless, in 2005–2006 the relative dominance of EU income was about double as high as for the other four universities in this study.

Figure 100 Grants for research and graduate education sought in competition. Only eight largest sources of income in 2007 shown in figure



Source: Analysis of HSV data

Figure 101 Ratio EU income to research and graduate education grants sought in competition, and total income for research and graduate education (i.e. including government grants and commissioned research), respectively



Source: Analysis of HSV data

VXU management notes that VXU's modest level of FP participation is to be expected since it is a young university with short track record and given that its research areas have not matched past FP priorities very well due to its emphasis on the humanities and social sciences; only about a third of research is technology-related. Given the low number of projects, any effects on the university's overall research priorities are expected to be limited. On the other hand, given the university's limited research intensity, an FP project may have notable relative effects on a specific research group. VXU management points out that grants give momentum that influences strategy and notes that the CHRISGAS project has resulted in obvious impetus to further engage in energy-related research. VXU management also sees FP participation as a strategically important means to enhance its international reputation and notes that international collaboration acts as inspiration to both researchers and students. Through the organisation SydSam[90], VXU helped lobby for the social platform in FP7.

E.3.2. Effects on individual researchers and research groups

Interviewees state that the strategically most important reason for participation in FP projects is to expand and maintain your network, and may in some cases be critical in building up your research group. Researchers prefer smaller projects of the STREP type, but it is pointed out that Networks of Excellence (NoE) projects may be appropriate for cultivating your network. Scientific production in FP projects is said to be lower than in domestic projects. While FP participation has had benign effects on collaboration networks, interviewed researchers claim that their FP participation has had no effect at all on the direction of their research. There is a certain effect on both graduate and undergraduate education, since students are engaged in FP projects.

Drawbacks of FP participation are that funding is not sustainable and that the administrative burden is considerable, which is further augmented by the fact that VXU's administration is said to neither have experience of nor understanding for the FPs' participation rules and the Commission's reporting requirements. Interviewees argue that this situation together with the lack of qualified administrative support infrastructure effectively discourages them from seeking to coordinate FP projects.

Any leveraging effect between being a recipient of FP funding and domestic funding is believed to be limited and then only through past projects

[90]SydSam is a networking organisation for regional self ruling authorities and municipal, cooperating authorities in the very south of Sweden. SydSam focuses on four areas: climate, transports and infrastructure, maritime matters and a research platform for social issues.

contributing to your curriculum vitae. There is some degree of cascading between FP projects (one project leading to another), but it seems equally common that there is no such effect.

Several FP projects, including CHRISGAS, include collaboration with industry in the energy sector, also with SMEs in the region around Växjö, but it is too soon to observe any concrete results. Other projects have indirectly influenced content of mobile services.

One interviewed researcher has suggested future research areas to the European Commission's project officer, but has not yet seen any results of his efforts. An ongoing FP project is to deliver a European research strategy, but this work is not yet completed.

E.4. References

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University personnel statistics from VXU annual report 2007 and Statistics Sweden (www.scb.se)

Appendix F Coding of Swedish life science participations

F.1. Disciplines

Pharma & drug development

infection

plant

chemistry, non-living, mainly biochemistry

neurosciencies

ageing

cardiovascular disease

diabetes, including obesitas

inflammation

regenerative medicine, stem cells

transplantation

oncology

biology, all living organisms including yeast, but except bacteria and viruses

ophthalmology

rare diseases

audiology

rehabilitation, orthopediae, bone

gynaecololgy

internal medicine, i.e. endocrinology, haematology

human: the whole (ill) human being, not specified.

surgery

F.2. Technology

Molecular, i.e genes and proteins

Celbiology, i.e cell and system based

vaccin

immunology

organisation, networks, conferences and workshops

tissue engineering, including gene therapie

genomics, including functional genomics, proteomics, metabolomics

bioinformatics

cure: translational and clinical research, including research into therapy

physics

epidemiology, cohort studies and biobanks

food (+ environmental factors), safety, risks, toxic etc

medical devices, including imaging

nano technology/ nanomedicine

Appendix G Breakdown of discipline and technology

Figure 102 Top-3 disciplines and technologies in FP3

Disciplines	Number	Technologies	Number
Infection diseases	5	Vaccine	3
Chemicals	1	Molecular	2
Diabetes	1	Cure	2

Source: Technopolis analysis

Figure 103 Top-5 disciplines and technologies in FP4

Disciplines	Number	Technologies	Number
Chemicals	72	Molecular	76
Infection diseases	44	Cell biology	63
Neuro	41	Immunology	28
Human	29	Cure	26
Pharma	23	Food	23

Source: Technopolis analysis

Figure 104 Top-5 disciplines and technologies in FP5

Disciplines	Number	Technologies	Number
Chemicals	48	Molecular	66
Infection diseases	42	Cure	46
Neuro	39	Cell biology	45
Human	28	Organisation	24
Oncology	26	Vaccine	20

Source: Technopolis analysis

Figure 105 Top-5 disciplines and technologies in FP6

Disciplines	Number	Technologies	Number
Chemicals	63	Genomics	69
Oncology	55	Molecular	55
Infection diseases	41	Organisation	47
Pharma	30	Cure	38
Human	27	Cell biology	33

Source: Technopolis analysis

Appendix H Distribution of life science participations over thematic programmes per Framework Programme

Figure 106 Distribution of life science participations over thematic programmes per Framework Programme (Technopolis analysis)

Framework programme	Thematic programme	Number of projects
FP3	STD 3	5
	HCM	2
FP4	ESPRIT 4	1
	BIOTECH 2 (with 8 subcalls)	**116**
	BIOMED 2 (with 8 subcalls)	**138**
	FAIR	24
	BRITE/EURAM 3	6
	SMT	6
	ENV 2C	1
	INCO	16
	INNOVATION	6
	TMR	43
	TELEMATICS 2C	2
FP5	IST	4
	QOL (with 13 subcalls)	**341**
	INCO	3
	IHP	48
	EURATOM	3
	GROWTH	4
FP6	Human resources and mobility	65
	Research and innovation	1
	Research infrastructures	4
	Science and society	1
	Life Sciences, genomics and biotechnology for health	**332**
	Information society technologies	10
	Nanotechnologies and nanosciences, knowledge-based multifunctional materials and new products processes and devices	36
	Food quality and safety	25
	Horizontal research activities involving SMEs	4
	Policy support and anticipating scientific and technological needs	4
	Specific measures in support of international cooperation	8
	Support for the coordination of activities	1

Appendix I List of interviewees

Sverker Ljunghall – AstraZeneca

Christina Herder – Biovitrum

Peter Olofsson – Redoxis (formerly Arexis and Biovitrum)

Leif Lindholm – Got A Gene

Heather Marshall-Heyman – Vironova (formerly KI grant office)

Nils Carlin – Crucell (formerly SBL Vaccine, before that a public vaccine institute)

Mats Berggren – SwedenBio

Ulla Mortensen – Swedish Institute for Food & Biotechnology (& consultant to small life science industry and SwedenBio, former grant office Lund)

Britta Wahren – Swedish Institute for Infectious Disease Control

Bengt Norden – Chalmers University of Technology

Anders Bjorklund – Lund University

Carl Borrebaeck – Lund University,

Lars Klareskog – Karolinska Institute, Stockholm

Tomas Olsson – Karolinksa Institute Stockholm

Appendix J Possible effects of Swedish participation in EU frame programmes 3-6 on bibliometric measures

Johan Fröberg and Staffan Karlsson,
Department for research policy analysis,
Swedish Research Council

September 12, 2008

Summary

This study presents a bibliometric analysis of EU-researchers at five Swedish universities. In order to try to search for effects of EU frame programme participation, the results for Swedish participants are related to all researchers at the five universities. The bibliometric measures used in the study, mean field normalised citation rates and number of addresses of co-authors from different countries, is thus primarily presented as ratios between the study group (EU-researchers) and the reference group. From the results we can conclude that no apparent effects from frame programme participation are found on the bibliometric measures. The group of EU-researchers can however be described as being more successful in terms of both citation rates and number of collaborations, already before participating in EU-financed projects. This suggests that one pre-requisite for being successful when applying for EU-funding is to already be an established researcher. Another conclusion is that the general trend towards an increased internationalisation of science has the effect that the differences between the two groups have decreased over time.

J.1. Introduction

Vetenskapsrådet, VINNOVA, FAS, Formas and Energimyndigheten[91] are commissioned by the Government to perform a study of the effects of Swedish participation in EU frame programmes 3-6. The study is carried out by Technopolis and covers Swedish universities as well as industry. For a

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[91] The Swedish Research Council, The Swedish Governmental Agency for Innovation Systems, The Swedish Council for Working Life and Social Research, The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, and The Swedish Energy Agency.

part of this study Vetenskapsrådet have been commissioned to perform a bibliometric study of such participations for the academic sector. In the terms of reference for the project, five Swedish universities were selected (abbreviations used in the report are given in brackets)

- Chalmers Institute of Technology (CTH)
- Göteborg University (GU)
- Karolinska Institutet (KI)
- Lund University (LU) and
- Växjö University (VXU).

The higher education institutions were selected in order to include different subject areas as well as different types of institutions in the study. In the selection process an effort was made to try to match the profiles of the selected universities with respect to the subject areas to that of the industry sectors included in that part of the overall study.

The frame programmes for which the participation has been analysed are described in Figure 107.

Figure 107 Frame programmes considered in the study

Frame programme	Time span
3	1990-1994
4	1994-1998
5	1998-2002
6	2002-2006

The study presented here covers the effects of EU project participation at the five institutions to the extent that this has an effect on publication measures. It is based on a bibliometric analysis of publication volume, citation measures and collaboration using the Swedish Research Council's database built from the ISI/Thomson Reuters reference database. The operational hypothesis is that participation in EU frame programme projects gives rise to distinct features in *e.g.* collaboration patterns and citation rates in comparison to researchers in general at the institutions.

In order to try to detect more systemic effects at the institutional level an analysis was carried out concerning how, if at all, the subject profile of the institutions has changed. This was done by studying in which subject fields the majority of the institutions' publications appeared during three different time periods.

J.2. Methodology

The study is based on two groups at each of the five universities:

a The study group, also referred to as EU researchers, which consists of researchers participating in one or more projects in one or more of the four frame programmes (FP 3-6).
b The reference group, which consists of all researchers at the five universities including those participating in EU projects.

It is thus an overlap between the two groups since group A to a large extent is a subset of group B. However, the study group (A) is, as we will see, responsible for not more than 20% of the total number of publications at each university, with the exception of Växjö University. The publication lists of the researchers in the study group also contain publications produced when they were affiliated with other universities than that which they belonged to when participating in the EU frame programme(s). This pattern is particularly pronounced for EU researchers at Växjö University.

Bibliometric statistics have been extracted from the Swedish Research Council's publication database built from the world data available in the ISI/Thomson Reuters database.[92] Following the structure in the material from ISI/Thomson Reuters, the database is based on publications (articles, notes, letters and reviews) in peer reviewed journals. The coverage varies with discipline being extensive in medicine and the natural sciences and less so in the engineering and agricultural sciences. Furthermore, the coverage is fairly poor in most of the arts and humanities and most subject areas of the social sciences, with the exception of in particular sociology, psychology and the economical sciences.

The following procedure was used to identify the publications of the study group.[93] First the names of the researchers who belongs to the five institutions in the study and who have participated in one or more of the frame programmes with at least one project were taken from a database supplied by Technopolis. This database was compiled based primarily on the information available in the Swedish database of EU participation maintained by VINNOVA. University affiliations and e-mail addresses were

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[92] Certain data included herein are derived from the Science Citation Index Expanded® prepared by Thomson Reuters®, Philadelphia, Pennsylvania, USA© Copyright Thomson Reuters® 2008. All rights reserved.
[93] The information in the database is in principle organised starting from the issue of the source identified as year, volume and number, and with reference to the page number where the publication starts. Each item in the database, which has a unique ID number, also has information on authors and information of their affiliations. However, the connection between authors and addresses is weak and a one-to-one relationship cannot be established. Thus, it is not possible to use the affiliations and author names alone to identify the publications of each of the researchers in the study group. Even if this had been possible we would still only have had the publications of the researchers which they have written while belonging to their present affiliations.

extracted from the database besides the name of the researchers.[94] An e-mail was sent out to 719 unique researchers identified in the database with a request of obtaining a list of publications. This list was to cover all of the researcher's publications as far back as 1990, regardless of connection between publications and the EU projects. The details of the response to the request can be found in Figure 108.[95] A first drop-off was caused by undeliverable e-mails.

Figure 108 Result from the e-mail request to obtain researchers' publication lists

Primary respondents	Undeliverable	Respondents reached	Responses	Response rate
719	131	588	296	50%

Secondly the publications of the researchers in the study group were manually identified in the publication database with the assistance of a specially developed computer program.[96] The result from the identification process was a list of the ID numbers for the publications of each researcher in the study group present in the publication database. Using these ID numbers, a subset in the database was identified and used for the bibliometric analysis. This subset contained information on researcher name, university, number of publications, a set of bibliometric measures as well as information about which countries the authors' affiliations belonged to.

In bibliometric analysis it is often preferable to use fractionalised counts, *i.e.* to divide each publication between contributing authors based on the available address information. As an example, a publication co-authored by three authors is divided into three shares one attributed to each author. However, for the study presented here which has a strong focus on collaboration we have chosen to use whole rather than fractionalised counts. The whole counts are calculated with respect to university and subject field, meaning that a publication is only counted once for any combination of subject and university. This has the effect that if more than one researcher at

[94] The version of the Technopolis database used for this study was dated February 26, 2008. Efforts were made to fill the gaps in the database arising from the fact that several e-mail addresses were missing. Later Technopolis supplied an updated and extended version of the database, dated April 16, 2008, which contained more names and which were more complete in terms of e-mail addresses. However, in order not to loose time the first version was used.

[95] A reminder was sent out three weeks after the initial request in order to increase the number of responses. This resulted in an increase from xx% to the final 50%.

[96] HEPP, developed by Magnus Gunnarsson, Department for Research Policy Analysis, Swedish Research Council. The manual identification was carried out by four students studying Biblioteks- och informationsvetenskap at Uppsala University: Karin Arbelius, Marie Hultqvist, Ulf Persson and Daniel Sundgren.

one university appears on any one publication the publication is still only counted once. Following the choice of whole counts the sums for periods and universities from different tables are not always comparable.

Using the information in the database supplied by Technopolis and the results from the identification process the following information about the study group can be compiled. For 14 of the 296 researchers the identification process resulted in no hits in the publications database. The remaining 282 researchers represented the five universities as described in Figure 109. The table also describes the number of researchers included in the study group at each university that participated in each of the frame programmes included in the study.

Figure 109 Number of frame programme participants at the different universities and their participation in the different frame programmes

		Number of researchers in the study group participating in the different frame programmes			
University	**Total number of participants**	**FP 6**	**FP 5**	**FP 4**	**FP 3**
CTH	44	32	8	3	1
GU	48	28	14	6	
KI	63	57	5	1	
LU	119	72	27	19	1
VXU	8	7	1		
Totalt	282	196	55	29	2

The subject field analysis of study groups and reference groups at the different universities were performed based on the classification of publications to different subject fields of the issues in which the publications were published. The information was extracted from the publication database for the two groups, EU-researchers and reference group, stratified by organisation and year (1990-2006), as well as for the total of the two groups with the same stratification.

For some parts of the analysis the groups in the two categories, EU-researchers and reference group respectively, were added over the five universities in order to create groups on an aggregated level. This is in part done in order to avoid too small counts, and in part to allow for more general conclusions about differences between Swedish EU-participators and a reference group.

Due to the low number of publications in some cases the results must be intepreted with care. The response rate was too low to allow for extended conclusions and whenever statements are made about differences between

EU-researchers and Swedish researchers in general this is valid for the study group, and only as a proxy for Swedish EU-financed researchers in general.

In order to smoothen out the relatively high variations between years inherent in bibliometric analysis, sliding three year averages were used when a division by year is presented. The distribution of the study group's participation in different frame programmes, which shows a heavy emphasis on the 6^{th} frame programme, does not allow for an analysis of the status before and after participation. However, the results are in some cases grouped into three time periods: 1990-1995, 1996-2000 and 2001-2006.

The bibliometric measures used in the study include

- the number of publications
- the number of citations for each publication (CitUS2) using a citation window of 2 years and after subtracting self citations,
- a mean field normalised citation rate (CitUS2/FCS) obtained by relating CitUS2 to the world average number of citations for publications of the same type (article or review), in the same subject field and the year of the publication (*i.e.* FCS),
- the share of publications resulting from collaboration with researchers in Sweden, EU* (=EU27 + Norway and Switzerland), UK and US.

For comparison some data are also presented based on a five-year or open citation window (CitUS5 or CitUSO). However, the effects of using a longer citation window do not alter the general impression of the results.

J.3. Results

J.3.1. Subject profiles

Based on the number of publications in different subject fields a subject profile of a unit can be constructed. Figures 1 and 2 illustrates the 25 major subject fields in the study group and the reference group, respectively, and a measure of the publication volume in each field expressed as the share of the total publication volume of each group found in each of the fields. Tables containing the number of publications, the share this corresponds to and the ratio between EU-researchers and the reference group in each of the 25 fields are found in Annex A, while the corresponding diagrams for each university are found in Annex B.

Figure 110 The 25 largest ISI/Thomson Reuters subject fields expressed as share of publications (whole counts) published by researchers in the study groups of all five universities during 1990-2006 and the corresponding share for the reference group

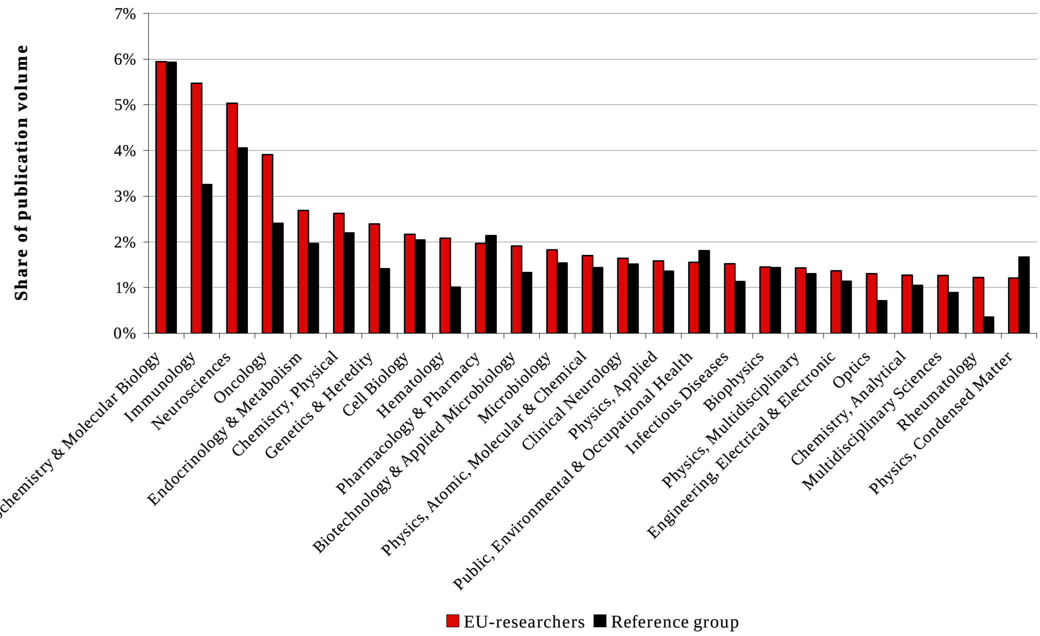
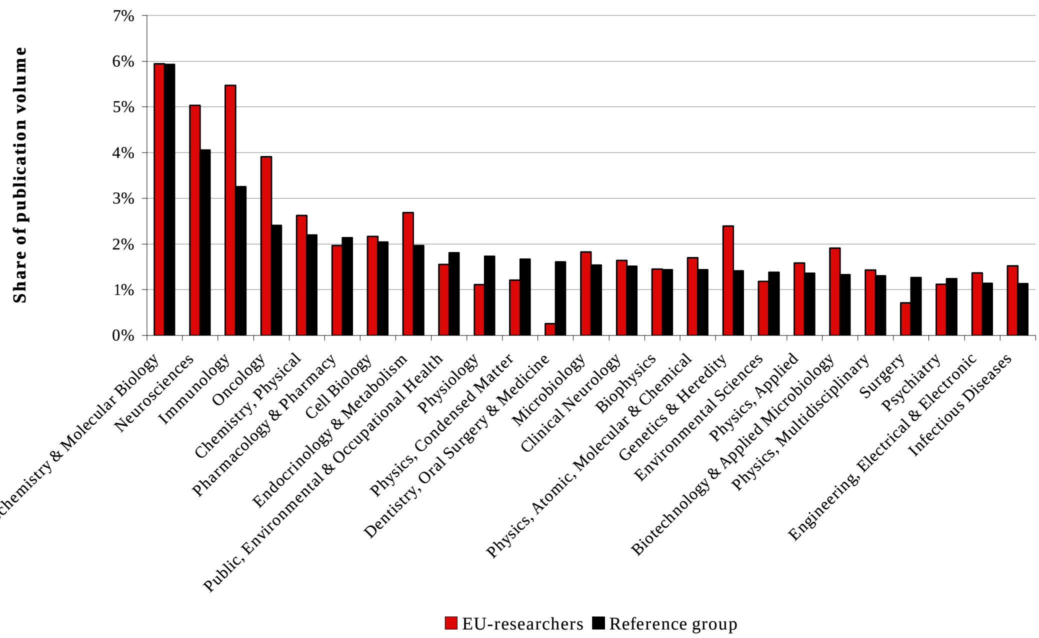
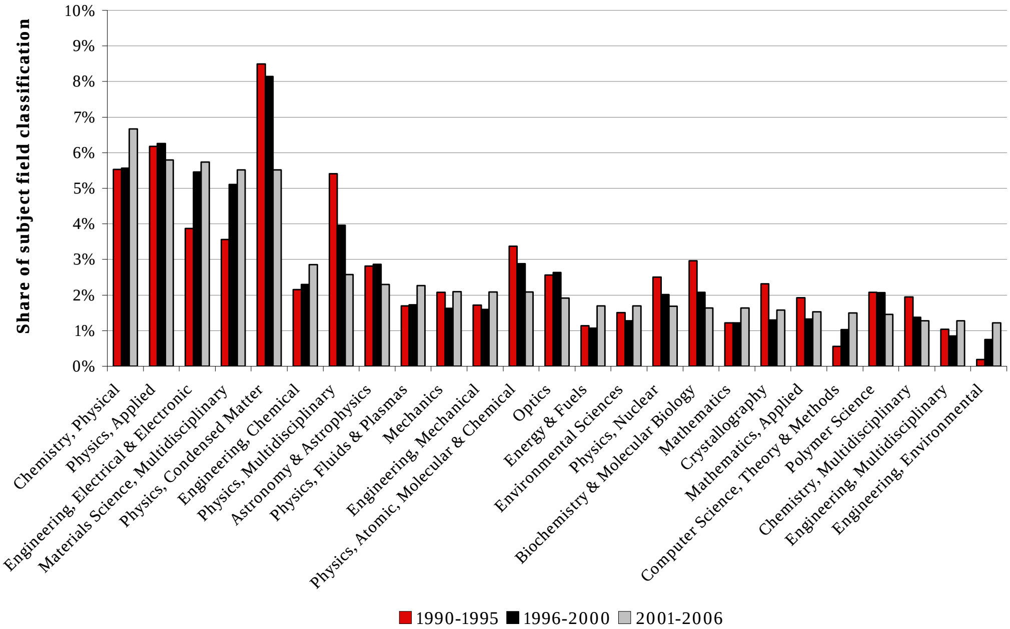


Figure 111 The same as in the previous figure but now based on the 25 largest subjects among all researchers at the five universities (reference group)



The data on publication volume within different subject fields can also be used for analysing the development of different subject fields at the universities, given the limitations set by the data. If the fields that have developed more strongly at the universities match the subject fields that have been in focus in the frame programmes this might suggest an effect of EU-participation. However, other incentives and causes might of course be more important for such changes. As an example, Figure 112 describes the 25 largest subject areas in terms of publication volume in the period 2001-2006 at Chalmers Institute of Technology, and how these have developed between periods. Corresponding diagrams for the other universities are found in annex C.

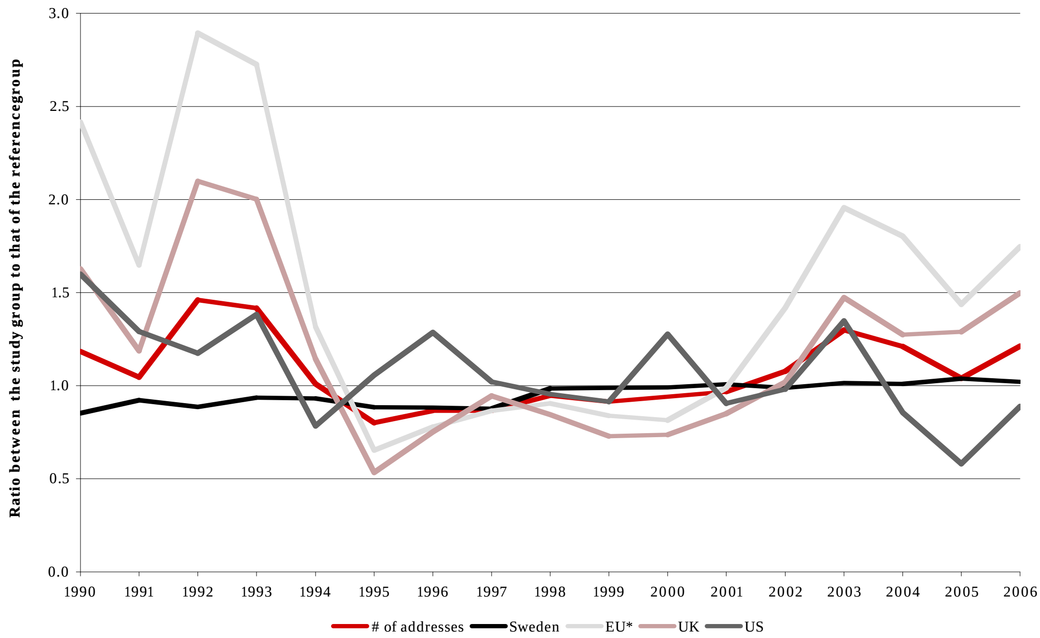
Figure 112 The 25 largest subject fields during the period 2001-2006 for Chalmers Institute of Technology expressed as share of subject field classification, and how the share have changed between periods



J.3.2. Collaboration

One of the aims of this study is to investigate if EU-financed researchers are different compared to Swedish researchers in general regarding collaboration. Figure 113 shows the ratio between the study group and the reference group during 1990-2006 when it comes to collaborations. The number of addresses on each publication is, with the exception of a few years in the beginning of the 1990s, more or less the same for the two groups. There are indications of an increasing difference during recent years when the number of addresses on papers from the EU-financed researchers tend to increase more than for the reference group. The number of Swedish addresses on the publications is very similar in the two groups during the latter half of the period. During the first part however, the publications of the EU-researchers in this study had fewer Swedish addresses than did the reference group. Simultaneously the EU-financed researchers had a much larger number of EU-addresses[97] on their publications than did the reference group. Interestingly this ratio for EU-addresses then decreases during the mid 1990s and reaches a similar level in the two groups, only to increase again from 2001 and onward.

Figure 113 Collaborations during 1990-2006 in terms of the ratio between the number of addresses from different countries on publications from the study group to the same measure for the reference group. Cf. annex D for data on collaborations of each group



[97] In this study EU is set equal to EU-27 plus Switzerland and Norway.

Figure 114 Data in Figure 113 grouped to three periods; 1990-1995, 1996-2000 and 2001-2006

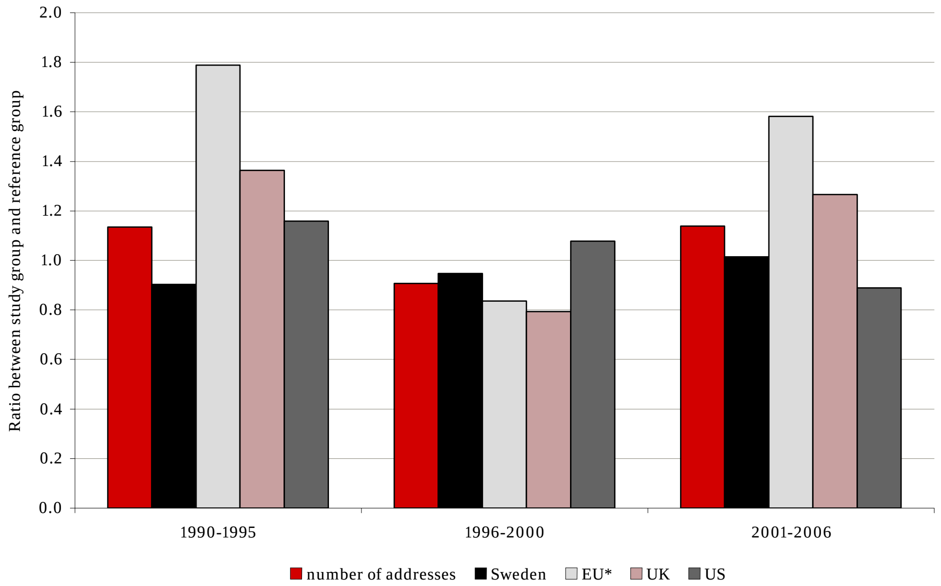
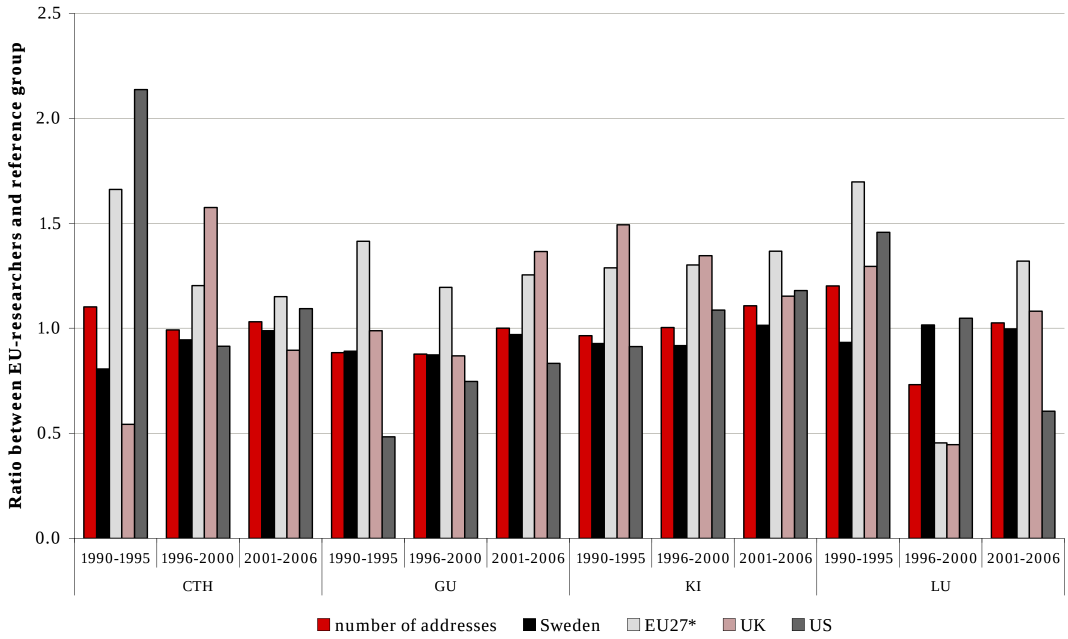


Figure 115 illustrates the information in Figure 114 presented for each of the five universities separately. The number of addresses on the publications is fairly similar between the study group and the reference group at each of the five institutions. During some periods the EU-researchers are collaborating more than the researchers in general, during others the situation is the opposite. At all institutions the EU-researchers are collaborating less with other Swedish institutions than the researchers in general at the corresponding institutions. At the same time their collaboration with countries within EU are more extensive. However, the difference is getting smaller during the studied period which is in accordance with what was found for the group as whole. The results for the collaboration with the US are more mixed. At Lund University this collaboration is fairly similar between the two groups while at Gothenburg University the study group collaborates less with the US than does the reference group.

Figure 115 Collaboration between researchers at four universities with different countries and with EU27 expressed as the ratio between the average number of addresses on publications from the EU-researchers and those from the reference group



J.3.3. Citation rates

In Figure 120 the difference between the two groups with respect to impact of publications, or attention, is shown as the ratio between the average field normalized citation rate for the study and the reference group, using a two year, a five year or an open citation window. The ratio is larger than one from 1990 to 2006 which shows that the EU-researchers are cited more than the researchers in the reference group during this period. However, it is also clear that the difference between the two groups is decreasing as the ratio approaches one during the later years. Another conclusion is that there is no major difference between using different citation windows, a representative measure is obtained using the attention gained within two years after publication. Hence, a two year citation window is the bibliometric measure used from now on.

Figure 116 Ratio between mean field normalised citation rates for the study group and the reference group during 1990-2006. Cf. Annex D for data on number of publications and citation rates for each group

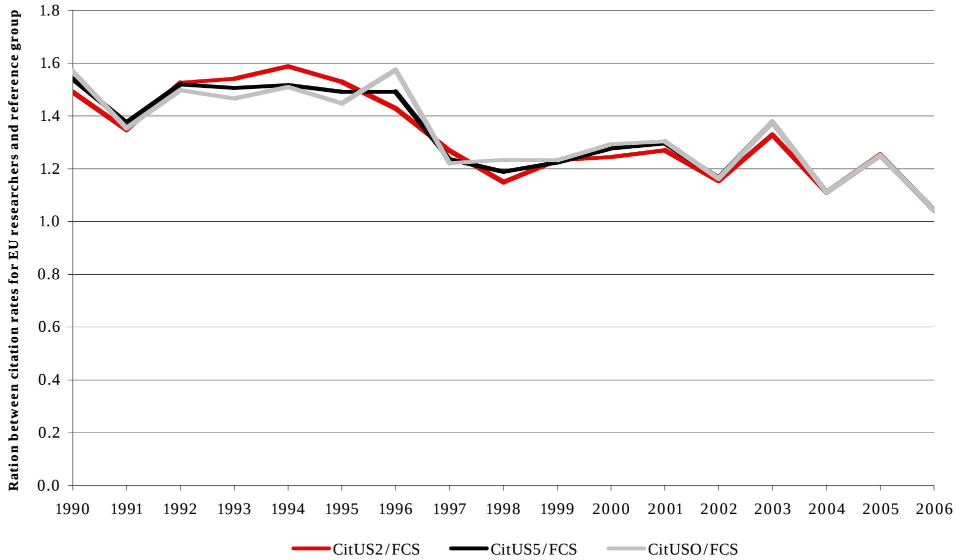
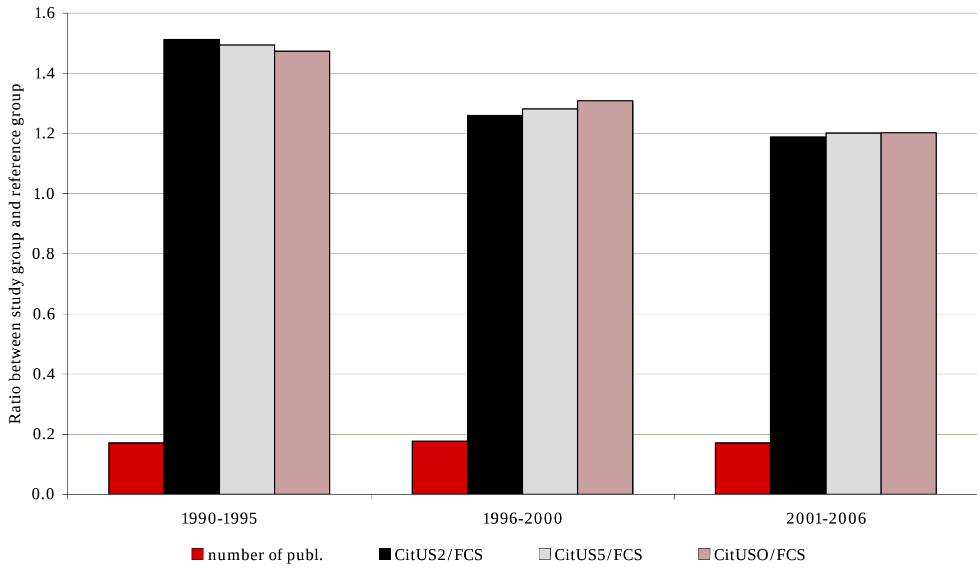
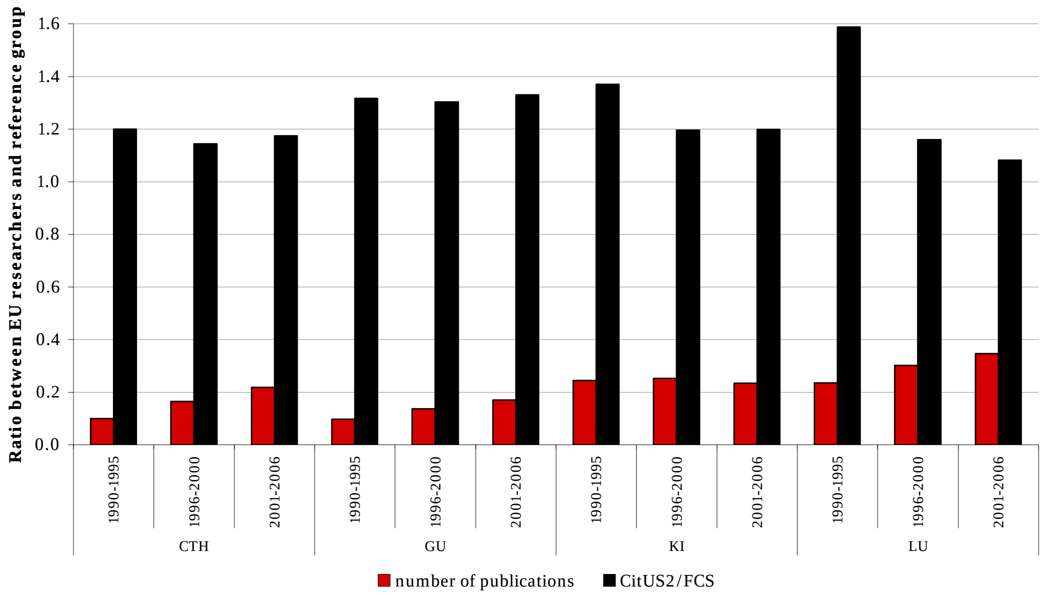


Figure 117 Publication volume and mean field normalised citation rates for the five universities aggregated to three time periods and expressed as the ratio between EU-researchers and researchers in general



We can disaggregate the data in Figure 121 in order to obtain the results for each university and the pattern in Figure 118. The number of publications for Växjö University is to low to allow for a meaningsful presentation and the results are not included. Except for Karolinska Institutet the number of publications (frequency) by EU-researchers is increasing to around one fifth of each university during the three periods. In other words, there are four papers by a researcher in the reference group for every paper by a EU-researcher. Publications from EU researchers at Chalmers Institute of Technology are on average cited more than those from the researchers in general, the same is true and even more pronounced for Göteborg University. This is also in principle constant between time periods. For Karolinska Institutet and Lund University the difference between the two groups are decreasing with time – publications from the reference group are getting more attention and thus the ratio is decreasing. Still, publications from EU researchers get more attention.

Figure 118 Ratio between EU-researchers and researchers in general at four universities regarding number of publications and mean field normalised citation rates during three time periods



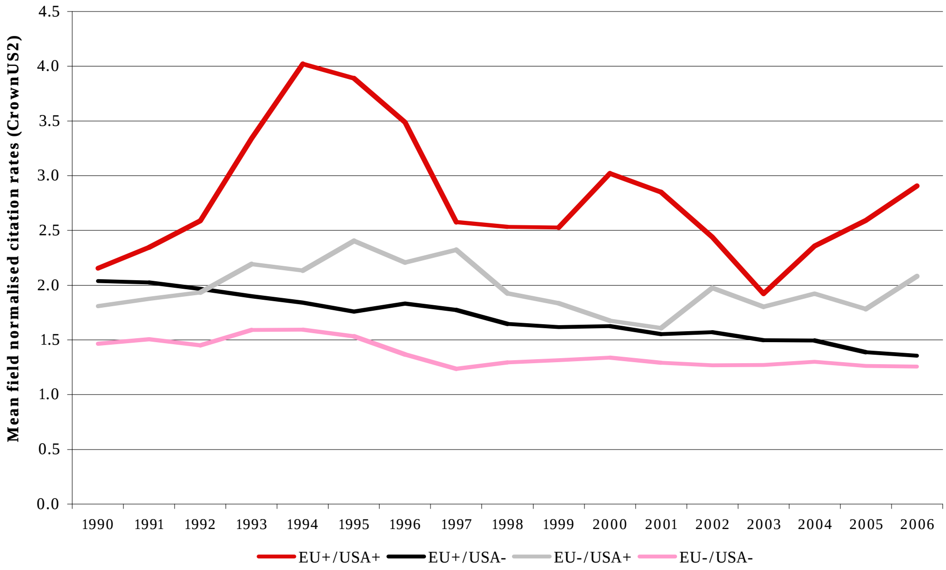
J.3.4. Collaboration and citation rates combined

So what happens if we combine the citation rates with collaboration information? Is there more to gain from collaborating with researchers from certain countries? Figure 119 shows the mean citation rate for the publications of the study group resulting from collaboration with different combinations of countries; with or without cooperation with the EU countries[98] and/or USA. The case of no address on the publication from either the EU or the US still gives a ratio well above one. However, the difference between the EU-researchers and the reference group is decreasing during recent years as can be seen from the ratio approaching one. If on the other hand there is at least one address from within the EU on the publication, the citation rate is higher for all years. The effect is again

[98] Including Norway and Switzerland

decreasing for each year and the effect is substantially less during recent years. Having at least one address form the US has a positive effect on the mean citation rate, especially in combination with an EU address.

Figure 119 Mean field normalised citation rates (CitUS2/FCS) for the study group as a function of collaboration without (-) and with (+) the EU and/or the US during 1990-2006

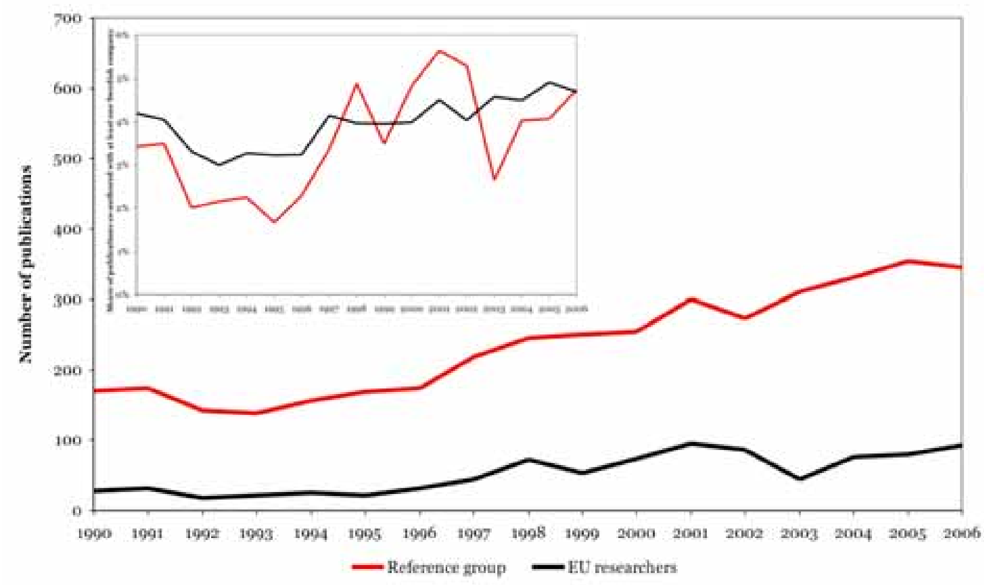


J.4. Co-operation between EU researchers and companies

Figure 120 illustrates the total number of publications from EU researchers and the reference groups at four universities (Chalmers, Göteborg University, Karolinska insitutet and Lund University) that contain at least one address of a Swedish company. The results show that the reference group publishes more or less to the same extent with Swedish companies as the EU researchers. The numbers are low and are responsible for only up to 5 % or less of the added publication volume from these universities (cf. the insert to Figure 120). The differences are small between the two groups making it difficult to draw conclusions on any effects of EU project participation on co-operation with Swedish companies. One should keep in mind that co-operation with companies outside Sweden might differ between the two groups.[99] The data does not allow for a discussion on the variation between universities.

[99] The information on addresses outside Sweden is not tagged in a way which allows for an analysis of co-operation with companies abroad.

Figure 120 Number of publications from EU researchers and the reference group co-authored with a least one Swedish company. The insert shows the share of the total publication volume of each group resulting from such co-authored articles



In order to try to show if collaborations with Swedish companies have had any affect on how much attention the publications receives we have chosen to use aggregated data for the four universities. The low number of publications again makes it difficult to draw any general conclusions. Figure 121 tries to illustrate the effect of collaboration with Swedish companies in terms of the ratio between the mean field averaged citation rates for publications with at least one Swedish company address on the publication and those without.

The first possible conclusion is that co-operation with Swedish companies most often increase the number of citations. This is in line with other studies which show that co-operation in general have a positive effect on the attention given to publications. There is however a perhaps surprising result in that the positive effect of collaboration with Swedish companies decreases quite substanially between the three periods for the EU researchers. In other words, it was more rewarding for them to co-operate with Swedish companies during the period 1990-1995 than it was during the period 2001-2006. During the latter period it was even negative since the publications together with Swedish companies received less attention than the rest of their publications did. Again it is important to note that among those other publications there might be a large number of publication resulting from other co-operations, abroad or with other Swedish R&D performers. However, the EU researchers in this study have on average had a decrease in mean field averaged citation rates between the three periods. The decrease is even more pronounced for publications resulting from collaborations with Swedish companies (cf. Figure 122). Simultaneously the publications from the reference group have in general received an increased number of mean field averaged citations while the citations to their publications with Swedish companies decreases during the last period after increasing between the two first.

Figure 121 Ratio between mean field averaged citation rates to publications with and without at least one Swedish company address during three time periods for EU researchers and reference groups. The results are aggregated for four universities

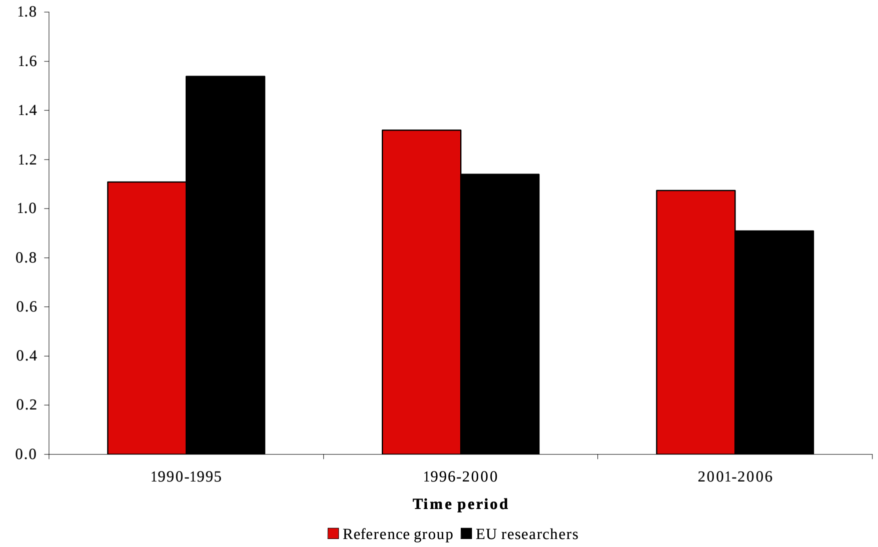
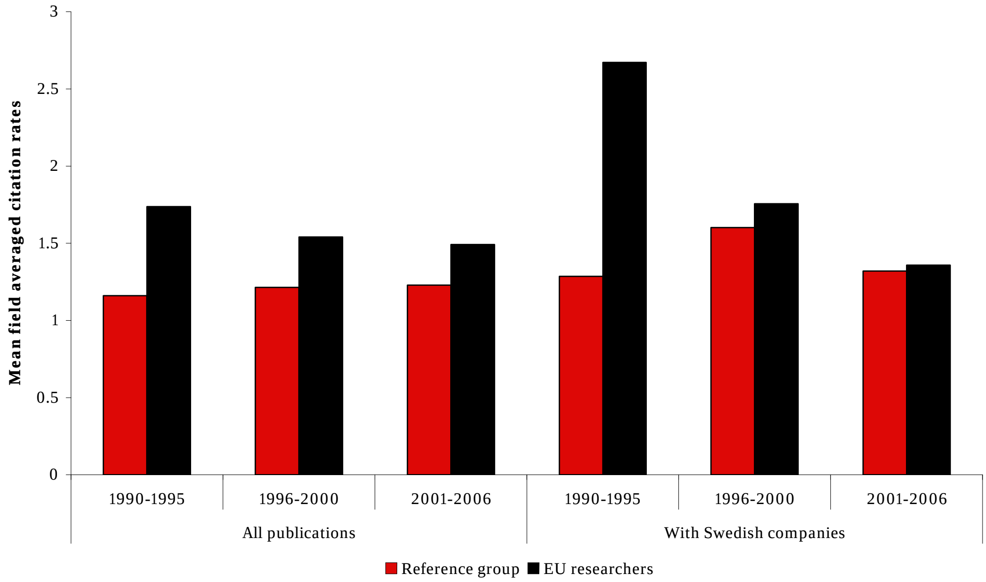


Figure 122 Mean field averaged citation rates for all publications and publications resulting from co-operation with Swedish companies



J.5. Discussion

One measure of the effects of frame programme participation is to what extent and in what way the subject profile of the university has changed during the studied time period. In a long period like this, 16 years, and with the EU-financing making up a relatively small part of the total funding of Swedish universities, 4.2 % in 2006,[100] other factors are likely to have a stronger influence on determining in which areas a university has its focus. Nevertheless, it is interesting to see if the subject profile of the researchers with EU funding matches that of researchers in general at the universities. Judging from Figure 110 and Figure 111 it is clear that for the five universities taken together there are distinct differences. The subject areas that dominate for the EU-researchers in this study are to a large extent also important subject areas for the universities in general. On the other hand, some of the subject areas important in defining the universities' profiles expressed in this way, are not areas in which the EU-researchers are very active. One reason for this is that the subject areas dominating at these universities as a group are not focused in the themes for the frame programmes. Another possible conclusion is that the universities, or the Government, have not created incentives to direct the research at the institutions so as to match the areas focused in the EU calls. This picture is even stronger judging from the corresponding Figures and Tables for each of the universities in the study (cf. appendices A-C).

Based on the information on collaboration in Figure 113 one can conclude that the researchers that have been successful in obtaining funding from EU are the ones that were involved in co-operation already before they where involved in any frame program. The group of EU-researchers in our material was also more active collaborators in general than the reference group based on the fact that the average number of addresses on their publications was larger. A somewhat surprising result is that the ratio between the number addresses per publication for EU-researchers and for the reference group were below one during the middle period, i.e. the second half of the 1990s, implying that the reference group were more active collaborators during this period. One explanation is that the reference group during this period increased the co-operation with researchers within the EU (*cf.* annex D) in order to be able to compete more favourably for EU-funding in the future. It is also in line with the more general trend in the scientific world of increased collaboration across national borders, a development which to a lesser extent effects the EU-researchers since they already are collaborating.

[100] Finansiering av forskning vid svenska universitet och högskolor, Vetenskapsrådets rapportserie 1:2008.

If we turn to the results from the citation analysis we again find that the group of EU-researchers are different from the reference group, but also that the differences are less pronounced during recent years. Publications from researchers with EU-funding are cited more than the publications from researchers in general at these five institutions. However, as can be seen from Figures 7 and 8 the ratio between the mean citation rate for EU-researchers to the researchers in general have remained changed or even decreased. From the table in annex E it is clear that the average citation rate for the EU researchers at Chalmers, Karolinska Institutet and Lund University has decreased during the period studied, while the same group at Gothenburg University has been able to increase its average citation rate. For the reference group at these four universities the situation is more positive, the average citation rate has increased or remained more or less constant between periods. The picture at Växjö University is somewhat more mixed for both groups but the analysis suffers from the low number of publications from this institution.

Figure 119 shows the impact of international collaboration on average citation rates. It is clear from this figure that in order to receive high citation rates one should have co-authors from both the EU and the US among the collaborators. Having co-authors from only the EU or the US do increase the average citation rate but not to the same extent. However, it is important to remember that specific subject fields might have a strong influence in this context. For instance, collaborations between large number of partners from both the EU and the US in physics often get a lot of attention which could affect these figures.

J.6. Conclusions

This study has shown that there are differences between the EU-researchers and the researchers in general at the five institutions in terms of bibliometric performance and collaboration. However, the differences are more pronounced during the first years included. This suggests that the differences are not an effect of frame programme participation, but rather that in order to be competitive for EU-funding it is necessary to be well established as a researcher and especially to already have strong international collaboration. It is perhaps also possible to conclude, although the causality is weak, that the strongest effect is more indirect. EU-participation has, in general, put strong emphasis on collaboration and acts together with other incentives and general trends to increase the international contacts between researchers. This is shown in this study in that the researchers in the reference group, i.e. researchers in general, have changed their collaboration pattern more than the group of EU researchers. It is however important to keep in mind that the EU-funding constitutes only

4.2 % (2006) of the total R&D funding at Swedish universities, although the level is somewhat higher at the five universities in this study.

The results from this study do not seem to indicate that the themes of the EU frame programmes have influenced in which areas research is carried out, at least not at these five institutions and as far as this can be studied based on the subject classification of publications.

J.7. Acknowledgments

Students Karin Arbelius, Marie Hultqvist, Ulf Persson and Daniel Sundgren from Uppsala University are acknowledged for carrying out the manual identification of the researchers’ publications in Vetenskapsrådet publication database.

Annex A: Tables of major scientific fields

The 25 major subject fields in the ISI/Thomson Reuters at each of the five universities in general and among EU-participants at each of the universities (1990-2006)

All universities ISI-category	**EU-res. share**	**EU-res. # publ.**	**Ratio EU/Ref**	**ISI-category**	**Ref. group share**	**Ref. group # of publ.**	**Ratio EU/Ref**
Biochemistry & Molecular Biology	5,95%	1 722	1,008	Biochemistry & Molecular Biology	5,90%	8 927	1,008
Immunology	5,47%	1 584	1,663	Neurosciences	4,09%	6 189	1,230
Neurosciences	5,03%	1 457	1,230	Immunology	3,29%	4 976	1,663
Oncology	3,91%	1 132	1,587	Oncology	2,46%	3 727	1,587
Endocrinology & Metabolism	2,69%	779	1,284	Pharmacology & Pharmacy	2,19%	3 316	0,896
Chemistry, Physical	2,62%	760	1,267	Endocrinology & Metabolism	2,10%	3 170	1,284
Genetics & Heredity	2,39%	693	1,718	Chemistry, Physical	2,07%	3 134	1,267
Cell Biology	2,16%	627	1,080	Cell Biology	2,00%	3 032	1,080
Hematology	2,09%	604	1,878	Public, Environmental & Occupational Health	1,83%	2 765	0,850
Pharmacology & Pharmacy	1,96%	569	0,896	Physiology	1,78%	2 696	0,622
Biotechnology & Applied Microbiology	1,91%	554	1,475	Dentistry, Oral Surgery & Medicine	1,64%	2 475	0,158
Microbiology	1,82%	528	1,173	Clinical Neurology	1,58%	2 393	1,037
Physics, Atomic, Molecular & Chemical	1,70%	493	1,299	Microbiology	1,55%	2 351	1,173
Clinical Neurology	1,64%	475	1,037	Surgery	1,50%	2 264	0,480
Physics, Applied	1,59%	460	1,289	Physics, Condensed Matter	1,49%	2 249	0,815
Public, Environmental & Occupational Health	1,55%	450	0,850	Biophysics	1,40%	2 118	1,036
Infectious Diseases	1,52%	440	1,322	Genetics & Heredity	1,39%	2 107	1,718
Biophysics	1,45%	420	1,036	Physics, Atomic, Molecular & Chemical	1,31%	1 982	1,299
Physics, Multidisciplinary	1,43%	413	1,109	Environmental Sciences	1,31%	1 975	0,902

All universities ISI-category	EU-res. share	EU-res. # publ.	Ratio EU/Ref	ISI-category	Ref. group share	Ref. group # of publ.	Ratio EU/Ref
Engineering, Electrical & Electronic	1,37%	397	1,243	Biotechnology & Applied Microbiology	1,30%	1 962	1,475
Optics	1,31%	379	1,964	Physics, Multidisciplinary	1,29%	1 946	1,109
Chemistry, Analytical	1,28%	370	1,230	Psychiatry	1,26%	1 906	0,891
Multidisciplinary Sciences	1,26%	366	1,389	Physics, Applied	1,23%	1 864	1,289
Rheumatology	1,22%	353	3,317	Pediatrics	1,17%	1 766	0,787
Physics, Condensed Matter	1,21%	351	0,815	Medicine, General & Internal	1,15%	1 744	1,024

Chalmers ISI-category	EU-res. Share	EU-res. # publ	Ratio EU/ref.	ISI-category	Ref. share	Ref. # publ.	Ratio EU/Ref
Engineering, Electrical & Electronic	*11,72%*	306	2,251	Physics, Condensed Matter	*7,26%*	1 533	1,118
Physics, Applied	*11,49%*	300	1,910	Physics, Applied	*6,01%*	1 270	1,910
Physics, Condensed Matter	*8,12%*	212	1,118	Chemistry, Physical	*5,55%*	1 173	0,951
Physics, Multidisciplinary	*5,67%*	148	1,501	Engineering, Electrical & Electronic	*5,20%*	1 099	2,251
Chemistry, Physical	*5,28%*	138	0,951	Materials Science, Multidisciplinary	*4,86%*	1 027	0,685
Optics	*5,02%*	131	2,157	Physics, Multidisciplinary	*3,77%*	797	1,501
Materials Science, Multidisciplinary	*3,33%*	87	0,685	Physics, Atomic, Molecular & Chemical	*2,69%*	568	0,427
Astronomy & Astrophysics	*3,06%*	80	1,147	Astronomy & Astrophysics	*2,67%*	564	1,147
Engineering, Chemical	*2,79%*	73	1,209	Optics	*2,33%*	491	2,157
Physics, Nuclear	*2,41%*	63	1,193	Engineering, Chemical	*2,31%*	488	1,209
Telecommunications	*2,37%*	62	3,213	Biochemistry & Molecular Biology	*2,11%*	446	0,109
Engineering, Mechanical	*1,80%*	47	0,950	Physics, Nuclear	*2,02%*	427	1,193
Energy & Fuels	*1,76%*	46	1,314	Mechanics	*1,93%*	408	0,832
Meteorology & Atmospheric Sciences	*1,76%*	46	3,719	Engineering, Mechanical	*1,89%*	400	0,950
Mechanics	*1,61%*	42	0,832	Physics, Fluids & Plasmas	*1,85%*	390	0,290
Engineering, Environmental	*1,45%*	38	2,021	Polymer Science	*1,78%*	376	0,172
Chemistry, Applied	*1,45%*	38	2,226	Mathematics, Applied	*1,61%*	340	0,190
Geosciences, Multidisciplinary	*1,34%*	35	2,319	Crystallography	*1,60%*	337	0,168
Environmental Sciences	*1,26%*	33	0,844	Environmental Sciences	*1,50%*	316	0,844
Thermodynamics	*1,26%*	33	1,879	Chemistry, Multidisciplinary	*1,49%*	315	0,796
Chemistry, Multidisciplinary	*1,19%*	31	0,796	Mathematics	*1,46%*	308	0,394
Nanoscience & Nanotechnology	*1,15%*	30	3,620	Nuclear Science & Technology	*1,40%*	295	0,356
Physics, Atomic, Molecular & Chemical	*1,15%*	30	0,427	Energy & Fuels	*1,34%*	283	1,314
Construction & Building Technology	*1,11%*	29	2,131	Computer Science, Theory & Methods	*1,16%*	244	0,828
Electrochemistry	*1,00%*	26	1,592	Engineering, Multidisciplinary	*1,09%*	230	0,211

Gothenburg University ISI-category	EU-res. share	EU-res. # publ.	Ratio EU/Ref.	ISI-category	Ref. share	Ref. # publ	Ratio EU/Ref
Immunology	*6,80%*	266	1,899	Biochemistry & Molecular Biology	*4,71%*	1436	1,330
Biochemistry & Molecular Biology	*6,26%*	245	1,330	Dentistry, Oral Surgery & Medicine	*4,19%*	1279	0,329
Marine & Freshwater Biology	*6,26%*	245	2,694	Neurosciences	*3,90%*	1190	0,662
Clinical Neurology	*3,89%*	152	1,549	Immunology	*3,58%*	1092	1,899
Environmental Sciences	*3,27%*	128	1,735	Clinical Neurology	*2,51%*	765	1,549
Ecology	*3,17%*	124	1,937	Endocrinology & Metabolism	*2,38%*	727	1,180
Psychiatry	*2,86%*	112	1,729	Marine & Freshwater Biology	*2,32%*	709	2,694
Endocrinology & Metabolism	*2,81%*	110	1,180	Microbiology	*2,25%*	685	0,888
Toxicology	*2,71%*	106	3,359	Physiology	*2,03%*	619	0,655
Public, Environmental & Occupational Health	*2,63%*	103	1,921	Pharmacology & Pharmacy	*2,02%*	616	0,405
Neurosciences	*2,58%*	101	0,662	Pediatrics	*1,90%*	580	1,290
Physics, Atomic, Molecular & Chemical	*2,51%*	98	1,725	Environmental Sciences	*1,89%*	575	1,735
Oceanography	*2,48%*	97	1,995	Cell Biology	*1,71%*	522	0,956
Pediatrics	*2,45%*	96	1,290	Psychiatry	*1,66%*	505	1,729
Microbiology	*1,99%*	78	0,888	Ecology	*1,64%*	499	1,937
Fisheries	*1,97%*	77	4,446	Chemistry, Physical	*1,62%*	493	0,838
Psychology, Developmental	*1,89%*	74	4,652	Physics, Atomic, Molecular & Chemical	*1,45%*	443	1,725
Genetics & Heredity	*1,76%*	69	1,231	Surgery	*1,44%*	440	0,443
Cell Biology	*1,64%*	64	0,956	Oncology	*1,44%*	438	0,338
Infectious Diseases	*1,58%*	62	1,170	Genetics & Heredity	*1,43%*	437	1,231
Rheumatology	*1,46%*	57	3,932	Public, Environmental & Occupational Health	*1,37%*	418	1,921
Biophysics	*1,38%*	54	1,272	Infectious Diseases	*1,35%*	413	1,170
Dentistry, Oral Surgery & Medicine	*1,38%*	54	0,329	Oceanography	*1,24%*	379	1,995

Gothenburg University ISI-category	EU-res. share	EU-res. # publ.	Ratio EU/Ref.	ISI-category	Ref. share	Ref. # publ	Ratio EU/Ref
Chemistry, Physical	*1,35%*	53	0,838	Plant Sciences	*1,23%*	376	0,187
Physics, Applied	*1,33%*	52	1,703	Biophysics	*1,09%*	331	1,272

Karolinska Institutet ISI-category	EU-res. share	EU-res. # publ	Ratio EU/ref.	ISI-category	Ref. share	Ref. # publ.	Ratio EU/Ref
Neurosciences	*11,69%*	1 182	1,534	Biochemistry & Molecular Biology	*8,31%*	4 417	0,928
Immunology	*8,68%*	877	1,640	Neurosciences	*7,62%*	4 054	1,534
Biochemistry & Molecular Biology	*7,71%*	779	0,928	Immunology	*5,29%*	2 813	1,640
Oncology	*6,18%*	625	1,209	Oncology	*5,11%*	2 719	1,209
Pharmacology & Pharmacy	*4,85%*	490	1,299	Pharmacology & Pharmacy	*3,73%*	1 985	1,299
Cell Biology	*4,22%*	427	1,231	Cell Biology	*3,43%*	1 825	1,231
Hematology	*3,44%*	348	1,950	Public, Environmental & Occupational Health	*3,42%*	1 818	0,576
Endocrinology & Metabolism	*3,24%*	328	1,116	Endocrinology & Metabolism	*2,91%*	1 546	1,116
Genetics & Heredity	*2,94%*	297	1,433	Physiology	*2,49%*	1 324	0,775
Clinical Neurology	*2,85%*	288	1,179	Clinical Neurology	*2,42%*	1 285	1,179
Infectious Diseases	*2,71%*	274	1,360	Genetics & Heredity	*2,05%*	1 090	1,433
Radiology, Nuclear Medicine & Medical Imaging	*2,16%*	218	1,911	Psychiatry	*2,00%*	1 066	0,982
Multidisciplinary Sciences	*2,04%*	206	1,375	Infectious Diseases	*1,99%*	1 060	1,360
Psychiatry	*1,97%*	199	0,982	Biophysics	*1,87%*	996	0,840
Public, Environmental & Occupational Health	*1,97%*	199	0,576	Surgery	*1,85%*	986	0,576
Physiology	*1,93%*	195	0,775	Medicine, General & Internal	*1,81%*	963	0,743
Microbiology	*1,90%*	192	1,292	Hematology	*1,77%*	939	1,950
Transplantation	*1,72%*	174	1,948	Pediatrics	*1,65%*	879	0,820
Virology	*1,65%*	167	1,192	Dentistry, Oral Surgery & Medicine	*1,58%*	842	0,069
Medicine, Research & Experimental	*1,62%*	164	1,088	Medicine, Research & Experimental	*1,49%*	793	1,088
Biophysics	*1,57%*	159	0,840	Multidisciplinary Sciences	*1,48%*	788	1,375
Pediatrics	*1,36%*	137	0,820	Microbiology	*1,47%*	782	1,292
Medicine, General & Internal	*1,35%*	136	0,743	Toxicology	*1,40%*	742	0,730
Rheumatology	*1,34%*	135	2,829	Virology	*1,39%*	737	1,192
Surgery	*1,07%*	108	0,576	Obstetrics & Gynecology	*1,28%*	682	0,170

Lund University ISI-category	EU-res. share	EU-res. # publ.	Ratio EU/ref.	ISI-category	Ref. share	Ref. # publ.	Ratio EU/Ref
Biochemistry & Molecular Biology	*5,80%*	692	1,002	Biochemistry & Molecular Biology	*5,79%*	2 852	1,002
Chemistry, Physical	*4,64%*	553	1,377	Chemistry, Physical	*3,37%*	1 658	1,377
Oncology	*4,09%*	488	3,624	Physics, Atomic, Molecular & Chemical	*2,30%*	1 133	1,319
Immunology	*3,70%*	441	1,642	Biotechnology & Applied Microbiology	*2,27%*	1 119	1,487
Biotechnology & Applied Microbiology	*3,38%*	403	1,487	Immunology	*2,25%*	1 109	1,642
Physics, Atomic, Molecular & Chemical	*3,04%*	362	1,319	Physics, Multidisciplinary	*2,18%*	1 075	0,749
Endocrinology & Metabolism	*2,86%*	341	1,890	Neurosciences	*2,00%*	987	0,724
Genetics & Heredity	*2,73%*	326	2,185	Environmental Sciences	*1,98%*	974	0,627
Chemistry, Analytical	*2,59%*	309	1,334	Chemistry, Analytical	*1,94%*	956	1,334
Microbiology	*2,16%*	258	1,210	Ecology	*1,83%*	899	0,978
Hematology	*2,00%*	238	2,432	Microbiology	*1,79%*	880	1,210
Optics	*1,94%*	231	1,904	Physics, Nuclear	*1,54%*	760	0,657
Ecology	*1,79%*	213	0,978	Physics, Condensed Matter	*1,54%*	757	0,584
Physics, Particles & Fields	*1,74%*	208	1,164	Cell Biology	*1,52%*	747	0,752
Physics, Multidisciplinary	*1,64%*	195	0,749	Endocrinology & Metabolism	*1,51%*	745	1,890
Food Science & Technology	*1,62%*	193	1,526	Physics, Particles & Fields	*1,50%*	738	1,164
Biophysics	*1,59%*	189	1,088	Biophysics	*1,46%*	717	1,088
Instruments & Instrumentation	*1,48%*	176	1,465	Physiology	*1,44%*	710	0,430
Neurosciences	*1,45%*	173	0,724	Pharmacology & Pharmacy	*1,39%*	684	0,284
Rheumatology	*1,35%*	161	3,536	Plant Sciences	*1,38%*	680	0,279
Medicine, General & Internal	*1,33%*	159	2,195	Biochemical Research Methods	*1,32%*	651	0,882
Peripheral Vascular Disease	*1,25%*	149	1,606	Chemistry, Multidisciplinary	*1,32%*	650	0,629
Environmental Sciences	*1,24%*	148	0,627	Genetics & Heredity	*1,25%*	616	2,185

Lund University ISI-category	EU-res. share	EU-res. # publ.	Ratio EU/ref.	ISI-category	Ref. share	Ref. # publ.	Ratio EU/Ref
Nutrition & Dietetics	*1,23%*	147	1,927	Physics, Applied	*1,19%*	585	0,748
Public, Environmental & Occupational Health	*1,21%*	144	1,122	Oncology	*1,13%*	556	3,624

Växjö University ISI-category	EU-res. share	EU-res. # publ	Ratio EU/ref.	ISI-category	Ref. share	Ref. # publ	Ratio EU/Ref
Physics, Multidisciplinary	*13,76%*	56	2,236	Physics, Multidisciplinary	*6,15%*	36	2,236
Physics, Mathematical	*13,76%*	56	2,515	Forestry	*5,81%*	34	0,042
Mathematics	*12,53%*	51	2,291	Physics, Mathematical	*5,47%*	32	2,515
Multidisciplinary Sciences	*6,88%*	28	13,415	Mathematics	*5,47%*	32	2,291
Mathematics, Applied	*5,16%*	21	1,161	Mathematics, Applied	*4,44%*	26	1,161
Statistics & Probability	*4,91%*	20	1,369	Statistics & Probability	*3,59%*	21	1,369
Engineering, Chemical	*4,18%*	17	3,491	Biochemistry & Molecular Biology	*2,74%*	16	0,000
Chemistry, Physical	*3,69%*	15	5,390	Ecology	*2,22%*	13	0,111
Environmental Sciences	*2,46%*	10	1,307	Materials Science, Paper & Wood	*2,22%*	13	0,111
Geosciences, Multidisciplinary	*1,97%*	8	2,300	Literature	*2,22%*	13	0,000
Biology	*1,97%*	8	1,643	Environmental Sciences	*1,88%*	11	1,307
Energy & Fuels	*1,97%*	8	1,278	Mechanics	*1,88%*	11	0,653
Paleontology	*1,72%*	7	2,515	Management	*1,88%*	11	0,000
Engineering, Mechanical	*1,47%*	6	1,078	Economics	*1,71%*	10	0,287
Biotechnology & Applied Microbiology	*1,23%*	5	0,898	Genetics & Heredity	*1,71%*	10	0,144
Optics	*1,23%*	5	1,797	Energy & Fuels	*1,54%*	9	1,278
Chemistry, Applied	*1,23%*	5	7,187	Engineering, Mechanical	*1,37%*	8	1,078
Mechanics	*1,23%*	5	0,653	Biotechnology & Applied Microbiology	*1,37%*	8	0,898
Geology	*1,23%*	5	7,187	Plant Sciences	*1,37%*	8	0,719
Thermodynamics	*1,23%*	5	1,437	Evolutionary Biology	*1,37%*	8	0,180
Plant Sciences	*0,98%*	4	0,719	Engineering, Chemical	*1,20%*	7	3,491
Computer Science, Information Systems	*0,98%*	4	1,437	Biology	*1,20%*	7	1,643
Engineering, Multidisciplinary	*0,74%*	3	4,312	Cell Biology	*1,20%*	7	0,000
Engineering, Manufacturing	*0,74%*	3	1,437	Psychiatry	*1,20%*	7	0,000
Education & Educational Research	*0,74%*	3	1,078	Business	*1,20%*	7	0,000

Annex B: Diagrams of major subject categories

Diagrams of the 25 largest subject categories and their share of the publication volume (1990-2006)

Figure 123 25 largest subject categories for the EU-researchers at Chalmers

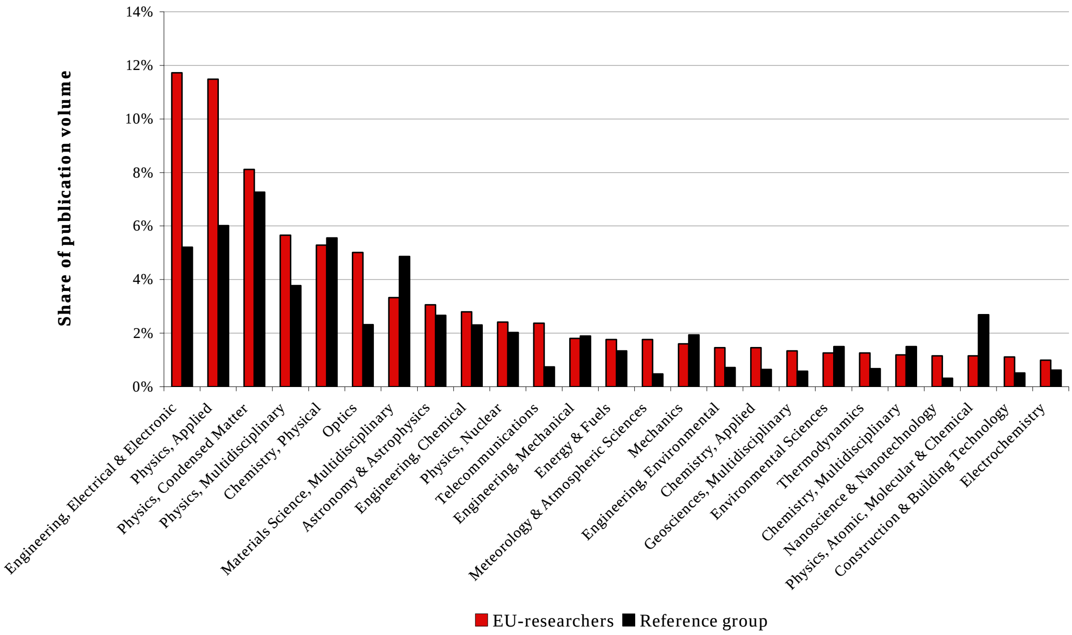


Figure 124 25 largest subject categories for the reference group at Chalmers

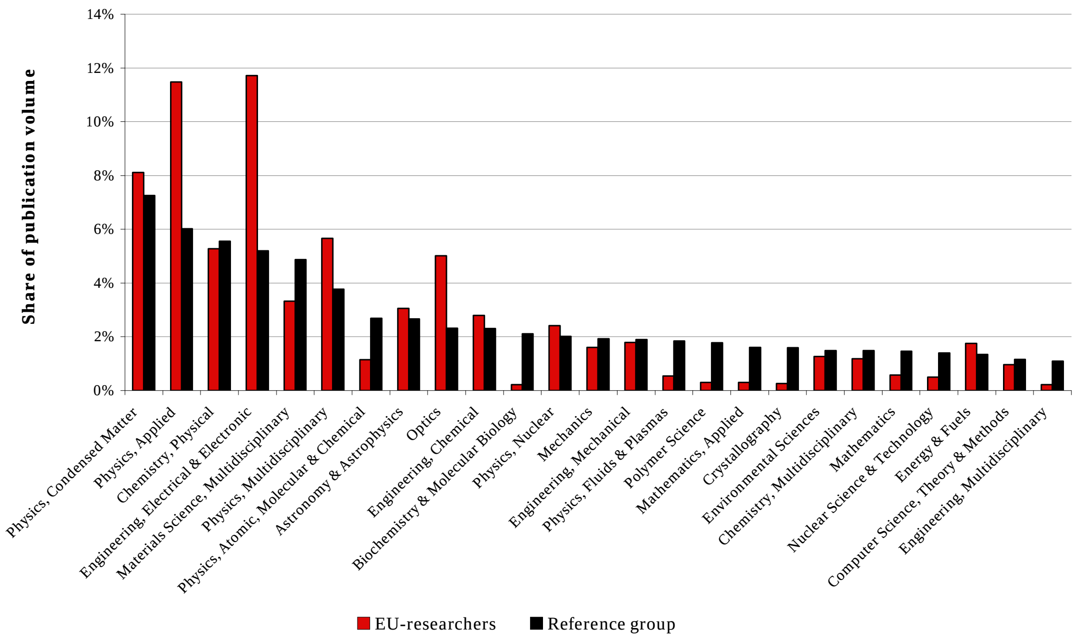


Figure 125 25 largest subject categories for the EU-researchers at Gothenburg University

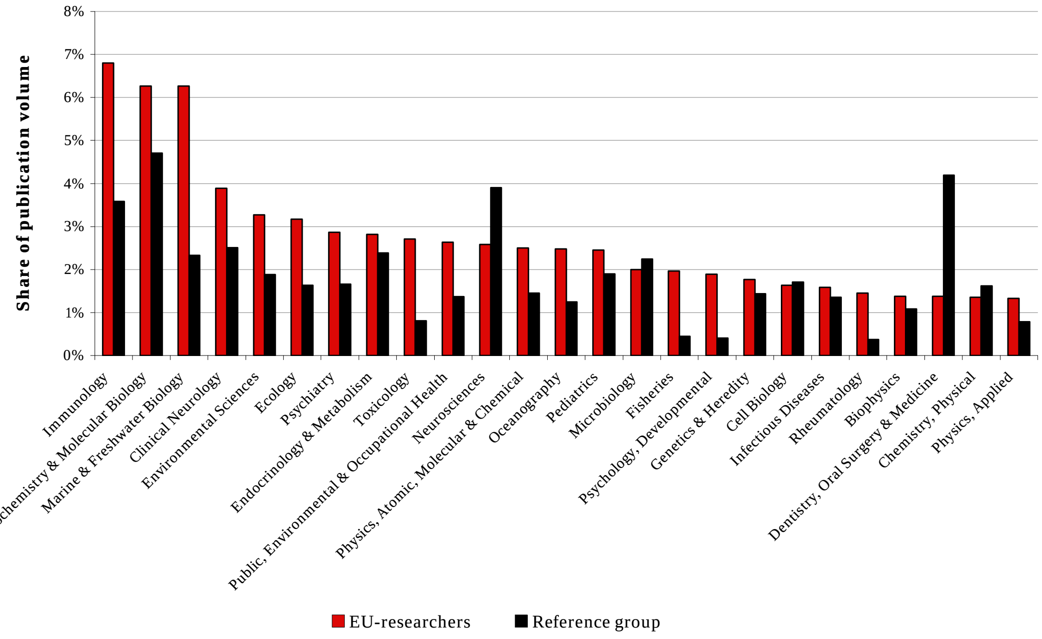


Figure 126 25 largest subject categories for the reference group at Gothenburg University

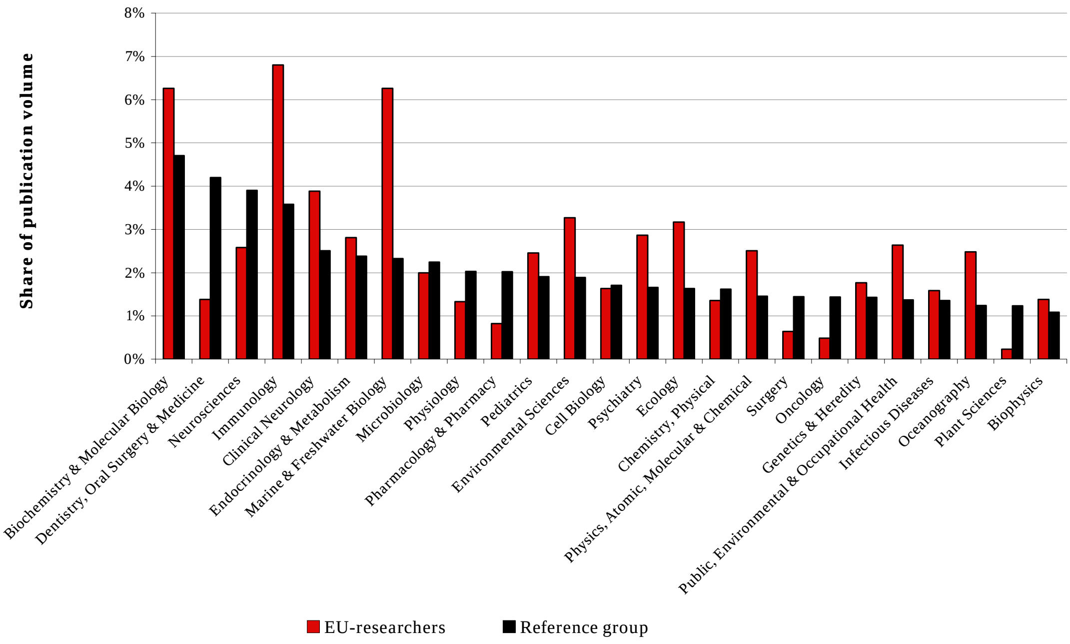


Figure 127 25 largest subject categories for the EU-researchers at Karolinska Institutet

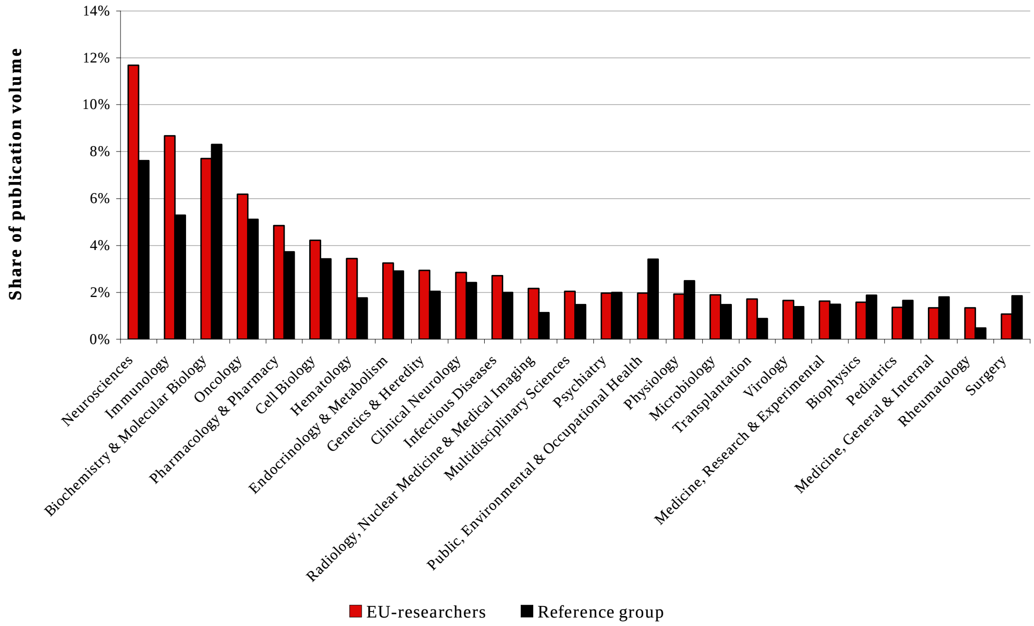


Figure 128 25 largest subject categories for the reference group at Karolinska Institutet

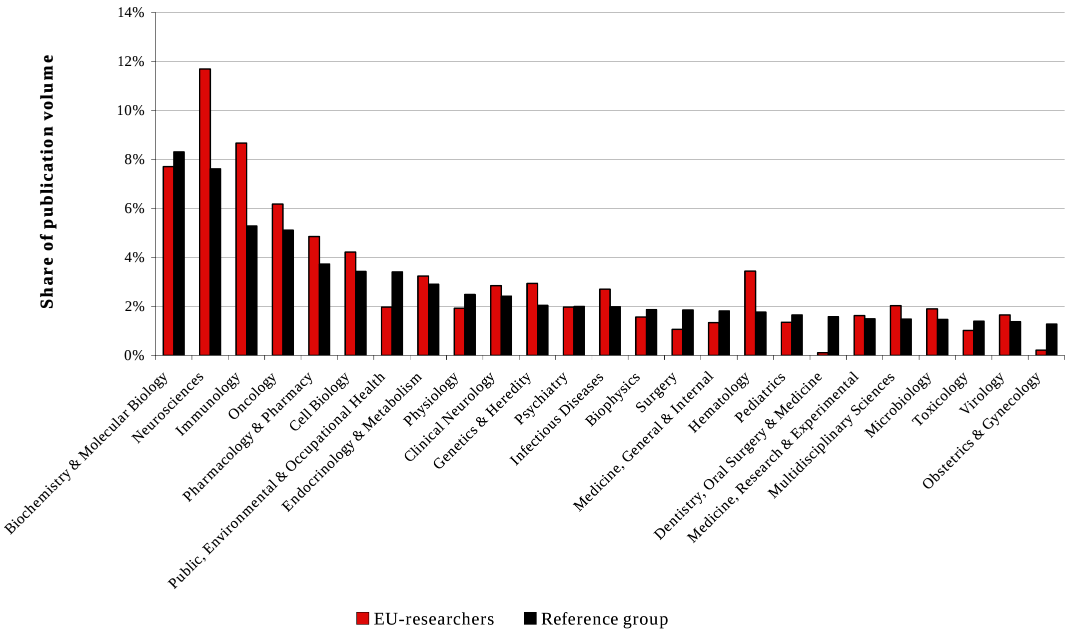


Figure 129 25 largest subject categories for the EU-researchers at Lund University

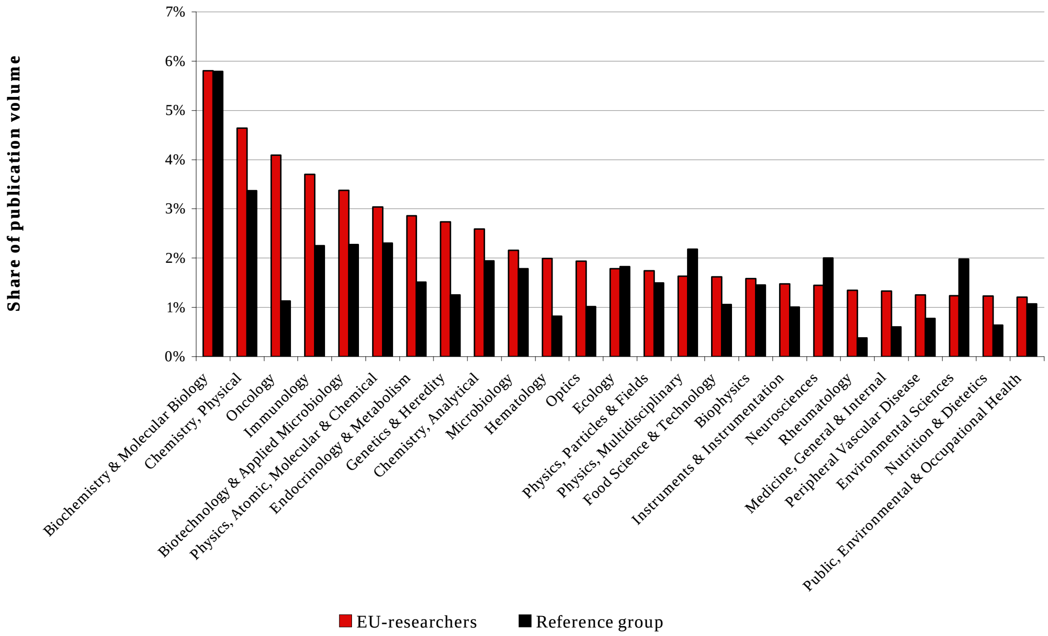


Figure 130 25 largest subject categories for the reference group at Lund University

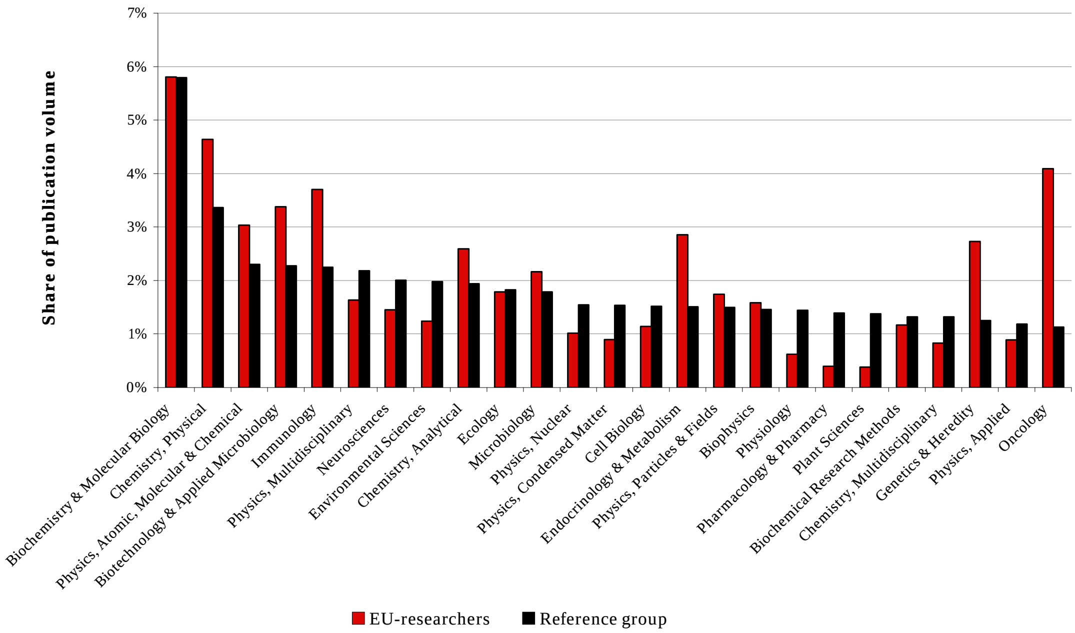


Figure 131 25 largest subject categories among the EU-researchers at Växjö University

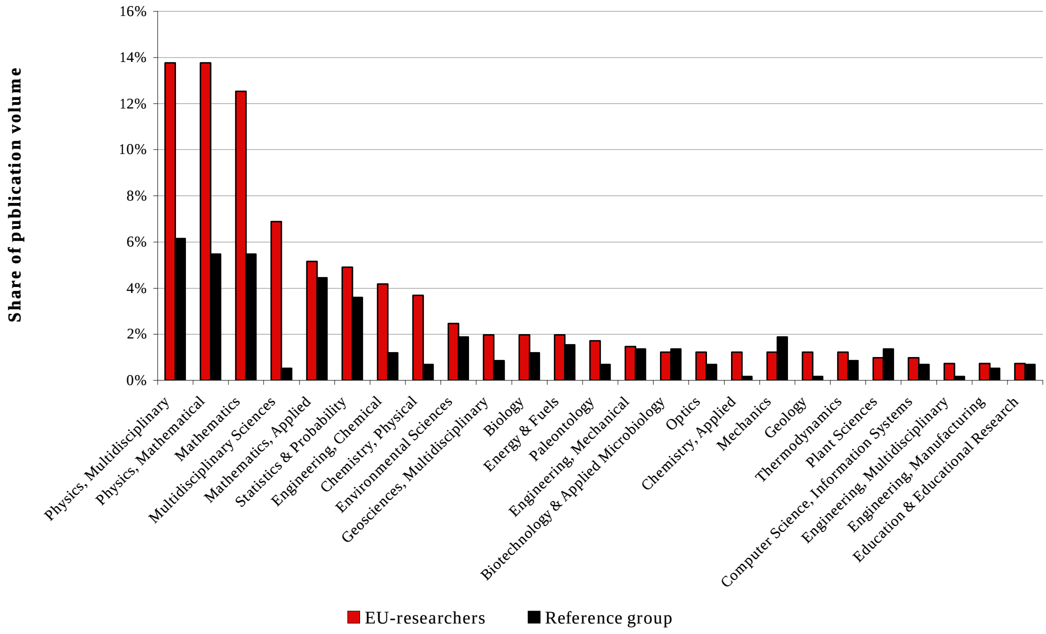
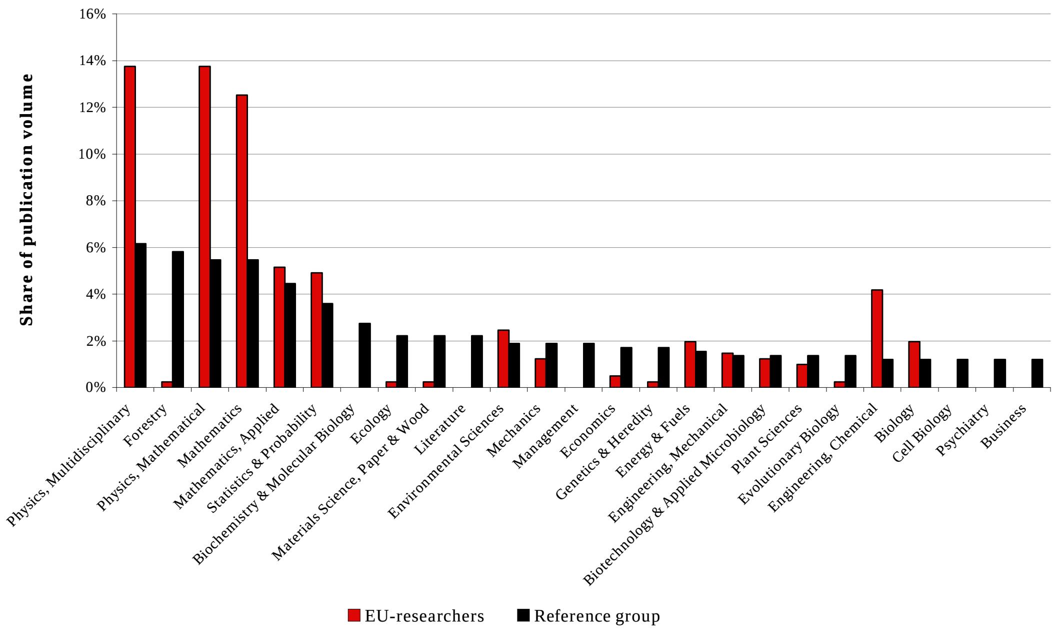


Figure 132 25 largest subject categories for the reference group at Växjö University



Annex C: Diagrams of subject field variation

Share of total publication volume in different subject fields during three periods for GU, KI and LU (cf. Figure 112 for CTH)

Figure 133 The 25 largest subject fields during the period 2001-2006 for Gothenburg University expressed as share of subject field classification, and how the share have changed between periods

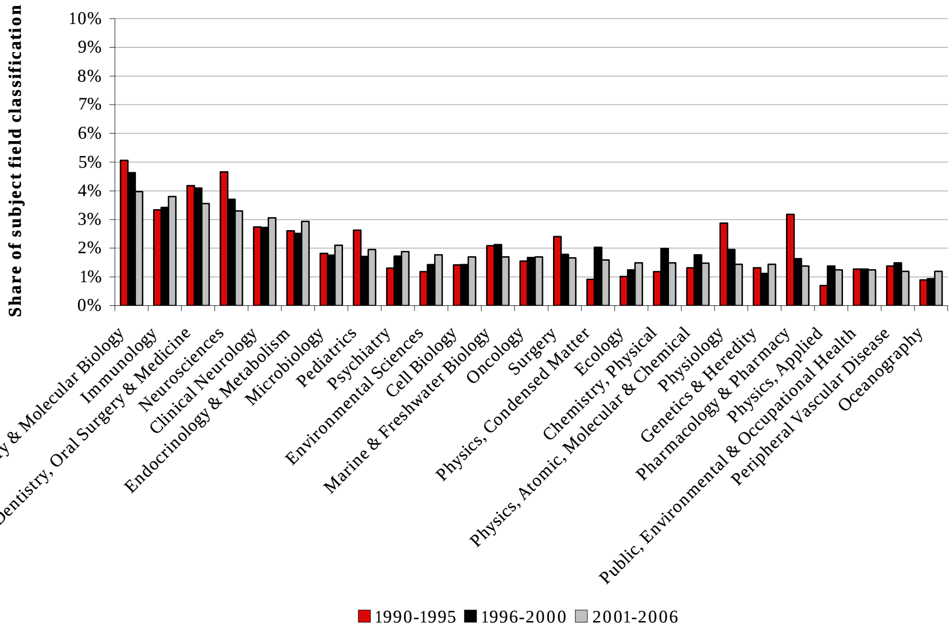


Figure 134 The 25 largest subject fields during the period 2001-2006 for Karolinska Institutet expressed as share of subject field classification, and how the share have changed between periods

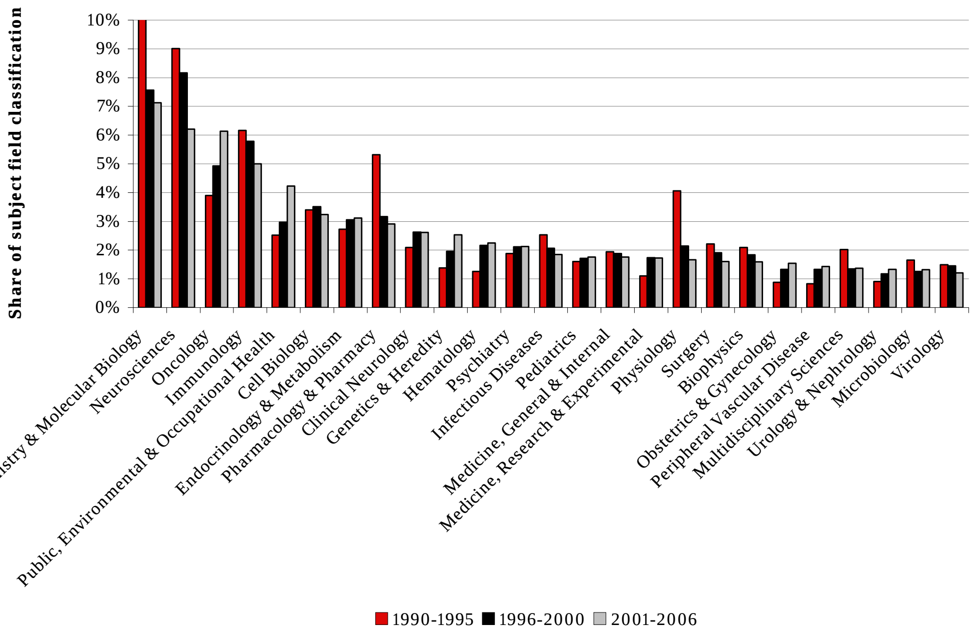
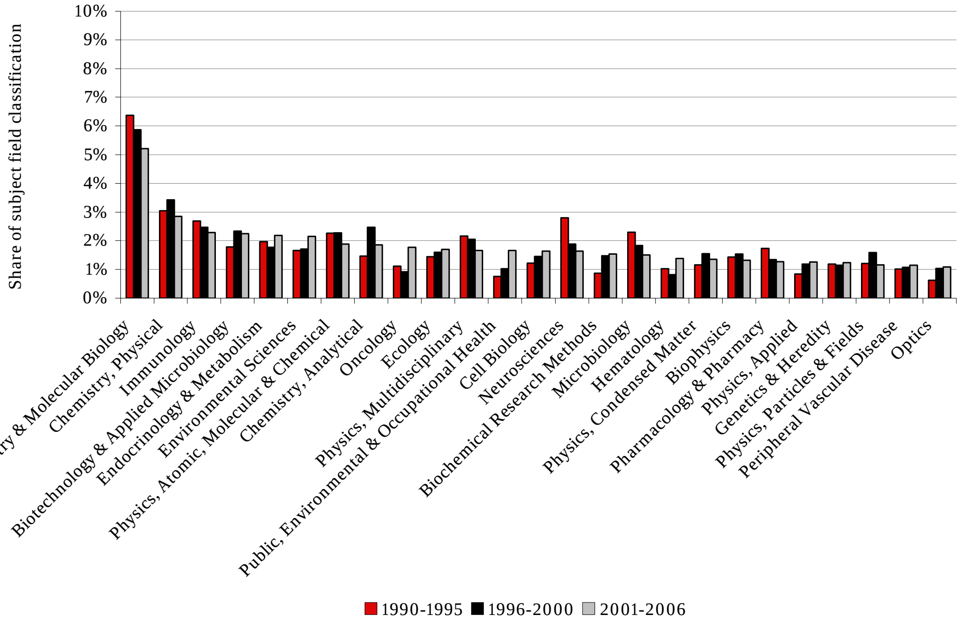


Figure 135 The 25 largest subject fields during the period 2001-2006 for Lund University expressed as share of subject field classification, and how the share have changed between periods



Annex D: Tables of data grouped by EU researchers and reference group

Number of publications, mean field normalised citation rate and average number of addresses data on aggregated from the five universities for 1990-2006, cf Figure 112 and Figure 113

	EU researchers									Reference group								
Year	**# of publ.**	**CitUS2/ FCS**	**CitUS5/ FCS**	**CitUSO/ FCS**	**# of addresses**	**Sweden**	**EU***	**UK**	**USA**	**# of publ.**	**CitUS2/ FCS**	**CitUS5/ FCS**	**CitUSO/ FCS**	**# of addresses**	**Sweden**	**EU***	**UK**	**USA**
1990	654	1,80	1,92	1,98	2,38	1,23	0,81	0,08	0,22	4 049	1,21	1,24	1,26	2,01	1,44	0,34	0,05	0,14
1991	700	1,47	1,57	1,63	2,05	1,31	0,45	0,06	0,20	4 303	1,09	1,15	1,20	1,96	1,42	0,28	0,05	0,16
1992	727	1,79	1,85	1,85	3,53	1,27	1,85	0,18	0,21	4 286	1,17	1,22	1,23	2,42	1,44	0,64	0,09	0,18
1993	808	1,76	1,78	1,74	3,23	1,33	1,48	0,14	0,21	4 633	1,14	1,18	1,19	2,28	1,42	0,54	0,07	0,15
1994	859	1,87	1,84	1,83	2,48	1,33	0,84	0,10	0,17	4 775	1,18	1,21	1,21	2,46	1,43	0,64	0,09	0,21
1995	938	1,83	1,84	1,80	2,11	1,29	0,51	0,05	0,20	5 246	1,20	1,23	1,24	2,63	1,46	0,78	0,09	0,19
1996	1 041	1,67	1,80	1,90	2,35	1,29	0,68	0,08	0,23	5 371	1,17	1,21	1,21	2,72	1,47	0,87	0,11	0,18
1997	977	1,52	1,51	1,48	2,35	1,34	0,67	0,09	0,20	5 292	1,20	1,22	1,21	2,71	1,53	0,77	0,10	0,20
1998	1 058	1,46	1,51	1,57	2,84	1,75	0,69	0,08	0,23	6 198	1,27	1,27	1,27	3,00	1,78	0,76	0,10	0,24
1999	1 072	1,55	1,53	1,54	2,95	1,82	0,75	0,08	0,23	6 366	1,26	1,25	1,25	3,23	1,84	0,90	0,11	0,25
2000	1 097	1,54	1,59	1,60	3,11	1,78	0,80	0,08	0,33	6 411	1,24	1,24	1,24	3,30	1,80	0,99	0,11	0,26
2001	1 145	1,54	1,60	1,62	3,14	1,86	0,86	0,10	0,24	6 686	1,21	1,23	1,24	3,24	1,85	0,87	0,12	0,26
2002	1 116	1,37	1,37	1,37	3,44	1,81	1,14	0,12	0,27	6 807	1,18	1,18	1,18	3,20	1,83	0,80	0,11	0,28
2003	1 135	1,56	1,63	1,63	4,35	1,91	1,72	0,16	0,40	6 808	1,17	1,18	1,18	3,35	1,88	0,88	0,11	0,30
2004	1 231	1,37	1,37	1,37	4,29	1,92	1,80	0,17	0,28	7 397	1,24	1,23	1,23	3,55	1,91	1,00	0,13	0,32
2005	1 325	1,54	1,53	1,53	3,99	1,98	1,48	0,19	0,27	7 260	1,23	1,23	1,23	3,84	1,91	1,03	0,15	0,47
2006	1 287	1,42	1,42	1,42	4,88	1,95	2,14	0,26	0,41	7 424	1,36	1,36	1,36	4,03	1,91	1,23	0,17	0,47

Annex E: Tables of data for five universities for three time periods

Number of publications, mean field normalised citation rate and average number of addresses from different countries on publications from the universities for three time periods, cf. Figure 115.

University	period	EU researchers							Reference group						
		# publ	CitUS2/FCS	# addresses	Sweden	EU	UK	USA	# publ	CitUS2/FCS	# addresses	Sweden	EU	UK	USA
CTH	1990-1995	363	1,37	2,31	1,15	0,56	0,02	0,31	3 660	1,14	2,10	1,42	0,34	0,05	0,15
CTH	1996-2000	699	1,32	2,53	1,52	0,61	0,11	0,15	4 248	1,16	2,55	1,61	0,51	0,07	0,17
CTH	2001-2006	1 228	1,32	2,78	1,65	0,67	0,07	0,18	5 630	1,12	2,70	1,67	0,59	0,08	0,17
GU	1990-1995	751	1,45	1,79	1,31	0,31	0,04	0,07	7 750	1,10	2,02	1,47	0,22	0,04	0,14
GU	1996-2000	999	1,48	2,24	1,55	0,45	0,06	0,14	7 317	1,13	2,55	1,78	0,37	0,06	0,18
GU	2001-2006	1 518	1,56	3,10	1,95	0,78	0,15	0,18	8 939	1,17	3,10	2,02	0,62	0,11	0,22
KI	1990-1995	2 379	1,69	2,15	1,50	0,43	0,08	0,15	9 709	1,24	2,23	1,61	0,33	0,05	0,17
KI	1996-2000	2 651	1,58	3,00	1,82	0,74	0,09	0,29	10 524	1,32	2,98	1,99	0,57	0,07	0,26
KI	2001-2006	3 458	1,55	4,06	2,29	1,11	0,13	0,40	14 746	1,29	3,67	2,25	0,81	0,11	0,34
LU	1990-1995	2 521	1,85	3,09	1,23	1,46	0,13	0,22	10 726	1,17	2,57	1,32	0,86	0,10	0,15
LU	1996-2000	2 962	1,45	2,64	1,55	0,71	0,07	0,23	9 821	1,25	3,61	1,52	1,56	0,17	0,22
LU	2001-2006	4 658	1,33	4,12	1,68	1,87	0,19	0,28	13 442	1,23	4,01	1,68	1,42	0,18	0,46
VXU	1990-1995	76	0,46	1,63	0,38	0,57	0,04	0,08	13	0,03	1,85	1,62	0,15	0,08	0,00
VXU	1996-2000	66	0,38	1,95	0,73	0,86	0,00	0,02	99	0,52	2,04	1,44	0,37	0,02	0,06
VXU	2001-2006	178	0,95	2,21	1,43	0,31	0,08	0,05	289	0,73	2,25	1,76	0,23	0,04	0,02

Appendix K Acronyms

ACARE	Advisory Council for Aeronautics Research in Europe
ACTS	IT programme in FP4
ALI	Working life research institute
ARC	Aging Research Centre
ASEA	The Swedish ASEA company - now part of ABB
BMC	Biomedical Centre
BRITE/EURAM	Part of the FPs, focusing on materials, engineering and production
CA-OE	Coordinated Action on Ocean Energy
CAT	Centre for Antiviral Therapy
CB	Centre for Biosciences
CBioSep	Swedish Centre for Bioseparation
CCK	Cancer Centre Karolinska
CEC	Centre for Co-ordinated Energy Research
CECOST	Centre for Combustion Science and Technology
CED	Centre for Economic Demography
CEPT	European Conference of Postal and Telecommunications Authorities
CERC	Combustion Engine Research Centre
CFA	Centre for Allergy Research
CHACH	Centre for High-Speed Technology
CHARMANT	Centre for Microwave Antenna Systems
CHARMEC	Competence Centre in Railway Mechanics
CHASE	Antenna Systems Excellence Centre
CHESS	Centre for Health Equity Studies
CHP	Combined Heat and Power Generation
CIM	Centre for Infectious Medicine
CIP	Centre for Intellectual Property
CKK	Centre for Competence and Knowledge Building in Higher Education
CMM	Centre for Molecular Medicine
CNRS	French National Centre for Scientific Research
COB	Centre for Oral Biology
CPM	Competence Centre in Environmental Assessment of Product and Material Systems
CRAFT	Part of the Framework Programme, formerly dedicated to the needs of small firms
CTH	Chalmers University
CTMH	Centre for Technology in Medicine and Health
CUL	Centre for Cognition, Understanding & Learning
DG	Directorate-General
DRIVE	Vehicle Telematic programme in FP2 and FP3
EASIS	Electronic Architecture and System Engineering for Integrated Safety Systems
EEA	European Economic Area

EEFAE	Environmentally Friendly Aircraft Engine project
EFTA	European Free Trade Association
EPA	Environmental Protection Agency
EPoSS	European Technology Platform on Smart Systems Integration
ERA	European Research Area
ERA-NET	An FP6 and FP6 instrument to enable national R&D funders to make joint funding initiatives
ERC	European Research Council
ERTICO	European Road Transport Telematics Implementation Co-ordination Organisation
ERTRAC	European Road Transport Advisory Council
ESPRIT	European Strategic Programme of Research in Information Technology
EST	Early Stage Research Training
ETH	Swiss Federal Institute of Technology
ETSI	European Telecommunications Standards Institute
EU	European Union
EUCAR	European Council for Automotive R&D
EUREKA	A pan-European research and development funding and coordination organisation
FFA	Aeronautics and defence research institute
FFP	Vehicles Research Programme
FOA	Aeronautics and defence research institute
FOI	Aeronautics and defence research institute
FP	Framework Programme
FRIST	Forum for Risk Investigation and Soil Treatment
FTE	Full-Time Equivalent
GERD	Gross Expenditure on R&D
GM	General Motors
GMMC	Gothenburg Mathematical Modelling Centre
GMV	Centre for Environment and Sustainability
GO	Grant Office
GSM	Global System for Mobile
GTC	Consortium Gas Turbine Centre
GU	Gothenburg University
HEI	Higher Education Institution
HIC	Health Informatics Centre
HIK	Kalmar University
HMI	Human-Machine Interaction
HSV	Swedish Higher Education Agency
HTC	Competence Centre for High Temperature Corrosion
ICT	Information and Communication Technologies
IEA	International Energy Agency
IMI	Innovative Medicines Initiative (a JTI)
IRIS	Strategic research centre for studies of Integrative Recognition in the Immune System
IST	Information Society and Technologies
IT	Information Technology

ITEA	IT cluster in the EUREKA programme
ITS	Intelligent Transport Systems
IVA	Swedish academy of engineering
IVF	Institute for production engineering
IVHS	Intelligent Highway Vehicle Systems
IVL	Environmental research institute
JTI	Joint Technology Initiative (part of FP7)
KCK	Competence Centre for Catalysis
KFB	Swedish Transport and Communications Research Board
KI	Karolinska Institute
KI-PARC	Karolinska Institutet Physical Activity Research Centre
KTH	Royal Institute of Technology
KV	Swedish academy of science
LERU	League of European Research Universities
LERU	League of European Research Universities
LiU	Linköping University
LTH	Lund University
LU	Lund University
MACH	Material Analysis at Chalmers
MAP	Multi-Annual Programme
MCC	Medical Management Centrum
MCR	Metal Cutting Research and Development Centre
NEM	Networked and Electronic Media
NMP	National Microelectronics Programme
NMT	Nordic Mobile Telephone
NUTEK	Swedish Agency for Economic and Regional Growth
OCIM	Osher Centre for Integrative Medicine
OECD	Organisation for Economic Co-operation and Development
PFF	Programme Board for Automotive Research
PLUS	Plastics for a Sustainable Society
PTT	Post and Telecommunications Authority
PV	Personvagn - Car
PwC	PricewaterhouseCoopers
RACE	Research and Development for Advanced Communications in Europe
RI	Research Institute
RIDE	R&D, Innovations and Dynamics of Economies
RTD	Research and Technological Development
RTI	Road Transport Informatics
RTN	Research Training Networks
SAFER	The National Vehicle and Traffic Safety Centre at Chalmers
SBC	Stockholm Bioinformatics Centre
SBI	Stockholm Brain Institute
SBU	Strategic Business Unit

SCeNDT	Scientific Centre of Non-Destructive Testing
SGC	Structural Genomics Consortium
SICOMP	Composites Institute
SICS	Institute for computer science
SIK	Institute for food and biotechnology
SLU	Swedish Agricultural University
SME	Small and medium enterprises
SMHL	Meteorology and hydrology research institute
SMI	Institute for public health
SMIT Centre	Swedish Microsystems Integration Technology Centre
SNRA	Swedish National Roads Administration
SNV	Swedish Environmental Protection Agency
SP	Former state meteorology authority
SSI	Institute for radiological protection
STEM	Swedish Energy Agency
STFI	Institute for pulp and paper
STREP	Specific Targeted Research Project - medium-sized projects in FP6 and FP7
STU	Swedish National Board for Technological Development
SU	Stockholm University
SWEREA	A group of Swedish Research Institutes
TFK	Transport research institute
TNO	Netherlands Organisation for Applied Scientific Research
TP	Technology Platform
UMTS	Universal Mobile Telephone Service
UMU	Umeå University
UU	Uppsala University
VINNOVA	Swedish Agency for Innovation Systems
VM	Vehicle Maker
VTI	State traffic and transport research laboratory
VTT	Technical Research Centre of Finland
VXU	Växjö Regional University

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04 The GSM Story - Effects of Research on Swedish Mobile Telephone Developments. *For brief version in Swedish or English see VA 2008:07 or VA 2008:06*

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VINNOVA´s mission is to promote sustainable growth
by funding needs-driven research
and developing effective innovation systems

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