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LONG TERM INDUSTRIAL IMPACTS OF THE SWEDISH COMPETENCE CENTRES

PETER STERN, ERIK ARNOLD, MALIN CARLBERG, TOBIAS FRIDHOLM,
CRISTINA ROSEMBERG & MIRIAM TERRELL - TECHNOPOLIS GROUP

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Author: Peter Stern, Erik Arnold, Malin Carlberg, Tobias Fridholm, Cristina Rosemberg & Miriam Terrell - Technopolis group
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Peter Stern, Erik Arnold, Malin Carlberg, Tobias Fridholm,
Cristina Rosemberg & Miriam Terrell

technopolis |group|

technopolis |group| United Kingdom
3 Pavilion Buildings
Brighton BN1 1EE
United Kingdom
T +44 1273 204320
F +44 1273 747299
E info@technopolis-group.com
www.technopolis-group.com

Preface

The Competence Centre program was launched by VINNOVA´s and the Swedish Energy Agency's predecessor NUTEK in 1993. 28 Centre consortia were selected from more than 300 applications to receive 10 years of funding, starting from 2005. When VINNOVA was founded, it overtook the responsibility for 23 Competence Centres and the 10 year commitment for funding. When the Swedish Energy Agency was founded, it overtook the responsibility for 5 Competence Centres and their funding, which still continues.

The Competence Centre program was launched to obtain the following goals:

- Performing industrially relevant research
- Producing high-quality scientific outputs
- Developing scientifically qualified human capital with skills in industrially relevant areas
- Encouraging the development of interdisciplinary critical mass within academia in areas of industrial relevance
- Changing research culture
- Producing innovations in the participating companies

Each Centre has had an annual budget of around 18 MSEK, of which the participating companies, the funding agencies and the host Universities have funded about one third each. The total budget for the Competence Centre program during its life time has been around 4,9 BSEK.

Each Centre has been evaluated three times by international teams of experts. As a basis for the evaluations and at the end of the 10 year funding period, each Centre has summarized its industrial and scientific achievements.

A first impact study of the Competence Centre program as a whole was done 2004.

This second impact study, done 2012-2013, has specifically focused on the long term industrial impacts of the Competence Centre program. More than fifteen years after the Competence Centres were established and more than six years after VINNOVAs funding ceased, this study was initiated to, based on interviews, identify and document direct and indirect effects in the companies participating in the Competence Centres. The study was also expected to provide recommendations regarding Competence Centres in future policy.

The study has been led by Prof Erik Arnold, Technopolis group, and has been carried out together with his colleagues Peter Stern, Tobias Fridholm and others in the Swedish subsidiary Faugert&Co.

Responsible for the study within the funding agencies has been Sven Gunnar Edlund, VINNOVA (project leader), Svante Söderholm, The Swedish Energy Agency and Lennart Norgren, VINNOVA

VINNOVA and the Swedish Energy Agency wish to express our sincere thanks to all the persons in the companies and the Universities involved, providing time and efforts to prepare and participate in interviews with facts and experiences. Without a high quality in these efforts by so many, this study would not have been possible.

We also express our thanks to the former Director for the Competence Centre program, Staffan Hjorth, who, as a background to the study, has provided the study with an impressive set of documents and facts, collected during the lifetime of the program.

Finally we thank the Technopolis group for all their work to carry out the study and produce this report, based on their comprehensive experiences of Competence Centers.

Stockholm in April 2013

Charlotte Brogren Director General VINNOVA	*Erik Brandsma* Director General The Swedish Energy Agency

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Summary

Introduction

This study of long-term industrial impacts of the Swedish Competence Centres (CC) programme was commissioned by VINNOVA and the Swedish Energy Agency. It forms one in a series of studies of the longer-term impacts of R&D funding by VINNOVA and its predecessor agencies and extends an evaluation of the centres done in 2004. It confirms many of the findings in these other studies that show both the long period of time that can be needed for the results of research to be felt at large scale and the need for careful programming of research funding in a way that is neither wholly bottom-up nor top-down but a mixture of the two informed by use of stakeholders' knowledge and interests.

Methods

The empirical input to the analysis mainly comes from five sets of sources: document studies (including review of international experience with CCs and of past evaluations); interviews with centre managers and other university representatives; interviews with company representatives; statistical databases on companies; and a survey sent to PhD holders who had graduated in the CC programme.

Competence centres

Competence centres are a type of research and innovation funding instrument that has been used since the 1980s. The centres are typically located on a university campus and involve a consortium of companies working together with people from more than one academic department in doing R&D, usually jointly. Sometimes research institutes may also be involved. CCs are distinct from run-of-the-mill academic-industry R&D collaborations in that they normally have **structural** objectives – not only producing knowledge for innovation but having an effect on the way research is done in the universities and in the companies as well as aiming to change aspects of university education. They are longer term and have higher rates of subsidy, to encourage more fundamental research to be done, and they involve PhD education.

The Swedish CC scheme ran 1995–2007. Some 28 consortia were selected from 300 applications to receive 10 years of funding from VINNOVA's predecessor Nutek. This was roughly to be matched by in-kind contributions by industry and again by the universities, so that the state, industry and the universities each contributed about one third of the cost of the programme. Peer review evaluations and a separate impact evaluation during the programme's life all pointed to high scientific quality and significant industrial impact.

The Swedish CC programme is part of an international movement that started with the National Science Foundation's Engineering Research Centres in the 1980s. Their design influenced the Swedish programme, which in turn has influenced programme

designs in Austria, Norway, Estonia and elsewhere. All the CC programmes – including the Swedish one – have a common set of goals.

- Performing industrially relevant research of a more fundamental kind than is normal in academic-industrial cooperation
- Producing high-quality scientific outputs, in line with the quality norms of the scientific community
- Developing scientifically qualified human capital with skills in industrially relevant areas
    - Integrating PhD training into the centres
    - Focusing the skills and experience of academic and industrial R&D workers in the scientific and technological domains of the centres
- Encouraging the development of interdisciplinary critical mass within academia in areas of industrial relevance and
- Changing research culture
    - Encouraging companies to engage in 'open' innovation (open both to academia and to interaction with other companies) and jointly exploring more fundamental questions than normal
    - Encouraging greater interest in and acceptance of the value of industrial collaboration within academia
- Producing innovations in the participating companies and through spin-outs

The US, Australian and Swedish CCs have all been quite intensively evaluated. The studies show significant direct and indirect economic impacts in industry, through the influence of industry together with academia over the research agenda as well as the spread of ideas and human capital. It seems that CCs produce people who are better suited to doing industrial innovation than other kinds of postgraduate training. The time constants involved, however, are often long and the greatest effects of CCs are sometimes visible only a very long time after the centres start work. Once the high subsidy level disappears, centres either die or become much closer to market in their focus.

The Swedish competence centres

In total, the Swedish programme cost around 4.9 BSEK, of which the funding agencies paid around 1.5 BSEK. By the final stage, there were about 200 companies involved, with the proportion of SMEs growing over time. Large companies accounted for about 80 per cent of the industrial contributions – most of which were in kind, ensuring that companies were actively involved in the research. While there are differences among centres in size and the proportions of in-cash versus in-kind contributions, the only clear relationship between funding and impact is that high industrial in-kind contributions are associated with high industrial impacts. Companies' main motives for participating were to obtain knowledge that would help them improve products and processes and to network with university researchers, getting access to knowledge from the research community and creating opportunities for recruitment.

As well as linking to the centres, industrial participants were well networked to each other through centre membership – partly driven by the technologies and branches within which they worked. But there were also major systems companies that linked together different branches and technologies. Many of the participants also had good international R&D links through the EU Framework Programme.

Industrial impacts of the competence centres

We found seven kinds of industrial impact.

Direct impacts on industry, through generating directly usable outputs in the form of products and (less often) processes. For example, with the help of Charmec, Abetong AB developed new design principles and a new type of concrete railway sleeper, replacing creosote-impregnated wooden ones with their environmental problems, yet with similar mechanical properties so that old and new sleepers can be mixed. This has dramatically increased the firm's sales, given the railways sleepers that now last 40-50 years and dramatically reduced maintenance. ISIS' input on control technology has allowed ABB Robotics to produce robots with significantly better control systems, leading to a large increase in their sales worldwide.

Direct impacts through behavioural additionality such as learning the value of more open innovation forms, more networking and recruitment of technical specialists. For example, the CPM centre has led companies like Akzo and AB Volvo to use Life Cycle Assessment not only in product design but in defining and managing customer relationships and influencing company strategy. This increases their credibility, improves customer service and reinforces long-term customer relationships, with a correspondingly positive effect on their sales.

Economic impacts on participants in the form of increased revenues or, in some cases, protecting existing market positions exposed to technology-based competition. About half the companies we interviewed had managed to make a significant innovation as a result of CC participation; very few had not innovated at all as a result of working with the centre. We must always be cautious with simple economic impact estimates – they over-simplify a complex reality, they have wide margins of error and there is always the problem that it is not clear whether all the benefits should be credited to the intervention or programme. Nonetheless, if the earnings and cost savings resulting from the CC programme that we could identify are all counted as impacts of the CC programme, the total impact of programme at the very least amounts to somewhere between 5.3 and 11.8 BSEK per year as of 2012. In other words, in 2012 alone the figure is between 1.8 and 3.9 times larger than the total investment from public funders in the ten-year CC programme, and at least 0.5 BSEK larger than the total investment in the CC programme if industry contributions are also included. A great part of the impact comes from one single case. Without this, the range of impacts identified here is 1.3 to 1.9 BSEK , producing benefits in one year that are of the same order of size as the total, 10-year public investment in the programme. We should not be fascinated by the numbers here so much as by the order of magnitude; however we count, the long term effects are very large.

Economic development of individual SMEs participating in CCs. These partly overlap with the wider economic effects listed above. Our tracking of SMEs involved in the programme indicated that their collective economic performance is stronger than the average in the economy. It remains unclear whether CC participation causes the good performance or whether it is the other way round. At the minimum we can say that if it is the good performance that leads to participation then the firms endorse the usefulness of the CCs in development and growth. The fact that there were many spin-offs from the centres suggests that the centres caused at least some of the good performance.

Indirect effects through adding to the firms' stock of internal resources, notably human resources and research capability. Capacity building has been one of the most important impacts that CCs have had on participating firms. This is to a large extent manifested in knowledge that cannot be attributed to specific goals, but which nonetheless has meant or will mean improved productivity. Internal resources involve not only science and technology but also personal and business networks and the upgrading of capabilities in entire supply chains, not just individual firms. Another important effect for the smaller firms was the 'seal of approval' that CC participation gave them; they could use membership as evidence of their technical competence.

Spillovers from the participating firms and universities to other knowledge users. The programme produced at least 43 spin-offs between 1995 and 2006. The majority of the PhDs went into industry, taking skills with them. There were also large numbers of scientific outputs in the form of papers, conferences and dissemination events. So the programme produced a lot of public goods, in addition to the short-term private benefits to the industrial participants.

Indirect effects, via the university system, such as access to more, more relevant graduates. The CCs did not only increase the supply of postgraduate recruits with relevant technical skills for participating companies but they also influenced undergraduate and masters-level curricula. This implies a much larger build-up of human resources in areas of clear scientific interest and importance to Swedish industry.

At the individual level, the main benefit that companies said they obtained from the programme was access to new ideas, some of which turn out to be useful in product and process development; others of which bring other benefits (such as understanding alternatives). SMEs were more focused on product innovation than the large companies. Most companies involved make complex products, so new ideas are more often incorporated in these rather than giving rise to wholly new products.

The economically most significant contributions have been through the improvement of existing products. This underscores the importance of large firm participation in the programme: not only to the have the internal resources to define problems and understand and analyse technical results, but also to have the presence and power to bring new ideas to market. There are benefits from SME participation, but these seem to be much smaller in financial terms than those that can be 'leveraged' by the market power of larger industrial players.

By training PhDs in relevant areas and linking masters students' final year projects to CC themes, the programme has helped increase the supply of relevant manpower as well as training that manpower in ways that make it more industrially useful. This is reflected in the high take-up rate of CC PhDs by industry in general and the CC partners in particular. Hence, a further key effect of the programme has been to help build capacity in participating companies and to build or strengthen the academic parts of those companies' networks. Capacity building has taken place also at higher levels within company R&D functions – the effect is not limited to new recruits. But the PhDs have another value: the general experience is that PhDs tend to recruit other PhDs, thus over time raising the capacity of their organisations through self-image recruitment. This is borne out by the presence of clusters of CC-trained PhDs in many of the partner firms.

One of the things that persists after the dissolution of a centre is the network of relationships among individuals. Generally, the company participants maintain relations with the university so many elements of the knowledge value collective remain in place. Network building is not restricted to technology. Centres are often organised around supply chains (there are few examples where direct competitors work together). The same is true of the Framework Programme projects in which some companies participate. Not surprisingly, therefore, the centres play an important role in extending and strengthening business networks.

The CCs play important roles in signalling – acting as 'focusing devices' that direct attention and R&D effort in both companies and universities to areas of problem and opportunity. This kind of agenda setting can help change the pattern of industrial innovation.

Competence centres in future policy

The CC programme played an important role in a portfolio of research and innovation support instruments. It worked to boost the growth of clusters of industrial capability that had already started to develop. While two of the problems originally addressed by the programme – namely, fragmentation in the universities and lack of sufficient culture and experience of working with industry on a mix of applied and fundamental research – appear to have reduced since the early 1990s, there remain good reasons to carry on with this type of funding as part of the larger mix. Other instruments are needed in addition to support more radical or disruptive changes in science and technology but CCs are a useful part of the portfolio and should be retained. While there are niches where a longer-term presence is helpful (as with the Energy Agency centres), CCs' more general role in change agency suggests they should have long but finite funding.

CC programmes need to have a significant bottom-up component, so that calls for proposals operate as 'virtual technology foresights', signalling the way to promising areas for development in research and industry. The high rate of subsidy and inclusion of more fundamental research in their portfolios are key success factors for CCs and should remain features of such programmes. Not only PhD training but other education benefits from CCs, so these human resource dimensions should be expanded in future programmes.

Provided it does not get too small, the CC concept is ‘scaleable’. The right scale for a given centre depends on its specific industrial and technological context, so programmes need to be flexible enough to accommodate a range of sizes.

It is important to get the governance and leadership of centres right. There has to be a balance of power between academic and industrial interests in order to keep centres both grounded in industrial needs and at the same time capable of producing scientificcally challenging results. Leadership has to be credible in both scientific and business terms and should be carefully chosen and trained.

Internationalisation of industry and supply chains suggests that the future scope of CC programmes should extend beyond Sweden’s borders.

IPR disputes can stop a CC in its tracks. A fair arrangement that protects background knowledge and provides access on fair terms to foreground knowledge is needed and should be imposed in a standard form on the whole programme.

We therefore offer the following recommendations for future programme design.

- Integrate CC programmes into the mix of R&D funding instruments. They provide an important way to stimulate development and growth
- Treat CC programmes as ‘focusing devices’ for supporting promising clusters and Knowledge Value Collectives (KVCs). Since they support existing and emerging areas, however, they need to be complemented by higher-risk, more radical funding instruments that can trigger changes in science and the emergence of disruptive technologies
- Continue to fund CCs in response to bottom-up applications. There is every reason to encourage interest from areas that are poorly represented in programmes but the act of building a committed consortium and a high quality proposal that will bear scientific and industrial scrutiny is a key test of viability
- Maintain competence centre style programmes with long funding horizons. These are needed in order to integrate Pasteur’s Quadrant research and PhD education into academy-industry collaboration. It becomes increasingly possible to ‘harvest’ impacts after five years or so, suggesting that the extended funding period is important not only to the centre participants but also to obtaining a return on the societal investment involved
- Ensure that PhD education is integrated into the work of the CCs and encourage the centres to involve also the Masters and even the Bachelors level. The operational logic of a CC is focused on doing the research. A major component of the impact of the CC on the research and innovation system is through the generation of human capital
- Overall state funding should be a high proportion of the total budget, in order to compensate for market failure. Reducing this ‘de-tunes’ the centre away from fundamental and towards applied research. Within limits, this provides the programme designer (or, if a sliding scale of subsidy is offered, the proposal writer)

the opportunity to tune the centre to the absorptive capacity of company consortium members

- Do not expect a kind of 'behavioural additionality' where companies learn themselves to pay for more fundamental research in competence centres. Companies will indeed from time to time find reasons to pay for some relatively fundamental research, but not on a large scale or in a way that can easily be programmed. Market failure is an economic phenomenon that does not go away. Some of the centres may survive the end of their funding but in a more applied form
- Be tactical about whether to extend competence centre funding beyond the normal period foreseen in the programme design. The semi-institutionalisation of the Energy Agency centres and of CHARMEC suggest that there are niches where it is useful to have a national resource of this type, but these need to be aggressively evaluated and if possible subjected to competition. The major role of competence centres is as change agents. They leave behind them new capacities, knowledge and networks, which will live or die according to need. Despite the sense of entitlement that beneficiaries understandably develop after a decade of funding, when the party is over it's time to go home
- Competence centres are to some degree 'scalable'. Be willing to fund both smaller and larger ones, where there is a clear case for doing so. CCs have start-up and overhead costs that involve some economies of scale, so overly small ones are likely to be inefficient. But size matters in the sense that there is a 'right' size for a given centre operating in its particular context. CC funding schemes should therefore tolerate reasonable diversity of size
- In general, a large part of the industrial contribution should be 'in kind' as this better integrates the work of the centre with that of the companies and makes the work more relevant and applicable in innovation
- In so far as competence centres act as change agents in science and technology, the ERC approach of integrating education down to the undergraduate level is the right one. Clearly, this will be more possible in some fields than in others. At a minimum, proposals that integrate education well should be assessed as being more fundable than ones that do not
- Large 'Swedish' companies as well as supply chains in general are becoming more international. Encourage international participation in future competence centres, where that has clear benefits for Swedish industry and universities
- The 1994 competition provided a 'snapshot' of promising areas for academy-industry collaboration in that year. VINNOVA's current practice of launching fewer centres per year but doing so more often enables the programme to adapt to changing needs. This practice should be followed also in future
- Small companies can play important roles in competence centres, but their resources are limited so it is hard for them to play a significant role in the more fundamental work of the centres. Equally, their ability to translate technical into financial success is modest. Focus the majority of the effort in competence centres on the large firms that have the resources to engage in the research and exploit the results
- Include Swedish subsidiaries of transnational companies, in order to help 'anchor' them in Sweden and improve the attractiveness of Foreign Direct Investment

- Test the adequacy of leadership and governance arrangements when assessing proposals. These are critical success factors. If leaders are not seen as legitimate or if there is an imbalance of power among the academic and industrial participants, centres are unlikely to succeed
- Another importance imbalance of power is where a single large firm dominates a centre. This situation should be avoided because it hampers spillover and encourages abusive relationships between the large and small firms
- IPR arrangements do not drive CC behaviour. Funders should establish an IPR regime that participants view as fair and that is workable – typically respecting participants' background knowledge while providing fair access to foreground knowledge generated in the centre. Once this is done, IPR is rarely a contentious issue

1 Introduction and Method

This is a study of the long-term industrial impacts of the Swedish Competence Centres (CC), scheme, 1995-2007. It has been commissioned by VINNOVA and the Swedish Energy Agency as one of a number of studies that explore the long-term effects of R&D funding by VINNOVA and its predecessor organisations. For a period in the 1990s, today's research funding by the Swedish Energy Agency was part of the responsibility of its predecessor, Nutek.

1.1 Introduction

This study of the Swedish Competence Centres (CCs) rests on a rather tight definition of 'competence centre', which is consistent with the way CCs have been defined in Swedish research and innovation policy. In this sense, competence centres are a type of research and innovation funding instrument that has been used since the 1980s. The centres are typically located on a university campus and involve a consortium of companies working together with people from more than one academic department in doing R&D, usually jointly. Sometimes research institutes may also be involved. CCs are distinct from run-of-the-mill academic-industry R&D collaborations in that they normally have **structural** objectives – not only producing knowledge for innovation but having an effect on the way research is done in the universities and in the companies as well as aiming to change aspects of university education.

- Three partners normally fund them: industry, university and a state agency.
- They involve an unusually high degree of subsidy compared with other academic-industry cooperations, often 60% or so
- They involve long term contractual arrangements, requiring a much bigger commitment than traditional project by project funding of collaborative R&D
- They create new on-campus structures, and therefore make new organisational and structural demands on the universities
- They are interdisciplinary and generally problem-focused in the research they do, demanding 'horizontal' networking across traditional university structures
- Their long-term presence on campus and their engagement with postgraduate education draws them into closer contact and co-operation with universities' 'core business' of education and research than is often the case with linkage actions, which tend to focus more purely on research
- By drawing industry personnel onto campus to join in research, they also extend academics' networks into the industrial research community
- It is central to the idea of competence centres that they aim to do more fundamental types of research than is normally possible in industry, or even in conventional

academic/industrial collaboration[1]. The extent to which this research is in an 'absolute' sense fundamental will vary with the stage of technological development of the innovation system within which the centres operate

The competence centres themselves produce (or contribute to the production of) public goods of various kinds – most obviously knowledge in publications and in other forms but also a supply of people and wider contributions to things like standards, norms, practices.

Their presence has effects on the universities. First, they change education, because the universities' education is based on their research activities. Second, they change the way the universities organise, govern and implement research, normally leading to more flexibility and interdisciplinarity. Third, they influence the direction of research – they act as 'focusing devices' that signal where interesting (fundable) research questions are to be found, whose solution will lead to industrial effects.

Participating companies get direct knowledge, network and people benefits – leading over time to innovations and income. Much of the report's attention – and most of the examples – are focused here. There are also spillovers to other companies – both from the changes in the universities and from the participating companies: people and knowledge move about in ways that the beneficiary companies cannot prevent.

Finally, the innovations and growth among both types of companies mean that consumers are offered new, better, cheaper, more efficient products and services, generating consumer surplus.

The aim of this study is specifically to explore the industrial impacts of the Swedish scheme that ran from 1995 to 2007. Our terms of reference say that we should

- Overview the programme and assess the role of its characteristics in generating industrial impacts
- Summarise existing evaluations
- Describe the characteristics of the company participants
- Document effects of participation on the companies
- Explain the role of competence centre participation in companies' strategies
- Analyse developments in company networks after the end of the 10-year funding period
- Make recommendations

1.2 Method

Our approach has been to work with VINNOVA, the Energy Agency and Staffan Hjorth (formerly responsible for the programme at VINNOVA) to collect and analyse proposal, monitoring and budget information for the centres, as well as to establish what the

[1] Erik Arnold, John Clark and Sophie Bussillet, *Impacts of the Swedish Competence Centres Programme, 1995-2003*, VA 2004:3, Stockholm: VINNOVA, 2004

archives could tell us about earlier impacts. The empirical input to the analysis mainly comes from five sets of sources: document studies, interviews with centre managers and other university representatives, interviews with company representatives, statistical databases on companies, and a survey sent to PhDs who had graduated in the CC programme.

1.2.1 Document studies

The document studies were based on programme documents of various kinds available at VINNOVA and the Swedish Energy Agency, material provided by interviewees, and publicly available information related to the R&D projects. More precisely, the document studies have been based on

- Activity reports and annual reports
- Articles in newspapers and journals, primarily industry media
- Documents, e.g. academic studies, summaries and project reports primarily provided by interviewed centre and company representatives
- Evaluation reports
- Final reports from the VINNOVA-centres
- Internal summaries from VINNOVA, e.g. on centre outputs
- Programme descriptions, calls for proposals etc
- Summaries and data collections
- Web pages of participating firms

1.2.2 Interviews with centre managers and other university representatives

Early in the study, we interviewed current and past centre managers, with the aim of identifying impacts likely to be of significance in economic terms, finding out which managers to talk to in industry and trying to obtain contact details for people who had written their doctorates in the centres. We also asked the managers about the impacts the centres had had on the host universities; the programme was intended to have an effect on restructuring and renewal in the universities – both in relation to research and teaching. These are in turn expected to have indirect effects on the companies, so we wanted also to explore these. The interviews with centre managers were later complemented by interviews with a small number of university leaders. In total we have interviewed 34 centre managers and university leaders. Most interviews lasted between 40-60 min. See Appendix I for a list of interviewees in this category.

1.2.3 Interviews with company representatives

The next stage was to do semi-structured interviews with company managers about their participation in the centres. Why were they involved? How did their participation fit with their other activities? What were the results for the company and what impacts did they have on the business? Where possible, we asked for quantitative information on effects. Not everyone could supply those, but we have nonetheless been able to compile a list of economically very significant impacts. In Appendix G we list the main results and impacts that have been listed in the final reports from each CC as well as those we have come across.

The companies were mainly selected based on the interviews with centre managers and the final reports. We deliberately chose to contact those companies (and a handful of other types of user-organisations) in which notable impacts could be expected. We also selected a few cases in which no or marginal impacts were reported, but where the companies had invested much time or cash in the centres. The strategy was chosen for two main reasons. First, we knew from previous studies that programmes of the CC type typically induce very skewed effects on participating companies in terms of effects that can be traced economically, with little or no impacts on a large majority of the participants, and very large impacts only on a few companies. Second, we chose to conduct interviews instead of e.g. sending surveys because we wanted to ensure good responses from the companies in which impacts could be expected, which also includes targeting those individuals who had the most knowledge on the companies' CC participations and subsequent effects.

The strategy proved successful; we were able to interview almost all companies in which the centre managers and the reports indicated that impacts could be expected. The downside of our strategy is that many companies have not been contacted – it is possible that we have missed cases of important impacts of which CC representatives are not aware. It is likely that such cases exist; we observed a couple of notable impacts that seemed to be unknown to centre managers. In total we interviewed 67 company representatives. A handful of these interviews concerned participations in more than one CC; in total the interviews covered 73 of the around 610 participations.[2] The interviews typically lasted between 45–75 minutes. Interviewed company representatives are listed in Appendix H

Respondents in this study have been able to differing degrees to assess the effects of CC participation on their companies. In some cases there has been a clear connection between activities and output, as well as between output and the development of a product or a process, and, ultimately, revenue. In the impact assessment, these outputs and revenues have been quantified and they are strongly linked to the CCs.

[2] The number of participations depends on how one counts changes in company ownership, as well as subsidiaries and reorganisations of subsidiaries. We have tried not to count changes in ownership as new participations. We have however counted all subsidiary participations as individual participations, also in cases where e.g. ABB has participated with three closely cooperating ABB subsidiaries in one KC at the same time. In some cases the participation has been registered on the headquarters while in other cases on subsidiaries closely connected to the headquarters, even if the actual participation in both cases has concerned subsidiaries. In those cases we have counted the participation on the unit on which the participation has been registered. Another challenge is how to handle mergers and acquisitions, especially since we for many of the participating companies did not have corporate identity numbers. These numbers follow the companies also if their names change etc. It is therefore likely that our number of unique participations is higher than it should be.

In other cases, our respondents have for different reasons not been able to assess or quantify the outputs and revenues induced by the CC. The specific output could be one of several inputs to a very complex product or system, the sales of which generates large revenues which are clearly, but not uniquely, linked to the CCs. They are, however, also linked to other R&D&I initiatives and activities, taking place elsewhere than in these specific CCs. Some of the respondents have been able to approximate the size of such contributions, while others have not.

Given the long lags between the period in which research occurs and the time when impacts are realised, some benefits of the CC programme still cannot be identified or quantified at the time of this study. There are some imminent outputs and effects which are anticipated to occur over the next five-ten years, where technology or specific output has been demonstrated or verified and the route to market seems relatively clear. The respondents are aware of them, but unable to quantify them.

The figures in this report therefore systematically underestimate the direct benefits of the CC programme, since it has not been possible to identify or quantify all of the impacts or to understand their full extent. Nonetheless, we can conclude that the CC programme's investment in R&D&I in Sweden has had widespread consequences for the economy and community, affecting practically every industry and sector.

1.2.4 Databases on company characteristics

We also used databases on company characteristics, in two main ways. First, we tracked the economic performance of small firms involved in the programme. It was not possible to demonstrate that their performance was driven by centre participation, but this performance was certainly (in the aggregate) strong. Second, we used databases to map company groups and participation of companies from different sectors. We later redefined both the sectors and the classification of company units to better reflect technological fields and actual activities in companies. The data were kindly supplied by VINNOVA. See Appendix D for more details.

1.2.5 Survey to PhDs graduating in CC programme

We sent questionnaires to those PhDs we could find, asking them about their careers and the role of the competence centres in affecting their career choices and opportunities. We tracked the PhDs by help of the centre managers and by e.g. googling based on the lists of graduates provided by the funding agencies. We were able to send surveys to 445 of the 520 PhDs and obtained 199 responses. The survey is presented in detail in Appendix J.

2 What we already know about Competence Centres

In this Chapter, we look at international experience of competence centres and especially their impacts. We start by describing the origins and overall shape of the Swedish programme. We summarise evidence from earlier evaluations about both the quality and the impact of the centres. We then set the Swedish scheme into its international context, remembering that it is a variant of the National Science Foundation's Engineering Research Centre programme. We recount some of the history of competence centre programmes and discuss the intervention logic for such programmes. Next, we discuss a number of impacts of competence centre programmes, based on evaluations. Finally we take up a number of more operational issues about how to set up and run such centres, also based on available evaluations.

2.1 The Swedish Competence Centres Programme

2.1.1 The programme

This study explores the industrial impacts of the Competence Centres programme launched by Nutek in 1994 and subsequently funded and managed by VINNOVA and the Swedish Energy Agency (Energimyndigheten). The justification for the programme was Nutek's perception that the incentives for Swedish scientists to interact with other parts of society were weak. Hence, there was too little investment in industry-related research by academia and there was a need to find new ways to organise research collaboration between universities and industry[3]. The choice to support industrial development and innovation through the universities reflected a long-standing Swedish policy of concentrating national research resources in the Higher Education sector, making less use of dedicated Institutes or Research and Technology Organisations than is the case in many other countries.

There is no clear statement of goals for the programme. The selection criteria Nutek published were that centres should have

1 Substantial effects on industrial renewal in Sweden, through interdisciplinary work or by other means
2 Undertake research of sufficient substance and with a sufficient basis in science to qualify as centres of academic excellence and to be able to undertake PhD training
3 Enough industrial relevance to attract industrial participation, involving sharing of research personnel with industry as well as contract research for industry and for society more generally

[3] Staffan Hjorth, *The Nutek Competence Centre Programme: An effort to build bridges between science and industry in Sweden*, (mimeo) Stockholm: Nutek, 1998

4 Sufficient critical mass to sustain their activities for 5-10 years

5 Sufficiently high levels of scientific capacity and quality to be attractive partners for leading research groups in their field outside Sweden[4]

Nutek used a two-step procedure to set up the centres. In the first step, it was possible to apply for grants to write a full proposal. In the second step the actual proposals were selected. Nutek received nearly twice as many proposals as it had given planning grants, confirming the high level of interest in the scheme.

Call for proposals	April 1993
326 applications for planning grants	September 1993
61 planning grants allocated	November 1st 1993
117 final proposals submitted to Nutek	February 1st 1994
Nutek´s decision (29 proposals selected[5])	June 1994
Approval and launch of the centres	During 1995-1997

The call for proposals was addressed to universities, and only research groups within academic institutions were allowed to submit proposals. It was clearly stated from the very beginning that a main selection criterion would be that a number of industrial companies financially supported and actively participated in the centre activities. In the final proposals submitted to Nutek, written commitments from these companies had to be provided.

Nutek appointed seven expert groups and a central policy group to assess the proposals. Members of these groups were more than forty experts from industry, research councils and universities in Sweden and other Scandinavian countries. The individual proposals were reviewed non-anonymously. No quotas regarding the number of centres between universities, technological areas or industrial sectors were allowed. However, the final decision was to a certain extent influenced by the ambition to involve various technologies and industrial sectors in the programme.

The programme funded 28 consortia (Figure 1), each comprising a mixture of companies and university faculty for ten years to do a mixture of applied and more fundamental research in areas of industrial relevance. At the end of the programme, the Energy Agency decided to continue funding its five centres indefinitely while VINNOVA (which had taken over from Nutek) launched a series of new competitions via the VINN Excellence Centre programme.

Each centre had a short name, an abbreviation of the full centre name. The centres were normally referred to by this abbreviation, and the abbreviations are also used throughout this report. All abbreviations and full names are listed in Appendix B.

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[4] Our translation from Nutek, *Inbjudan till forskare och forskargrupper vid universitet och högskolor, industriforskningsinstitut och svensk industri: Industri- och energirelevanta kompetenscentra i anslutning till universitet och högskolor*, Stockholm: Nutek, 29 April 1993

[5] One was subsequently closed after stage 1

Figure 1 Competence Centres Funded in the Programme

Chalmers University of Technology, Gothenburg	Catalysis, KCK* Combustion Engines Research, CERC* Environmental Assessment of Product and Material Systems, CPM High Speed Technology, CHACH High Temperature Corrosion, HTC* Railway Mechanics, CHARMEC
Karolinska Institutet, Stockholm	Research Centre for Radiation Therapy
Linköping University	Bio- and Chemical Sensor Science and Technology, S-SENCE Information Systems for Industrial Control and Supervision, ISIS Noninvasive Medical Measurements, NIMED
Luleå University of Technology	Integrated Product Development, Polhem Laboratory Minerals and Metals Recycling, MiMeR
Lund University	Amphiphilic Polymers from Renewable Resources, CAP BioSeparation, CBioSep Circuit Design, CCCD Combustion Processes, KCFP*
Royal Institute of Technology, Stockholm	Bioprocess Technology, CBioPT Customer Driven High Performance Production Systems, Woxéncentrum/Workshop design Electric Power, EKC* Fluid Mechanics for Process Industry, Faxén Laboratory Inorganic Interfacial Engineering, Brinell Centre, BRIIE Parallel and Scientific Computing Institute, PSCI Speech Technology, CTT Surfactants Based on Natural Products, SNAP User-Oriented IT-Design, CID
Swedish University of Agricultural Sciences, SLU, Uppsala	Wood Ultrastructure Research Centre, WURC
Uppsala University	Advanced Software Technology, ASTEC Surface and Micro Structure Technology, SUMMIT

Source: VINNOVA. Energy Agency-financed centres are asterisked

2.1.2 Earlier evidence about the programme and its effects

The programme has been subject to a massive evaluation effort through its life, for two reasons: first, to ensure that the work of the centres is of high scientific quality; second, to look for evidence about the success of the centres in building academic-industry relations, contributing to the development of the universities and to themselves becoming sustainable. A total of six experts in centre development and management and 95 scientific peers took part in the evaluation work. There were three rounds.

- An initial assessment after two years, largely focused on managerial issues, to make sure the centres were establishing themselves well
- A second after 5 years, focusing on scientific and industrial performance
- A third after 8 years, also evaluating on scientific and industrial performance but also considering centres' ability to sustain themselves after the end of the 10-year funding period

The overview of the third evaluation concluded that

> *By any metric the programme has been a tremendous success of great value to the Swedish industry. Some Competence Centres have played a critical*

role in maintaining worldwide competence leadership of Swedish companies, some have been instrumental in promoting the economic competitiveness and growth of Swedish industry, and some have been essential in jump-starting industry sectors previously non-existent in Sweden and yet deemed to be vital.[6]

The earlier evaluation of the CCs in 2004[7] reviewed the evaluations of 26 of the centres that took place in 2003 and 2004, and used the experts' comments as a basis for scoring centre performance on key dimensions. It concluded that scientific performance, in terms of quality and the relevance of the work to scientific research elsewhere in the world, was adequate in 3 three cases, good in 11 cases and very good indeed in 12. All the centres had managed to achieve a good national standing. 17 had managed to become visible 'players' on the world research stage – and a handful of them were among the world leaders in their field. 17 of the centres were having a strong impact on industry, and a further four had a very strong effect. Only one had a performance that was less than satisfactory. Twenty of the 26 centres had clearly established themselves as unique centres of academic-industrial excellence. Most of the rest worked in areas in which there were also other important Swedish players. Twenty-one of the evaluations suggested the centres had reached adequate or strong critical mass. The evaluators suggested that all of the centres had a good prospect of surviving beyond the end of their 10-year funding period, raising some level of doubt in only two cases. In this they appear to have been optimistic.

The 2004 impact evaluation found that the CCs occupied a distinctive place in the research and innovation system and had generated

- Long-term linkage between industry and academic research, which tackles more fundamental questions than are handled in normal bilateral research relationships or than are available from VINNOVA's network programmes (AIS, VINNVÄXT)
- Longer term research than is typically provided by research institutes, focusing especially on 'Pasteur's Quadrant' of use-oriented fundamental research
- A mechanism to build (permanent or temporary) critical mass in subjects directly relevant to industry but within the university research system
- A large supply of research-trained people, who are already used to working with industry and who are highly sought-after by industry. These become members of networks of people in industry and the research sector whose interests and abilities focus on an area of science, technology and innovation. Such networks enhance innovation and can be more sustainable than individual organisations because their members can move between employers

[6] John Baras and Per Stenius, 'Third evaluation of competence centres: overall impressions and programme-wide issues,' note to VINNOVA and the Swedish Energy Agency, 23 March 2004
[7] Erik Arnold, John Clark and Sophie Bussillet, *Impacts of the Swedish Competence Centres Programme, 1995-2003*, VA 2004:3, Stockholm: VINNOVA, 2004

- Enhanced networks or collectives among people working with distinct bodies of industrially relevant knowledge, leading to increased co-operation and personnel mobility within the relevant clusters or sub-systems of innovation
- A supply of innovations and company spin-offs, with considerable economic value
- A mechanism to increase the attractiveness of the Swedish knowledge infrastructure to existing companies, new start-ups and foreign investors. Competence centres have played a significant role in retaining in Sweden parts of the R&D capability of major firms
- Most of the innovation benefits could not be quantified. However, on a crude estimate of value generated by a handful of successful innovations, the programme triggered more than €200m in increased business among participating firms, €45m in additional economic value from PhD education and a further €25m from spin-offs. The total of €270m was about three times the state's investment in the programme. Increased innovation had protected the position of major companies in Sweden, preventing or slowing down the loss of industrial activity, especially in vehicles and aerospace. It appeared likely that the **identifiable** economic benefits were well in excess of the total investment by the state and industry in the programme and the total benefits much higher.

2.2 The International Competence Centres Movement

Competence centre programmes have spread internationally since the mid-1980s, building on the design of the National Science Foundation's Engineering Research Centres programme.

2.2.1 History

The NSF's Engineering Research Centre (ERC) scheme[8] was the first one that we would recognise as a 'competence centre' programme in the current sense. Its design was an important influence on subsequent programmes around the world.

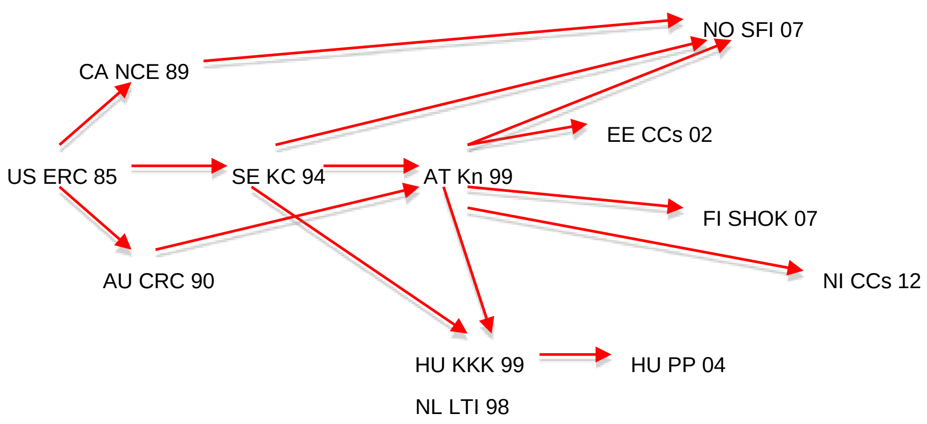
Figure 2 summarises the history of CC programme design, as we understand it. The NSF design was very influential. Canada set up Networks of Centres of Excellence in 1989, which largely function as virtual ERCs. Australia followed in 1990 with Cooperative Research Centres. In line with Australia's natural endowments, these were more focused on agriculture and natural resources than the predominantly industrial ERCs. The Swedish CC programme (1994) also owes a lot to the ERC design, and involved ERC expertise in evaluating the centres through the life of the programme. With the move to Europe came an addition – not always explicitly stated – to the intervention logic. European universities tended in the 1990s still to be rather fragmented, with powerful professors often running their research groups rather separately from the rest of their colleagues. Reducing this fragmentation and building critical mass in the universities became an additional motive for funding CCs. This in

[8] Linda Parker, *The Engineering Research Centres Programme: An Assessment of Benefits and Outcomes*, Arlington, Va, NSF, 1997

turn supported the efforts being made in many countries to modernise the structure and governance of the universities.

Following study-visits to the USA, Australia and Sweden, Austria set up three CC programmes in 1999: K*plus* (funded by BMVIT, the Federal Ministry of Transport, Innovation and Technology) and K*ind* and K*net* funded by BMWA, the Ministry of Industry and Labour). K*plus* centres were styled on the ERCs while the other two programmes involved smaller centres with more modest ambitions to do fundamental research, working rather close to market. The accumulated knowledge used in designing the Austrian centres in turn influenced the design of the Estonian and Norwegian programmes quite directly, and the Finnish SHOKs and the recently launched Competence Centres in Northern Ireland less directly. Swedish and Austrian thinking seems also to have influenced the small KKK programme in Hungary and the later, regional Pázmán Péter centres. About ten years ago, CC programme designers and managers formed a network ('MAP') funded by the European Commission to exchange experience. Subsequently the COMPERA ERA-NET was established to the same end. Both have used a rather wider definition of 'competence centre' than we do in this study but they have nonetheless ensured that programme designers and managers have had detailed access to each other's experience. The design of the Dutch centres seems to have been arrived at rather autonomously, though NL Agency is a member of COMPERA.

Figure 2 Evolution of Competence Centre Design



Note: *Numbers are the year of programme start-up*

NSF launched the ERC programme in 1985 as a response to the National Academy of Engineering's finding that rapid technological advances at the boundary between engineering and other disciplines were not being incorporated into US engineering research or practice. The Academy also said that there was a growing gap between engineering education and practice. Hence there was a need for an interdisciplinary programme to close these gaps through cooperation between universities and industry. Like the Swedish CC programme, it operated via university campus-based consortia made up of a number of companies and different groups within the university. NSF provided funding for ten years, after which the centres were expected to continue by other means. They were allowed to re-enter the competition and to qualify for a second funding period, but in practice few succeeded in doing so.

The Canadian Networks of Centres of Excellence started in 1989/90 with 15 networks, funded by the Industry Canada ministry together with three research councils and co-funded by universities and industry[9]. They were to perform a combination of fundamental and applied research in order to; stimulate fundamental and applied research in areas critical to Canadian economic and social development; develop and retain world-class researchers in these areas; create multidisciplinary and multisectoral research partnerships; and accelerate the use of the knowledge generated in industry and the state. The NCEs were, in effect, a networked variant of the ERCs. In the first four years, the federal government paid about 80% of the costs. Thereafter, its share fell to about 50% as the university and industry contributions grew.

The Australian Cooperative Research Centres programme began in 1990, with an initial tranche of 15 centres funded for seven years each. Its aim was to match Australia's research base better with the demand pull of industry and other research users. It shared the ERCs' ambition at once to link industry and academic research and to reform engineering education, although it was initially more permissive about the need for interdisciplinarity.

Over the first decade or so, CRC's were funded 25% by the programme, 36% by the universities and CSIRO (chiefly in kind) and 14% by industry (some 59% of which was in kind). Other funders provided the remaining 25%. Through the 1990s, the CRCs were evaluated to have led to changes in research culture in industry and the universities. Their objectives were gently tilted away from longer-term research and towards commercialisation through the decade. One of the drivers for this change was the need for the programme to demonstrate impact via 'paths to adoption' of CRC-generated technologies and to incorporate these in commercialisation plans.[10]

In Sweden, STU had co-funded a number of 'materials consortia' together with the natural sciences research council NFR, which operated as mini-competence centres. Based on this experience[11] and influenced by the ERC design (and, apparently, to a minor extent also by the modus operandi of the Fraunhofer Society)[12]its successor organisation Nutek set up the CC programme in 1994. Twenty-eight centres were launched in 1995, out of about 300 applications. Subject to positive peer review-based evaluations, funding was available to each centre for 10 years with roughly equal shares

[9] Dennis Rank, Evaluation of the Networks of Centres of Excellence, Ottawa: Industry Canada, 2002
[10] Howard Partners, Evaluation of the Cooperative Research Centres Programme, Howard Partners: Barton, ACT, 2003
[11] Lennart Stenberg, Learning and policy development at STU/Nutek: Competence centres as an example, Department of Policy Studies, Stockholm: Nutek, 1997
[12] Staffan Hjorth, The NutekCompetence Centre Programme: An effort to build bridges between science and industry in Sweden, Stockholm: Nutek, 2000

being provided by Nutek in cash, the universities in kind and industry in a mix of cash and in kind.

The Dutch Leading Technology Institute (LTI) scheme was set up in 1998[13]. Centres were funded 25% by companies, 25% by universities and 50% by the Ministry of Economic Affairs (EZ). Funding was provided in 4-year periods. The scheme does not have a legal document that describes its objectives and modalities. However, the 1996 government memorandum 'Towards Leading Technology Institutes'[14] lists the key characteristics of an LTI.

- A recognisable institute led from one position and, if required, physically concentrated
- The LTI focuses on one coherent scientific area of fundamental-strategic research
- This area is chosen in close consultation with knowledge intensive enterprises
- The LTI harbours researchers and equipment of global excellence
- This excellence forms an attraction for knowledge intensive firms and international top-talent
- The LTI has a training component through PhD and designer courses
- Enterprises should have a strong commitment to the LTI

Thus, the main assumption for the impact of this instrument was that by stimulating scientific excellence in a focused area relevant for industry, concentrating public efforts on this area, and by increasing the influence of industry on the agenda setting of this institute, industry would acquire innovation capabilities which would lead to improved competitiveness. In addition, this 'pool of competence' would act as a magnet for international top talent and R&D investments.

The other competence centre schemes referred to in Figure 2 are largely variations on the Swedish design. Austria and Estonia chose to implement their centres as limited companies; the others as consortia. The Hungarian centres are smaller-scale and considerably shorter-term.

2.2.2 Goals

The broad rationales for CC schemes have been discussed above. In many cases, the intervention logic has not been very explicit; in some, there is a clear agenda to influence the structure and behaviour of universities and to entice industry into more 'open' innovation without this necessarily being clearly stated. While educational change was designed into the ERCs, this has tended to be less prominent in other CC programme logics. Broadly, the goals of CC programmes shown in Figure 2 span

[13] Geert van der Veen, Erik Arnold, Patries Boekholt, Jasper Deuten, Jan-Frens van Giessel, Marcel de Heide and Wieneke Vullings, Evaluation Leading Technology Institutes, report to the Ministry of Economic Affairs, Amsterdam: Technopolis, 2005

[14] 'Op weg naar Technologische topinstituten', The Hague: Ministry of Economic Affairs, 1996.

- Performing industrially relevant research of a more fundamental kind than is normal in academic-industrial cooperation
- Producing high-quality scientific outputs, in line with the quality norms of the scientific community
- Developing scientifically qualified human capital with skills in industrially relevant areas
  - Integrating PhD training into the centres
  - Focusing the skills and experience of academic and industrial R&D workers in the scientific and technological domains of the centres
- Encouraging the development of interdisciplinary critical mass within academia in areas of industrial relevance
- Changing research culture
  - Encouraging companies to engage in 'open' innovation (open both to academia and to interaction with other companies) and jointly exploring more fundamental questions than normal
  - Encouraging greater interest in and acceptance of the value of industrial collaboration within academia
- Producing innovations in the participating companies and through spin-outs

2.3 Impacts

The US and Australian political contexts are highly sceptical about state intervention so there is considerable interest in trying to use quantification to test its effectiveness. Hence, the ERC and CRC schemes are the most intensively studied of all CC programmes. Evaluations of the European centres tend to be done at mid term, to be more process-orientated, often using panels and aiming to test whether centres are working well. All the programme level evaluations are positive. (Some individual centres have of course received poor reviews.) In the following section, we summarise some of the evidence from the evaluations about impacts and about key success factors in centre and programme management.

2.3.1 Human capital

Changing the nature of education so that people trained in the centres have better industrial understanding and are more useful to industry is a common theme across most of the programmes. For example,

> *One of the three common elements identified for all ERCs under the 1983 NAE guidelines for the ERC Program was the mandate to "contribute to the increased effectiveness of all levels of engineering education." In the first years of the Program, the latter came to be associated with creating a "new breed" of engineer. Drawing from the principle that the ERCs were to act as change agents in academic and industrial culture, this new type of engineer should reflect the features that make ERCs distinctive. That is, he or she should be adept at working in collaborative teams on interdisciplinary topics, approaching problem solving from an engineering systems*

perspective, and staying attuned to the needs of industry. The new engineers were also expected to use an integrative approach to their work and have technical breadth as well as depth.

The ERCs actively involved students in their programmes in pursuit of this ideal. Over 80% of both their industrial supervisors and other industrial representatives rated the quality and industrial effectiveness of ERC graduates as significantly higher than that of their non-ERC-trained peers. Those who had done postgraduate work in ERCs were more highly rated than others after graduation, both by their immediate line managers and by the formal representatives of the companies in the ERCs[15].

Human capital development was also an important impact of the CRCs[16]. The involvement of non-university people in supervision and the large-scale involvement of MSc and PhD students increased the industrial orientation and relevance of dissertation research.

A questionnaire-based study of CRC- and non-CRC doctorands[17] confirms that CRC PhDs appreciated their training more highly and felt better positioned to work with industry than non-CRC PhDs at the same university. They appreciated the equipment available more, were more positive about working in industry, their career prospects and their ability to switch between fields during their careers. They were less likely to think that industry involvement compromised traditional academic values.

2.3.2 Innovation impacts

The evaluation of the ERCs in 1997 found that they had been very effective. The biggest benefits industry obtained were

• Access to new ideas, know-how or technologies	84% of firms
• Technical assistance	63%
• Interaction with other participating firms	50%
• Access to ERC equipment and facilities	40%
• Hiring ERC students and graduates	40%

Almost a quarter of the firms reported that they had developed a new product or process as a result. The majority said the ERC had influenced their research agenda and two-thirds said it had increased their competitiveness. Firms participating in the ERCs tended to be multidivisional. In almost 80% of cases, their main motivation for joining was to access new ideas generated by the ERCs[18] They experienced the centres as 'windows' onto large bodies of local and international research in fields of interest to

[15] Linda Parker, *The Engineering Research Centres Programme: An Assessment of Benefits and Outcomes,* Arlington, Va, NSF, 1997
[16] CRCs, 2003
[17] Harman, K., (2004), Producing 'industry-ready' doctorates: Australian Cooperative Research Centre approaches to doctoral education, *Studies in Continuing Education*, 26 (3), November 2004
[18] Feller et al, 2002

them[19]. In other words, their main interest was to increase the number and type of innovation options they have and to boost their absorptive capacity. Feller et al's survey of ERC participant companies showed that new ideas were the major direct benefit and that they influenced companies' R&D agenda in over half the cases. Over 40% reported product or process improvement. Half this number adopted an ERC technology. But the most important impact was from recruiting ERC students or graduates, which some 40% or so of companies did[20].

Australia's CRCs produce patents and spin-off companies as well as upgrading the skills and knowledge of existing companies. A key output not always counted is start-up companies established by students graduating from the centres[21].

In the first four-year period, the Dutch LTI scheme participants realised that there was no strong mechanism for the uptake of results by participating companies. As a result, these were encouraged to set up 'mirror' projects and the LTIs themselves started 'valorisation' projects to transfer knowledge. Companies participated to acquire complementary and more fundamental knowledge, to network with other firms and to recruit R&D personnel. Almost all the participants valued the new knowledge generated: 90% valued it highly; 60% said they used it in innovation processes. Some 40% saw IPR as an important output of their centre. People trained in the programme were seen as more immediately useful in industrial R&D than their peers. About 40% used results in product innovation and a further 25% in process innovation. Participants were largely unwilling to quantify benefits, though the handful of estimates produced were in the millions of Euros. Dutch subsidiaries of foreign multinationals found their position in internal competition for R&D work to be strengthened. The mid-term evaluation of the scheme (after 6 years) found more industrial impacts from the applied than the more fundamental research[22].

Estonia launched a CC scheme in 2003. In a small, transition economy its beneficiaries and effects differed from the experience in other countries. Company partners were almost all small firms. Two thirds of them were exporters. They made strategic decisions to partner with the CCs but their aims were mainly to get short-term help with product and process development. The CCs tended to function as 'industry platforms' where members networked and got business and well as technological benefits. The main benefits were improved knowledge and R&D capability as well as near-to market technology transfer. Companies tended to see their centre participation as related to their core technologies and business areas, being strategically important in connection with their longer-term innovation effort, linked to that internal effort and as reducing both technical and commercial risks. Human resources produced via the centres were

[19] Parker, 1997
[20] Feller et al, 2002
[21] Howard Partners, 2003
[22] Geert van der Veen , Erik Arnold, Patries Boekholt, Jasper Deuten, Jan-Frens van Giessel, Marcel de Heide and Wieneke Vullings, Evaluation Leading Technology Institutes, Amsterdam: Technopolis, 2005

important to the companies. The centres often were a source of 'inspiration'– raising their and their employees' technical ambitions[23]. The importance of the Estonian example to the present study is that it illustrates the possibility of running a 'CC lite' programme in an innovation system that is not well developed – but that this will result in work that is close to development and less research that is fundamental.

2.3.3 Economic impacts

Our earlier study of the Swedish CCs found that companies almost never make financial cost-benefit calculations in regard to CC participation[24]. Feller et al[25] obtained the same result for the ERCs, with one exception, where a company did extensive calculations about its involvement in several ERCs that showed some $110m in increased income.

There is nonetheless intense policy interest in cost-benefit calculations. The CRCs are the most intensively studied centres in these terms. A 2005 study of the CRCs that aimed to understand at least some of the economic effects of the CRCs and to extra-polate these to the Australian economy found that the most important benefits came from relatively mature centres, in turn took a long time to realise and foreshadowed further potential benefits, not realised at the time of the study[26].

The study's authors based their work on consortium members' estimates of benefits already realised. shows that the time between setting up a centre and it being possible to estimate economic effects was long. The study attributed 100% of the value of all increases in revenue or savings in costs triggered by the CRCs to the programme and used a macroeconomic model of the Australian economy to compared the actual situation with a scenario where the programme funding is spent on other government expenditure. It found a small but significant increase of $143m in 2005 GDP as a result of the programme, compared with funding for the CRCs in scope to the analysis of $113m. The study points out that there are economic returns from patents and licensing and the creation of spin-off firms, but that these are dwarfed by the benefits of innovations made by existing members of CRC consortia. For the centres involved, contract research and consultancy income is also much larger than income from licensing centre technology.

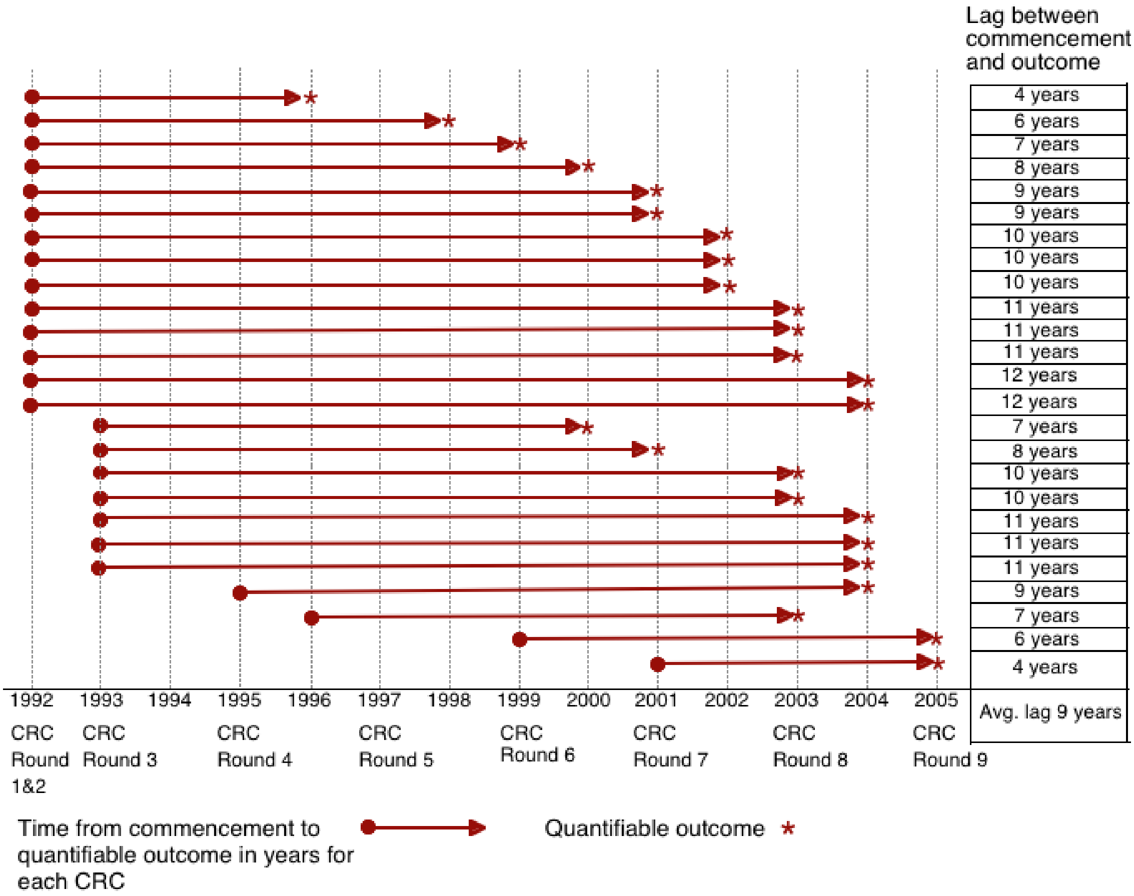
[23] Erik Arnold, Katrin Männick, Ruta Rannala and Alasdair Reid, *Mid-term Evaluation of the Competence Centre Programme*, Report to the Estonian Ministry of Economics, Brighton: Technopolis, 2008

[24] Erik Arnold, John Clarke and Sophie Bussillet, Impacts of the Swedish Competence Centres Programme, 1995-2003, VA 2004:3, Stockholm: VINNOVA, 2004

[25] Feller et al, 2002

[26] Allen Consulting, The Economic Impact of Cooperative Research Centres in Australia: Delivering Benefits for Australia, Melbourne: Allen Consulting, 2005

Figure 3 The Time Lag Between The Commencement Of A CRC And The Achievement Of A Quantifiable Economic Impact



Source*: Allen Consulting, 2005*

A subsequent study[27] used the 25 impacts and added a further 27. Quantifying each impact involved a 'mini-project', doing specific research into the effects. The team used a macroeconomic model first to estimate the effect of reallocating cost of the CRC programme to tax cuts and then to understand the effects of removing its innovation impacts. It concluded that

- The direct impacts described by the beneficiaries as having already been realised added a cumulated total of $A1,157m to Australia's GDP (in 2005 dollars)
- Adding in less direct impacts, only a fraction of whose benefits were attributed to the programme, suggested the programme had added $A2,554m to GDP
- Third, additionally including benefits related to proven technologies and which the informants regarded as being 'imminent' brought the total increase in GDP to $A2,697m. This would imply that for each dollar invested n the programme
    - Australian Gross Domestic Product is cumulatively $1.16 higher than it would otherwise have been

[27] Insight Economics, *Economic Impact Study of the CRC Programme*, Melbourne: Insight Economics, 2006

- Total Australian Consumption is $A1.24 higher than it would otherwise have been (Private Consumption is $A0.10 higher and Public Consumption is $A1.14 higher)
- Total Investment is $A0.19 higher than it would otherwise have been.

A further study in 2012[28] surveyed the then existing CRCs and asked them to make impact estimates for both past and 'imminent' impacts. While the earlier studies attributed 100% of the results of consortium members' R&D in the CRCs to the programme, this study attributed only half of them – responding to the argument of Australia's 2007 productivity Commission that "it is highly improbable that many circumstances arise when the partners in CRCs would have produced research of zero value in the absence of the program"[29]. The study suggested that, taken together, the existing direct and collaborative benefits together with benefits expected still to come were worth a total of $A14,452m (2012 dollars) to the economy.

2.3.4 Impacts on the universities

A study of the cultural impacts of the first seventeen ERCs[30] found that

- They demonstrated, created routines for and increased the legitimacy of large-scale interdisciplinary research in the universities
- Universities had to 'educate' their promotion and tenure committees about the different balance of publication, departmental work and ERC activity needed. There were cases where junior faculty were discouraged from participating in the ERC and some cases where those who did failed to obtain tenure
- Virtually all the ERCs created new courses or modified existing ones, reflecting the interdisciplinary and more systemic approaches taken by the ERC. Undergraduate participation is a requirement of the EC programme, so there was influence down to the undergraduate level
- In general, the ERCs led the universities to place increased value on industry collaboration

Our earlier study of the Swedish CCs found that the CC programme had contributed to an increased willingness in the universities to set up various kinds of (often interdisciplinary or applied) research centres and increasingly to work with industry on more fundamental and longer-term research.

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[28] Allen Consulting Group, The Economic, Social and Environmental Impacts of the Cooperative Research Centres Programme, Melbourne: Allen Consulting Group, 2012

[29] Productivity Commission 2007, *Public Support for Science and Innovation*: Research Report; cited from Allen Consulting 2012

[30] Catherine P Ailes, Irwin Feller and H Roberts Coward, *The Impact of Engineering Research Centers in Institutional and Cultural Change in Participating Universities,* Science and Technology Program Arlington VA: NSF, 2001

2.4 Operational and design issues

2.4.1 Governance, management, leadership

Many CC studies identify management as a key issue. Managers need to bridge the academic and industrial communities, be seen as legitimate by both science and industry. World-class science has the greatest effect. “The ‘matrix’ structure of CRCs creates a management challenge of the highest order and places a premium on chief executive officers … who are: scientifically credible; have knowledge of Intellectual Property; and, have commercial and businesses acumen. This is in addition to strong leadership qualities.”[31]

A governance system that maintains an appropriate balance of power and influence over the research agenda by the research and industry sides is needed in order to maintain the appropriate balance between short- and long-term R&D. Austrian experience shows that the relative power of industry and academia determines the ‘centre of gravity’ in this respect. The failure of the Finnish SHOKs to engage academics in what were intended to be CCs starkly illustrates the effects of failing to involve both sides in governance[32].

ERC companies that claimed to have a high influence over their centre’s agenda reported greater benefits than those with less influence. Effects on competitiveness increased the longer the firms stayed as members of the Centre. Active participation of industry personnel in the Centre research increased the benefits obtained by the companies: “’sweat equity’ is important for the partnership to be fruitful”. (This principle was reflected in the Swedish CC programme’s insistence on the importance of company in-kind contributions.) Key success factors for companies’ participation in ERCs were the existence of an ERC ‘champion’ within the company; the receptivity of company technical staff to ERC ideas; and the commitment of company top management to the ERC.[33] However, the overridingly most important factor determining the level of benefits obtained by ERC participants was the relevance of the technological area to their needs. In general, this has to be close to the core of the company’s business.

Long-run funding is a key. The Estonian scheme lengthened its funding period based on early experience[34] while the Hungarian ones found that short funding periods

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[31] Howard Partners, 2003

[32] Kaisa Lähteenmaki-Smith, Kimmo Halme, Tarmo Lemola, Kalle Piirainen, Kimmo Viljamaa, Katri Haila, Annu Kotiranta, Mari Hjelt, Tuomas Raivo, Wolfgang Polt, Michael Dinges, Michael Ploder, Susanne Meyer, Terttu Luukkonen and Luke Georghiou, Licence to SHOK? External evaluation of the strategic centres for science, technology and innovation, Helsinki: Ministry of Employment and the Economy, 2013

[33] Oarker, 1997

[34] Erik Arnold, Katrin Männick, Ruta Rannala and Alasdair Reid, *Mid-term Evaluation of the Competence Centre Programme*, Report to the Estonian Ministry of Economics, Brighton: Technopolis, 2008

undermined commitment[35]. The Dutch LTI scheme's practice of funding a series of short periods rather than providing a longer term prospect led participants to optimise their activity to the short periods rather than the whole period of funding that was finally provided[36].

There is disagreement in the CC community about the usefulness of centres being organised as legal persons rather than as consortia. Both incorporated and non-incorporated CRCs have been successful, but unincorporated ones incurred substantial legal costs. At the minimum an agreement template was needed to reduce transaction costs. Overall, however, management and leadership – not legal form – were decisive for determining CRC performance[37]. Our own experience with the Austrian and Estonian centres suggests that organising a CC as a company in which participants hold shares encourages appropriation of results by participants, attempts to extract value from share ownership as opposed to CC participation and to prevent new and additional members from joining. This tends to defeat some of the 'public goods' production objectives of the CCs.

Other success factors identified for the CRCs were

- An integrated research programme, in which the themes are mutually self-supporting
- A multidisciplinary approach, in which 'peripheral disciplines' are well integrated into the network strategy[38]

An OECD review of the Austrian programmes argued that the K*plus* approach to IPR represented best practice[39].

- Basic research. In this case all IPRs belong to the centre and each partner has the right to use the results.
- Industrial research with partner companies. In this case all IPRs belong to the centre and each partner of the project has the right to use the results. The participating company has to define, for each project, an area of interest. Within this area the company is allowed to give sub-licenses to connected companies. Outside the area of interest, the centre is allowed to commercialise the results. Within the area of interest of the partner companies, the centre is permitted to use the results for further research, also with third parties. In case of an industrial property right, it is up to the partners and the centre to decide who will file the patent.

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[35] Erik Arnold, Niels Busch, Jasper Deuten, Gilbert Fayl and Ken Guy, Pilot Monitoring of Centres in the Pázmán Péter and Asbóth Oszkár Programmes, Report to NKTH, Brighton: Technopolis, 2006
[36] van der Veen et al, 2005
[37] Howard Partners, 2003
[38] Howard Partners, 2003
[39] *Public-Private Partnerships for Research and Innovation: An Evaluation of the Austrian Experience*, Paris: OECD, 2004

2.4.2 IPR

The LTIs experimented with IPR conditions. After some time, it became the norm that the LTI would hold and manage any patents obtained; that IPR could be freely used for research by all consortium members; and that licence fees were partially offset by contributions to the research budget, so that those who had contributed the most to generating the IP paid the least to commercialise it. Similarly, the funding model of LTIs, which is based on research activities and company membership fees, provides little room for developing activities to disseminate research results to non-members, or to attract SMEs to take part in dissemination activities such as workshops, demonstration projects, training courses and so on.

Including industrial impacts in centres' routine reporting makes it easier to make and test claims about them, though this is no guarantee of completeness or accuracy[40].

The presence of three CC schemes in Austria provided an unusual opportunity to compare the apparent effectiveness of each[41]. K*plus* succeeded in making more significant changes in culture and research and innovation processes than the other two schemes because it was organised in a highly prescriptive way with transparent and independent management and evaluation, clear rules on participation and intellectual property and the use of international experts in quality control. The structure and legal form of the centres and the rules on ownership of intellectual property were prescribed. It induced firms to invest additional resources in R&D, speeded up their rate of innovation and increased their willingness to cooperate, especially in large 'horizontal' projects tackling longer-term and more fundamental questions that the companies would otherwise addressed. K*plus* centres attracted foreign participants. In contrast, the two other schemes were more flexible in accommodating to the preferences of companies that already benefited from a range of other innovation supports. Participants could themselves design the structure, legal form and IPR arrangements for their centre. Both K*plus* and K*ind* had rates of subsidy of up to 60%. The greater flexibility of K*ind* led to some free riding and little change in either the innovation rate or the propensity to cooperate. There was little international interest in participating and there appeared to be little difference between the effects of K*plus* and K*ind* and other national innovation support schemes.

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[40] Howard Partners, 2003

[41] Jakob Edler, Susanne Huuhrer, Vivial Lo, Claudia Rainfurth and Stefan Kuhlmann, *Assessment, 'Zukunft der Kompetenzzentrenprogramme (K plus und K ind/net und Zukunft der Kompetenzzentren'*, Fraunhofer-ISI and KMU Forschung, 2004

2.4.3 Life after centre death?

A study[42] of the first 33 ERCs to 'graduate' (ie to reach the end of their NSF funding period) showed that some 80% continued to operate, usually with a reduced focus on long-term research and with a lot less funding (although in a small number of cases centres found new and additional funding and actually grew.) Two-thirds of the centres aimed to continue as 'unofficial ERCs'. Since the NSF funding was generally used to pay for the hardest-to-fund activities, graduated centres tended to do less fundamental research, outreach, undergraduate support and spend less on infrastructure than before. The fact that the ERC agenda was embedded in education was an important factor encouraging the persistence of the centres. Centres that survived tended to have strong central support from their universities and high-quality centre management. Nonetheless, two thirds of the survivors did smaller projects in smaller teams spanning fewer disciplines and taking a less systemic approach than before. Early centres tended to be ill prepared for the transition, often relying on re-competing and then being unsuccessful in their application; later ones had seen the problems and started planning earlier.

[42] James E Williams jr, Courtland S Lewis, *Post-Graduation Status of National Science Foundation Engineering Research Centres: Report of a Survey of Graduated ERCs*,, Grand Rapids, MI: SciTech Communications LLC, 2010

3 The Swedish competence centres

In this chapter, we outline funding and participation in the Swedish CC programme, covering both the state and industry. We analyse the centres' budgets and discuss the shape of the network of companies and centres formed by the programme. We review company partners' Framework Programme participation and look at the extent to which centres and partnerships survived the end of the funding from VINNOVA.

3.1 Organisational participation

3.1.1 Funding overview

The CC programme was based on a model where the programme funders, the host universities, and the participating companies each would provide around 1/3 of the centre resources. Universities were granted funding from the programme funders, normally 6 MSEK per year, if they were able to present companies that together promised to provide at least as much input – either in cash or in kind or as a mix of the two. The universities were in turn expected to co-finance the CCs by offering in kind work by researchers at an amount equivalent to the cash from the programme funders. Each CC would thus have a budget of about 18 MSEK per year.

After a build-up period during the first two years (stage one of four) most CCs stayed at roughly the same size throughout the programme period. The incentives to grow were weak, for two main reasons. First, although the programme funders did not impose any upper limit on contributions from industry or universities, they did not reward large centres by increasing funding. Second, a large centre would run the risk of being too fragmented and/or difficult to manage, which not only could be negative in the evaluations but also make participating companies less engaged.

The funding scheme served several purposes. The comparably high rates of public subsidy – roughly 2/3 of the budgets – would stimulate industry engagement and allow relatively fundamental research. Funding conditioned on company engagement would encourage university researchers to seek active collaborations. In kind contributions would make collaborations closer and more routine, as well as stimulate the formation of personal networks between university researchers and R&D personnel in the companies. Finally, the size and long time frames would put organisational and structural demands on the universities. The engagement and broader collaborations were further secured by having all participants in each centre sign a common contract which specified the cash and in kind contributions from each company for the next two or three year.[43]

Table 1 Overview of contributions to the CC programme

Funder	Cash (MSEK)	In kind (MSEK)	Total (MSEK)	Share of total
Industry	547.1	1207.6	1754.7	36 %
Universities and research institutes	231.3	1331.8	1563.1	32 %
Nutek/VINNOVA/Swe. Energy Agency	1447.0	0	1477.0	30 %
Other	77.1	0.7	77.8	2 %
Total	**2302.5**	**2540.1**	**4872.6**	**100 %**

Table 1 provides an overview of the contributions to the CC programme. The table should illustrate the fundamental thought behind the programme well. Industry provided 36 per cent of the total resources, of which roughly 2/3 was in kind. Industry here refers to both firms and other user organisations. The host universities contributed 32 per cent of the resources, of which in kind contributions were the by far most important. The programme funders Nutek, VINNOVA and the Swedish Energy Agency provided cash representing 30 per cent of the total resources. Detailed accounts on the resources available to each CC are presented in Appendix E.

Some CCs report cash contributions from universities, which probably to a large extent are connected to overhead costs.[44] The definitions of what to count and report as cash contributions most probably differ significantly between universities. About ten CCs also list funding from other research funders. The latter contributions are included in Other in the table and together represent two per cent of all resources.[45]

In addition to the contributions presented in Table 1, many research environments hosting CCs also received funding from CC partner firms to do commissioned research on topics that were connected to the CC projects but from an IPR perspective too sensitive to handle in ordinary CC projects. Although typically approved by CC boards and managements, such projects were formally not part of the CCs and therefore not reported to the programme funders Nutek, VINNOVA and the Swedish Energy Agency. Data on commissioned projects is for that reason not included here.

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[43] Staffan Hjorth, The Swedish Competence Centres Programme, Country report Sweden, STRATA Thematic Network "MAP-TN", 2002

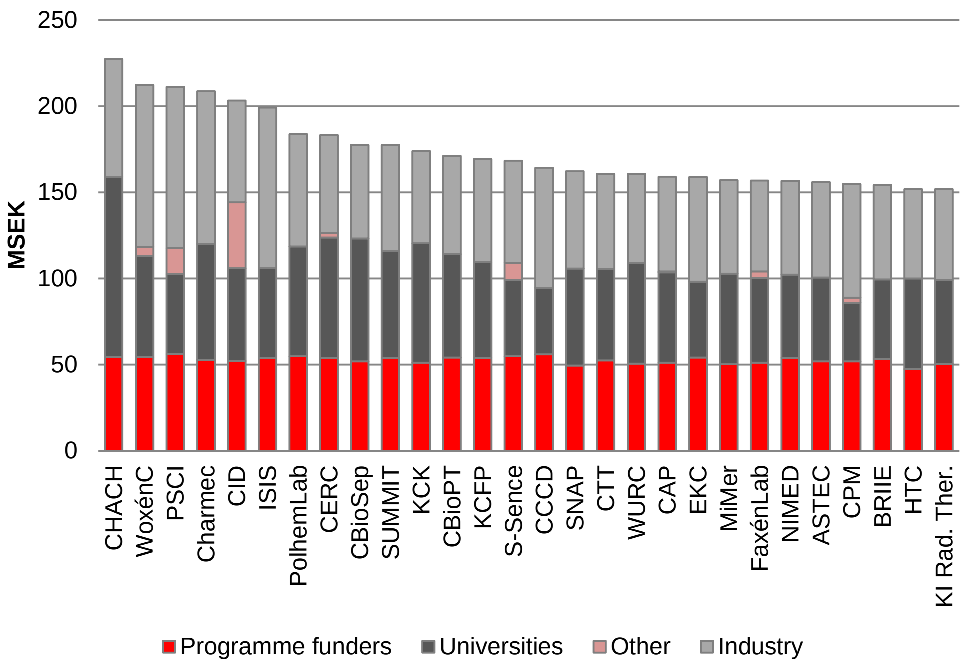
[44] The contract with the programme funders only granted universities cover for overhead costs to a certain limit. Several university managers observed that the actual overhead costs were higher, and therefore pointed out that the universities also 'subsidised' the CC by accepting the level of the programme funders. This 'subsidy' was in some cases reported as cash contributions from the universities' central administrations to the CCs.

[45] Only a handful CCs report research funding from other research funders, e.g. the Swedish Research Council, research foundation and the European Union, as part of the CC. It is likely that most research environments of which the CCs were parts in one way or another enjoyed such complements to the centre activities, but that most CCs did not include such funding in the reports.

3.1.2 Contributions per CC

Due to the funding structure outline above, the CCs were relatively equal in size. Figure 4 outlines the total contributions per centre. The largest centre, CHACH, totally comprised 227 MSEK while the smallest one, KI Radiation Therapy, received a total of 152 MSEK in contributions. The differences between the centres are mostly found in the contributions from industry and universities; the contributions from the programme funding agencies were more or less the same across all centres.

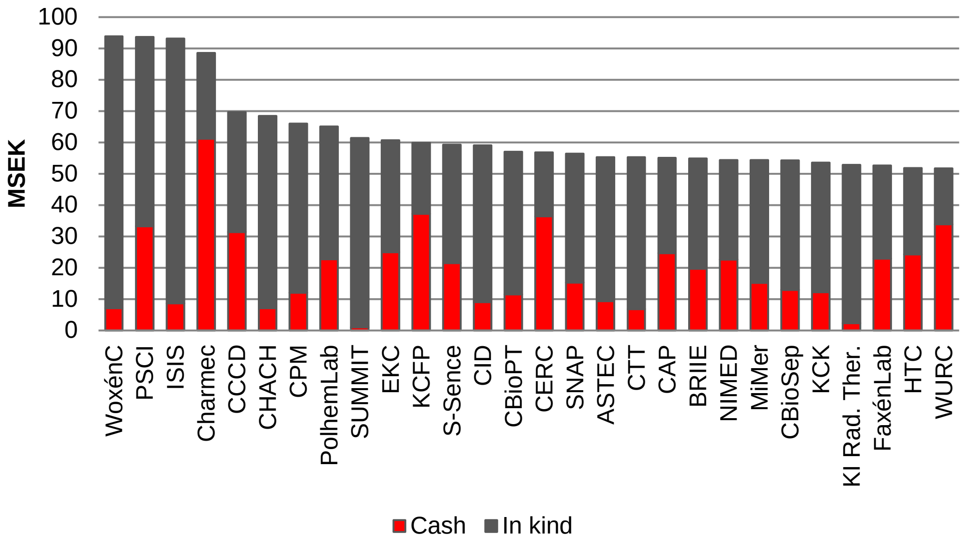
Figure 4 Total contributions per CC



Four centres received larger industry contributions than the others, see Figure 5: WoxénCentrum, PSCI, ISIS and Charmec. In the case of Charmec, the main source of the large industry contributions is 31.3 MSEK in contributions from the Swedish Rail Administration during stages 2–4, mostly in cash; the Swedish Rail Administration was also an engaged user of Charmec's output. In the cases of PSCI and WoxénCentrum the large industrial contributions are mainly explained by the large number of participants – 36 and 34, respectively – while ISIS instead kept the centre small in number of partners but reported large contributions from those companies.

The figure also reveals significant differences between the CCs in terms of balance between cash and in kind contributions. The difference is largely explained by differing management strategies. Some centres decided to only have a small membership fee, typically about 20-100 kSEK per stage for each company, and opt for mainly in kind contributions. In some cases that was necessary due to partner firms' limited ability to provide cash, for example in SUMMIT, which had many SMEs among its members. In the cases of Charmec and WURC most partner firms were short of R&D staff capacity in the CC area and therefore had to contribute mainly with cash. A couple of CCs (e.g CCCD, Faxén and NIMED) were organised largely to have companies pay for university-based PhD students who worked primarily with one company; those CCs also report a higher share of cash contributions than most of the others do. The share of cash versus in kind can also depend on how close the CC technologies were to become transferred to companies. KCFP for example, report high shares of cash contributions probably partly due to its focus on technologies that still were quite far from being incorporated into its partner firms' products. Details on all company participation in the CCs are presented in Appendix F.

Figure 5 Industry contributions per CC



Note: Industry contributions for Charmec includes 31.3 MSEK from the Swedish Rail Administration, of which 26.0 MSEK was in cash and 5.3MSEK in kind

3.1.3 Company participation per size and ownership

The CC programme organised between 314 and 337 companies during each stage, with the exception of stage one in which 240 companies participated, see Table 2.[46] Quite a few of the participating companies were subsidiaries of larger corporate groups – for example, ABB participated with at least 18 subsidiary companies, and Heidelberg Cement Group participated through the subsidiaries Abetong AB and Cementa AB. If companies are aggregated at corporate group level, we see that the total number of participating corporate groups grew for each stage, from around 150 in the first stage to around 200 in the fourth, final stage.

Table 2 shows participants separated per different types of actors. Almost all companies in the CC programme were of Swedish origin. However, many of them belonged (for parts of the period) to corporate groups with headquarters in other countries, including well-known 'Swedish' companies such as ABB, Volvo Cars and AstraZeneca. The

[46] The figures of participating firms might not be completely accurate – the CCs are not consistent enough in the way they report company participation to allow the tracing of all subsidiary companies to large corporations

group of companies owned by foreign corporations grew notably throughout the CC period, especially between the first and second stages, while the number of large Swedish companies decreased. Foreign-owned firms with no activities in Sweden could participate only with the consent of the rest of the consortium.

Most participating companies were relatively large. The number of large Swedish companies was always larger than the number of Swedish SMEs, although the latter category increased in number throughout the CC period.[47] Unfortunately the data do not allow the identification of large companies and SMEs among the foreign-owned or foreign-based companies, but it is likely that a majority of those would qualify as large companies. Large companies contributed more resources per participation than SMEs did, especially in terms of cash, but also in kind.

There were also a small number of public and non-profit organisations among the participants. Originally the CC programme ruled out participation from organisations that were not companies, but the restrictions were (at least after negotiations in each case) removed at the beginning of the programme. The participation of public and non-profit organisations was low in all centres throughout the programme period.

Table 2 Number of industrial participations per stage in the CC programme, subsidiary level

Type of actor	Stage 1	Stage 2	Stage 3	Stage 4
Large Swedish companies	128	145	126	108
Foreign-owned companies based in Sweden	76	110	106	99
SMEs	30	47	50	56
Foreign-owned companies based outside Sweden	3	7	17	21
Public sector	8	7	5	12
Other	4	7	6	8
Unknown	18	14	18	10
Total	**267**	**337**	**328**	**314**

3.1.4 Company participation per industrial sector

The top industrial sectors[48] in terms of number of participants remained relatively stable throughout the programme period, see Figure 6. The microelectronics and telecom sector was always the largest, with between 29 and 42 participations. Pharmaceuticals and medical devices, mining, steel and metals and the engineering sectors were well represented throughout the period. Two sectors grew notably: the two service sectors: software programming and engineering consultants, and services, the latter which include for example publishers, logistics and also some software companies. The paper, pulp and forestry sector and the automotive decreased slightly towards the end of the

[47] A large company is defined according to EU standard: more than 250 employees or an annual turnover of more than €50M or annual balance sheet total of more than €43M.

period in terms of participants. Also the engineering sector decreased, owing to reorganisations of subsidiaries among a couple of large firms. Few firms changed category between stages.

The sectors that dominate in number of participants also dominate the contributions, see Figure 7. The microelectronics and telecom sector was by far largest, contributing 300 MSEK in cash and through in kind work. Pharmaceuticals and medical devices was the second largest sector, contributing 184 MSEK. The automotive and engineering sectors came next with around 170 MSEK each, followed by the mining, steel and metals sector with 150 MSEK in total contributions. The energy sector was weakly represented, but energy-related issues were of concern also for many companies in the other sectors.

The balance between cash and in kind contributions differs among sectors, probably based on the R&D resources available. Microelectronics and telecom, pharmaceuticals and medical devices, engineering and automotive sectors all contain several large firms with extensive R&D resources. Microelectronics and telecom, pharmaceuticals and medical devices and the service sectors also have a relatively short step from basic research to product development, which means that they include relatively high numbers of R&D intensive small firms.

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[48] The definition of industrial sectors is based on the Swedish SNI codes. However, those categories turned out to be inappropriate in many cases, for two main reasons. First, the participations were in a significant number of cases registered on the headquarters, while the actual participation was carried out by subsidiaries. Second, the SNI codes were not appropriately defined to catch R&D intensive activities; most notably, a very high share of companies, active in wide range of sectors, were classified into 'machinery'. Based on the SNI codes and we therefore, after careful investigation of company's main activities and customer bases, reclassified a quite large number of companies and created a couple of new categories to better catch the 'actual sectors'.

Figure 6 Number of participations per industrial sector and stage, subsidiary level

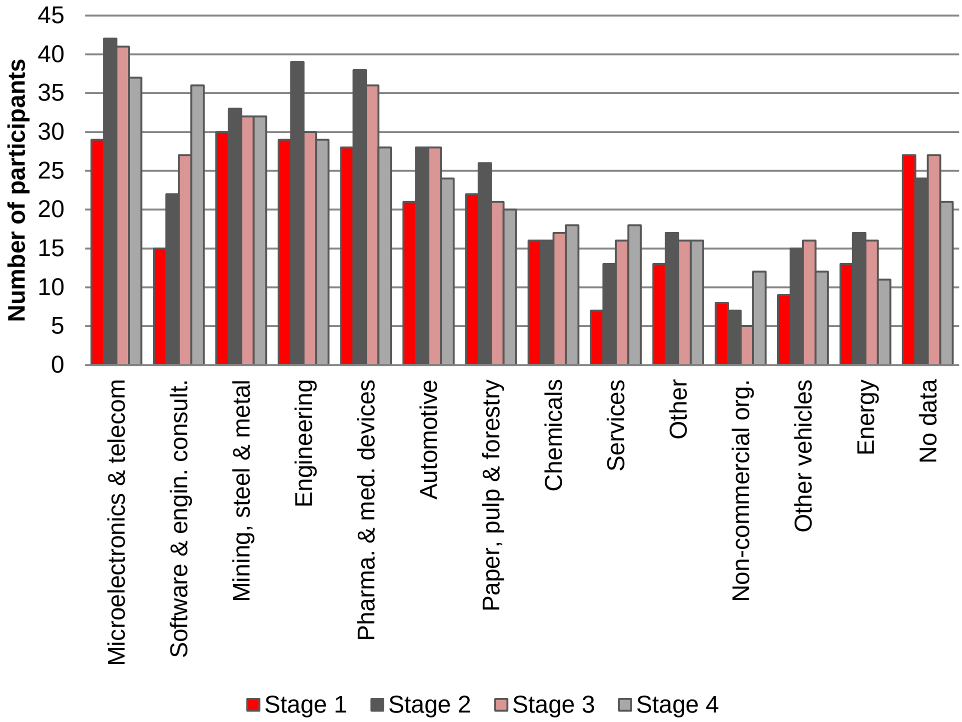
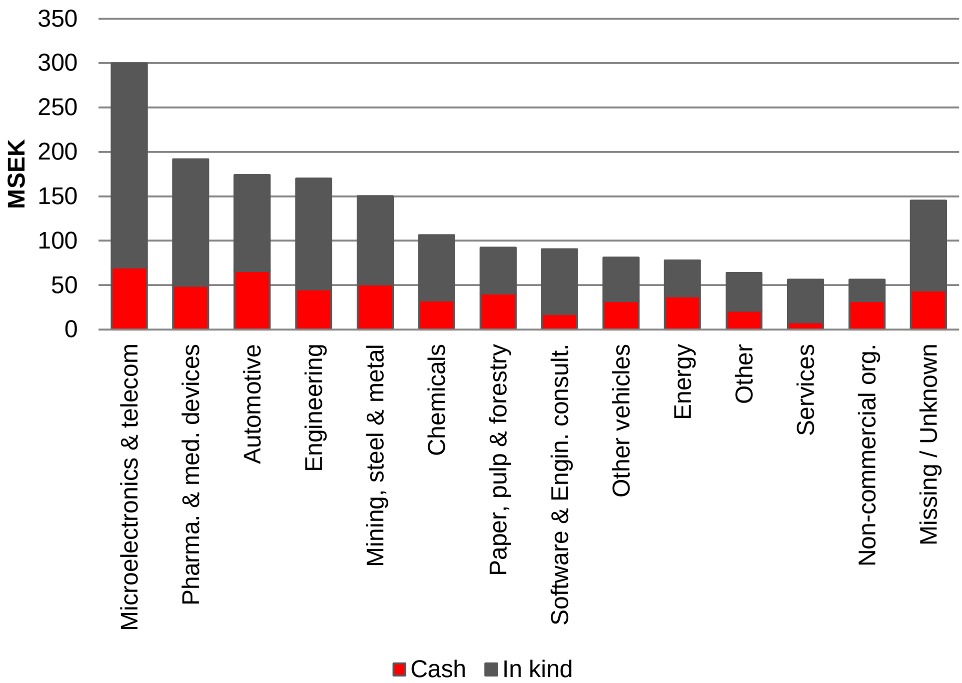


Figure 7 Cash and in kind contributions per industrial sector, all stages



3.1.5 Top participants

The CC programme engaged most of the largest companies and corporate groups in Sweden. Table 3 shows the 20 corporate groups that contributed most to the CC programme in terms of combined cash and in kind contributions, and the number of centres in which they were involved. We see that the CC programme was relatively dominated by a small number of large corporations. The 25 investigated centres totally received 1754.7 MSEK in industrial contributions. Ericsson alone contributed with 8.9 per cent of those resources through its participation in 11 of the 28 CCs. The top 5 corporations represent 26.5 per cent and top 20 stand for 48.9 per cent of the total contributions. The remaining around 250–300 corporate groups (which mostly consist only of one company) thus represent just a little more than half of the total industrial inputs to the programme.[49]

Table 3 Top 20 most contributing corporate groups

Corporation	Number of CCs	Cash (MSEK)	In kind (MSEK)	Total (MSEK)
Ericsson	11	37.1	118.5	155.6
ABB	13	31.2	71.1	102.2
AB Volvo	11	29.8	58.1	87.9
AkzoNobel	8	19.6	41.1	60.7
SAAB AB	7	13.5	44.6	58.1
Sandvik	7	19.6	28.5	48.2
Ford (Volvo Cars)	6	19.0	23.5	42.5
Vattenfall	10	15.1	26.0	41.1
Astra/AstraZeneca	5	11.9	26.5	38.4
Telia/TeliaSonera	5	9.1	27.0	36.1
Pharmacia & Upjohn/Pfizer	4	10.9	15.8	26.7
Scania	3	8.8	13.7	22.5
AlfaLaval	4	1.9	17.3	19.2
StoraEnso	5	7.3	11.3	18.6
Elekta Instruments	2	4.1	13.5	17.7
IBA-Scanditronix	1	1.0	16.3	17.3
Sydkraft	3	11.6	5.5	17.1
SSAB	2	2.2	14.1	16.3
HeidelbergCement	3	8.1	8.0	16.0
SCA	4	8.3	7.7	16.0

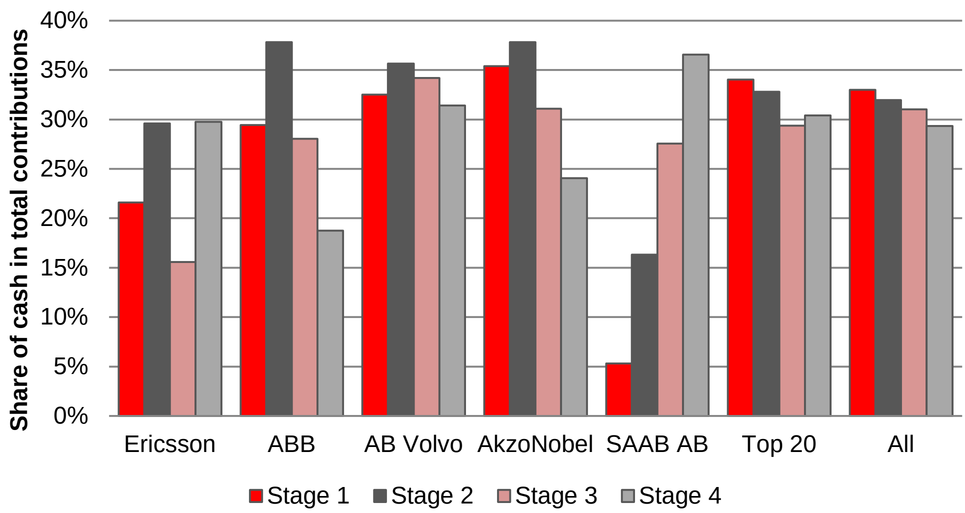
Can we from the economic data see signs of shifting strategies among the most important participants? Figure 8 compares the balance between cash and in kind contributions from the top five contributors with top 20 and all participants. The general tendency during the CC programme was a slight decrease of cash contributions – i.e. the

[49] We have not been able to trace corporate groups in a precise manner, mainly because we have lacked corporate identity numbers for a significant number of the participating firms. The top 20 list should nevertheless be accurate.

‘traditional way of collaboration’ – in favour of in kind. This tendency is also reflected among the top 20 corporations. However, the picture is not uniform among all large corporations: ABB did not decrease its rate of cash input until the last stage (when it dropped considerably) and SAAB[50] increased its cash contributions considerably for each stage, starting from a very low level. Ericsson’s balance between cash and in kind contributions fluctuated, largely due to financial difficulties in the beginning of the 2000s which led the corporation drastically to reduce its cash input during the third stage. Ericsson’s level in the final stage is almost entirely explained by reduced in kind contributions; the cash input did not increase much in absolute terms.

In several cases interviews and the economic data indicate that large corporations have increased the share of in kind contributions along the way because they find personal interaction fruitful. This seems to be the case for at least AkzoNobel, AstraZeneca and Sandvik.

Figure 8 Balance between cash and in kind contributions among top contributors



Patterns in the balance between cash and in kind contributions are however overall difficult to explain. On the one hand, growing shares of in kind contributions might be a natural development as collaborations mature, which includes more efficient personal interaction and initially more fundamental projects which approach the development phase and thereby makes industrial in kind more relevant. On the other hand, we know that many firms have reduced the size of their R&D departments, which could speak in favour of more cash contributions. Firms also make strategic decisions on whether they find cash or in kind contributions more efficient for collaborations. On top of this, there is the fluctuating economy which changes a corporation’s possibility of providing especially cash at times, as well as a pre-history where we know that several large

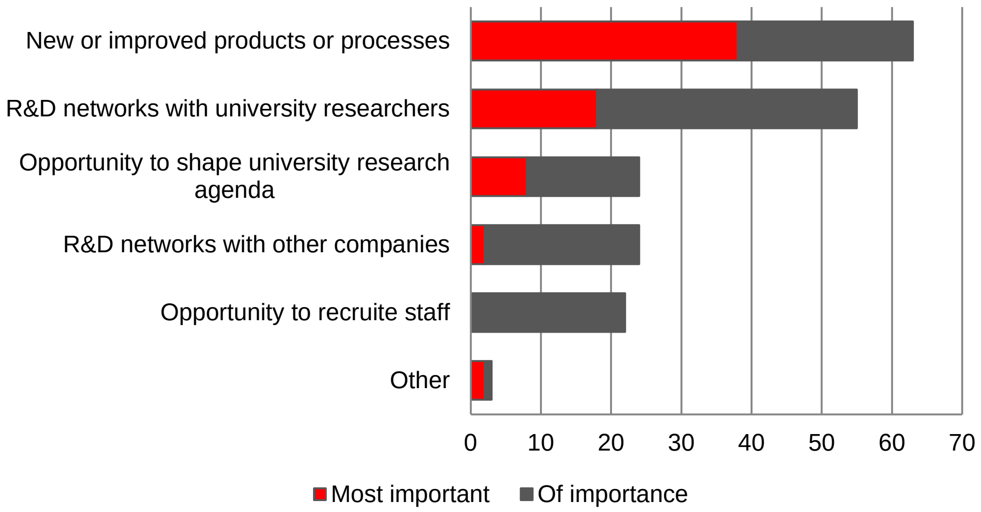
[50] SAAB AB is a corporation within the defence industry. SAAB Automobiles has throughout the CC period been part of General Motors, which are just outside Top 20.

companies had deep and in kind-based relations with the university research groups already at the start of the CC programme.

3.2 Company reasons to participate in the CC programme

Figure 9 shows that the opportunity to develop new or improved products was the most important reason to join a CC among the interviewed companies, followed by opportunities to build R&D networks with university researchers. Opportunities to shape research agendas of universities, to create R&D networks with other companies, or to recruit staff mattered as well, but were all less important than the former two. Participation because of opportunities to develop products or processes was particularly important for small and less R&D intensive companies. The opportunity to shape research agendas at universities and recruitment of staff was mostly mentioned by large companies. Since large companies are over-represented among respondents, responses to the latter two alternatives are therefore probably skewed.

Figure 9 Reasons to participate in CC



Note: N=68

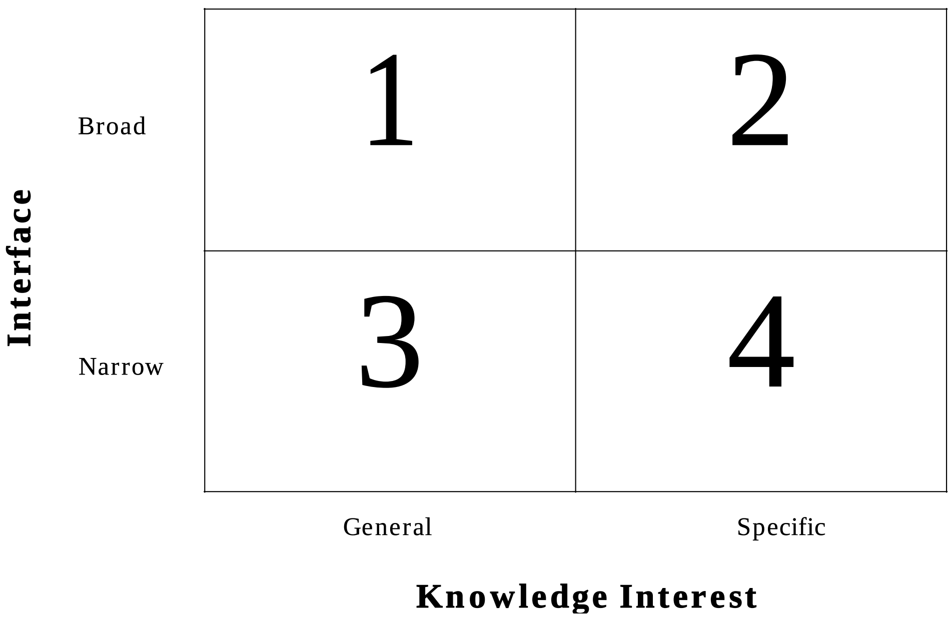
More broadly, when it comes to company motives for participation in the CCs, there are a number of different views depending on a number of different circumstances. In general, it is possible to state that the companies are in it for the results generated in the projects, which also serve as the grounds for their ability to develop and innovate. It is, however, far from always the case that the results obtained in the CC activities are directly applicable in the company development of products or processes. They often need further refinement to make that possible.

Apart from the specific results from project participation, the companies are also generally in it for a general knowledge development, from which they are able to benefit on a long-term basis. They are further in it for the opportunity to minimise risk. The university is often perceived as an actor that can take technological risks not viable to the companies. Where a mistake would cost the company a lot of money, for the university it is rather seen as representing learning and pushing the research frontier further. The networks built in the CC context are also seen as valuable both as knowledge development and business development networks, and an important part of the motive for the company participation. And, finally, many companies point to the possibilities to recruit highly competent people that are skilled in relevant areas.

For the companies, the CC model has been very rewarding, since it encourages an extensive and good dialogue and a mutual understanding between companies, universities and other government agencies involved. It has created an added value for the companies by leverage of their financial input, and by helping to open up the universities to deal with research problems relevant to company development.

The participating companies are in fact actors who develop and maintain a knowledge interest that is either general or specific, and an interface with the university sector which is either narrow or broad. It is possible to structure their different kinds of motives and behaviour along these dimensions. This is illustrated in Figure 10 and suggests that CCs can address the needs of quite disparate kinds of company.

Figure 10 Fields of company knowledge interest and interface with the university sector



In the figure there are four different combinations of a company knowledge interest and interface with the university sector. In the first quadrant, the company tends to be large, to have a general knowledge interest and a broad interface with the university sector in Sweden and abroad. This would typically be a response to the notion of the world developing fast, a need to form many alliances in larger networks to cope and therefore some interest in open innovation. Swedish companies of this type often fund chairs in more than one country as well as participating in different competence centres and both domestic and international programmes of other kinds. This way, the company seeks knowledge to support multiple lines of business where it can be found. It is clearly not an option for a small company with very limited resources to spend on R&D activities, let alone any long-term basic research. Examples of CC companies in this quadrant might be Höganäs AB and Volvo Car Corporation.

The second quadrant represents the combination of a specific knowledge interest and a broad interface with the university sector: relatively specialised but generally large firms looking for knowledge and human capital inputs from several universities. Company motives tend towards getting access to international expertise and/or a general technological development to achieve usable knowledge or help solving some specific problem of significance to the company's development. Examples of CC companies in this category might be AstraZeneca and Sandvik.

The company with a general knowledge interest and a narrow, focused interface with the university sector, as in the third quadrant, is likely to engage in joint efforts to build competence and to be a long-term promoter of both undergraduate and graduate education. It is interested in good research results, which can be used to enhance both capability and competence. Examples of CC companies in this category might be Ericsson AB and ABB.

Finally, the fourth quadrant represents the combination of a specific knowledge interest and a narrow interface with the university sector. Clearly, this is what characterises many of the small companies participating in the CCs. For them, it is a way of obtaining research, efforts skills and resources that they do not possess themselves. They can be taken to be in need of competence and skills in specific technical areas, and looking for new technical solutions. Examples of CC companies in this category might be Lucchini, NIRA Dynamics and Omnisys Instruments AB. Companies in this quadrant tend to be smaller.

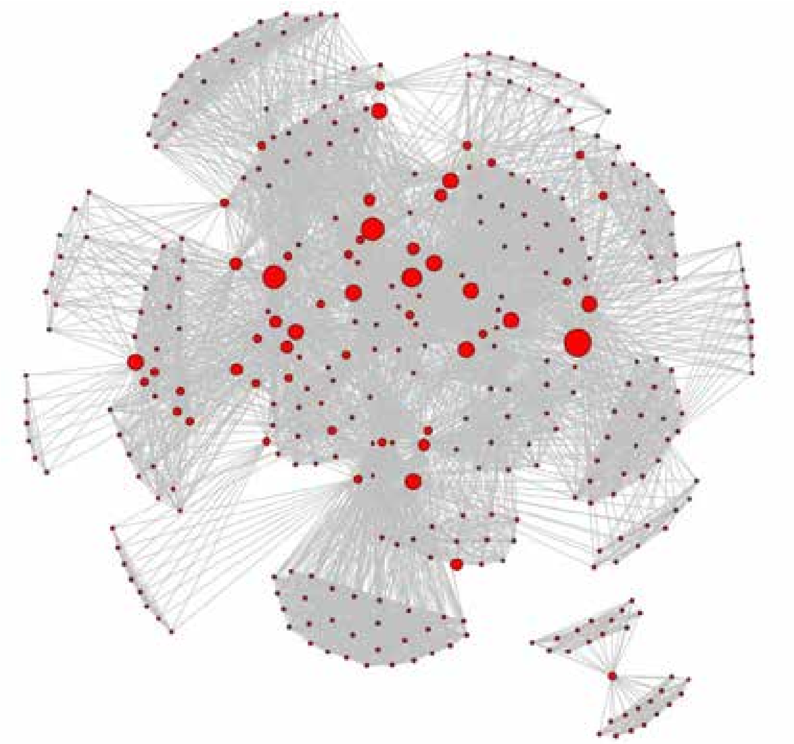
This way, the Swedish competence centres programme, and the way it regulates and establishes the relations with and between participating companies, has been able to serve the interests of quite many companies that were different in terms of both their size, their knowledge interest and their narrow or broad interface with the university sector. Thus, the relationship between each participating company and the university part of the centre, as well as how results from the CC projects have been utilised, largely depend on how companies stand in these respects.

3.3 Network analysis of the CC programme

Figure 11 is a representation of the complete network of companies that have been participating in the CC programme (a detailed version of the figure, with names of selected companies, is presented in Appendix H). In this CC universe, some distinctive features and patterns are visible. The size of the nodes is proportional to companies' numbers of participations. In other words, a general interpretation of the picture is that proximity between companies indicates closeness in terms of collaboration in centre activities. This would tend to create agglomerations or clusters of companies, which correspond to the specific CC's in which the participation takes place.

Several companies have been participating in more than one CC, and should consequently at the same time be close to other, completely different companies in other CCs. These companies are pulled out from any specific single agglomeration or cluster of companies, and located somewhere in between the different groups of companies belonging to the CC at hand. These companies located 'between' more CC-specific networks therefore span different technology or business communities. Companies participating in more than one CC are among the larger companies, with a portfolio of complex products and relations to several technologies on which their production and product development are dependent. The Swedish CC universe as a whole is so closely interconnected that almost every one of the participating companies is at least indirectly linked to the others through their participation in a CC.

Figure 11 Company network relationships within the CC programme



Different parts of the network can be interpreted as representing different technologies and sectors, which define the business of participating companies as well as the problem areas which provide the basis for the collaboration between the CC actors.

The obvious place to start would be in the south, south east sector of the network. Here we find the two clusters that are disconnected from the rest of the network. Located furthest out is the group of companies that have been active in the KI Research Centre for Radiation Therapy, and next to that those belonging to NIMED. Both of these CC's are in the area of medical technology, and the companies involved are mostly producers of medical instruments of equipment.

The companies in these groups are connected to each other, but not to any others with only one exception. Elekta, was part of both KI Radiation Therapy and NIMED.

Moving to the very southern part of the picture, there is a group of companies that have mostly been involved in the IT software sector, and were a part of CID as a CC. Being in the IT software sector would actually mean that these companies would be expected to show up more in the eastern part of the network (more on that later), but the very specific focus on user orientation that was an attribute for CID obviously made them closer to each other than to anyone else, even though they also are linked to many other companies. It also seems that when, for example, Telia was involved, it was other parts of the company than those participating in other CCs.

To the west of the former group is another group of companies in the railway sector, linked to Charmec. They are in turn connected to other companies in the network that are in the engineering sector.

Moving upwards, to the north, from the railway cluster, we come to the western part of the network, which is characterised by the fact that most companies are part of the chemistry sector mostly from a biochemistry technology point of view. An important actor in these areas as a company is AstraZeneca, which has also been involved in four of the CC's. As a large company, AstraZeneca differs a bit from the other large companies in that it seems more specialised and with more or less exclusive relations to only those companies involved in its own part of the network.

In the figure, AstraZeneca is situated together with most of the companies that also were a part of CBioSep. Immediately to the south of this group, most of the companies that were part of CBioPT are found. To the south west of the company, the group of companies which mostly belonged to SNAP are found, and to the north west of AstraZeneca we see most of the partners in CAP.

Thus AstraZeneca, although one of the larger companies, will still be a little isolated. When compared with for instance EKA Chemicals, who was a partner in two of the CC's, CAP and CBioSep, the latter company was also at the same time involved in KCK, S-SENCE, FaxénLab and WURC, which makes it connected also with other technologies and sectors, such as mechanical engineering, manufacturing, pulp and paper and the automotive sector. The same actually goes for Pfizer Health who, apart from having shared involvement with AstraZeneca in CBioSep and CBioPT, also was active in S-SENCE and PSCI, from which followed that it became more a part of the IT and manufacturing sector as well.

Companies operating in materials technology are situated in the most northern parts of the network. They include companies from the mining, metals machines and tools sectors. The north-western group of companies generally belonged to MIMER, and the other northernmost, smaller group a little to the east mostly belonged to BRIIE.

Squeezed in between the materials groups and the larger group of closely interconnected companies, a couple of smaller groupings are found, with companies from the automotive sector, which have been parts of centres on catalysis and combustion engine research.

As we move southwards in the figure on the eastern edge of the network structure, the different groups of companies in information technology and the manufacturing, hardware and software sectors show up. The centres where they have been involved were, in turn, ISIS, ASTEC, CHACH, CTT and CCCD. This is as apparent as the chemistry/ biochemistry properties found in the western part of the network. The larger companies closest to the groups of companies in these centres and sectors are the likes of Ericsson, Saab and ABB Automation/Robotics, which were also all parts of several of these centres, and therefore are at least pulled towards the east.

Finally, there is the quite large number of interconnected companies that are found closer to the centre of the network structure. The composition of companies in these parts of the network is clearly an illustration of the technology fields and the sectors at the heart of the complete CC initiative. A substantial share of all participating companies are from the manufacturing and mining industries. In the central parts of the network many of these show up. They are often in the production engineering or information technology field, and or manufacturing sector more generally.

The CC's involved have been FaxénLab, WoxénLab, ASTEC, ISIS, PolhemLab, CPM, and PSCI, and here is also where we find several of the large companies, like two Volvo companies making cars and trucks respectively, Scania, Alfa Laval, Sandvik and other parts of ABB.

The overall meaning of the pattern of the Swedish CC network would thus be that it decomposes into a number of knowledge and technology areas, where the participating companies have different roles depending on their product portfolio, whether their knowledge interest is general or specific and the character of their interface with the university sector, whether it is narrow or broad. Companies develop different strategies for the production, dissemination and use of knowledge depending on the needs of their specific products. Their size and the availability of resources for R&D influences their networking behaviour.

Bozeman and Rogers[51] have developed the idea of 'Knowledge Value Collectives' (KVCs), to describe networks of people and institutions that work with related sets of knowledge. They need not all know, or even know of, each other. But, in effect, we can think of KVCs as being building blocks of innovation systems. They do not coincide with programmes, projects or institutions – crucially they are not the same as firms. The human capital of a KVC outlives the creation or death of individual companies. Thus, Ericsson's large lay-offs of R&D personnel in the early 2000's led to a lot of new entrepreneurial activity in the Stockholm region rather than to decline and the Stockholm IT cluster continues to be robust.

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[51] Barry Bozeman and Juan Rogers, 'A churn model of scientific knowledge: Internet researchers as a knowledge value collective,' *Research Policy*, Vol 31, 2002, pp 769 - 794

The boundaries of the knowledge value collectives are not either exactly the same as for the different competence centres the companies are parts of. The complexity and the types of relations between participants also differ between CCs, depending on whether companies also make use of either knowledge or components produced by other participating companies, even if they are not even necessarily subcontractors in the case of knowledge.

This is the way to understand how for example Volvo Cars navigates in the CC landscape and connects to different knowledge and technology areas. As a manufacturer of cars with significant resources for R&D and an interest in competence centres, it spans multiple sub-networks in search of inputs to its wide-ranging innovation processes. By having a complex set of needs for different kinds of knowledge and by connecting to these different areas through several CCs, Volvo Cars becomes one of the central and interlocking nodes in the network.

This would also be the way to understand the role and position of Ericsson in the network structure. Its involvement in several CCs corresponds to the different knowledge needs it has with respect to the development of the different parts of its complex product businesses. It too has large, internal R&D resources, which to a significant extent are used to collaborate with researchers at different universities and competence centres.

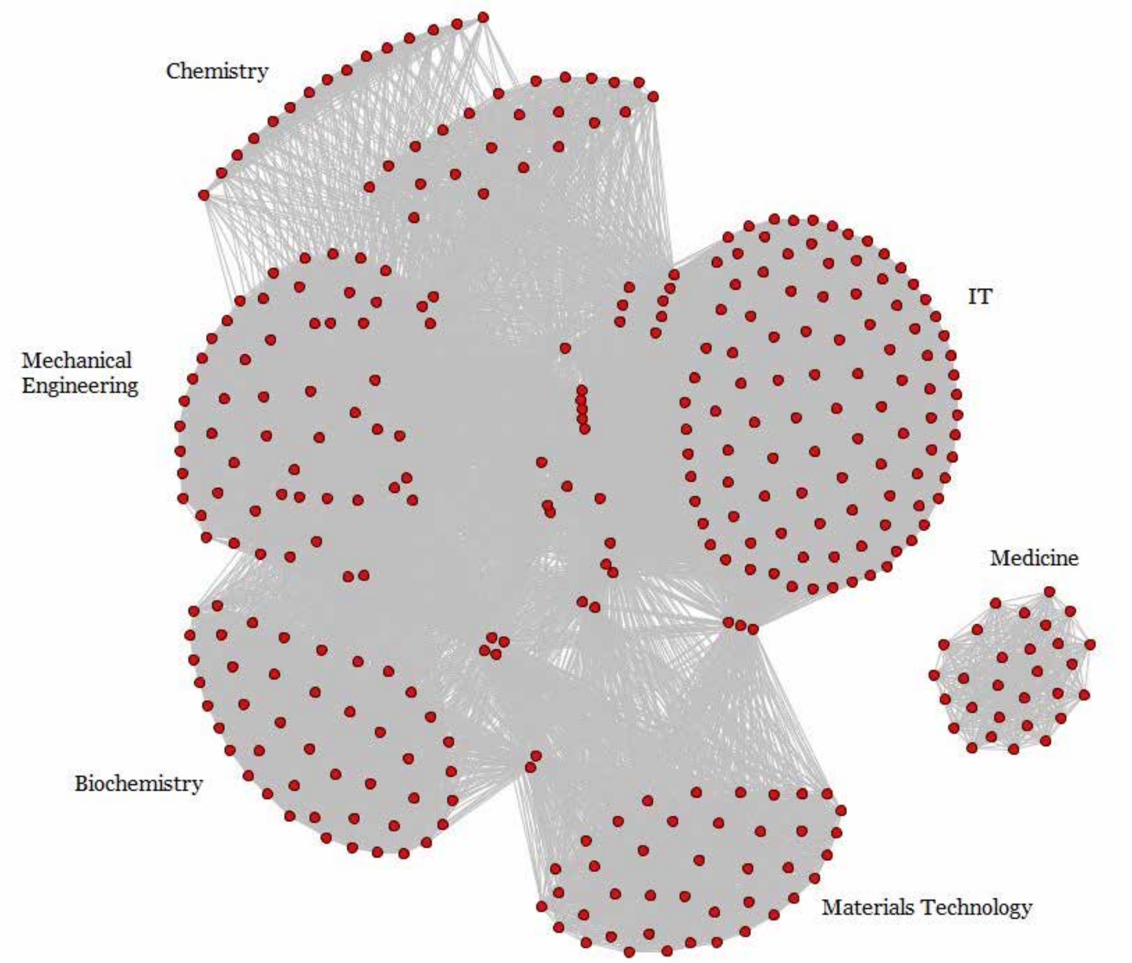
Another clear example of an interlocking node, but on slightly different grounds, is EKA Chemicals (part of AkzoNobel). It does not, in the same way as Volvo Cars, use knowledge from different domains to develop smaller parts of a limited number of complex products, but is rather involved as a supplier of chemicals to different companies for different use in different sectors. Its innovation process and therefore its networks are strongly driven by individual customer needs. Hence it has to be present in very many places and therefore several CCs.

Having these different approaches to the development of knowledge and competence and executing different roles in the systems, the large companies participate in between three and nine CCs, which also makes them important as both generators and receivers of ideas and results also from other participating companies.

The smaller companies generally have a different type of product portfolio, often a more specific knowledge interest and narrow interface with the university sector. Hence, their role in the system is obviously not the same as the larger companies. Those companies that have the interconnecting role described above are in fact very few. A vast majority, around 82 per cent of all participating companies, participate in only one CC.

Networks of participating companies can be assembled in different ways. If we put together the network with each CC’s technological field as base, we get the picture visualised in Figure 12. The figure thus shows the interconnections between technological fields through companies in the CC programme. The distance between chemistry and materials technology means that the two fields had little or no interconnection through CC companies. The red dots in the middle represent companies that to various degrees participated in centres in several technological fields. Most of these are large firms – towards the upper part of the middle we find mostly large companies with interest in IT, for example Ericsson, ABB, TeliaSonera and AB Volvo. In the lower part of the middle we mostly find Sandvik and other companies focusing more on materials.

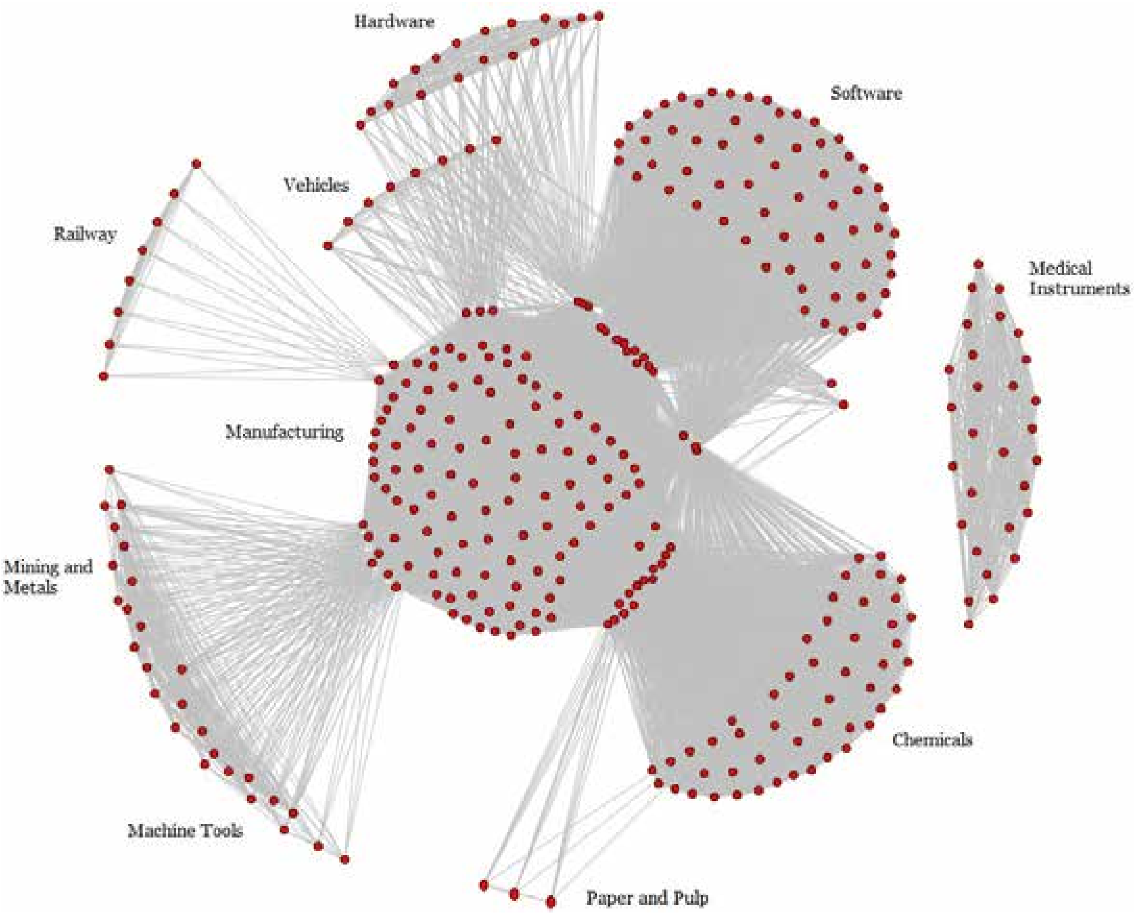
Figure 12 CC company network relationships based on technology



A network based on the industrial sector – a 'top-down' approach compared to the 'bottom-up' of technological fields – based on a classification of CCs is shown in Figure 13. We then find that one industrial sector, manufacturing, serves as a central sector to which other, often more specific sectors link. The 'strings' of red dots between two sectors represent companies that were active in CCs belong to both sectors. We find a remarkable concentration of top contributors in the boundary between manufacturing and software: these dots represent companies such as Ericsson, ABB, SAAB and TeliaSonera. The string between chemicals and manufacturing primarily contains companies in the paper and pulp industry and in pharmaceuticals.

To sum up this section, the network constituted by the CC programme as a whole is well interlinked. The network images reveal clusters of firms from the same branches, usually involving more than one centre. This is where the knowledge value collectives are most importantly found. There were also more functionally oriented centres, which provide links among branches. The highly connected network of CC participants suggests an industry structure within which information travels rather easily.

Figure 13 CC company network relationships based on industrial sector



3.4 Company participation in European Framework programmes

The CC scheme involves a large number of companies that are members of international R&D networks. Some 116 of the companies involved in a CC have also participated in at least one of EUs Framework programmes studied here (FP4, FP5 and/or FP6). A rough estimate is that somewhere between one in three and one in four of the CC companies have also participated in EU Framework programmes.[52] As shown in Table 4 the majority (57 per cent) consist of large companies, a fifth is SMEs and 23 per cent are subsidiaries of foreign corporate groups. 54 per cent of the 116 companies participated in FP4 (1994-1998) and equally many in FP5 (1998-2002). Slightly fewer participated

[52] Participation in EU Framework programmes is more often than CC participation registered on the headquarters of the corporate groups, not subsidiaries, which makes it difficult to estimate the exact share of companies that have participated in both.

in FP6 (45 per cent, 2002-2006). The percentages are calculated on companies for which consistent data has been available regarding size of the company at the time of their CC participation; consequently data are missing for five of the CC companies participating in an EU FP.

As also can be seen in Table 4 there is an opposite distribution regarding size of the companies which have not participated in any of the FPs mentioned above. 46 per cent are SMEs and a third is large companies. The share of subsidiaries of foreign groups is 24 per cent which almost equals the share of those who are participating in a FP. Because of the same reason mentioned above data are missing for 39 of the companies not participating in a FP.

More than half of the CC companies (56 per cent) who have been involved in projects within any of the FPs have participated in particularly one FP during the CC programme. More than a third (34 perc ent) has been involved in two FPs while only 9 per cent has been involved in all three FPs.

Table 4 Number of CC companies distributed on FP participation and size of company

	SMEs	Large companies	Subsidiaries of foreign groups	Total
Number (share) of CC companies participating in EUs FP4, FP5 and/or FP7	22 (20 %)	63 (57 %)	26 (23 %)	111
Number (share) of CC companies not participating in an EU FP	79 (46 %)	53 (31 %)	41 (24 %)	173

The currently ongoing FP7 runs from 2007-2013 and started after the CC programme was ended. The data available so far show that 36 per cent of the CC companies that participated in any of the earlier FPs (4^{th}-6^{th}) also participated in FP7. In addition 17 CC companies are only participating in FP7. When FP7 is included the share of CC companies that participates in all four FPs is 7 per cent.

The CCs and areas in which they are active in can be split up in different technologies and sectors. When comparing the type of CC activities with activities in the FPs for the companies the overall picture is that most of them are active in the same kind of sector or area.

3.5 Company engagement after CC termination

At the end of the ten-year funding period of the CC programme the Energy Agency decided to continue funding for the CCs. VINNOVA stuck by the original position that centre funding should last only for ten years, allowing it to replace it with other programmes and centres, most notably in the VINN Excellence Centre Programme. What has happened to the terminated CCs?

Table 5 shows which VINNOVA funded CCs that continued as centres after VINNOVA terminated CC funding. Eight of the 23 centres continue. Two centres, Charmec and CPM, with the same name as during the CC period but in smaller format, and six former CCs live on as new centres in other VINNOVA programmes. A relatively large share of CC firms decided to continue in the new centres. Two former CCs have a higher rate of drop-outs than the other four, CCCD and PolhemLab, which mainly seems to be due to more radical strategy changes between the CCs and the new centres than in the other four cases.

In addition, several CCs that did not continue as new centres have to various degrees formed parts of new VINN Excellence Centres. ASTEC and SUMMIT form much of the basis for WISENET. Researchers in S-Sence have split up on a couple of new centres, including FUNMAT. A couple of research groups in SNAP are part of SuMo Biomaterials.

Table 5 What happened to the VINNOVA centres after the funding period

Name of CC	Continuation	Number of CC firms that continued in new centre / Number of firms in Stage 4 that did not continue
ASTEC	No new centre	
BRIIE	New centre, HERO-M (VINN Excellence Centre)	5 /2
CAP	No new centre	
CBioPT	No new centre	
CBioSep	No new centre	
CCCD	New centre, SoS (Industry Excellence Centre)	5/5
CHACH	New centre, GigaHertzCentrum (VINN Excellence Centre)	5/2
Charmec	Continues in smaller scale, supported by Swedish Transport Administration and participating companies	
CID	No new centre	
CPM	Continues in smaller scale, supported by participating companies	
CTT	No new centre	
FaxénLab	No new centre	
Isis	New centre, LINK-SIC (Industry Excellence Centre)	4/2
KI Rad. Ther.	No new centre	
Mimer	No new centre	
NIMED	No new centre	
PolhemLab	New centre, Fastelaboratoriet (VINN Excellence Centre)	6/6
PSCI	No new centre	
SNAP	No new centre	
S-Sence	No new centre	
SUMMIT	No new centre	
VoxénC	No new centre	
WURC	New centre, CRUW (BFP, Sectoral R&D Programme for the Forest-based Industry)	6/2

In the other 13 cases, no new centres have been formed. A couple of those seem to have had to some extent limited interest in continuing as a centre due to technological developments or changes in industry structure that had made the CC theme a bit outdated. In the other cases unsuccessful efforts were made to attract new funding from for example the VINN Excellence Centre programme. A handful of former centre directors and participating companies express great disappointment at VINNOVA: they point at very positive evaluations, proved research excellence and great engagement from participating industry – and they point at considerably lower research funding today, and networks that only live on as personal, not organisational links. Overall, terminated funding particularly seems to have affected the ability to maintain a broad platform for seminars and meetings where firms and researchers meet each other. Participating firms have in no case – also not in Charmec and CPM –been willing to increase their cash provision to partly compensate for the withdrawn VINNOVA funding. Quite a few companies in terminated CCs still work with researchers in the CC, but almost exclusively on a bilateral level. Only two CCs live on without new programme funding, in both cases with less funding for academic research than before. The ability for terminated CCs to live on without other programme support thus seems to have been very limited, often despite considerable interest from participating industry in continuing.

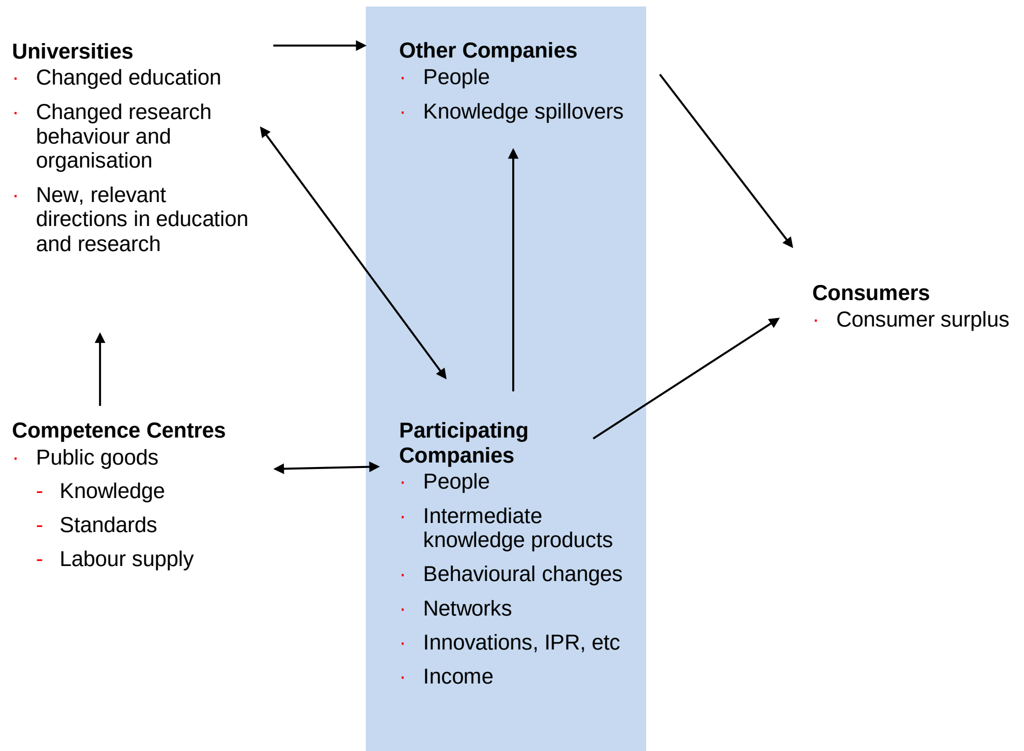
4 Industrial impacts of the competence centres

In this chapter – the main chapter of the report – we describe impacts on companies deriving from their participation in the CC programme. These impacts have been grouped as

- Direct impacts on industry, through generating directly usable outputs
- Direct impacts through behavioural additionality, including creation of knowledge networks
- Economic impacts on participants
- Economic development of individual SMEs participating in CCs
- Indirect effects through adding to the firms' stock of internal resources
- Spillovers
- Indirect effects, via the university system

This report focuses on the **industrial** impacts of the competence centres programme over the long term. These are a combination of short- and long-term effects – both direct and indirect. Figure 14 offers a (simplified) model.

Figure 14 Hypothesised impacts of the Swedish competence centres



Effects and impacts of the CC programme can be conceived of in several ways. There are a number of direct impacts of the CC programme, which include the direct impacts of the outputs from the CC at hand. Examples of this are direct increases in revenue following from increased sales, productivity improvements, cost savings, royalty payments, the value of spin-off companies established, the provision of education and training, reduced emissions, increased energy efficiency or improved health and well-being.

The character of R&D&I investments is also such that a number of indirect impacts, benefits and spillovers, arise, which are expected to improve productivity, diffuse innovations, increase quality and so on. Data about the output and impact a CC produces are not readily available. In this study we have had to rely on estimates and approximations obtained through interviews with participants in projects and management of the CCs. Although in many ways very knowledgeable, these people have generally not systematically gathered data and insight on these matters.

There is little evidence that outputs and effects are consistent across participating companies, sectors or the economic variables considered, because of the nature of the CC programme and the clearly differing outputs produced by each CC. Some of these include investment benefits, such as future cost-saving opportunities, and efficiency gains, while others are more focused on the export market and improving the competetiveness of the companies and Swedish industry. The economic gains will also vary across industries and technologies, since some industries are generally more receptive to the creation and implementation of new technologies, whereas others have reached a stage where new technologies are harder to come by.

By no means all of these effects can be quantified. Nor could they necessarily be added together if a common denominator could be found, because many of them belong in multiple categories, so adding would also involve double counting. However, the collective impacts are clearly substantial.

4.1 Direct impacts through directly usable outputs

4.1.1 New products

Some companies have as a result of participating in CCs developed and put whole new products on the market. The number of those products is not very large. As with other pre-competitive, collaborative R&D programmes, the main outputs of the CCs are ‘intermediate knowledge products’. Most CC participants offer products that are complex and/or very expensive and time-consuming to develop. Knowledge generated in working with the CC is more likely to solve a specific problem within the product development process than to define an entire product. Hence, few firms have had entirely new products as main goal for CC participation. Most of them however hoped to improve existing products, and nearly all of them participated in order to build capacity or to develop their processes. In addition, many firms were able to exploit the high rate of subsidy in the CC funding deliberately to take significant risks in the CC-projects, which increased the risks of failure.

There were also a number of cases in new products were almost realised, but due to external factors did not make it to the markets because of

- Changes in markets. Markets are difficult to predict – new standards, changed customer preferences, or new products offered by competitors can make the most successful projects obsolete
- Changes in finances. The development of the national and global economy, an unexpected dip in the company's sales, or (especially for SMEs) changed strategies among external investors can make also promising projects impossible to fund
- Changed corporate strategies. Many CC-participants were or became parts of large MNCs, which could change strategies or sell divisions that participated in CCs; a result could be that the participant lost interest in the CC area

Large companies are generally better able than SMEs to handle external shocks, for reasons such as better finances (which also enable more long term strategies), more diversified supplies of products, and more established positions on the markets.

We would nonetheless expect to find new products primarily in SMEs, most fundamentally because SMEs had limited resources for activities where pay-offs can be expected in the long-term. Participating in CCs mainly because of capacity building or networkking – like some of the large companies did – would to many SMEs be a 'luxury' they could not afford. SMEs were therefore more focused on products. In addition, most large companies in CCs worked with products too complex to be developed solely as a result of CCs (e.g. ABB, Ericsson, Sandvik and participants from the automotive industry).

We observe two main categories of new products launched based on CC-projects. The first category is products that had a short and comparably cheap transition from research to market. Such products are observed in three companies.

- Abetong AB has with the help of Charmec developed a new type of railway sleepers in concrete, which also led the company partly to rebuild its manufacturing plant. Abetong is a subsidiary to Heidelberg Cement, which is one of the world's largest cement producers. Abetong has about 500 employees in Sweden and an annual turnover of around 1 BSEK. The new sleepers are designed to replace wooden ones impregnated with creosote oil. Creosote is harmful to the environment and will therefore be banned from 2018, which creates a demand of around 40 000–120 000 new sleepers per year. Charmec has helped Abetong to develop concrete sleepers with mechanical properties similar to wooden sleepers; without similar properties wooden sleepers and concrete sleepers cannot be mixed. The Swedish Transport Administration, which is the main customer to Abetong, also requires long lifespans of sleepers – the by far largest costs for railways relate to maintenance. The new sleepers have an expected lifespan of 40–50 years. Charmec has developed a design tool that Abetong uses to optimise sleeper designs. The tool takes into account the entire track structure, including the interaction between train and track. The tool has been further refined by Abetong. As part of its analysis Abetong has used the tool to determine how various design parameters affect the full track structure. The new product has contributed significantly to Abetong signing a new contract with Swedish Transport Administration. With the new contract Abetong controls 60 per cent of the market segment in Sweden, which equals sales of around 135 MSEK per year, equivalent to between ten and 15 per cent of the company's annual turnover. Abetong has also filed a patent application for the new sleeper.

- AkzoNobel Surface Chemistry AB has with the help of SNAP developed a set of low-foaming alkyl glucosides sold as hydrotropes and wetting agents in alkaline or high electrolyte applications. Demand for such products is found in agricultural applications, where glucosides are often used as secondary surfactants. The company has put two such products on the market. The markets for the products are small, but AkzoNobel has large shares of the European markets. The sales of the products amount to around 2.5 per cent of AkzoNobel Surface Chemistry's sales in Europe, which means about 40-60 MSEK per year
- Lyckeby Starch AB has developed a new product as a result of participating in CAP. Lyckeby Starch is part of The Sveriges Stärkelseproducenter Group, which has about 600 employees in Sweden and an annual turnover of 1.2 BSEK. Lyckeby Starch develops and sells starch products for technical applications, fibre, protein, adhesives and construction paper, mainly based on starch from potatoes. Customers are mostly found in the chemical and construction industries. With the help of CAP the company developed a product based on amphiphilic polymers for use in emulsions in food products such as mayonnaise and dressings. The product has brought the company into new markets

The second category is new products whose 'cores' were developed in CCs. Those products include start-up companies formed around single products based on very specific technologies, and products based on computer programming and algorithms.

- NIRA Dynamics AB has as a result of participating in ISIS developed a method to measure the pressure in car tyres. NIRA Dynamics was founded in 2001 and is today part of Volkswagen Group. The company currently has 34 employees and had a turnover of around 52 MSEK in 2011. The company develops and sells sensor fusion based systems for vehicle applications. Sensor fusion is described by the company as "using information from several different physical sensors to compute new, virtual sensor signals".[53] So far the company has only put one product on the market: a system that monitors pressure in car tires. The product is expected to result in more optimal air pressure in ties, which should prevent accidents and contribute to more environmentally friendly driving. The core of the technology is a method developed in ISIS. The innovation made NIRA Dynamics world leading in the area, which resulted in Audi, Volkswagen Group buying 95 per cent of the company in 2006. The competitors of the company offer products based on a different method, which is less advanced. The product was first installed in Audis in 2006 and is now used also in several Seat and Volkswagen models. The company also has other large producers of cars and car equipment as customers or partners.

[53] www.niradynamics.se

Monitoring systems for car tires has been mandatory for new cars in the U.S. since 2007, and from November 2012 it is also mandatory in the European Union, which makes NIRA Dynamics' market grow. See case study of NIRA Dynamics in ISIS, section A.9

- ProcessFlow Oy in Turku, Finland, developed a simulation model for flow in pulp for paper making as a result of participating in FaxénLab. ProcessFlow is a small consultancy firm focused on mathematical modelling and simulation. In August 2012 the company had 23 employees. The product was based on a model that used data on e.g. pulp characteristics and pressures to predict the flow of the pulp in paper production processes. Based on the product ProcessFlow has both been able to establish relations with new customers and deepen relations with existing ones. The project at FaxénLab directly led to a large project with a paper producer, and the product has later been used in collaboration with Metso and other paper producers
- Södermalms Talteknologiservice (STTS) entirely builds on its participation in CTT. STTS is a small privately owned SME, founded in 2002, that in 2011 had about five employees and an annual turnover of 8MSEK. The company develops and sells language and speech technology, mainly lexicon databases, speech synthesis and speech recognition. It also produces tools for development in the speech technology field. STTS's prime product is a dictionary for GPS services. The company is the largest subcontractor to the world's largest producer of GPS services. STTS is about to release several more products that build on work done in CTT. STTS is not a spin-off from the CC, but was founded by former employees in the research environment hosting the CC and has therefore been capable to maintain close links with the researchers. See case study of STTS in CTT, section A.11
- Gotmic AB develops and sells high-speed circuits based on wireless LAN (WLAN) for very high frequencies. The company is presented in 4.6.1
- Intenz Biosciences AB is a biotechnology spin-off based on an innovation that AstraZeneca made in SNAP. The innovation is to use enzymatic catalysis of chemical reactions to produce compounds that are more difficult or costly to produce by other types of catalysis, in a process that is also relatively environmentally friendly. The idea is to use the surfactant in products that interact with human skin, mucosae, or other sensitive tissues; primarily pharmaceuticals, but the company also hopes to use it in for example shampoos and cosmetics. Intenz Biosciences does in October 2012 not have a product on the market and had in the end of 2011 no reported employees, but has attracted venture capital. The company is presented in more detail in section 4.6.1 and in the case study of AstraZeneca in SNAP in section A.13

4.1.2 Improved products

A common direct effect in companies participating in CCs is improvement of existing products. This is essentially because most participating firms develop and sell products that are very complex and expensive to develop, or have products that are so 'em-bedded' in technological systems in production or in their customers' businesses that incremental improvement is often the only feasible option.

In several of Sweden's largest firms input from CCs have led to new or significantly improved key components in complex products. The large sales of these products mean that this is where the CCs have had the biggest economic effects. The most significant cases are

- ABB in ISIS. The company has based on ISIS developed control technology for industrial robots. ABB considers itself world-leading in control technology for robots, largely due to ISIS. The company estimates that the ISIS input has generated 150 000 new customers and been the most important factor explaining the company's current global market share of 15 per cent. The technology is included in robots which ABB sells for at least 4 BSEK, possibly 10 BSEK, per year. See case study on ABB in ISIS in section A.2 .
- Ericsson AB in ISIS. ISIS has made significant contributions to algorithms that regulate the signals between mobile telephones and base stations in 3G networks. Ericsson's occupies 40–50 per cent of the global market and sells products in this market that are worth more than 10 BSEK annually. See case study on Ericsson in ISIS in section A.8
- Ericsson AB in CCCD. CCCD has assisted Ericsson in the development of analogue-to-digital converters, which are key components of all mobile telephones. Mobile telephones have been important for Ericsson; from 2007 to 2011 Sony Ericsson sold about 335 million mobile telephones. However, it is very difficult both to state the significance of the particular research from CCCD in the telephones sold, and to express how much of Ericsson's sales that follow from qualities in the converter. See case study on Ericsson in CCCD in section A.3

Although these three cases are economically most significant, the key question concerns the added value of the CC. In the two cases with Ericsson, the company points out that the two components are so crucial, that if the CCs had not existed, the company would had assembled resources in-house to develop the same components of the same quality. The added value of the CCs in those cases thus pertains to cost reductions in the development processes and – more importantly, and the main motive for Ericsson to let the CCs do the research – to the reproduction of highly competent research environments in areas of key interest to Ericsson.

In the case of ABB in ISIS, the added value of the CC is higher. ABB observes that even though the company has significant resources for in-house research, it would probably not have been able to develop control technology of similar quality. The company also observes that its market position largely stems from its excellence in this area. The economically most critical direct impact of the CC programme is therefore the input of ISIS to ABB.

Beside those very large impacts, there have also been a number of cases where CCs have led to major improvements in technology, in some cases with significant economic impacts for the companies. In these cases the companies would not had been able to assemble the resources themselves; the added value from the CCs is thus high. Noteworthy examples include:

- ABB in FaxénLab. Based on the project ABB developed an algorithm that simulates turbulence caused by electromagnets in melted steel. About 100 jobs at ABB in Västerås are dependent on the electromagnets, which are a small segment at the company. Electromagnets are used in steel making to decrease the turbulence in melted steel, but also cause unwanted votices. ABB had struggled with the problem for some time, noting that the whirls seemed occur in a largely systematic fashion – better simulations could therefore help ABB prevent most of the vortices. However, the work with the simulations was considered too much of basic research to fit in ABB's research department. When FaxénLab started in 1995, ABB brought the problem to the CC as a suitable PhD project. Most of the work was carried out by the PhD student responsible for the project, with a research manager at ABB as supervisor. A computation engineer at ABB also put much time into the project. The project was successful: a code was developed and inserted into the simulation codes in all electromagnets for steel production that ABB produced at the time and to some extent still use today. It is unclear if the reduction of whirls as such has led to more sold electromagnets. However, ABB notes that it is important to show an interest in innovation in order to sell products of this type, and in this way the project at FaxénLab might have contributed. ABB often presented the project to customers and other parts of ABB as a prime example of successful collaboration with university researchers: beside successful research it included close and efficient collaboration, dialogue with research at FaxénLab around other matters than the project per se, and good networks with academic researchers. After the project ABB as a whole has been more determined to seek university collaborations with a similar format as in FaxénLab, which the respondent thinks is to some extent inspired by this project. After graduation the PhD student went to work at a research institute in Grenoble but was several times asked by ABB to join at sales visits, for example in Japan. The PhD student was later employed by ABB, and today he also has a 10 per cent employment at KTH that ABB pays for. See case study of ABB in FaxénLab in section A.12

- Omnisys Instruments AB in CHACH. The company is small; during the CC-period it grew from five to 14 employees, today it employs 27 people. Omnisys Instruments mainly produces hardware for space flights. The company has throughout the period had close collaboration with the CC – most of the time the entire R&D staff has worked with the CC. With the help of CHACH the company has developed all its products, which the company estimates has increased its sales with around 30-50 %. In 1998 Omnisys Instruments had a net turnover of 7.5 MSEK; in 2010 it was 37.5 MSEK. See case study on Omnisys Instruments in CHACH in section A.4
- RUAG Space in CHACH. The company has developed a new microwave mixer. The mixer is a key component in the company's products and has been the most important reason behind the company's growth from ten to 30–40 per cent of the global market. The current market share is worth around 130 MSEK per year. RUAG expects to use the mixer in their products for a long time. See case study on RUAG Space in CHACH in section A.14
- Saab AB in ISIS. Saab has as a result of participating in ISIS improved several functions in JAS Gripen military aircraft. Improvements particularly concern the navigation system, where algorithms developed in ISIS solved the problem of locating the horizon when flying in poor weather conditions. An alternative to the algorithms would have been to install larger screens on the instrument panel, but there was not enough space. With the help of ISIS Saab was also able to improve systems that detect errors. The work in ISIS led Saab to change technological

principle; the firm implemented new principles in non-linear modelling. Improvements primarily concern back-up systems. Continuous innovation is crucial for Saab due to high demands from customers, but sales of military aircrafts depend on other factors in addition to their technological level. It is therefore not possible to state any impact from ISIS on the sales of Saab

- Sandvik AB in BRIIE. The company has with assistance from BRIIE developed a new hard metal for cutting rock. The new metal has become a corner stone in a new concept – the ICUTROC system – launched in 1999, with twice the strength as earlier systems. It enables the working of rock that has previously only been workable by drilling or blowing up the rock. It has also environmental and economical importance for mechanical excavation in harder rock conditions. The ICUTROC system is a multi million business for Sandvik. Sandvik has also developed three new varieties of sialon cutting tool material, which is mainly used in the aircraft engine industry, which has generated business for around 10-15 MSEK/year during ten years – by far less than ICUTROC. See case study of Sandvik in BRIIE in section A.1
- Volvo Aero in PolhemLab. Volvo Aero's (now a part of the British company GKN Aerospace) participation in the Polhem laboratory, and the useful results achieved from it, is associated with the company's growing interest in functional sales during the 1990s. At that time Volvo Aero started to change its business model towards a higher proportion of maintenance. This was partly company driven, with an ambition to build closer relations to customers and to obtain a better control of the aftermarket. That way, the company would be in control of the whole affair. There was, however, also customer requirements involved, that had to do with their cost control and predictability. The meaning of functional sales in this case is that the company went from 'only' selling aircraft engines, spare parts, maintenance and services separately to become a provider of the service "power by the hour", which contained combinations of all of the aforementioned. This called for both an increase in competence and even theory development that the company was not in a position to develop by itself. Volvo Aero had also been in contact with Luleå University of Technology (LTU) since the end of the 1980s, when the company showed interest in their education in product development and applied mechanics. The collaboration grew through a number of joint research projects and the joint efforts within the Polhem laboratory, and somewhere along the way, around the year 2000, the term 'functional products' was coined. This is how the most recent joint research has been labelled. It has been aimed at improved product development, with a focus on lifecycle commitment, to meet the needs created by functional sales rather than the business model itself, which was clearly involved in establishing the company's participation to start with. The specific content in the projects run in the Polhem laboratory was within product development and computer simulation. The company's production involved substantial amounts of welding, and at LTU they had expertise concerning simulation of details both before and after welding. There was also a general interest to introduce IT in product development and simulation, which was not very common at that time. The innovation developed upon results from the centre is a light-weight concept which became world leading. The company roughly doubled its share of the world market from a couple of per cent to around five per cent. The large actors in the sectors, such as General Electric and Rolls Royce, have outsourced about 40-50 per cent of the work to the suppliers.

Volvo Aero was able to win between five and 15 per cent of this, thanks to its ability to compete with both European and Japanese firms through its own patents and designs. Due to the activities in the Polhem laboratory and other publically funded R&D initiatives during the period, the foundation was laid for the company's backlog for the following 30 years to a value of around 120 billion SEK. The company's own total investment in the Polhem laboratory was 13.5 MSEK

- Voestalpine GmbH, Vossloh Cogifer, Swedish Rail Administration and Deutsche Bahn have together with Charmec in an EU-programme, INNOTRACK optimised rail switches and crossings. The result is switches and crossings that are expected to have 24 per cent lower lifecycle costs than existing ones. Improvements include 10.2 per cent savings connected to changed design and new material choices, 11.7 per cent savings due to more efficient driving and locking devices and 4.2 per cent lower costs when monitoring can be decreased. The calculation also includes costs for expected train delays.[54] The project was formally not carried out in Charmec as a CC; it was mainly carried out at a later stage, when Charmec's base funding came from the Swedish Rail Administration. The new switches and crossings today only exist as a few demonstrators. Charmec estimates that the improved switches and crossings will, when implemented in larger scale, save at least 100 MSEK per year in e.g. railway maintenance and traffic disturbances in Sweden. The input from Charmec's researchers is estimated to amount to at least 10 MSEK per year[55]

There are also cases in which technological improvements have been significant, but where most or all economic impact is yet expected to come. These include most notably:

- AXIS Communications in CCCD. A PhD student in CCCD supervised bv AXIS developed a technology that will become a key component in products representing at least 75 per cent of AXIS projected sales in the coming years; equivalent to sales that in 2011 amounted to 3 000 MSEK and which AXIS expects to grow by around 25 per cent per year during the coming years. AXIS sells network cameras for security supervision. The company is currently the world's largest in its market niche. The market has grown rapidly during the last years, which explains AXIS growth of in average 26 per cent per year during the last six years. The company currently has around 1 000 employees. The technology developed in CCCD is a method to realise silicon on circuits for image handling. The method is believed to increase the capacity of image handling, which is very important in AXIS core strategy of developing cameras that allow user-generated content for image handling, such as algorithms to analyse images. The capacity of the circuits is a core bottleneck in that strategy; AXIS hopes that the innovation from CCCD will result in more efficient hardware. The example from AXIS is illustrative of the serendipity of innovation processes, hence also the difficulties in impact analyses: AXIS were interviewed for this study in August 2012. At that time the story of the company's participation was very negative; the results were not only of no use, the company

[54] Anders Ekberg and Björn Paulsson (2010). Concluding Technical Report: INNOTRACK. International Union of Railways

[55] Anders Ekberg (2011), Forskningsprocessen – hur man får en effektiv järnvägsforskning. Memo, Charmec, Chalmers University of Technology

had even developed better results in house in a quarter of the time it took for a PhD student at CCCD. In November 2012, short before this report would be handed in, the contact person at AXIS returned with the information that another technology from CCCD – ‘delivered’ in 2002 – during October 2012 went from being of no use to become a key input in a new technological platform

- Saab Electronic Defence Systems in CHACH. The company develops and sells products for radar and electronic warfare. The company is made up of entities previously known as Saab Avitronics and Saab Microwave, both bought from Ericsson in 2006. Saab has together with CHACH developed materials and designs for semiconductors. Implementation is expected to lead to a shift in semiconductor technology at Saab. Semiconductors are key components in the products at Saab Electronic Defence Systems. At present the technology is used only in a minority of the products and has therefore only had little economic impact, but Saab estimates that in 10-15 years the technology will be used in a majority of its products. See case study of Saab Electronic Defence Systems in CHACH in section A.5
- Volvo Powertrain in CERC. Volvo Powertrain produces drive line components for all companies in Volvo Group[56], and has as result of participating in CERC learned how to burn DME in large diesel engines. DME is a biofuel from black liqueur. The basic problem was to combine low emissions with low fuel consumption. The project at CERC made the company adjust the system for fuel injection and develop a new piston. DME is comparably environmentally friendly since it does not produce soot and generates 95 per cent lower emissions of carbon dioxide than ordinary petrol and diesel. With the input from CERC Volvo has been able to reduce emissions of carbon monoxide by 90 per cent and the fuel consumption by 20 per cent. This far Volvo has developed about ten test vehicles. Market introduction of trucks with engines for DME would require relatively stable supply of DME as well as infrastructure for refuelling. Volvo Group is the world’s second largest producer of lorries
- Sandvik in HTC. The company has developed two or three completely new metal alloys for high temperatures and discovered a new application. None of them have however yet been implemented in products; the development process for new high temperature materials is often 15 years

In other cases the economic impacts of a technology might never be discernible, but the development can still be important, for other reasons. Examples include:

- Volvo Car Corporation and Saab Automobile improved their combustion engines as a result of participating in CERC, KCFP and KCK. In particular Saab claims significant use of the centres. The CCs helped Saab to be at the forefront in combustion systems development and engines. Saab has for example developed engines that can be fuelled by pure ethanol, by using higher compression in the engines. Due to Saab’s weak position in the General Motors Group, the innovations were however primarily implemented in other General Motors brands. See case study of Saab Automobile in CERC, KCFP and KCK in section A.7

[56] Volvo Car Corporation is since 1999 not part of Volvo Group.

- Volvo Car Corporation has also had secondary use of ISIS. The fundamentals of the technology that ISIS developed for military aircrafts at Saab were later used in a PhD project partly funded by the IVSS-programme[57] (outside ISIS), which formed the basis for an automatic brake system for cars developed by Volvo Car Corporation. The brake system automatically makes the car brake to avoid collisions. It is the only such system that is able to brake for pedestrians. The system was introduced in Volvo cars in 2010 and is under development to also be able to detect e.g. wild animals
- Lucchini in Charmec has with the help of the CC gained new insights into cracks in railway wheels caused by winter conditions. Lucchini have together with LKAB, Bombardier and Swedish Rail Administration been able to upgrade the Iron Ore Line (Malmbanan) in the North of Sweden to allow higher axle loads. Lucchini changed the wheel design; they found out that the wheels did not fit well enough with the rails, which caused costly damages. LKAB has saved about 8 MSEK on the wheel maintenance. The earnings due to more efficient transportation are unclear. The lessons from the Iron Ore Line also led the Swedish Rail Administration to raise the allowed axle loads on several railway lines in Sweded, which had much high economic impact, see 4.1.4 . Lucchini also observed that EU norms for railway wheels do not cover winter conditions well enough; the company now tries to convince EU to change the norms, which would give the company an advantage on the market. See case study of Lucchini in Charmec in section A.10

4.1.3 New or expanded services

A number of firms have as a result of participation in CCs been able to improve the services offered to customers. Services may include advanced customer support, for example by abilities to offer staff that helps the customer to implement the product in order to maximise its utility. The product is thus for many firms not only a limited material or immaterial thing; it often also includes knowledge on how the product fits with different kinds of systems, under what circumstances it works the best, how it can be tailored to meet the specific needs of the customer, and so on. Much of this knowledge is very difficult to write down and transfer to a customer. The producer therefore often has to offer also continuous access to highly skilled technical staff.

Many items of capital equipment that are developed with the help of CCs are very important to the buyers. Buying them often require significant investments which need to return cost savings or incomes. Interruptions t prouct in production because of malfunctioning new investments are also costly. Buyers of many advanced products thus take considerable risks, and they want the risks to be minimised.

Buyers typically do not want to invest in a completely new product but prefer continuous updates and upgrading – smaller system changes decrease the risk of

[57] IVSS stands for Intelligent Vehicle Safety Systems. The programme was part of the Program Board for Automotive Research (PFF) and run in a joint venture between Invest in Sweden Agency, Scandinavian Automotive Suppliers, Scania AB, Swedish Transport Administration, VINNOVA and Volvo Car Corporation.

unpredicted disruptions. If the seller is able to offer a product that will be continuously improved, tested, and adapted to developments of other technical systems, the likelihood of finding a seller often increases significantly.

A seller must therefore often present a credible promise of continuous innovation. Innovation this way turns into an activity undertaken not only to make a product work better in itself, but an activity that will make a product continue to work also when the technical environment around it changes. Firms must innovate not only to develop new products, but to keep the products match ongoing technological development and to maintain the firm's knowledge base.

Offering high quality services is particularly important for firms in high cost countries such as Sweden, which can often not compete on price. Besides lowering the risks of costly situations such as standstills and new investments, advanced services also mean that the customer and the seller develop a deeper and more reciprocal relation to each other. The risk of losing a customer therefore decreases.

The development of services is most probably an important effect of CCs on industry. However, it is also one of the effects that is most difficult to trace; it is easier for respondents to link improvement of products or enhanced steps in the production processes to CC-participation than to identify how capacity building of staff involved in CCs had lead improved customer support. Thus, although several examples have been brought up, many more are expected to be hidden.

One indication that many firms may have improved their services is that a large majority of respondents held capacity building and the creation of Knowledge Value Collectives as key effects of CCs (see also chapter 4.5). In kind participation by industry means that capacity building becomes 'embodied' in the staff of the firm in a more profound way than if the work is carried out by university researchers and delivered in project reports. It also means that personal networks become deeper and more likely to live on. In addition, it is also probable that knowledge from CCs have spread within the firms. Although industry staff involved in CCs normally worked with R&D, they are likely to have contributed to capacity building also outside the R&D departments. That has given companies better opportunities to offer more services.

A good example of a firm that has improved its services is Södra Cell in WURC. WURC was in more explicit way than most other CCs a centre focused on capacity building; in WURC's case it concerned knowledge on the ultrastructure of wood fibres in the paper and pulp sector. Södra Cell is a leading producer of pulp for paper-making, with specific strengths in high quality pulp and fibres. Its strategy is to stay out of paper-making in order to focus on providing paper manufacturers with pulp and knowledge resources to support their businesses. Södra Cell is today recognised as world leading on wood fibre knowledge and gives courses on the topic to its customers; much of that competence has been developed as a result of participation in WURC. See case study of Södra Cell in WURC, section A.15 .

Another example is Sandvik's participation in BRIIE. The part of Sandvik that participated in BRIIE produces cutting tools. Sandvik's approach to the market has evolved. It no longer sees itself only as a producer of tools and equipment but increasingly aims to sell productivity connected to cutting tools. Included in the 'productivity package' are beside the tools also full solutions to the customer's problems which include for example continuous support and training of the customer's staff. See also the case study of Sandvik in BRIIE, section A.1

A third example is the chemistry company Kemira, which participated in SNAP. When participating in SNAP the company produced surfactants for washing detergents. Knowledge gained in SNAP enabled the company to offer better arguments in selling situations, for example to better point at how the potential customer could implement the product most efficiently, or how the customer and Kemira could organise a common project around a product.

There is also one example where a firm has developed services as a product on its own: The biotechnology company that today is called Sobi participated in CBioPT and CBioSep as first Pharmacia and after being spun-off as BioVitrum. Pharmacia/ BioVitrum was able to 'productify' into new services some of the capacity building it acquired in the CCs. The company then sold the services as consultancy to other biotechnology firms.

4.1.4 New or improved processes

Almost all participating firms had a goal to improve their processes, either in their R&D activities or in production. The goal would primarily be reached by improving the firm's knowledge base. A firm's knowledge base includes both competence among the employees and competence readily accessible through networks with individuals or organisations outside the firm. Higher competence means better decisions, which will result in better products and more efficient processes in R&D and production.

The CC format was particularly appropriate for that purpose. The requirement of in-kind contribution meant in many cases that industrial R&D staff interacted with university researchers while focusing on a common problem. In the interaction many of them naturally also got the chance also to discuss other problems. It is likely that many new CC projects were born in this way. Most CCs also organised seminars and workshops where firms could send staff for capacity building purposes.

Quite a few companies, especially the large ones, were particularly interested in developing the knowledge base by recruiting new staff through the CC. The CCs have clearly made an important contribution in this point: more than 500 PhD students have graduated in the CCs, many of whom have ended up in industry. Of the 199 former PhD students that responded to the survey in this study, 134 had at some point worked in industry – many in firms that participated in the CCs. Several former PhD students today occupy key positions in the firms; a good indication is that a notable number of company representatives interviewed in this study had received their PhDs in a CC. See section 4.8 for the results of the survey to the former PhD students. A couple of firms also report recruitment of senior staff from the universities. CCs however do not seem to have caused increased mobility of staff among participating firms.

Some firms, especially large corporations, also hoped that the CC would be an instrument to make the undergraduate education better adapted to the needs of industry, which would enable the recruitment of highly skilled master students. A (probably quite small) number of companies have participated in undergraduate education by e.g. giving guest lectures. The main effect that CCs have had on industry with respect to recruitment of students seems to concern Master students; many CCs in the engineering sciences have put participating firms in touch with Master students doing their degree projects. Apart from that, almost all former heads of CCs report limited impacts from CCs on the form and content of education.

Beside internal capacity building and recruitment of staff, most participating firms also hoped to improve their knowledge bases by establishing networks with individuals and other organisations. The CCs clearly have been an efficient vehicle in this respect – formation of often relatively persistent networks is widely held as a valuable impact by a majority of the interviewed participating firms.

What are the direct impacts of capacity building on the internal processes in participating firms? Tracing impacts from capacity building requires discernible ‘pieces’ of knowledge. In this context that would typically mean knowledge of a distinct method or a project report that opens up doors.

Several CCs were specifically focused on process development in industry. The most notable impacts come from three of these CCs

- CBioSep, which focused on developing methods for separation of bio-products such as proteins
- CPM, which provided industry with methods and support primarily connected to Life Cycle Assessments
- WURC, which primarily aimed at increasing competence of wood fibres in the paper and pulp industry

These CCs have all resulted in capacity building that all interviewed participants regard to be of major importance. Examples of effects these CCs have had on the processes of participating firms include

- ABB has in close cooperation with university researchers at CPM developed Environmental Product Declarations for about 100 key products and systems. Life Cycle Assessments lie at the core of this work. The work with CPM has also led ABB to develop internal protocols for monitoring sustainability impacts of all products under development. In addition, the company has been able to develop a comprehensive database to better assess environmental impacts of the products. As an example, the respondent at ABB mentions that CPM made the company realise that 99.95 per cent of the environmental impact of a transformer that weighs 300 tonnes comes from operating it, which has led ABB to focus environmental work on the operations instead of the construction. CPM researchers have been important by supporting and verifying all this work. The CC also offered an arena for large companies interested in the same issues, which resulted in of one of the prime examples of a Knowledge Value Collectives of CC programmes; a collective that still maintains relatively close contact. ABB considers itself leading in the application of Life Cycle Assessments

- AkzoNobel has with the help of CPM developed Eco-Efficiency Assessments for 330 key products throughout the whole corporation and developed methods that the whole corporation must use when making investments of more than 5MEuro, and to some extent also for all smaller investments. Eco-Efficiency Assessments includes mapping of eco-footprints “from cradle to grave”. An eco-footprint includes both the carbon footprint and the water footprint, which means that it includes all main environmental flows. AkzoNobel has developed a formalised method used throughout the corporation, in which information regarding manufacturing is collected at site level and complemented with e.g. data on the amounts of emissions and waste generated. The results are presented in leaflets for each product. AkzoNobel is one of the world’s largest chemical corporations, with 57,200 employees and sales in 2011 of 15.7 BEuro. The subsidiary AkzoNobel Surface Chemistry AB in the Gothenburg region had been leading the work with Life Cycle Assessments within the corporation since 1993, from 1996 by participating in CPM. A corporate Sustainable Development-group was gradually formed, almost entirely consisting of staff at AkzoNobel in Gothenburg. In the early 2000s demands from customers on environmental impacts of AkzoNobel’s products increased, which led in 2005 the corporate management to decide that the Sustainable Development-group would be responsible for introducing Eco-Efficiency Assessments within the whole AkzoNobel corporation. Since then the group manager is part of the AkzoNobel corporate management. AkzoNobel appear to be frontrunners in sustainable development work, which is indicated by the company supporting ThyssenKrupp Group – one of the world’s largest steel producers – with knowledge on sustainable development work. CPM is held as crucial to this development, by just in the case of ABB supporting and verifying the work and offering an highly useful platform for interfirm discussions
- BioInvent International has by the help of CBioSep been able to implement a range of new techniques and statistical methods in its production processes, which have both improved quality and reduced costs. BioInvent is a relatively small biotechnology company, serving as subcontractor to large corporations that produce pharmaceuticals. The company has saved significant amounts of money through more efficient processes. The biggest importance the new methods and techniques have had for Bioinvent, is however that the company has been able to customers that it is able to keep an advanced level unusual for such a small company. That quality is likely to have rendered contracts. The input that BioInvent gives to their customers implicates exponential cost savings later, once a pharmaceutical is produced for the markets. On this aspect, the impact from the CC still remains to be seen – most input from BioInvent has concern pharmaceuticals that are (still) not on the market. BioInvent estimates that the CC inputs will save hundreds of MSEK for a pharmaceutical product on the market.
- Volvo started to work with Life Cycle Assessments in the 1980s, and intensified the work in the mid-1990s, about the time the company joined CPM. At that time also Volvo cars were involved, but after the separation of Volvo cars from the Volvo

Group, focus was on lorries. CPM has supported Volvo's work primarily by developing databases on environmental impact of various input materials. The input from CPM has been usable both in basic research at Volvo and in applications. Volvo developed a group for environmental analysis and analysis of materials which has been working together with CPM. Volvo however had problems attracting staff from the vehicle production units, which would have made the impact of CPM stronger. Volvo observes significant learning from CPM, for example the important of using lightweight materials to reduce energy consumption; this has led Volvo to use more plastics and less metal. Volvo has integrated Life Cycle Assessment into all parts of the corporation. Today it is mandatory to use Life Cycle Assessment in the development of new products. The company claims to that it thanks to CPM is the only producer of heavy duty lorries that can offer a complete Life Cycle Assessment of a lorry

There have also been notable cases of process development as a result of other CCs than the four mentioned above.

- AstraZeneca has with the help of SNAP saved at least 10 MSEK per year by making the production process of one of its products more efficient. The project leading up to the improvement was really intended for another application, but the company found that the method developed in SNAP could be applied also on other processes. One case in which it could be used was a key process in the production of a product on the market. The process has been implemented also in in other cases, but the respondent cannot estimate those impacts in monetary terms. See also case study of AstraZeneca in SNAP, section A.13
- ABB has with the help of EKC developed diagnostic tools for cables, transformers and rotating machines. The company wanted to develop methods for examinations of electric cables that would give (more or less) as good results as methods that destroy the cables do. ABB had discussed the problem internally, but there was little interest among the R&D management to fund such a project. An adjunct professor from ABB therefore brought the problem to EKC. The project was successful, and the method turned out to be useful also for other applications. A second project started, focusing on transformer diagnosis. Also that project gave good results, and ended up as an application that is commercially more valuable than the first one. The method for transformer diagnosis is today used in all ABB's service facilities for transformers. The company has also developed methods for diagnosing rotating machines based on the same technology. The method is efficient since it does not require dismantling or even destruction of parts of the examined materials. Instead of using scheduled maintenance or change a part e.g. the third time a problem occurs, ABB can now quickly diagnose the functionality and change the parts only when needed. The methods are only used internally. The economic impacts have not been calculated
- LKAB and StoraEnso have together saved 700 MSEK per year between 2006 and 2009 due to increased axle loads on around 40 per cent of the Swedish railway net, including the Iron Ore Line on which iron ore is transported to the ports in Luleå and Narvik, and large amounts of wood is transported to pulp and saw mills. The savings are partly a result of Charmec's collaboration with LKAB, Lucchini and the Swedish Rail Administration, which both led to improved wheel design of LKAB's

iron ore wagons and subsequently to increased axle loads and thereby more loads in each wagon. The Swedish Rail Administration calculated the savings for LKAB and StoraEnso in 2009.[58] If the same figures apply also for 2010–2012, the total savings for the two companies this far amount to 4200 MSEK. Also other companies using the railways for their freight have been able to increase their loads[59]

- Volvo Aero in Polhem has improved its whole organisation of products and processes partly as a result of participating in the CC, see section 4.1.2

Industry has most certainly benefitted from capacity building also in many other cases that each is less significant but which together have meant improved productivity. Many of those cases relate to individuals getting deeper insights in general into a field of knowledge Tracing impacts of such knowledge development is practically impossible, partly because such capacity building goes on slowly and therefore largely unnoticed, partly because knowledge is constantly under transformation, made up by combinations of inputs from many different situations.

4.2 Direct impacts through behavioural additionality

4.2.1 Effects on company strategy

The CCs have affected company strategies in two main ways. The first is when projects of significant importance to the companies have been successful and therefore driven decisions on e.g. product portfolios or technological platforms. The second case is when companies have found the CCs or the CC format valuable, and therefore changed their preferred formats of R&D collaborations. This section focuses on the first case. The second case will be discussed in the next section.

Changes in company strategies due to successful projects can be due to projects leading up to new or improved products or processes. Several cases in the previous section have led firms to develop new strategies. Changes can also be caused by negative results in projects of significant importance to the firm. A negative result does not necessarily mean that the project ‘failed’; if it was carried out properly it can provide the basis for a key strategic decision on which way to go.

First, some examples of companies that have made important strategic changes due to CC input:

- ABB, AkzoNobel and AB Volvo have all after participating in CPM introduced Life Cycle Assessments or similar tools as key processes in their entire corporations. CPM has in all three cases played an important role in the new strategies, by providing data, support, and – not least important – credibility. In the case of AkzoNobel, it seems that CPM has helped to attract the company’s global unit for

[58] Charmec (2009). Charmec. Triennial report 2006–2009, page 84

[59] Anders Ekberg (2011), Forskningsprocessen – hur man får en effektiv järnvägsforskning. Memo, Charmec, Chalmers University of Technology

sustainability to Göteborg. The cases of ABB, AkzoNobel and AB Volvo in CPM are described in more detail in section 4.1.4

- Abetong AB in Charmec. Abetong has with crucial input from Charmec developed a new type of railway sleepers, which has resulted in a large contract with the Swedish Transport Administration. The new sleeper constitutes an important product at Abetong, and has also led to a reorganisation of the production line at Abetong's production plant. The project has also contributed to Abetong being asked by the national railway authority in India – one of the world's largest buyers of sleepers – to conduct a minor R&D project. Abetong carried out the project together with Charmec, and hopes to have a way into the Indian market. The case is described in more detail in section 4.1.1
- BioInvent International in CBioSep. Input from the CC provided scale, scope and a quality level made the firm 'dare' to invest time and efforts to implement the instruments that researchers at CBioSep had helped the company to develop. The instruments included new techniques and statistical methods in its production processes, which have both improved quality and reduced costs. The case is described in more detail in section 4.1.4
- Ericsson AB in CCCD. Without the research environment at CCCD, Ericsson would not have invested in Bluetooth back in the 1990s. That strategy has in turn led to several projects and close dialogue between Ericsson and CCCD which continues today. Research at CCCD has also influenced Ericsson's recent decision to invest in circuits for radio communication. See also case study on Ericsson in CCCD, section A.3
- Höganäs in MiMer. Höganäs produces metal powder and has around 1,600 employees in 15 countries. The company joined MiMer because it wanted to better understand how to make use of waste products. Although participation in MiMer has not resulted in any new products or directly led to the development of processes, Höganäs observes clear links between the capacity it has built in MiMer and strategies for waste products
- Pfizer in CBioPT and CBioSep. Pfizer in Strängnäs believes that links to the two CCs helped the unit to attract an internal investment of around 1500 MSEK to the production plant in Strängnäs, opened in 2009. The investment is regarded as the largest single investment a foreign owned corporation has ever made in the Swedish bio-pharmaceutical sector. Although such a venture depends on many factors, Pfizer in Strängnäs observed that its ability to show high competence and good links to leading research environments was a key factor, and the unit had previously impressed staff in Pfizer's U.S. headquarters and other U.S. locations. Pfizer in Strängnäs had for example been able to spread insights from the CCs on how the temperature cycle affects the quality of the medium, which is important knowledge in biotechnological production
- RUAG Space in CHACH. Together with researchers at CHACH, RUAG has developed new microwave mixers for applications in space technology. The mixers are key components in RUAG's products and are the main reason to RUAG's growing share of the global market. More or less every product that RUAG offers contains the new mixer. As a consequence of the successful development and the increased sales, the product area has become prioritised in the RUAG Group, which contains several other divisions apart from RUAG Space. It has also led the RUAG

Group, headquartered in Switzerland, to channel more R&D funding to RUAG Space in Göteborg, Sweden. See also case study on RUAG Space in CHACH, section A.14
- Saab Electronic Defence Systems in CHACH. Saab has together with researchers in CHACH developed a new technological platform for semiconductors, which includes both new materials and design. In 10-15 years Saab expects the technology to constitute a basis in a majority of its products. Semiconductors are key components to Saab. See also case study on Saab in CHACH, section A.5
- Sandvik in HTC. Together with HTC Sandvik has gained important new knowledge on corrosion of high-temperature materials, and developed three new materials. Altogether, the input has lifted the field within Sandvik, since the company has observed that it largely thanks to HTC possesses expert knowledge in the area and – more importantly – new products are within reach. Sandvik currently invests in product development based on results in HTC
- SKF Group in CPM. SKF has most probably thanks to CPM selected Chalmers University of Technology as its partner university for sustainability, which beside participation in CPM also includes funding of the SKF-Chalmers University Technology Centre for Sustainability, inaugurated in March 2012 with more or less the same topics as CPM and led by former CPM staff. SKF Group is a large engineering corporation, supplying bearings, seals, mechatronics, lubrication systems and services. In 2011 SKF had sales of 66.2 BSEK and about 42,900 employees. CPM has also provided support during SKF's development of its portfolio of environmentally friendly products, launched in early 2012 as the largest investment SKF has ever made. The portfolio comprises 12 products and a method for environmental analysis
- Volvo Aero in Polhem has changed its business strategies partly as an outcome of participation in the CC. That includes 'repackaging' the idea of what the company sells from e.g. aircraft engines and spare parts to 'power by the hour', i.e. a function that the customer can use . For the full story of Volvo Aero in PolhemLab, see section 4.1.2

There are also a few examples of strategic decisions based on negative results in CC projects. Typically in those cases, companies have used the CCs as 'focusing devices' by experimenting with projects of great significance but with uncertain outcomes. A negative result has then enabled the company to choose direction – 'now we know this does not work, so we go the other way'. There are only a few such examples in the material, probably because most companies did not intend to use the CC in this way, or because several firms of this type probably withdrew from the CC at an early stage during the 1990s. Below are some notable cases when strategic decisions have been based on negative results:

- Pharmacia/BioVitrum in CBioSep. The company learned that a core method – "two-phase systems" – it hoped to implement in the production of protein based pharmaceuticals would not be possible to use. The company therefore decided to opt for another method. That decision was largely by the help of a researcher in CBioSep who was an expert in the area. The researchers did analyses that the company did not have competence to do on its own

- Radi Medical Systems in SUMMIT. Radi Medical used SUMMIT to try out a high-risk project. If the project had generated a positive result, the company projected vast incomes. Thus, although participation in SUMMIT did not lead to observable progress in the company, Radi found its participation successful. Radi Medical produces instruments for cardiology. The company started in 1985 as a spin-off from Uppsala University and has maintained close links with academic research environments in primarily Uppsala and Stockholm since then. It was a natural for the company to participate in SUMMIT, but SUMMIT was all the time only a fraction of Radi's local university collaborations, and most of the extensive R&D at Radi was financed by the company itself. Radi Medical Systems grew rapidly from the late 1980s; the average growth was around 20 per cent per year during 20 years. In 2009 the company had 400 employees and was sold to St Jude Medical for 2 BSEK
- AB Volvo in CERC, KCFP and KCK. The company used the CC primarily to probe new ideas. Much of Volvo's participation thus concerned high-risk projects with uncertain outcomes. The respondent at Volvo observes that "in a CC, a ten per cent hit rate on new ideas is good". One example where Volvo has used a CC in this way would be the development of an engine for burning DME, described in section 4.1.1. When a project in CERC led to the development of a new piston, the development track looked promising enough for Volvo to make the strategic decision to equip about ten test vehicles with new engines and to market the project on DME-fuelled engines as an important project for the future

4.2.2 Effects on the 'innovation model' used by the firm

The CC programme has undoubtedly had relatively large impacts on the innovation models in many participating firms. Many firms brought ideas for projects to the CCs. The key question is whether the CCs were instructed to run projects that the firms were interested in but did not have resources to run on their own, or if the CCs were primarily used to reduce costs for projects that would have been carried out anyway.

The answer is that almost all firms appear to have used CCs for projects of significance, but either too risky or costly to carry out in-house, or too demanding in terms of competence. The CCs thus seem to have worked as intended. Curiously, the one company that stands out by having let CCs do projects it could have run in-house, is Ericsson: the two key inputs Ericsson received from ISIS and CCCD, respectively, could also have been produced in-house, since they concerned crucial components in key products. Ericsson's main motive to participate was however to ensure reproduction in research environments of relevance to the company. Apart from these two cases, companies with large R&D budgets claim to have let the CCs do projects they would not have funded on their own.

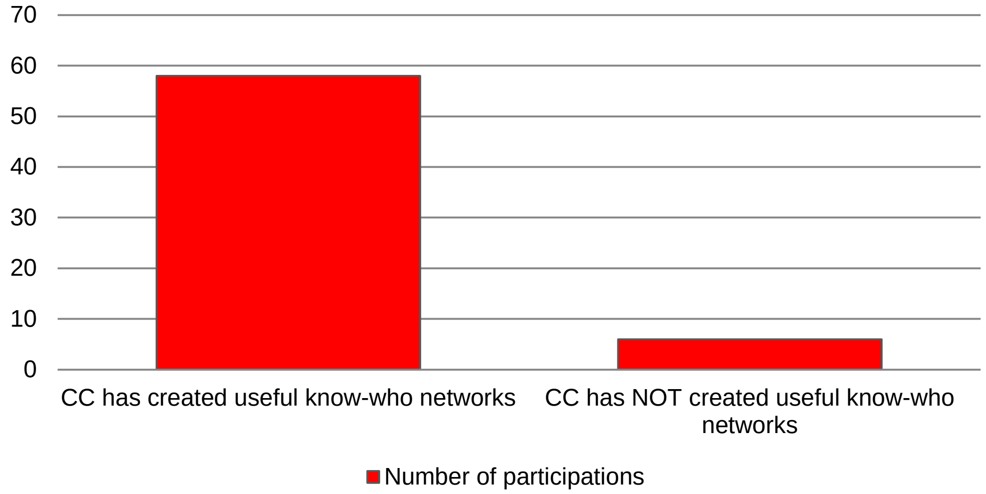
The CCs were a version of 'open innovation'. The demands for in-kind input, the idea to create meeting places for firms with common interests connected to a specific field of knowledge, and the comparably long time-frames were to some extent new features at the time.

A first impact thus concerns understanding of the format. Both companies and university researchers were inexperienced of the CC format, which meant that many CCs took quite long time before their 'innovative take-offs'. A majority of the effects observed in this study seem to be generated by projects initiated in the middle or last periods of the CCs. The main reason is that it in many CCs took quite some time before the participants had learned what types of projects to prefer to get the most added value, and how to organise the work. A not insignificant number of respondents also observe that it took time before (some of) the university participants had understood how CCs and projects with industrial participants should be led.

A second impact concerns learning on how to collaborate in a context of property rights. It was apparent that innovative collaborative projects and discussions required openness to an extent that skilled other participants could figure out things that were protected by property rights. For momentous innovation to take place, the CC participants thus needed to reach agreements within each CC on how to handle these situations. A number of CCs were initially plagued by long discussions on this point. During that time their participants were defensive, reluctant to give other participants insights into patented knowledge. In CCs working in knowledge areas where the step from basic research to commercially valuable knowledge is short – such as in biotechnology and microelectronics – several participants were also sceptical of the university researchers; they were afraid that university researchers with less experience of property rights would either (accidentally) leak important knowledge to other participating firms or if relevant even to their own start-ups. In almost all cases suspicions towards other participants – firms or researchers – decreased over time to become more or less insignificant. The long-term format of the CCs was instrumental in this respect. Another contributing factor was the promises of in kind work and shared projects: most firms found the advantages of working together attractive enough to dare revealing some core competence if necessary. Respondents from a couple of large firms indicate that once the firm's own law people was out of the way and the agreement on property rights was in place, the R&D people could start collaborating in 'a more proper' way with other firms, i.e. in ways to which the legal people would have objected. Mutual trust between firms – which largely depends on the attitude of participating individuals from those firms – is a foundation for a successful CC.

A third impact concerns the formation and utilisation of knowledge networks. It is evident that CCs have played an important role in this respect; almost all respondent claim access to valuable knowledge networks from the CCs also after the centres have been dissolved, see Figure 15. Most participants engaged in CCs because they saw a chance strategically to expand their R&D activities by establishing closer links with university researchers and to some extent with other firms. Such networks would enable the firms to better catch up with the research frontier and to have access – mostly on the personal level – to competent people who in different ways could assist in problem-solving. It would also give them a better chance to shape the research agendas (and indirectly the content of undergraduate education) at universities. Networking of the former kind was an important motive to many participants, especially the more technologically advanced companies. Networking to shape research agendas at universities was primarily of interest to large firms. In both cases the respondents generally express satisfaction. Also in the case of lasting knowledge networks, the long time-frame has been important – it enabled personal relations to become tight enough to last also without the organisational arena.

Figure 15 Creation of useful ‘know-who’-networks in interviewed companies



Note: N=64

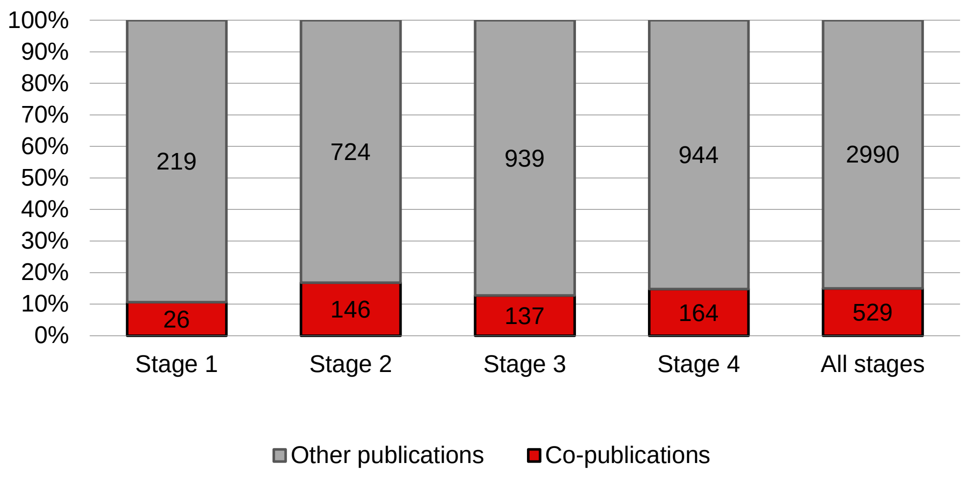
The CCs have clearly played an important role in ‘teaching’ many firms and university researchers how to collaborate successfully. Running common projects around relative-ely generic types of knowledge means attractive additionality of scale and scope. In around half of the CCs, projects with inputs from more than one company dominated. To most firms in those CCs that was a new way of R&D collaboration, and the experi-ences seem to have been overall positive, making the firms interested in continuing to participate in such projects. It is difficult to estimate the degree to which the CCs have made firms more interested in such types of collaborations. Many firms participate in similar projects in other contexts, but that participation cannot only be attributed to the CC programme; the programme was part of a general trend, although one of the first examples.

In the other CCs projects were mostly run by one firm and the university researchers, but the projects were initiated by the board and all participants took part of the results. The additionality of those CCs was primarily the discussions in the boards and at seminars, which most respondents found fruitful. Only a couple of CCs seem to have lacked the meeting point between firms. Those CCs also seem to have generated little impact in terms of new or improved products or processes. The less a CC differed from an ‘ordinary’ collaboration, the less impact it can have made on a company’s ‘innovation model’.

The most evident impacts the CCs have had on the ‘innovation models’ are visible in continued participation. The number of drop-outs due to factors other than economic problems, acquisitions or strategy changes in corporate top management was very low. Most participants were active during most or all stages, which indicates a widespread belief in the CC way of working. When VINNOVA terminated the CC programme in 2006, many CCs were able to mobilise strong support behind applications to for example the VINN Excellence Centre programme. A handful VINNOVA-funded CCs live on, although in mostly changed formats, with the most engaged firms from the CC periods still participating.

The CC programme seems however to have had limited impact on the readiness of company researchers to write scientific articles together with the academic researchers. Figure 16 shows the share of co-publication per stage in 15 of the 28 CCs.[60] The share of co-publications was stable between ten and 17 per cent of all publications, with no clear trend between stages. Some CCs had a relatively high share of co-publications, most notably CCCD. Also ASTEC, SUMMIT and CTT had during some stages high shares of co-publications.

Figure 16 Co-publications, per stage, 15 CCs



Note: Numbers in bars represent total number of publications

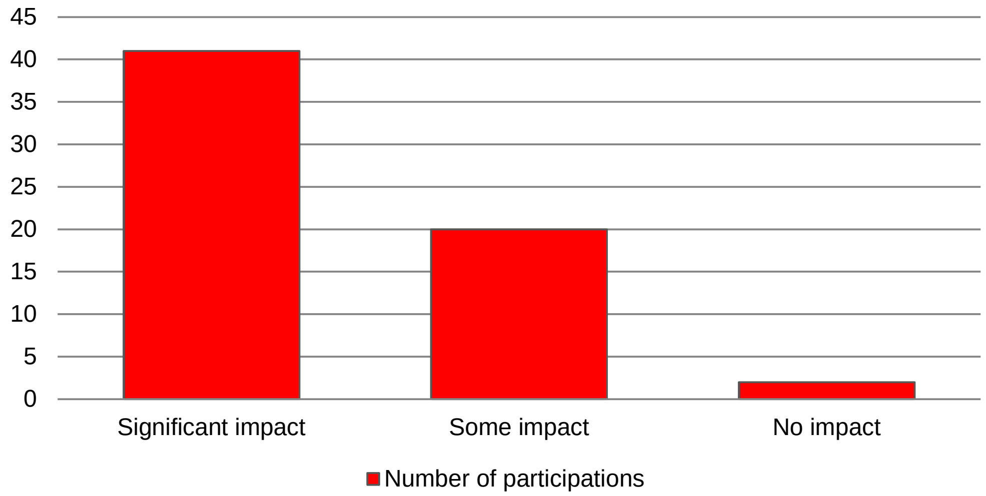
4.2.3 Effects on human capital and R&D management

The CCs have had a substantial impact on the skills of R&D staff, see Figure 17. The firms' capacity to absorb and efficiently utilise new knowledge has thus increased. Almost all participants claim capacity building being one of the most important impacts that CCs have had. The capacity has increased both by development of skills among existent staff and by recruitment of new staff such as PhD students. Many companies' needs in this respect are strikingly expressed by the respondent at Höganäs in BRIIE: "In product development it doesn't matter if you don't understand everything, as long as it works. But sooner or later you get to a point where you need better understanding in

[60] CCs inlcuded in the figure are: ASTEC, BRIIE, CBioSep, CCCD, CHACH, Charmec, CTT, ISIS, KCK, NIMED, KI Radioation Therapy, SNAP, SUMMIT, WoxénCentrum and WURC

order to move on.” For companies making products based on technologies such as software, hardware and biotechnology, deep understanding is always a prerequisite for commercial success. Those sectors move rapidly, which means that continuous learning is important.

Figure 17 Impact on technological competence in interviewed companies



Note: N=63

The CCs have generally not had any impact on R&D employment. Decisions to expand or decrease R&D departments are typically based on overarching analyses in which R&D success in an area is only one part. In fact, success in CCs might rather have contributed to *less* R&D staff in the firms: if the firms saw that such projects were reliable in providing good input and close links with university researchers, that could be a good reason for cutting down on in-house research. WURC for example concerned the paper and pulp sector, where outsourcing of R&D to universities has been substantial; this trend, the respondents from WURC underlined, was an important reason to support WURC. The few cases where growth has occurred mainly concern smaller firms that have been able to expand based on successful CC results. Omnisys Instruments is a good example, see case study in section A.4 .

No firm observes learning in internal R&D management as a result from CC participation. That does not necessarily mean that no such learning has taken place, but indicates that the learning has been relatively marginal and incremental. Learning in this respect seems to have gone in the other direction: several respondents point out that the university researchers in general developed significantly in terms of project management, which they find is an impact from participating companies.

4.2.4 Improved access to external facilities

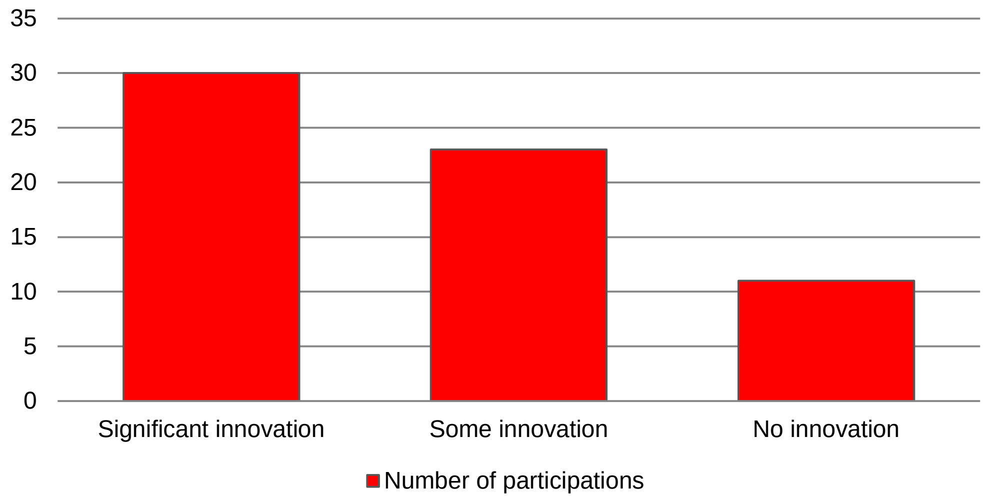
A number of firms point out improved access to infrastructure as a positive outcome of CC participation. This particularly pertains to certain technological fields, where infrastructure is particularly expensive, or where the firms are unusually pressured by small profit margins. In the two biotechnology CCs, CBioSep and CBioPT, infrastructure was a particularly important factor. CBioPT had for example built a very attractive and advanced test laboratory where firms producing biotechnological product could rent access (including support staff) or work together with researchers. Infrastructure was also important in CCs that develop materials and hardware.

Some firms, such as Pfizer in CBioSep and several firms in WURC, also observe that the improved access to facilities has been two-way: researchers at universities have tried out methods on full-scale and 'real' environments in production plants, not only to fulfil promises within CC projects but also for scientific use. This is obviously a good way to ensure industrial relevance of academic research.

4.3 Economic impacts

About half the companies we interviewed had managed to make a significant innovation as a result of CC participation; very few had not innovated at all as a result of working with the centre (Figure 18). However, only 40% said that this had increased their market share.

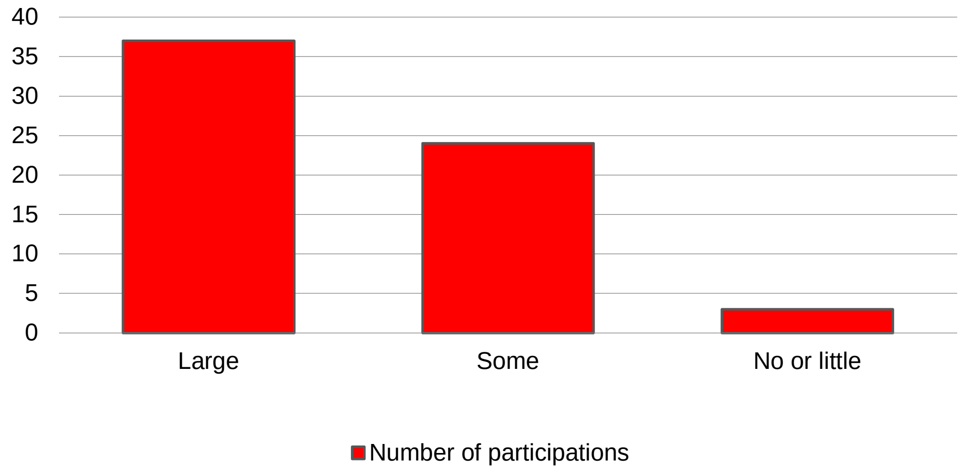
Figure 18 Estimated innovation in interviewed firms as a result of CC participation



Note: N=64

Some 58% of those we interviewed said that they had obtained a large amount of added value from CC participation. Almost none saw no added value (Figure 19).

Figure 19 Estimated added value of CC participation in interviewed firms



Note: N=64

What economic impacts can be traced from the programme? Has the quite significant investment of around 3 BSEK of public funding and 1.75 BSEK in cash and in kind from industry paid off? The answer is clearly positive. Table 6 and Table 7 show the figures for earnings (sales, or in the case of start-ups, total turnover) or cost savings from products and processes that are strongly linked to CC activities and for which it has been possible to estimate an economic value. All estimates are based on information from industrial representatives or, in the case of Charmec, the CC's own careful calculations. If those earnings and cost savings are fully counted for as impacts of the CC programme, the total impact of programme *at the very least* amounts to somewhere between 5.3 and 11.8 BSEK per year as of 2012.[61] In other words, *in 2012 alone* the figure is between 1.8 and 3.9 times larger than the total investment from public funders in the ten-year CC programme, and at least 0.5 BSEK larger than the total investment in the CC programme if also industry contributions are included. A great part of the impact comes from one single case, ABB in ISIS. Without this, the range of impacts identified here is 1.3 to 1.9 BSEK , producing benefits in one year that are of the same order of size as the total, 10-year public investment in the programme.

For one CC, Charmec, data are available that covers more or less all impact from the centre. Between 1995 and 2011, Charmec has altogether strongly contributed to an economic impact for society and industry that can be estimated to between 1035 and 1430 MSEK per year.[62] During those 17 years, Charmec received around 230 MSEK in cash and 120 MSEK in kind contributions from governmental funders, the host

[61] Abetong AB is not included in the lower figure, to avoid possible double-counting when adding the other Charmec impacts
[62] Abetong AB is not included in the lower figure, to avoid possible double-counting when adding the other Charmec impacts

university and industry.[63] The investments in Charmec have thus, from a societal perspective, paid off by at least four times in only one year. The most important impact is the increased axle loads on around 40 per cent of the Swedish railway net, including the Iron Ore Line.

Needless to say, the figures on economic impacts in industry should come with a word of caution. The sales and costs generated are of course also a result of further R&D and other activities in the companies, which has been crucial for any sales or cost savings to occur. It is in many cases also likely that the sales and cost savings for the same product categories in these companies would have occurred also if there was no CC: most likely, quite a few of these companies would have found other – perhaps even the same – research groups to work with. In the ABB case the company would most certainly had improved its industrial robots anyway, but perhaps not reached the same quality and thereby sold them smaller quantities. It is also possible that Abetong would have sold sleepers for a similar purpose also without Charmec. However, in all the other listed cases, interviews and other data indicate that no product would have been accomplished without the research that took place in the CCs. Finally, much of the sales and cost savings have been made by reducing sales for other companies (albeit mostly companies from other countries), which thereby lowers the utility for society.

Table 6 Economic impacts from products and processes that are strongly linked to CCs

Company	CC	Economic impact
ABB	ISIS	4 000–10 000 MSEK per year
LKAB and StoraEnso	Charmec	700 MSEK per year
Abetong AB	Charmec	135 MSEK per year
Sandvik AB	BRIIE	Probably > 100 MSEK per year
RUAG Space	CHACH	20–90 MSEK per year
NIRA Dynamics AB	ISIS	52 MSEK in 2011
AkzoNobel Surface Chemistry AB	SNAP	40–60 MSEK per year
Omnisys Instruments AB	CHACH	11–19 MSEK per year
Södermalms Talteknologiservice	CTT	5–8 MSEK per year
TOTAL		**5 063–11 164 MSEK per year**

[63] Charmec received 236.5 MSEK in cash and 125.6 MSEK in kind contributions for the period from 1995 and until June 2012

Table 7 Charmec's impact on societal cost savings in Sweden or globally

Function / process	Estimated cost saving
Software programmes	~ 200–400 MSEK per year globally
Switches and crossings	> 100 MSEK per year in Sweden*
Noise reduction	~ 200–300 MSEK in Sweden
Wheel pressure	~ 10–40 MSEK per year in Sweden
Reduced costs due to prevented accidents and breakdowns	~ 10–40 MSEK per year in Sweden
Corrugated rails	10 MSEK per year, much more around the years 2000–2002 in Sweden
Support in introducing new technologies	5 MSEK per year in Sweden
TOTAL	**335–595 MSEK per year + about ~ 200–300 MSEK in total for noise reduction**

*Note: Some of these impacts were generated between 2006 and 2011, after Charmec exited the CC programme and continued without VINNOVA funding. It is not possible to separate impacts that were generated by activities before 2006 from those generated by activities later on. However, without the CC programme, Charmec would most probably not have existed in its present shape, with its present partners. *Not yet introduced in large scale; the technology only exists in successful demonstrators*

There are also a couple of cases in which economic figures have been estimated or possible to calculate for products and processes that are less strongly linked to CCs. These are shown in Table 8 and Table 9. Although less clearly linked to CCs, which in all three cases is due to complex products, the figures indicate that the CCs have made important contributions to important products – the total value per year is estimated to 11.0 BSEK for Ericsson AB and Volvo Aero, and 3.0 BSEK in the case of AXIS Communications. The component in AXIS Communications has however not yet been implemented, and the figure indicates total sales of the product instead of added value from the CC.

Table 8 Economic impacts from products and processes that clearly, but not strongly, depend on CCs

Company	CC	Economic impact
Ericsson AB	ISIS	> 10 000 MSEK per year
Volvo Aero	PolhemLab	> 1 000 MSEK per year
TOTAL		**> 11 000 MSEK per year**

The economic figures presented above only include products and processes for which data on sales have been possible to estimate. There are plenty of other examples in the report in which CC research most probably has generated significant economic values, either in sales, cost savings or for the betterment of society through for example more environmentally friendly products.

Table 9 Value of products and processes that will be importantly improved as a result of CCs

Company	CC	Value
AXIS Communications	CCCD	> 3 000 MSEK per year

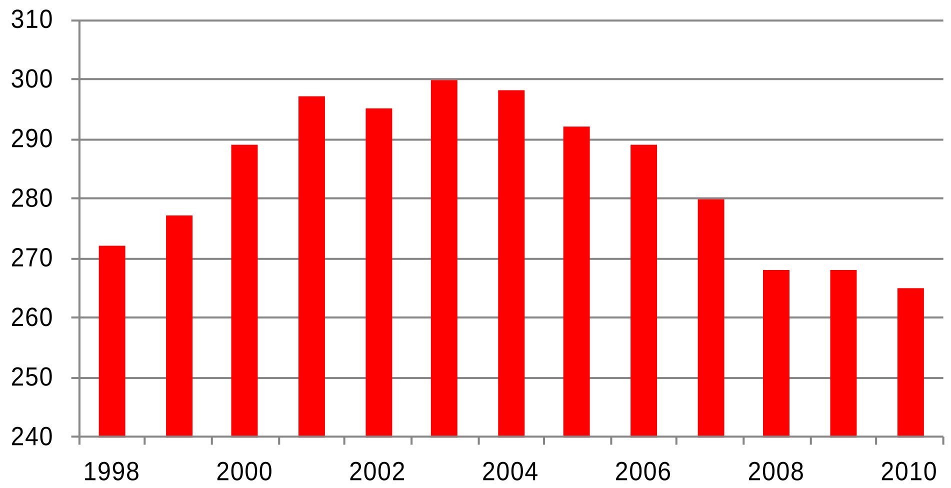
4.4 Economic development of SME's participating in CCs

Small companies can play important roles in competence centres, but their resources are limited so it is hard for them to play a significant role in the more fundamental work of the centres. Equally, their ability to translate technical into financial success is modest. We were nonetheless keen to learn about their development because – in general – small firms depend on a small range of goods and services. Unlike in large conglomerate firms, where the effects of participation tend to be hard to follow through multiple parts of the firm and complex innovation processes, the effect of successful innovation in SMEs is more directly visible in their overall performance.

Data on the economic development of participating companies are available for the period 1998-2010. Hence, some of the data describe a period when the companies were active in the CC, and some are derived from after the CC period. The population of companies consists of all companies that have been a partner in any one of the CCs.

In total, there are data for between 272 and 300 companies at subsidiary level each year, with an average of 284 companies. Fluctuation is due to the fact that new companies have started and become partners in CCs during the period of their activities and to the demise of companies whose business concepts do not hold and who eventually go bankrupt. The number of companies in the database for each year is shown in Figure 20.

Figure 20 Number of companies in the database on company economic development 1998-2010



The figure clearly indicates a growth of the number of companies, which peaked in 2003 at 300 companies, and then declined over the years as companies fell off and eventually reached the level of 265 companies in 2010.

The participating companies are not evenly distributed among sectors. A clear majority, an average of 48 per cent over the years, are from the manufacturing and mining industries. 13 per cent are information and communication companies, 12 per cent are private business services, 10 per cent are R&D establishments and 8 per cent are trade and commerce companies.

4.4.1 Performance

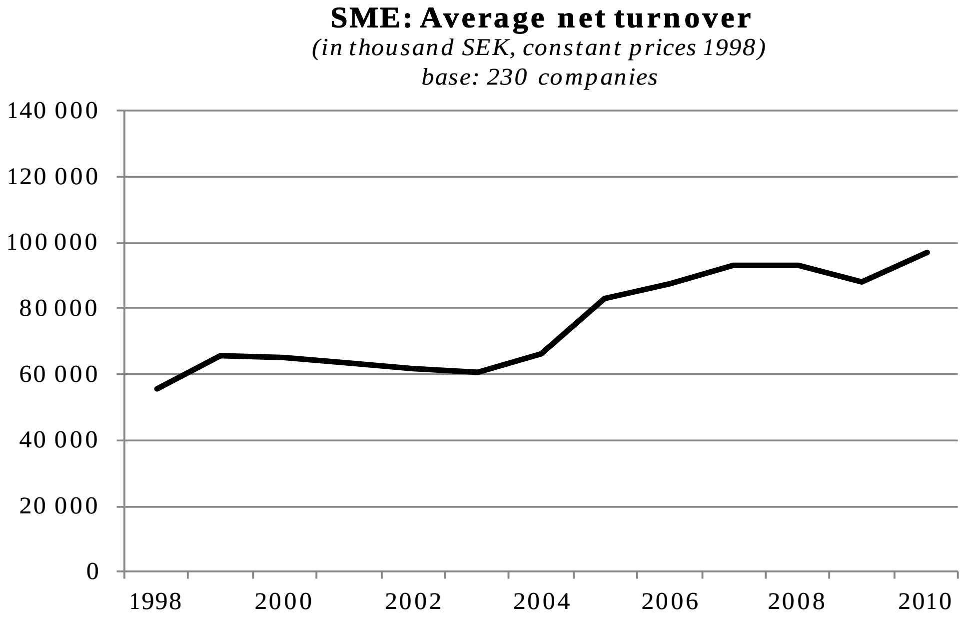
Among the companies in the database, SMEs (with fewer than 250 employees) constitute 30 per cent of the population of companies that participated in the different CCs. This differs a lot from the composition of companies in the rest of the economy, which is mainly formed by what might be called micro companies (with less than 10 employees), who are 97 per cent of all companies in Sweden.[64]

The data on performance for these companies are presented at parent company level. This means, for instance, that the turnover figures have been aggregated by adding up the information corresponding to each of the subsidiaries of a parent company that have participated in the different CCs.

From this also follows that the results do not necessarily reflect the performance of an entire company, but focus on the performance of those areas or departments of the company that were actually involved in a CC in some shape or form.

Figure 21 shows the evolution on average net turnover for participant SMEs. This graph shows that, on average, those companies experienced an upward trend in net turnover from 2003 onwards until 2009.

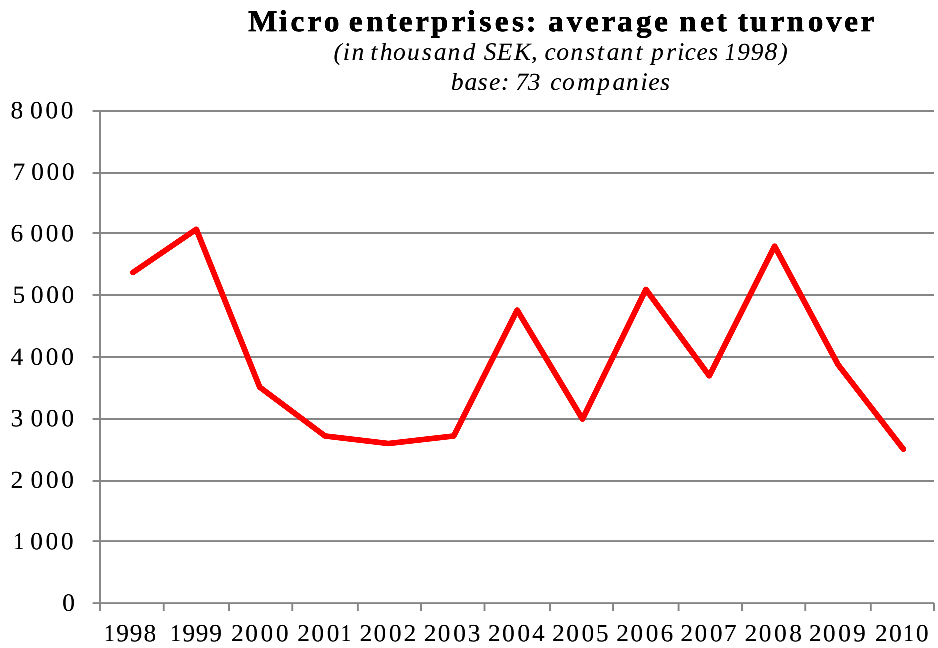
Figure 21 Participating SME's performance 1998-2010



Source: Financial data on participating companies from annual reports, provided by VINNOVA

[64] Statistics Sweden (SCB), Structural Business Statistics, 2010.

Figure 22 Micro enterprises' performance 1998-2001



Source: Financial data on participating companies from annual reports, provided by VINNOVA

When taking a special look at the micro companies, a less clear pattern emerges, which is shown in Figure 22. The irregular behaviour illustrated in this graph can be partially explained by the relatively small number of companies included under this enterprise class size (around 25 each year). However, it is also explained by the high variability in net turnover from one year to another, within the same company. Growth rates have been as high as 6000 per cent for one company, as low as -99 per cent for another.

It is worth noting, though, that some companies registered a turnover of zero in a given year, even though they had been active. In these cases reported profit is negative; hence it is difficult to tell whether the actual turnover was zero or if it was simply not reported.

Between 1998 and 2010, the average net turnover of the SMEs increased by 57 per cent. (See Table 10 below). The same growth rate is observed between 1998 and 2008, a period that excludes the effects of the global financial crisis in 2009. This shows that participating SMEs were able to quickly recover from the consequences of the crisis. This is, by the way, also the message in the Statistics Sweden report on Structural Business Statistics, 2010.

Similar, but less strong growth patterns are obtained after removing values of potential outliers from the sample. In this case, the average net turnover of SMEs increased by 28 per cent in 1998-2008 and by 26 per cent in 1998-2010, which confirms the robustness of the results.

In addition, the SMEs have grown, on average, more than the participating large companies, irrespective of which reference period is used to make the calculation.

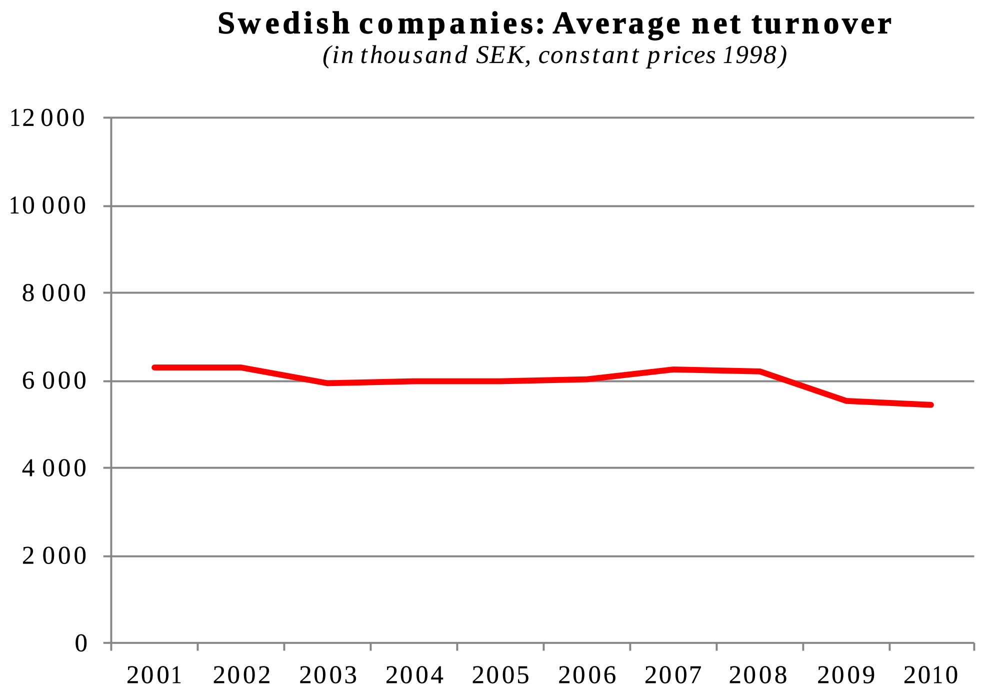
Table 10 Growth in (mean) net turnover

	Large (250 employees or more)	SME (between 10 and 249 employees)	Micro (less than 10 employees)	Total
1998 vs 2010	16%	57%	-53%	-4%
1998 vs 2008	30%	57%	8%	7%
2001 vs 2010	12%	44%	-7%	1%
2001 vs 2008	25%	45%	115%	12%
After excluding outliers				
1998 vs 2010	16%	28%	-42%	-6%
1998 vs 2008	36%	26%	-20%	11%
2001 vs 2010	7%	44%	31%	-5%
2001 vs 2008	26%	41%	81%	12%

4.4.2 Comparison with the rest of the economy

The performance of SME's participating in the CCs has clearly been stronger than the rest of the Swedish economy during the period. According to Statistics Sweden, the average turnover of all companies in the Swedish economy was around 6 billion SEK between 2003 and 2008, with a mild decline after 2009 (See Figure 23 below). This translates into an overall decline of 2 per cent between 2001 and 2008, which is of course accentuated when taking into account the post-crisis year.

Figure 23 Average net turnover for all Swedish companies 2001-2010



Source: Statistics Sweden (SCB), Structural Business Statistics, 2010

4.4.3 Value added

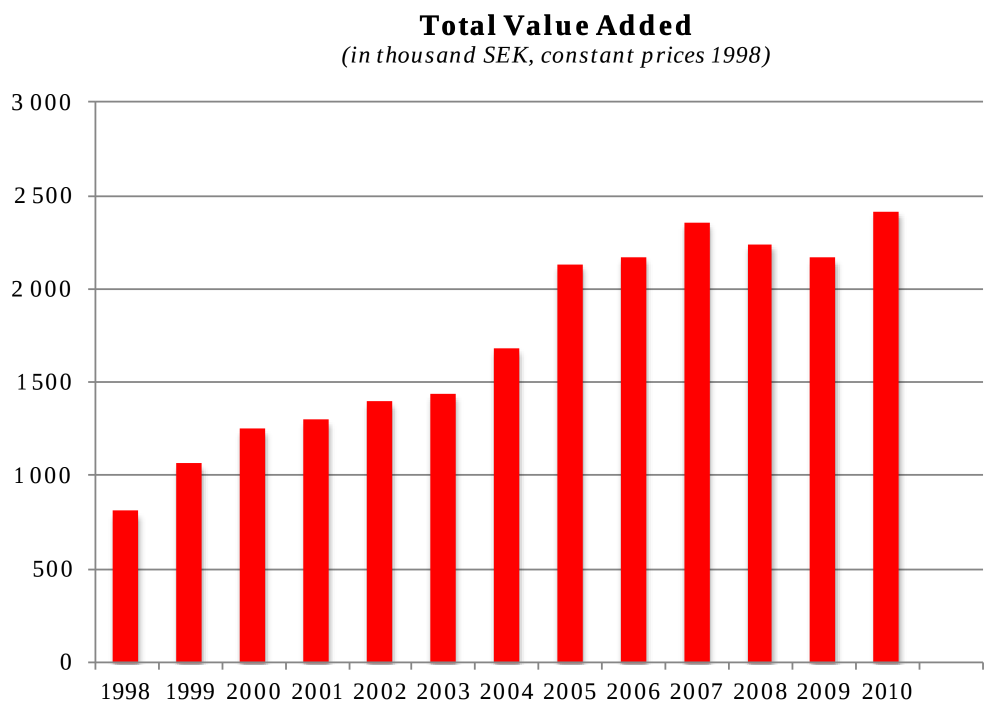
The total value added of a group of companies give us an estimation of how many additional outputs has been produced within each of these companies. We do not have enough information to calculate how much added value has been produced by each of the participant companies in the CCs, since this will require having access to information on intermediate goods purchases as well as indicators of depreciation and amortisation.

However, it is possible to estimate the value added using ratios of turnover and value added calculated for the rest of the economy. According to information published by Statistics Sweden, each SEK of turnover translates into 0.28 SEK of added value. In other words, for each SEK that a company sells, 0.28 SEK can be directly attributed to its own production process, which means that we also assume that the remaining 0.72 has been produced down in the supply chain.

The total value added produced by the participating SMEs and micro companies has increased year after year, and it reached 2.4 billion SEK in 2010, which represents 0.2 per cent of the value added generated by the whole economy that year.

Because we have no systematic information about the individual links between the SMEs and the CCs, there is no certain way to attribute credit to the CCs for SME's performance or the extent to which they have out-performed the economy as a whole. CC membership is nonetheless associated with good performance. Nonetheless, it is clear that strong economic performance and CC membership is associated.

Figure 24 Value added generated by participating SMEs and Micro companies 1998-2010



Source: Statistics Sweden (SCB), Structural Business Statistics, 2010

4.5 Indirect effects by adding to the firm's stock of internal resources

4.5.1 Intermediate knowledge outputs

Capacity building has been one of the most important impacts that CCs have had on participating firms. This is to a large extent manifested in knowledge that cannot be attributed to specific goals, but which yet has meant or will mean improved productivity. Many of those cases relate to individuals getting deeper insights in general into a field of knowledge. Several CCs have for example been running seminars, workshops and PhD courses and other training where R&D staff from the participating firms has been invited.

The CC programme has also clearly resulted in the establishment of valuable 'know-who' networks, both between firms and between firms and university research environments. In many of the dissolved CCs, those networks still live on. CPM, presented below, is arguably the finest example, but also in dissolved environments such as CBioSep, CBioPT and SNAP, relatively dense networks between individuals in the different firms persist. In almost all other dissolved CC environments a significant number of firms maintain some kind of links with the university researchers, including bilateral projects. Both capacity building and the formation of networks of this kind crucially depend on the long time-frames and the in kind contributions, which enabled individuals to interact with one another for a long period of time around a relatively focused knowledge field.

Three CCs stand out as efforts to introduce relatively recent technologies to industry:

- CPM, which focused on methods and support primarily connected to Life Cycle Assessments
- SUMMIT, a centre for the field of micro systems technology, which started to emerge in the mid-1990s
- WURC, which addressed the paper and pulp industry, aiming at building capacity and knowledge networks focusing the ultrastructure of wood fibres

With the exception of CPM, these centres have had relatively marginal direct effects on products and processes in participating firms. It is however apparent that they all have made significant contributions with regard to general capacity building, network formation and general awareness of the technological fields.

CPM has – as described by the cases of ABB, AkzoNobel, SKF and AB Volvo in section 4.1.4 – had a major impact on environmentally friendly products and processes in a number of large MNCs. The CC has supported general capacity building and also developed databases and verified the work of the firms. Databases were crucial. The firms could not have built them on their own. Also verification has been important: in the environmental field judgements from impartial experts are important for credibility, both towards customers and in the internal lobbying that the firms' environmental experts have conducted within their respective organisations. Implementation of e.g.

Life Cycle Analyses has meant that a large number of people in the corporations have had to devote attention to environmental aspects, and integrate that perspective in their operations. A consequence has been a general increase in knowledge and awareness of environmental aspects in those firms, to be used also in the future. CPM has also contributed greatly to the formation of the perhaps most engaged and tightly knit knowledge value collective of all CCs. CPM still lives on with six large MNCs and four other organisations (one public authority, two research institutes and one research centre) as members, driven as much by the researchers as by the participating firms, which have established a very important platform for discussions.

SUMMIT achieved important benefits by gathering significant parts of the Swedish industry interested in the emerging field of micro systems technology, disseminating research and supporting the firms in applications. In the early years of the centre, it put most of the efforts into educating the community of firms; the field had almost no active firms, but the interest was high. Micro systems technology – today often called micro-electromechanical systems (MEMS) – concerns very small electronic devices that typically contain a data processing component and communication components such as microsensors. The field matured significantly during the ten years of SUMMIT, which led the centre to devote the last phase to pushing small start-ups. Several of those companies went on to receive support in VINNOVA's Forska&Väx programme. As areas of application have developed, the field is today too wide to have a general centre like SUMMIT. Several successful firms have participated in or in other ways benefitted from SUMMIT. Successful members include Radi Medical Systems (today St Jude Medical Systems), see description in section 4.2.1, and Åmic. Åmic, bought by the MNC Johnson & Johnson in 2009 and then relocated to the U.S., has spun out several small companies often listed among promising start-ups, such as Gyros AB and Sigolis AB. Åmic's technology also connects to technology in Q-Linea, listed by Sweden's leading technology newspaper Ny Teknik as one of the 33 hottest Swedish firms in 2012. Also Rolling Optics, on Ny Teknik's top-33 list for three consecutive years, 2010, 2011 and 2012, has worked with SUMMIT and uses technology developed in the CC. Rolling Optics also received 300 kSEK in additional support from VINNOVA in late 2005, in a call directed to start-ups from CC environments. Sweden's prime 'success story' in the field, Silex Microsystems AB, founded in 2000 and with 190 employees in 2011, was never part of the CC but has benefitted indirectly for example by recruiting a number of PhDs from SUMMIT.

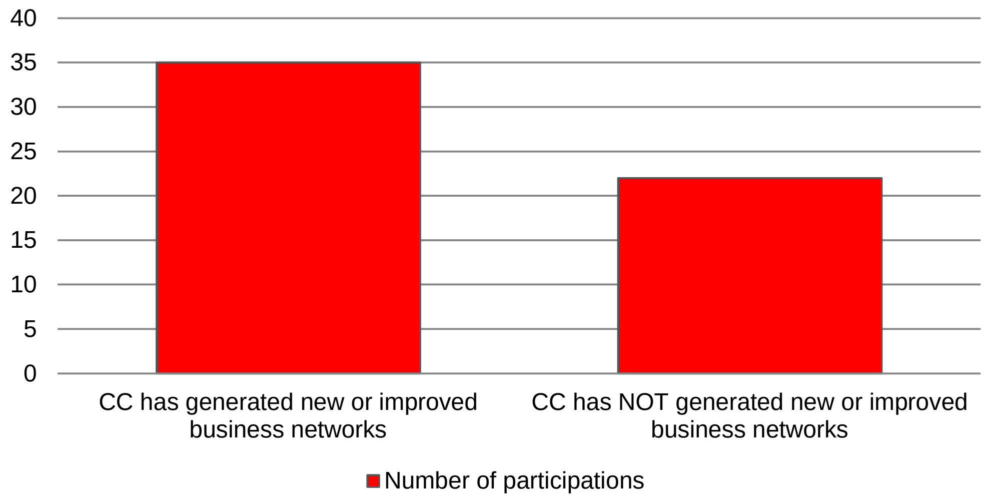
WURC was established to increase the competence in the paper and pulp industry of the properties of the wood fibre. Wood fibres are fundamental in the sector. At the beginning of the CC, there was a significant gap between the level (and possibilities) of university research and the level of competence in industry on the field. Despite being dominated by large corporations, the industry also struggled with small resources for R&D, and had limited connections with universities conducting basic research – the sector had thus far mostly worked with more applied research institutes. In addition, some of the corporations were among each other's strongest competitors. Initially WURC therefore provided relatively basic research, presented to build capacity and promote the field in industry. During the second half of the CC, industry's capacity to absorb WURC's research was higher, and the character of the projects could therefore shift towards more applied research. However, due to the competition between the participants, projects never became particularly applied, and the companies were careful not to reveal business strategies based on the research. WURC has clearly made an important contribution to the sector: all five responding firms praise the CC for proving highly useful capacity building in the sector. WURC has also formed the basis for much of present collaboration between the paper and pulp industry and universities. The CC still lives on in a smaller and more applied format, CRUW, within the Swedish national research programme for the forest-based sector.

Also CID, which focused on user oriented design in ICT and human–computer interaction, seems to have made a valuable impact among some of its participants on the general awareness of the potential of the field. The CC mostly worked with highly applied projects, often with actors that are normally not part of this type of centres. Projects include the establishments of a videocafé in Vattenfall's boardrooms, exhibitions at museums and ICT-support for education in schools. Sweden's largest labour union, LO, participated in CID. CID appears to have significantly risen LO's awareness of how to map quality and user-friendliness of ICT in the public sector, as well as its awareness of the potential that lies in collaboration with university researchers.

4.5.2 Networks for technology and business

A majority of the firms interviewed find that CCs have improved their business networks, see Figure 25. The extended networks primarily concern that firms have become more aware of each other's competences and product offers, which has occasionally led to minor collaborations such as exchange of information and small projects together. There is no evidence of firms that have developed supplier-customer relations of magnitude as a direct result of participating in the same CC.

Figure 25 CC impact on business networks in interviewed companies



Note: N=57

Many CCs contained supplier-customer partnerships, but in most of those centres that element was relatively limited. SNAP is the most evident example of such a CC; the centre contained representatives from the full value chain, from raw material to end users. SNAP focused on developing new and more environmentally friendly surfactants, based on a vision to replace some of the petroleum based surfactants that dominate many parts of the industry. The relatively broad spectrum of participants not only contributed to a valuable variety in perspectives, it also meant that the firms more or less did not compete with each other. Rather, they were each other's customers and as such commonly interested in progress. After the termination of SNAP, several industrial participants continued to collaborate with each other in two new centres (VINN Excellence Centre SuMo Biomaterials and Institute Excellence centre CODIRECT) and in the EU-project Self-organisation under confinement.

Another example of a CC with relatively extensive supplier-customer relations is Charmec, which concerned railway mechanics. During the entire period when Charmec was a CC (the centre still lives on), a representative from the Swedish Railway Administration (today part of Swedish Transport Administration) was head of the board. As such, the practically only end user in railway mechanics was part of the centre. All other interviews participants found that highly valuable, since it enabled a constructive dialogue around technical issues instead of, as phrased by one participants, "that the Swedish Railway Administration post a list of new demands". The presence of the Swedish Railway Administration also helped to attract Austrian Voestalpine, one of the large companies in the sector, to the CC – one of the few examples where a company without Swedish roots has joined a CC. Charmec also contained other important supplier-customer relations, such as the triad Lucchini (see case study in section A.10), LKAB and the Swedish Railway Administration. By serving the railway infrastructure and bringing together many of the most important actors in the sector including the Swedish Railway Administration (today the Swedish Transport Administration), many of Charmec's results are as important for society and the taxpayers as for the participating companies. Charmec has put together an impact analysis on their own, in which notable impacts of the latter kind include:[65]

- Noise reduction: Charmec estimates that its research and support has saved a couple of hundred MSEK in Sweden – probably mostly in the public sector – by for example reducing costs for noise abatement deals due to less nosiy trains
- Wheel pressure: Charmec research has enabled savings of tens of MSEK per year since 2009, probably mainly in the public sector, by showing that the correlation between amount of cargo in a wagon and risk for rail cracks was relatively weak. Based on the result, the Swedish Rail Administration decided to allow more cargo and the use of new detectors that decreased the need for inspections and thereby stops in the traffic

[65] Anders Ekberg (2011), Forskningsprocessen – hur man får en effektiv järnvägsforskning. Memo, Charmec, Chalmers University of Technology

- Corrugated rails: Charmec has developed knowledge on corrugation of rail tracks, which has enabled better wheel grinding. Charmec estimates the savings today to around 10 MSEK per year, but notes that the savings were much larger in the early 2000s when the X2000-trains that operate between most large cities in Sweden had severe wheel problems, which largely depended on corrugated rail tracks
- Software programs: Charmec researchers have developed two software programs, DIFF and FIERCE, which are widely used across the world and which Charmec estimate save hundreds of MSEK per year globally by reducing the need for tests on real tracks and by reducing the degree of 'trial-and-error'
- Support in introducing new technologies. Charmec estimates that its support when new railway technologies – such as new types of trains – are introduced has saved around 5 MSEK per year
- Reduced costs of accidents and breakdowns. Charmec has provided research and other support that probably has prevented accidents that otherwise would have happened. It is not possible to estimate the savings made, but Charmec researchers guess that it might be tens of MSEK per year

Several respondents point out that Charmec is highly useful not only for its excellence in the field, but also by being an impartial and highly credible actors lubricating the relations between suppliers and customers – damages caused by railway mechanical problems can be very expensive, which (as happened in the case of the Iron Ore Line) can cause tensions in the relations between suppliers and customers.

4.5.3 Reputational assets

Participation in CCs often carries a symbolic value. Several respondents, notably producers of complex and technologically advanced products, have pointed out that customers value innovation because it indicates an interest in further development of the product and of the competence of (support) staff. One example is ABB in Faxén-Laboratoriet, which several times presented the project to customers as a good example of their competence and interest in improving the product. A related example is Sandvik in BRIIE, which observes how customers, especially large corporations, appreciate that Sandvik offer full range of products. Thus, to show important improvement on one product can mean that a customer also chooses to buy 20 other products.

CC participation also often has a symbolic value when recruiting new staff: if a company wants to recruit an individual who possesses a PhD, it is typically positive to be able to point at links with (leading) university research environments.

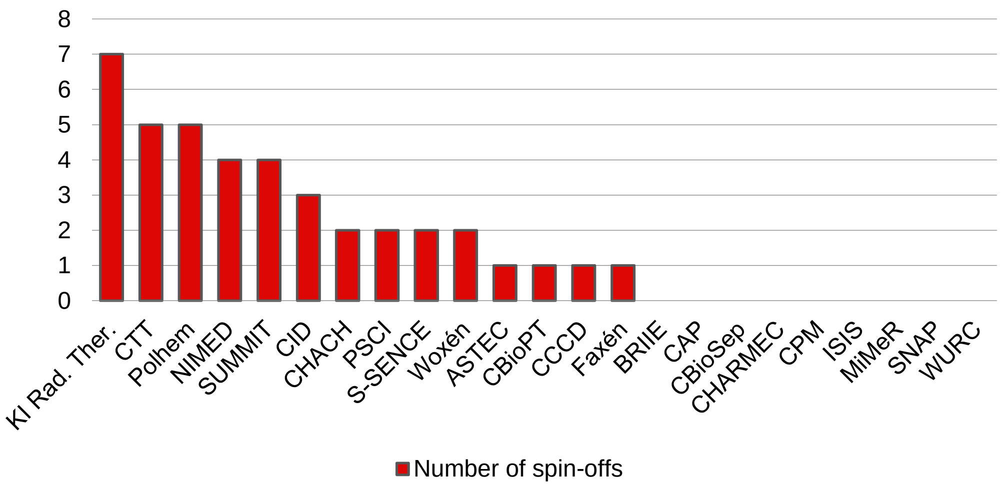
For small companies, participation in CCs is also a good way to market themselves towards large firms and towards university researchers. One example is small biotechnology company Protista in CBioSep. Protista claims that participation in CC, where they were mostly surrounded by large corporations, has given them respect – both among companies and researchers – they would otherwise not have. That partly symbolic aspect has improved their sales. It has also led to new collaborations with researchers and companies in Sweden and internationally. Protista's respondent points out, "if you want to work with the best professors, you have to show immediately that you are good, otherwise they will not listen to you". Being able to point at experience from CBioSep was positive in that respect.

4.6 Spillovers

4.6.1 Spin-off firms

The CCs spun off 43 new companies between 1995 and 2006. Forty of those were created in VINNOVA centres, see Figure 26. Another three – at least, data are uncertain – were formed in centres run by the Swedish Energy Agency. As the figure shows, the number of spin-offs varied between CCs. Five (18 per cent) of the 28 CCs were responsible for 25 (58 per cent) of all known spin-offs.

Figure 26 Number of spin-off firms from VINNOVA-funded CCs, 1995-2006



Source: VINNOVA 2006

Why is the distribution of spin-offs skewed? The main factor concerns the technological fields in which the CCs were active. Four of the five most spin-off prone CCs concerned relatively 'new' technological fields in which new firm formation was natural. The most prominent example is SUMMIT, described in section 4.5.1, which served to establish a new and promising research field in industry. KI Radiation Therapy, CTT (speech technology), NIMED (medical technology) and CID (user-oriented IT-design) were also active in such fields. They also had a comparably high number of small firms as participants in the CCs. PolhemLab is the exception, focusing on implementing methods and technologies to improve the product development processes and dominated by large firms. PolhemLab seems to have given birth primarily to consultancy firms. In all five cases, spin-off formation appears to have been actively encouraged by CC management. Two examples of spin-offs are:

- Phase Holographic Imaging, which is an academic spin-off that was "incubated" in CCCD. They develop a new type of microscopy based on holographic images. The company was started in 2001 and was at that time lacking crucial competence in algorithms. CCCD helped them with the algorithms and also with circuit design. The company has had products on the market since 2011. This far they have sold about 15 instruments, which each cost around 250 kSEK. When the CC was terminated, CCCD and VINNOVA helped the company by allocating a remaining 300 kSEK in the CC to the university, on the premise that the university bought and tried out an instrument from the company. That was the first instrument the company sold, and a great help when the company needed to attract more venture capital. See also case study of the company in section A.6

- Gotmic AB is a spin-off that develops and sells high-speed circuits based on wireless LAN (WLAN) for very high frequencies. The company is a spin-off from Chalmers University of Technology. In 2011 Gotmic reported three employees and an annual turnover of 2.2 MSEK. The technology is developed partly in CHACH with special collaboration with Ericsson. Gotmic's products are expected to increase speed in wireless communication, for example in mobile phone networks. Gotmic collaborates closely with Ericsson

However, CCs can also generate spin-offs also after the centres have been terminated – new technologies sometimes need to be developed further, before they can form a solid basis for a new company. One notable such example:

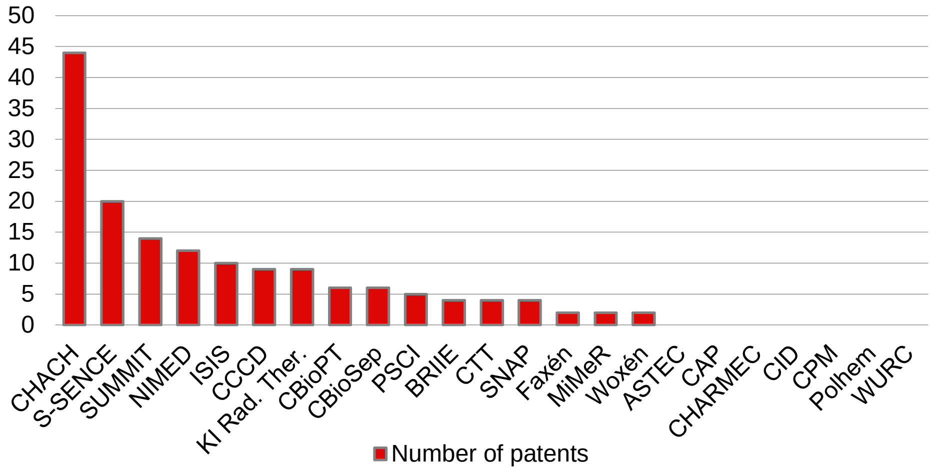
- Intenz Biosciences AB, a biotechnology spin-off based on an innovation that AstraZeneca made in SNAP. The company is therefore not included in Figure 26. Intenz Biosciences was founded in 2005 to capture inventions from Greenchem, a research programme funded by the MISTRA foundation and run by Lund University. In 2010 the company was restructured to focus on commercialising a sugar-based surfactant that was originally developed by AstraZeneca in SNAP. At the end of SNAP the surfactant was still too immature be used at AstraZeneca. The company therefore further developed the invention in Greenchem, which had a more applied focus than SNAP had. In 2010 AstraZeneca decided to let Intenz Biosciences, partly owned by a former AstraZeneca manager, develop the surfactant further, provided that AstraZeneca had right of first refusal of a final product. The innovation is to use enzymatic catalysis of chemical reactions to produce compounds that are more difficult or costly to produce by other types of catalysis, in a process that is also relatively environmentally friendly. The idea is to use the surfactant in products that interact with human skin, mucosae, or other sensitive tissues; primarily pharmaceuticals, but the company also hopes to use it in for example shampoos and cosmetics. Intenz Biosciences does in October 2012 not have a product on the market and had in the end of 2011 no reported employees, but has attracted venture capital. In early 2012 the company received financial support from the VINNOVA programme Forska&Väx. See also case study of AstraZeneca in SNAP in section A.13

4.6.2 IPR and technology transfer

Generating IPR was never a focus for most CCs, mainly because the format with several (potentially competing) firms in the same CC was found risky. Even if participants in all CCs agreed – sometimes after long discussions – on how property rights to potential new technologies in the centres would be handled, the close collaboration meant that most firms were unwilling to use the CCs for projects that were close to being patented.

The agreements reached typically meant that a potential patent would be assigned to the company/companies that funded the specific project, and that all other participants would have a right to licenses. That format generally worked well. Another reason for the often limited focus on patents, is that the link between knowledge creation and commercial success due to innovation does not necessarily include patents. A number of respondents make this point. The main argument is that knowledge embodied in a company's staff is more important that knowledge inscribed in a patent. However, to large companies such as Ericsson, patents are also to some extent products in themselves, since licensing enables them to extract money from or negotiate with their competitors. Historically, Ericsson was little interested in patenting until it entered the mobile telephone business, where it needed to negotiate with Motorola for access to its vast patent portfolio. As a result, Ericsson started aggressively to pursue patenting, as a means to horse-trade with Motorola and others.

Figure 27 Number of patents generated by VINNOVA-funded CCs, 1995-2006



Source: VINNOVA 2006

Figure 27 shows the number of patents generated in VINNOVA-funded CCs between 1995 and 2006. Data for the five CCs funded by the Swedish Energy Agency are uncertain, but they generated at least eleven patents during the same period. The distribution of patents is even more unevenly distributed among CCs than are spin-off firms. The 23 VINNOVA-funded CCs had by 2006 generated 153 patents. Forty-four (29 per cent) of those patents came from one single CC: the CHACH centre. The top five CCs were responsible for 100 (65 per cent) of the 153 patents. It is likely that companies have patented more inventions building on CC work in the subsequent period. It has however not been possible to collect that data for this study, mainly because the individuals with knowledge on the large firms' CC-participation have limited overview over further technological development.

The top patenting CCs all have in common that they developed knowledge suitable for patents: knowledge that was relatively close to implementation in processes or products, and that had the potential to be packaged such that patenting could be possible. CCs focusing on capacity building, such as CPM and WURC, and CCs working mainly with process changes in manufacturing, such as Polhem and Woxén had limited possibilities to generate patents.

The successes of the top CCs can mainly be attributed to three factors. Firstly, they were all active in fields where the time from basic research to implementation is relatively short and competition is fierce. In CHACH, SUMMIT, CCCD and ISIS for instance, computing is important; even basic computing can take place in an applied context Secondly, most of these CCs – partly due to the short step from basic research to applications – mainly consisted of projects where only one firm worked with the researchers. Thirdly, in at least some of these CCs, for example in CHACH, the management readily accepted commissioned projects parallel to the CC projects. Such commissioned project were formally not part of the CCs, but it is possible that patents generated from such projects because of their close links with CC projects are included in the statistics in Figure 27.

ASTEC is a peculiar example in terms of IPR. ASTEC worked with tools and techniques for software development, and had specific competence in the programme language Erlang. Erlang was developed by Ericsson and Swedish Telecom (Televerket) and later tailored for mobile communication networks, and the reason why Ericsson joined ASTEC in 1995. In 1998 Ericsson decided to release Erlang as open source, partly because the company did not have resources to lead the development of the language, partly because Erlang was questioned within Ericsson. University researchers in ASTEC made several important contributions within Erlang, but since the language is open source the contributions can only with difficulty be tied to economic value. The open source has led to the spread of Erlang into other large companies and the creation of quite a few start-ups globally. Ericsson follows closely the development of the Erlang community and the language has during the last years had a revival at Ericsson.

Technology transfer in a CC can also occur in other ways than through IPR. The most important ways are through mobility of people between organisations and through problem-oriented dialogues between partners in CCs. The CC-format, with in kind work and collaborative projects involving several firms, implicates lower odds that knowledge 'leaks' across organisational boundaries. A PhD student who did his or her project with a specific firm and after graduation gets employed by another company in the CC – there are plenty of such examples – brings with him or her some knowledge of the other firm's core competences. And the close the dialogue between companies in common projects or at seminars, the more insights they get into each other's businesses and competences, including knowledge that is protected by IPR. Firms were aware of this situation, but typically concluded that the potential positive effects triumphed the negatives ones. A couple of respondents at larger companies also note that the R&D staff to a slight extent deliberately went behind the backs of the company's own law people; without doing so the dialogues would have become too superficial.

What are the effects of the CC programme on technological spillovers of these types? By providing a long-term arena where collaborations and trust between individuals was enabled grow relatively deep, the potential for spillovers was higher than in most other cases. It is however practically impossible to estimate the weight of it. Not surprisingly, no respondent in this study is aware of any evidence of technology transfer from his or her company to other participating companies in the CC (except when units have been sold). However, several of them claim that their own companies have had good use of learning from other companies, and, in a couple of cases, that they in common projects were able to observe key processes in other (mainly customer) firms, which helped them to develop their own products. Such statements indicate an imbalance between awareness of negative and positive spillovers – i.e. that leakage has occurred – but the value or usefulness of such technology transfer cannot be estimated.

4.6.3 Scientific outputs

Scientific outputs are generally not regarded as important by the participating firms. However, there are significant discrepancies between the firms, where some find it quite important. Those firms are all conducting advanced R&D and see a need to publish scientifically in order to get access to the research frontier and dialogue with university researchers.

The main importance ascribed to scientific publications, is that it helps to attract PhDs, who typically want to stay in touch with their research fields by occasional publishing. Scientific publications are also believed to attract PhDs and pave the way for new collaborations through the marketing aspect, especially when presenting a paper on a conference. In a few cases – e.g. Sandvik in HTC, see description in section 4.1.2 – the marketing aspect has also worked internally in the firm, by indicating in which research areas the company holds specific expertise.

4.7 Indirect effects via the university system

There are several effects on and via the university system reported from the CC activities. Some centres have not been directly involved in undergraduate teaching at the university, but an influence through faculty teachers active in the centre sharing their experience from company collaboration is more or less inevitable anyway. Laboratories involved in centre activities may also occasionally have some undergraduate teaching volume. If involved in education at all, the main teaching by centre personnel is generally done at the graduate level.

In other cases, the involvement in and contributions to both undergraduate and graduate education are significant. At these centres, thesis workers at different levels seem to have understood that interesting projects between the university and industry were available. The close contact with industry was generally much appreciated in these cases. There are examples of centres being able to show a higher rate of PhD production, than the surrounding university departments, which is then seen as a consequence of large industrial investment and efforts. One mechanism involved here is that the graduate students' dependence on one single supervisor diminishes. The companies involved act as support, and at the same time a little pressure is put on the supervisor at the university.

In this way, students at different levels get a good sense of the most current activities in the research field as part of their education. Some of the software developed in centres has further been used in the student exercises. In addition, special study programmes, or profiles were established within education in engineering. Another variant is represent-ted by the centres where activities and knowledge produced has caused a shift of focus in a number of regular courses given at the university.

Centres have also played a role in the specific development of both undergraduate and graduate courses, as well as even international master programmes. Also doctoral programmes were brought to new levels, through both industrial and international collaborations. Some courses which were initially developed to support a project in the centre have lived on, and come to focus modern applications. Events have been laun-ched which were also open to partners and graduate students not associated with the centre, and that way actually became part of a national education resource.

In addition to giving lectures at the own university, senior centre researchers have also given lectures and seminars at other universities, as well as invited students from other universities to lectures and demonstrations.

The activities and projects in a centre often involved several departments, and thus became a likely start-up also for further interdisciplinary collaboration. Many projects in the departments were also, in general, interrelated with CC projects.

Specific graduate schools have been established to provide a broader curriculum for graduate students. The goal has been to educate the students with a broad and integrated view across the whole spectrum of centre topics. When established, many students have been enrolled through such graduate schools, making the research goals of the centre and the graduate school programme match. The centres have therefore contributed to changing or developing the graduate courses.

4.8 Graduate students' career development

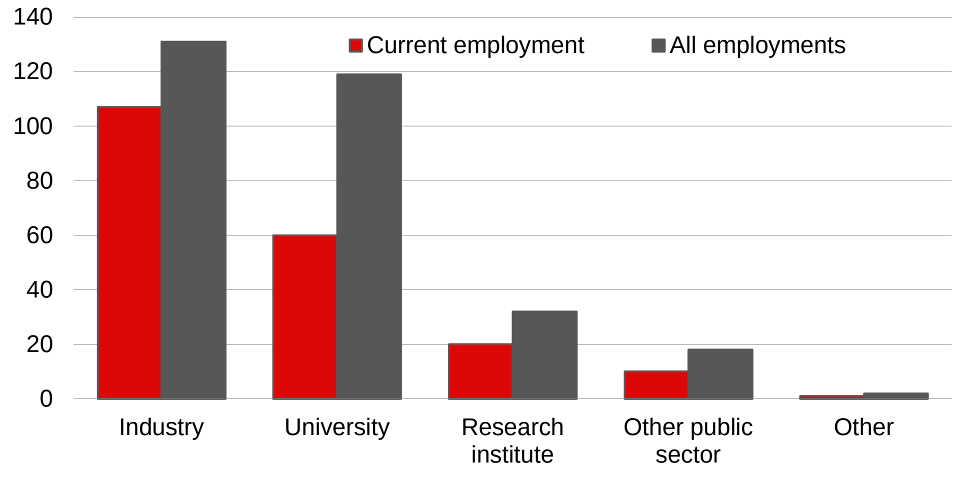
In many of the participating companies there has been a clear awareness of and a strategy towards the possibility to recruit both graduates and undergraduates with a specific competence following from long-term acquaintance and deep learning within a knowledge area of great importance for the companies' ability to develop.

There has been a considerable mobility between centres and their industrial partners, which has taken a number of forms. Some of the more common include when a CC partner have employed graduate students, when senior researchers went to work for industry and when the university has taken in adjunct professors from partners. Other forms of exchange have been co-publication with partners and having the partners involved in the board of the centre.

As a part of this study, a survey was sent to 425 individuals who graduated in the CC environments. Some of the contact data proved to be irrelevant, but the survey generated responses from 198 individuals. 185 of these answered all the questions in the survey. The contact details were collected from former CC directors and by Internet searches. Foreign-based individuals and individuals working in industry are probably over-represented among non-respondents and among individuals for whom contact details are missing, partly because the CC directors can be expected to have more knowledge of those working in academia and in Sweden, partly because university staff, unlike industry staff, usually have a personal webpage and are in other ways more visible on the Internet than industry staff is. Sixty-two per cent of the 179 individuals who indicated their year of birth and the year of graduation were between 30 and 40 years old when they graduated. The average graduation age was 33.

Figure 28 shows the current and previous employments of the PhDs graduating from the CCs. Around 30 per cent of the graduates are still employed at a university, which is in line with the national average: between 29 and 37 per cent of the PhD students who graduated in the engineering sciences (which dominate in the CCs) at Swedish universities in 2000, 2002 and 2005 still worked at a university in 2008.[66] A little more than half, 54 per cent, of the graduated PhD students in CCs currently work in industry, a figure that also should reflect the national average. It should however be noted that the survey respondents only constitute a minority of all CC graduates; as noted above, a majority of the non-respondents probably work in industry, which means that the total relative share of industry is probably higher than in the figure. A total of 80 individuals currently work in universities and research institutes.

Figure 28 Employment after PhD graduation, per type of organisation



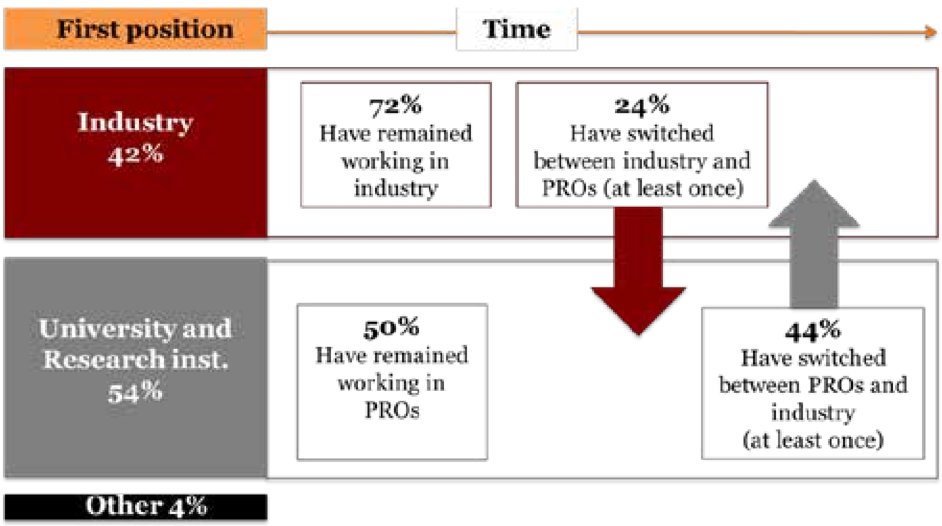
Note: N=198

[66] Swedish National Agency for Higher Education (2010). Doktorsexaminerades etablering på arbetsmarknaden. Rapport 2010:21 R

The grey bars in Figure 28 represent all 302 recorded employments, both current and previous employments after graduation. The difference between ‘current’ and ‘all’ employments is large for the university sector, which indicates a relatively common career trajectory that begins with employment in university after graduation, and continues with employments in other sectors, most notably in industry, where the relative difference between bars is low.

The trajectory is confirmed in Figure 29, which shows mobility between industry and universities or research institutes after the first employment, The figure shows that 42 per cent of the PhDs started their careers in industry. Of that total, 72 per cent have remained working in industry ever since. In contrast, if the career started in academia only 50 per cent remained. While 24 per cent of those who started their careers in industry moved back to university at some point, 44 per cent of those who started their careers in academia moved to industry. The 24 per cent (representing 20 respondents) who moved from industry to academia should yet be seen as a relatively large number; mobility from industry to academia is generally very low.

Figure 29 Mobility between industry and universities/research institutes



Note: ‘Other’ includes both other public sector and other types of organisations. N=198

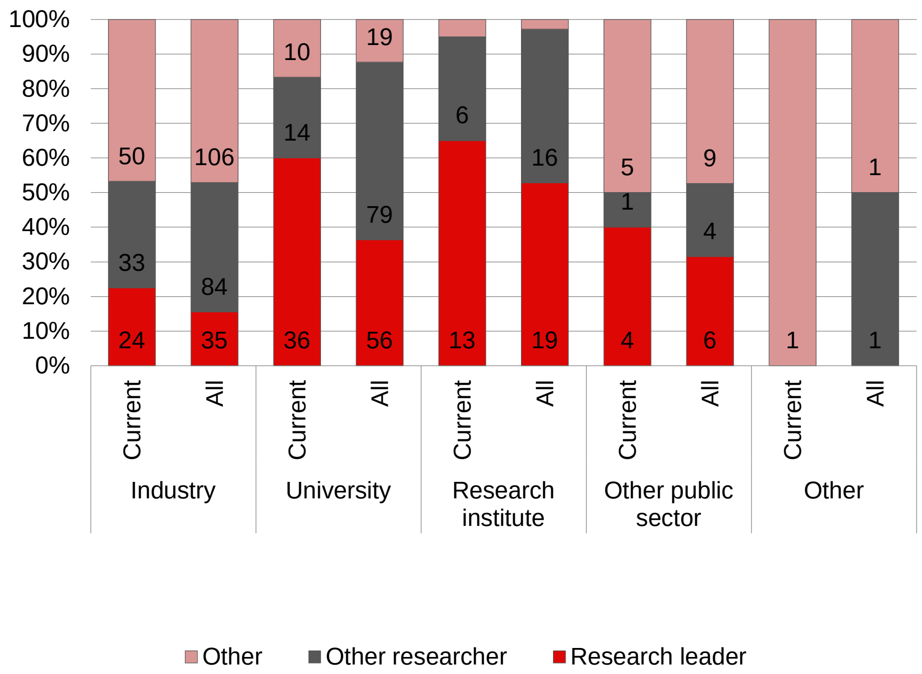
Figure 30 represents current and previous work tasks for the graduated CC-PhDs. Currently, bit more than half of those employed in industry work with research. An estimated other 10-20 individuals[67] in the category ‘other’ in industry work mainly with product development or software programming, which means that around 67-77 individuals work currently work with R&D in industry. The remaining respondents working in industry mainly seem to work with sales, marketing and overall management. Eleven respondents currently mainly work with non-research related tasks in universities and research institutes. Five work with R&D in the rest of the public sector.

[67] Estimate based on open responses; ’Comments, e.g. what work tasks you have had if you stated ’other’’

The shares have been relatively stable over time, i.e. when comparing current and all employments.

The figure also shows that in total 77 respondents (39 per cent) currently have management responsibilities within R&D. Individuals with management responsibilities are in particular found in universities and research institutes, while a substantially lower share of the researchers in industry are managers. As expected, there is – due to growing experience and merits among the PhDs – a higher share of research leaders among current employments than among all employments. The shares of graduates with management responsibilities can be expected to increase also in the future. The relatively high numbers of individuals with R&D tasks and with management tasks within R&D should be seen as a positive outcome of the CC programme.

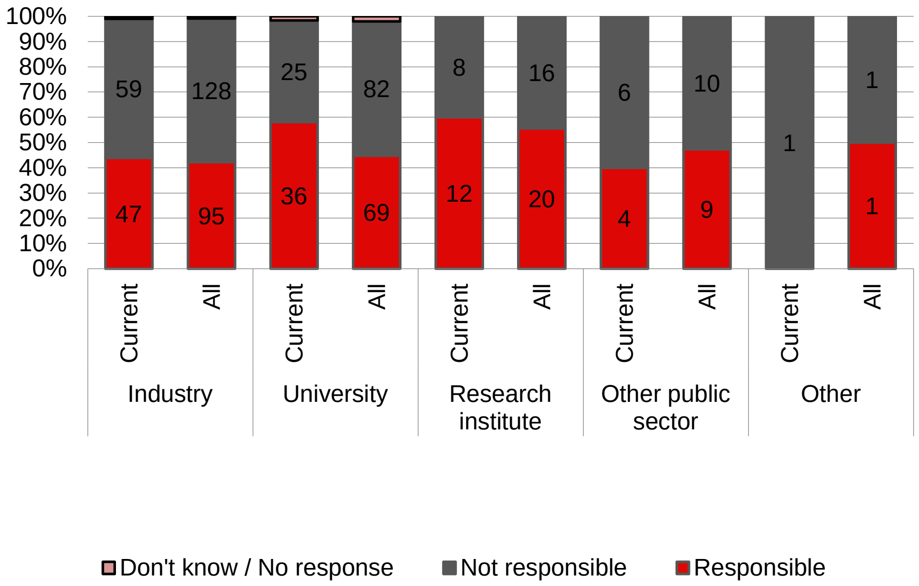
Figure 30 Main work tasks, current and all employments, per type of organisation



Note: Numbers in bars represent number of employments per category. N = 198

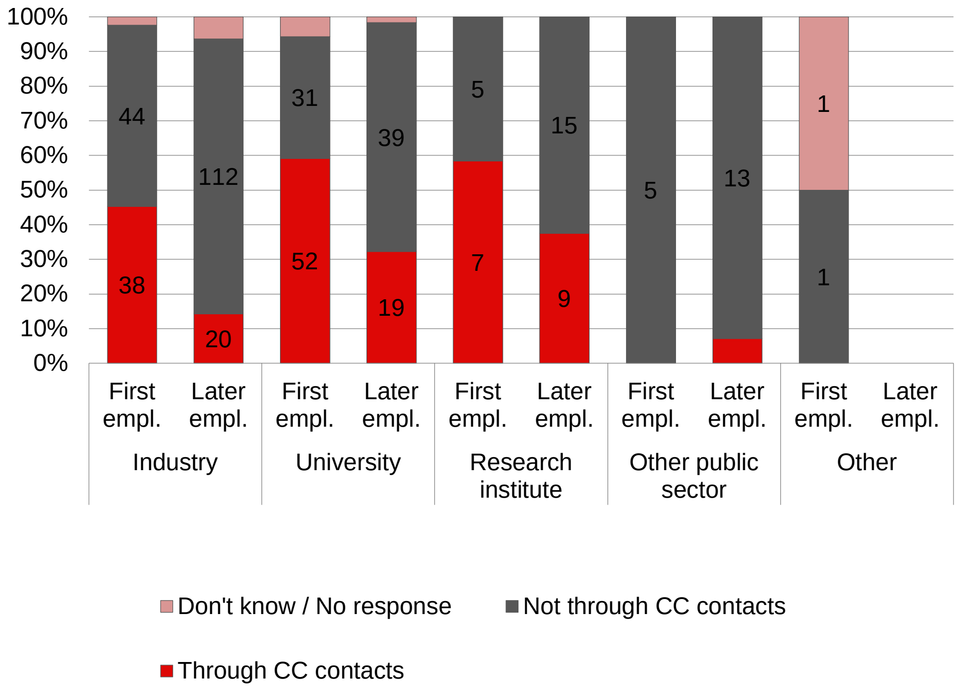
Being arenas for collaborations and interaction between university researchers and companies, CCs had excellent opportunities to educate PhD students able to manage industry-university relations. Figure 31 shows that more than 40 per cent of the former PhD students that now work in industry are responsible for relations with universities or research institutes, and that almost 60 per cent of those currently working in universities and research institutes have responsibilities for relations with industry. The shares have grown slightly over time, primarily in the PROs. Viewed together with the relatively high shares of PhDs working with R&D, this indicates that the CC programme has been successful in providing PhDs able to occupy positions of great importance in dynamic innovation systems.

Figure 31 Responsibility for industry–university/research institute relations, current and all employments, per type of organisation



Note: Numbers in bars represent number of employments per category. N=198

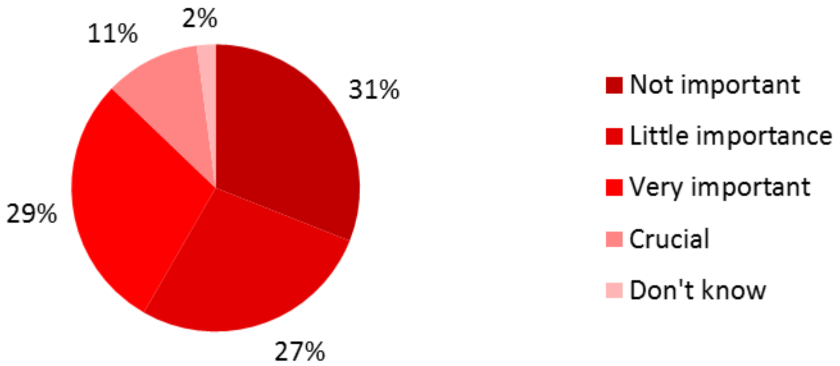
Figure 32 Employments through contacts in CCs, first and later employments, per type of organisation



Note: Numbers in bars represent number of employments per category. N=198

Figure 32 indicates to which extent the CCs have provided the PhD students with 'entrance tickets' to the labour market. As expected, contacts from the CCs were important for the first employment after graduation – although other factors than personal networks matter too, of course – and that the CC contacts were of less significance later on, when the individuals had been able to expand their networks and obtained promotion. It is undoubtedly positive that almost half of the PhDs who started off their careers in industry were recruited through CC contacts. This reflects the interviews, in which a significant number of industry respondents state interest in recruitment and also point out that CCs are excellent 'shopping windows' since the firms are able to observe the PhD students in action before they need to offer any employment.

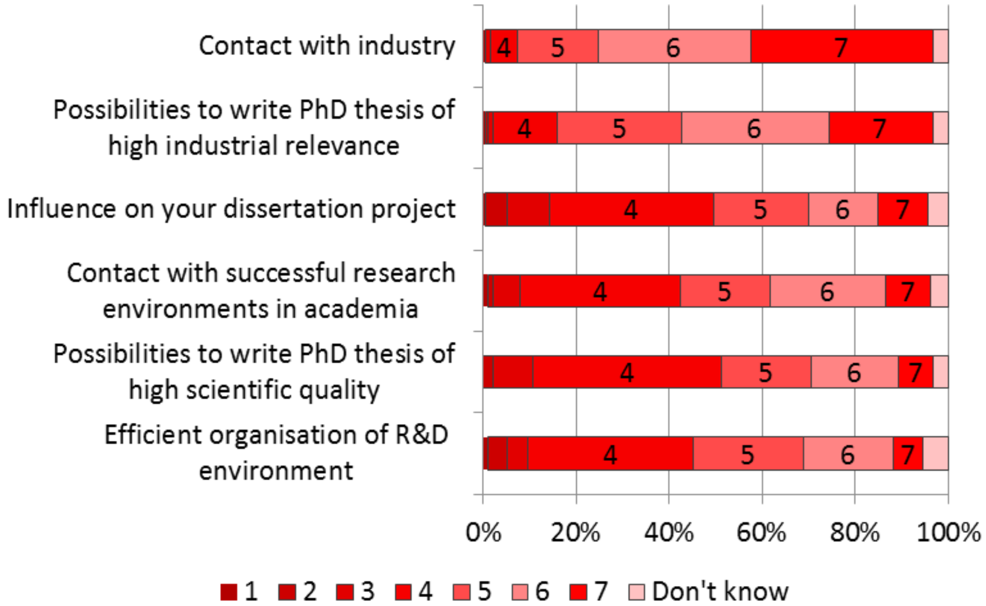
Figure 33 Importance of CC in choice of research environment for PhD studies



Note: N = 187

As shown in Figure 33, 40 per cent of the respondents indicate that the presence of a CC was very important or crucial (11 per cent) in their choice of research environment to pursue doctoral studies and graduate in. A third of the respondents indicate that the presence of a CC had no importance and 27 per cent indicate little importance. The figure might be affected by the fact that some (a small minority) of the respondents had already started their doctoral studies before the CC was established. A couple of respondents specifically comment that the choice to pursue doctoral studies was completely dependent of the presence of a CC.

Figure 34 Assessed differences between CCs and other research environments in the same fields



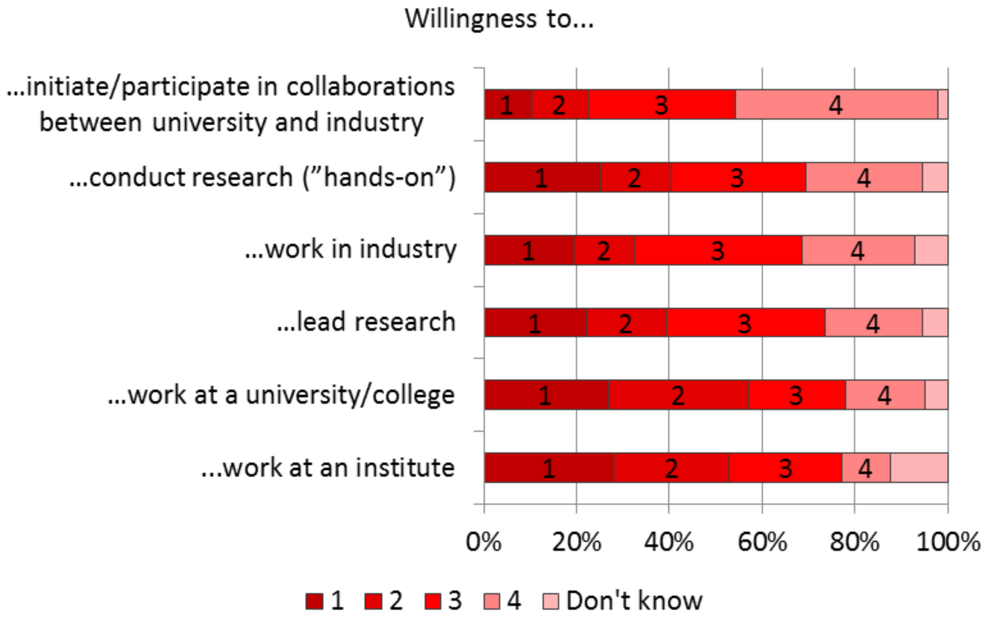
Note: 1 means 'much less', 7 means 'much more'. 4 should be understood as 'no difference'. N = 187

Figure 34 shows how the respondents assess possible differences between the research environment they graduated in and other research environments in the same field. The results are generally positive. The first two points concern industry relevance. The very high frequency of 6 and 7 are expected and positive, since the CCs were intended to maintain close links with industry. Practically no respondent returned a negative answer (below 3) on the two points.

The three issues at the bottom concern conditions for high scientific quality rather than industrial relevance. The positive results also on this point are notable: between 20 and 30 per cent state 6 or 7, which indicate that they regard the research environments as unusually strong from a scientific point of view.

Respondents also found that they had significant influence over their dissertation projects, which is positive and a result that perhaps is surprising; a common argument is that increased industrial relevance and collaboration with industry decreases researchers' room for action.

Figure 35 Assessed impact of CCs compared with more ‘traditional’ research environments



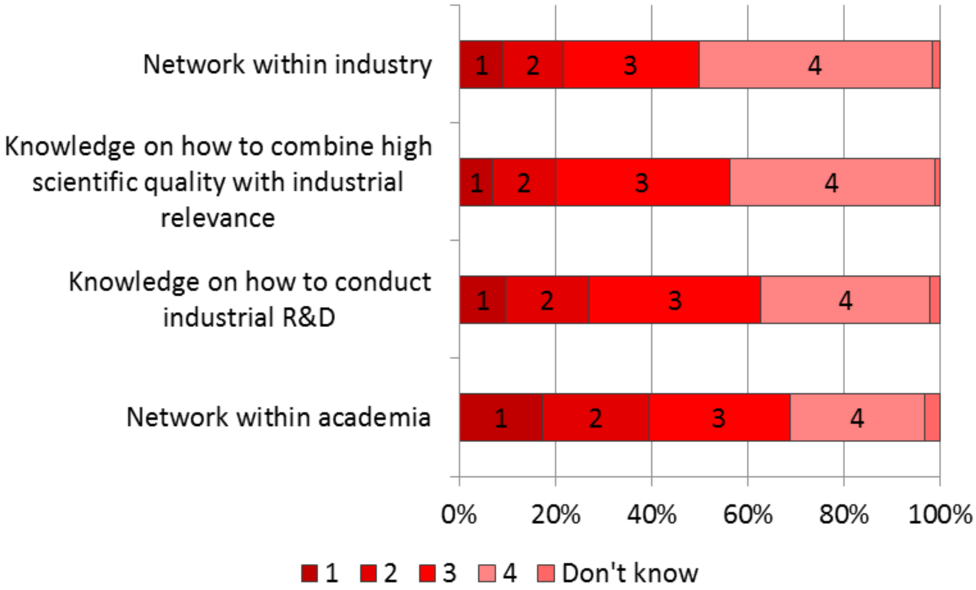
Note: 1 means ‘very low extent’ and 4 means ‘very high extent’. N = 186

Figure 35 shows to what extent the PhDs believe that their CC graduation had an impact on them on some key aspects, compared with if they had graduated in a more ‘traditional’ research environment. Also on this point, results are generally positive. An important aim of the CCs was to educate PhD students more able than others to bridge the gap between universities and industry. Three in four indicate that graduating in a CC, to a high or very high extent has had an impact on their willingness to initiate and participate in collaborations between university and industry, which is a very positive result.

It is also positive that 61 per cent to a high or very high extent have been influenced to work in industry. CCs also seem to have been successful in educating research leaders; 55 per cent believe that CC participation has positively influenced their willingness to lead research. The often project-based organisation of CC activities, with deadlines and stricter timeframes than in most other academic environments probably explains this result.

The impact of CCs in terms of willingness to work at universities or research institutes was markedly lower, which is natural since the CCs probably did not differ much from other research environments on this point. The results should also be seen in comparison with the influence on industry collaborations or careers.

Figure 36 Assessed added value of personal networks and knowledge on R&D management

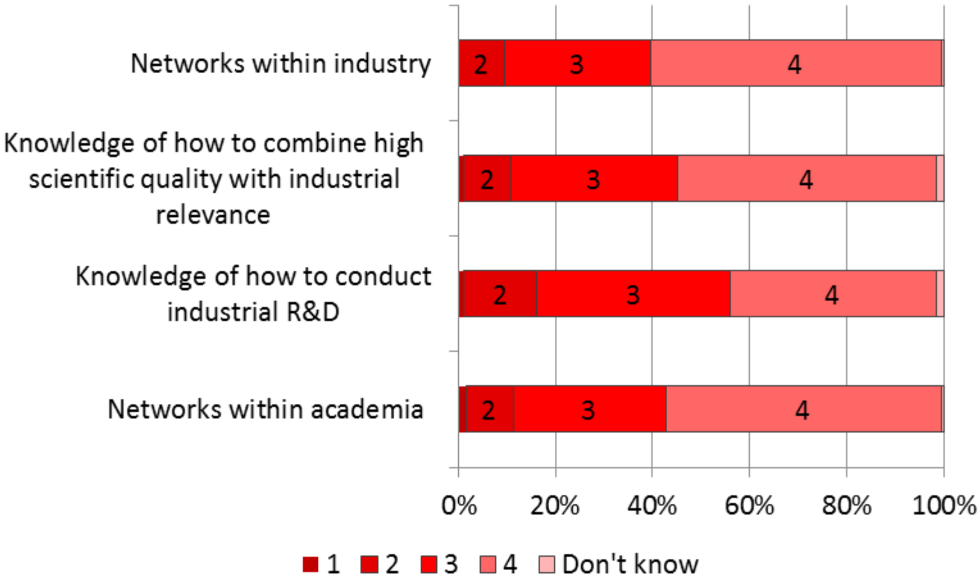


Note: 1 means 'no added value' and 4 means 'large added value'. N = 187

Figure 36 shows how the respondents assess the added value of graduating in a CC with respect to opportunities to form personal networks and develop knowledge on how to manage R&D processes. The results are very positive. Between 55 and 80 per cent return positive responses on each of the points, and the highest score is a common response on all points. The results are not least positive given that these are assets that largely persist also when a CC is terminated and the constellation of individuals is dissolved.

All four points concern very important assets from an innovation system perspective. They are all also viewed as very important from the perspectives of individuals, as shown in Figure 37. The results indicate that the CCs generally gave satisfactory results. The exception is networks in academia, which is held as important as networks in industry. The point is notable since a substantial majority of the respondents work in industry; personal networks with academic researchers are thus important also to industry staff. Other R&D programmes should arguably look at this point and try to foster better academic networks.

Figure 37 Assessment of usefulness of personal networks and knowledge on R&D management to a newly graduated doctor



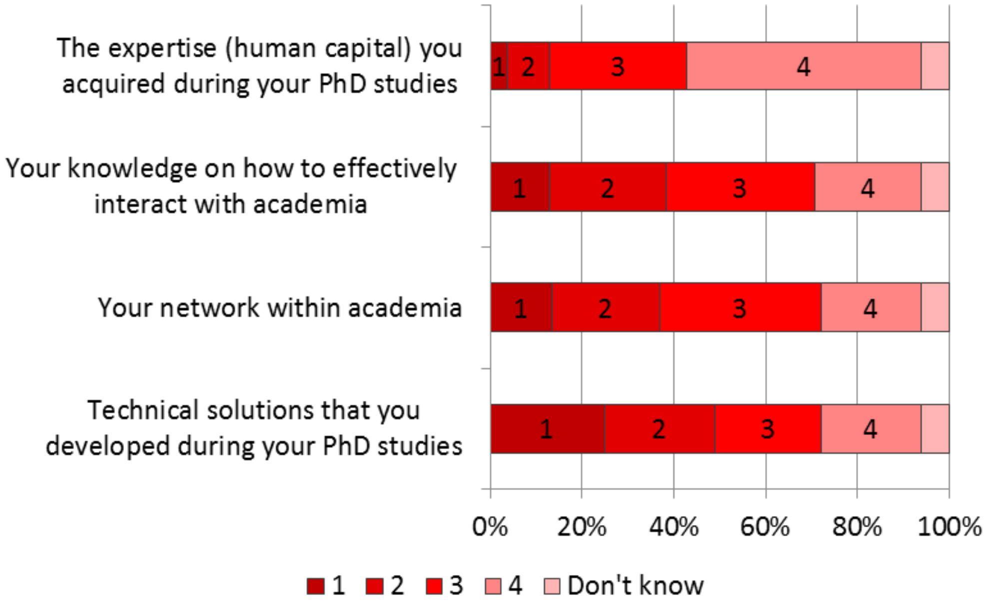
Note: 1 means 'not at all important' and 4 means 'very important'. N = 187

In the survey we also asked those who are or have been working in industry to what extent the companies had benefitted from their expertise in different areas. Results from the question, shown in Figure 38, indicate the matching and utility of the human capital and technologies that were developed in the CCs. Not surprisingly, companies seem to have made most efficient use of the human capital, which is expected since it is a quality that all respondents possess. Much of the human capital development involves relatively generic competencies such as problem solving, understanding and critically examining R&D reports and results.

A majority of the respondents also report that the firms have made good use (3 or 4) of their networks and knowledge of how to collaborate with academic researchers. However, since all respondents possess assets on these two points and most of them seem to more or less remain within the same field, the companies seem to possess unused capacities, given the relatively high numbers of 1 and 2.

The answers regarding the technical solutions they developed during their doctoral studies are evenly spread (22–25 per cent) across the scale from very low to very high extent. We know from experience that few PhD students are able to come up with technical solutions that industry makes use of. If one in four have contributed to their firms in this respect, that is no doubt a positive result.

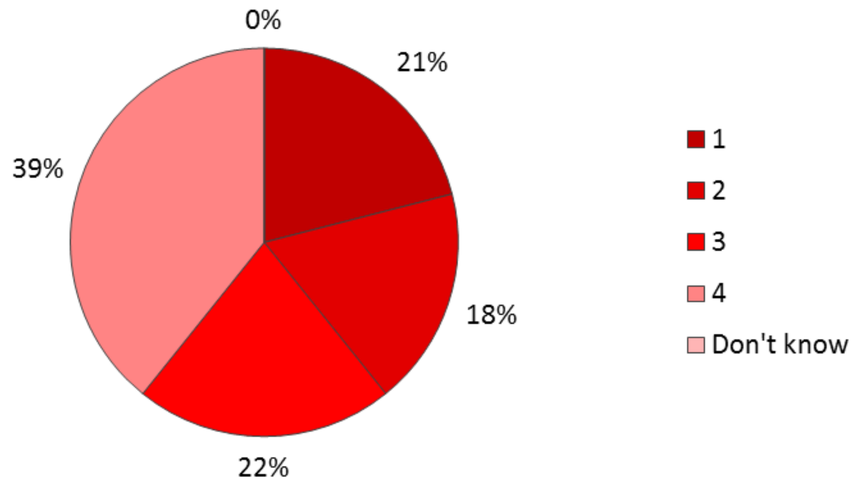
Figure 38 How companies benefit from employed CC PhD's



Note: 1 means 'very low extent' and 4 means 'very high extent'. N = 133 (Question only directed to those who had worked in industry)

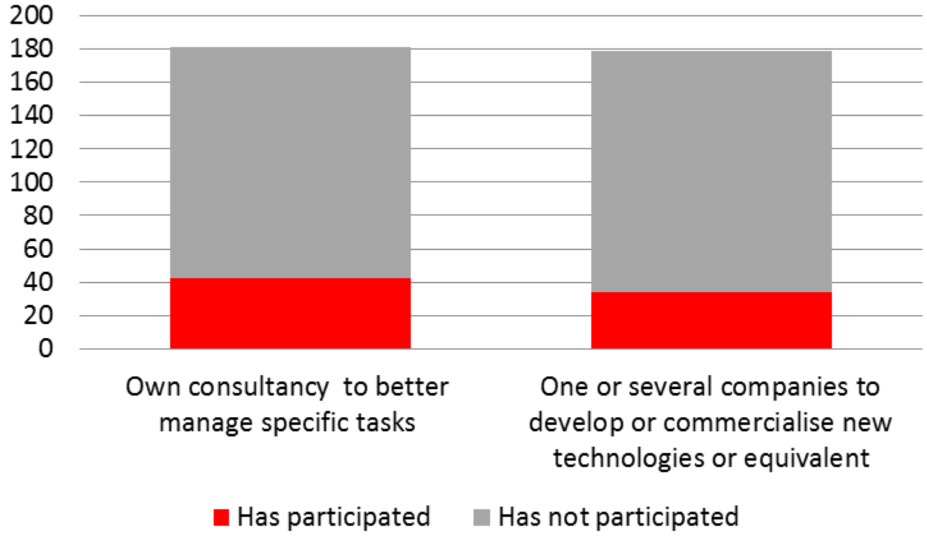
Slightly more than 60 per cent of the respondents (whereof 40 per cent to a very high extent) are currently working on the same issues/problems as they were during their doctoral studies, see Figure 39. As also shown in the figure, a fifth of the respondents now work on issues/problems far from the area they were focusing on as students.

Figure 39 Extent to which respondents work on the same issues as during their PhD studies



Note: 1 means 'very low extent' and 4 means 'very high extent'

Figure 40 Respondents' involvement in start-up companies after graduation



As can be seen in Figure 40, 23 per cent of the respondents have after their graduation been involved in starting their own consultancy company to better manage specific tasks. Nearly 20 per cent has started one or several companies to develop or comercialise new technologies or equivalent. The results are relatively positive, especially that one in five have participated in start-up companies.

A few respondents comment upon their participation in start-up companies. A couple of respondents started companies to commercialise results from their doctoral theses. Some other have been involved in developing products at the CCs which later have been commercialised through new companies.

Figure 41 Degree of contact with former academic and industrial colleagues

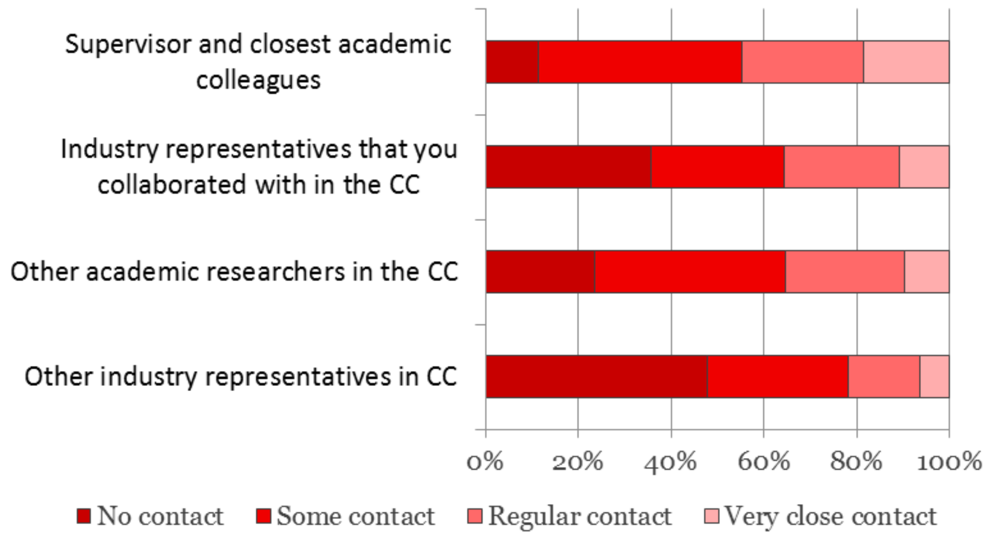


Figure 41 shows the degree to which different kinds of personal networks persist. Almost half of the respondents are in regular contact with their former supervisor or other close academic colleagues and almost as many have regular contact with their former industry partners. A significant number of those respondents probably work in the same environments as those individuals. It is therefore at least as positive to note that a large majority of the respondents have some contact with individuals three of the categories, and that as many as half of them have some contact with industry representatives whom they did not collaborate with. This indicates that the CCs generally served very well as vehicles to form Knowledge Value Collectives in different technological fields.

To sum up, this analysis shows that there is a strong propensity for CC-graduated PhDs to work in industry, where they assume responsible positions. They are unusually mobile between academia and industry and often act as links between the two. In many but by no means all cases, they were attracted to a CC as a good place to do a PhD. CCs are good 'shop windows' for graduate students, as potential employers can assess them in the course of cooperation. Generally, the PhDs felt that doing their PhD at a CC had been good for their employment prospects, especially by increasing their understanding of industry and easing their transition from university to industry. Graduates' networks were wider and more inclusive of industry than would otherwise have been the case so they gained useful 'know-who' as well as 'know-how'. Some 40% of those who had gone into industry were still working in the area of their doctorate. The graduates were quite likely to set up their own company or join other start-ups.

4.9 The role of the CCs as 'focusing devices'

The centres in the CC programme have had a role as focusing devices in several ways. Apart from being places where interesting research is performed, they have also been a meeting place for research and industry, and thus often helped to make the universities attractive partners for the industry and partners in international projects. The visibility of the university has increased. In some cases joint efforts and projects between centres and central bodies of the universities have been carried out.

Centres have managed to shift entire departments concerns and boardroom discussions towards the issues and problem areas treated by the centres. Previously, discussions could have taken place mainly in laboratories, corridors and by mid-level managers, but that has turned to issues high on the corporate agenda, and influencing long-term corporate strategy decisions.

This works through many mechanisms. By starting new collaborations with industry, of which many continued also after the CC period, and new academic collaboration, which also could form the basis for EU-projects, relationships were generally established that enhanced relevance and helped to focus on issues that were common to all participants.

The genesis of the centre also seems to be crucial for the CC role as focusing devices. The fact that researchers and companies put some work into a common problem definition also supports their efforts to launch activities and produce results that are really common concerns. This is also helped by the fact that CC activities are important in establishing research fields, that they significantly contribute to the scientific output of the university, that interaction between academy and industry is strengthened, and that the production and results of the centres are generally in agreement with the role the university wants to take in society.

5 Conclusions and Recommendations

In this final chapter, we first examine the impacts of CCs. We start by looking at international experience and then on the specific experience of the Swedish programme, focusing on the impacts in industry. Second, we discuss what our findings mean for policy. We explain the theory behind the high subsidy rate used and show that CCs fit into the current conception of 'industry policy', where we try to strengthen thematic competences in the economy without 'picking winners'. Third, we draw specific lessons for the design of future CC programmes. These are in the first instance intended to apply in Sweden, but since they are based on international as well as Swedish experience, we believe they are also of international significance.

5.1 Industrial impacts of competence centres

5.1.1 Conclusions based on the international literature

Competence centres, as the Swedish programme and we define them, have a special role in the portfolio of research and innovation policy instruments. They aim to introduce an element of fundamental research into long-term academic-industry research collaboration, changing research culture in the organisations involved. In principle, they should change the way universities operate, increasing critical mass, legitimising close cooperation with industry and producing graduates at various levels who are better able to work effectively in industry. Companies involved engage in more open styles of innovation than normal, but this also limits the extent to which they can cooperate in near-to-market work in Competence centres. While there is often an ambition to induce companies to learn to do or fund more basic research themselves, the general experience is that they do not do this. Thus, once the supernormal subsidy rate normally applied to competence centres in order to provide an incentive for company involvement in fundamental research is withdrawn at the end of a funding period, competence centres tend to revert to more normal, shorter-term and more applied research or to disappear. In other words, competence centres do not change the economics of knowledge: they temporarily counteract market failure.

In principle, the societal effects of competence centres are far reaching. They produce public and private knowledge, much of which spills over within and outside the centre consortium. They train people and influence education, generating further spillovers. Ultimately, they contribute to economic development and welfare.

In contrast to the old style of industrial and technology policy, competence centres tend to be generated 'bottom up' in open competition. They effectively reflect points in the national innovation system where there is a coincidence of academic and industrial strength and development potential. This means that the call for proposals also serves as an 'implicit technology foresight'. Since they involve a cluster of organisations, the state’s subsidy is not held hostage to the fortunes of a single organisation. One of the key results of success in a competence centre is the creation or strengthening of a network of people with skills and capabilities to innovate that stretch beyond the lifetimes and fortunes of individual firms.

The design of competence centre programmes has evolved and been subject to local adaptation since the NSF started its Engineering Research Centre programme. Close contact between programme designers (and evaluators) means that there has been a small international community organising policy learning in relation to this instrument with a lot of exchange of experience and practice. It appears to address common structural issues, as well as the common problem of insufficient academic-industry research interaction. Within the spectrum of competence centre schemes, it is possible to put varying emphasis on short or longer-term research. The balance of power in the governance of centres and the degree of subsidy are important levers that affect this and can be manipulated to that end in order to ‘tune’ programmes to their context.

Competence centre programmes have significant impacts. One is on human capital formation, with graduates – especially PhDs – being significantly better trained and in tune with the needs of industry than their peers who have not been educated in a competence centre. There is no indication in the literature that this comes at the cost of quality, though faculty involved in centres may have to trade their participation off against their volume of scientific publication. Competence centre graduates are especially likely to work in industry.

The main reason companies participate in competence centres – and the main benefit they derive – is access to new ideas, know-how or technology. Interacting with other firms and hiring centre graduates are also important impacts. These lead in a significant number of cases to new or improved products or processes, which tend to be developed by companies on the basis of centre-derived knowledge rather than being designed in the centre and transferred to industry. Active participation in centre research and the existence of counterpart projects inside the company increases the rate and degree of take-up of ideas from the competence centre. It also appears to increase companies’ technological ambitions, willingness to take risks and their ‘reach’ into world science.

As in this study, others have tried to understand the size of the economic benefits that accrue to company participants in competence centres. The main effort has been in relation to the Australian CRC programme. These efforts show that it takes quite a long time – normally several years – before economic effects become detectable. The effects seem to be cumulative – the longer a company remains involved with a centre, the bigger the amount of accumulated knowledge that it can use and – we suspect – the more likely it becomes that the knowledge used is at least in part a result of fundamental research. Successive assessments of CRC economic impacts increase as the evaluators find more impacts to count. As the CRC history shows, however, there is a logical problem of attribution. Obviously, economic effects occur not only as a result of competence centre efforts but also a large number of other factors such as in-house development and investment, complementary knowledge and even the effects of other support programmes. The amount of 'credit' that should be attributed to the competence centres for their role in these bigger processes is arbitrary. There is no sensible way to decide, since the economic success will be the result of a number of necessary (but individually not sufficient) conditions being met. There is not a linear relationship between the knowledge production and the economic effects. Other kinds of non-linearity are also involved, such as the exploitation of knowledge produced a long time ago whose 'time has come', usually for reasons unconnected with that knowledge. The CRC studies go on to feed well-meant but arbitrary and rather inexact economic impact estimates into macro-economic models in order to explore their effects at the national level. These are interesting thought-experiments but it is probably not wise to regard their results as literal truths.

An interesting observation about economic impacts is that the effects of collaboration – take-up and use of knowledge from the centres by the companies involved – dwarf university income from patents and licensing, suggesting that cooperation is a far more powerful means than the Technology Transfer Office function to obtain societal and economic returns for the taxpayer.

The evaluation evidence confirms that competence centres do indeed affect the behaviour and structure of universities as well as affecting education. Good leadership and an appropriate balance of power among participants is key to centres operating successfully. Company-internal behaviour is crucial to obtaining benefits from the centre – as in almost anything else, in the absence of internal commitment external ideas are not taken up.

5.1.2 Conclusions based on the Swedish programme

The Swedish CC programme was like others in that the proportion of subsidy was high, with the funding agencies, the universities and the companies each contributing about one third of the resources. The agencies together contributed almost 1.5 BSEK over the ten years of the original programme. Two-thirds of the industry contribution was in kind. It was an article of faith in the programme that kind was better than cash, in order to ensure the active involvement of industry, mirroring the experience of the ERCs, where it was also clear that 'sweat equity' was needed for the partnership to be fruitful. This faith is borne out by this study – in general, in-kind contributions make centres more likely to generate industrial impacts, even if there are tactical exceptions, such as Ericsson's choice to invest a lot of cash in a centre to reinforce the strong links it maintains with Lund University, which is a key source of manpower and knowledge for its Lund plant.

Industry clearly learnt to value the CCs, as the number of companies involved grew through the programme, tailing off only at the end. This was a programme largely for the technologically capable, dominated by large firms and – as large Swedish companies increasingly were merged into transnational ones – providing an R&D 'anchor' for them in the Swedish innovation system. It is not clear that this was ever alone sufficient to retain the R&D function in Sweden but there were certainly examples where the Swedish subsidiary's hand was strengthened in the internal competition for R&D and production. The number of SMEs rose gently through the programme. These are almost all technology-intensive.

Sectors represented in the programme to some degree reflect the 'high points' in the structure of Swedish industry when the programme started – electronics, engineering and pharmaceuticals – and given the long-term nature of funding it tended to remain fairly stable. Growth in participation came from software and other services, probably reflecting structural changes in the economy.

Companies' reasons for participation were the same as in foreign competence centres: to get the knowledge needed to make new products and processes and to access the scientific community and 'knowledge base'. Almost all the companies claimed that the projects they undertook were 'additional', in the sense that they would not have done them if they had not been in the CC programme. Companies typically used the CCs in one of four ways. Some (large) firms used CCs as part of wider strategies for understanding and cooperating with the scientific community in a wide range of areas of interest to them, often funding work in several different countries. Other large players were more focused on a specific sub-set of disciplines and technologies but nonetheless pursued relationships with multiple institutions. Yet others looked for a small number of academic partners who nonetheless gave them access to a broad base of knowledge. Small firms tended to focus narrowly – both in terms of the technologies on which the focused and in terms of focusing attention on a single partner. Smaller companies have been able to use the CCs as an exclusive channel to market themselves to large companies.

The network constituted by the CC programme as a whole is surprisingly well interlinked. There are branch-based clusters, usually involving more than one centre and to some degree representing knowledge value collectives, but the more functionally based centres provided links among branches. This kind of rather dense, highly connected network suggests a structure of industry and cooperation within which information travels rather easily. Almost one third of the companies were involved in the EU Framework Programme. This confirms their technological capability and ensures that the CCs are themselves well connected in European research. Because the CCs are not legal persons, it is not possible to see the universities' centre-specific participations in the Framework Programme. Our impression is that all or almost the centres were involved, however.

Following the end of the programme, the majority of the VINNOVA funded centres have ceased operations. Six of the VINNOVA-funded centres now form the core of new VINN Excellence Centres and have taken about 60% of their former industry partners with them. Two centres have continued at reduced scale but with similar partnerships. Company behaviour is therefore consistent with the underlying economics of knowledge – not even ten years experience changes companies' ability to fund fundamental research. The policy conclusion is that where academic-industry research relationships that involve fundamental work are needed, these continue to need a high level of subsidy. In this context, it is important to recall that the industry and research landscape are in constant evolution. There are certainly rather ‘fixed points’ – the Charmec rail-track centre probably represents one such point, where there is likely to be a research agenda for as long as we have railways, and here the centre has survived at reduced scale. But other research agendas change. The KCK catalysis centre largely solved the problems it was intended to address. Not surprisingly, company engagement with such centres is episodic. Large and capable companies tend to maintain a portfolio of academic relationships that evolve along with their internal needs. In many cases, therefore, it is not clear that the termination of a centre is a problem.

5.1.3 Conclusions about effects on the participating companies

The main benefit companies obtained from the programme was access to new ideas, some of which turn out to be useful in product and process development; others of which bring other benefits (such as understanding alternatives). SMEs were more focused on product innovation than the large companies. The big firms have the resources and breadth of products to let them take a portfolio approach to extra-mural research. Small ones tend to be ‘a project in a box’ and to have resources only for that project so they can only afford to be involved in research collaboration that is directly pertinent to the development or improvement of that product.

As in other collaborative R&D, companies are usually reluctant to do ‘open innovation’ too close to market. This is one reason why there were few products or processes developed in the centres and simply transferred to company partners. The other reason is that the companies involved almost all work with complex products and processes, so CC work is much more likely to contribute to or enable incremental innovation than the delivery of entire new innovations. The few new products that were brought more or less from centre to market were fairly simple ‘stand-alone’ affairs: new railway sleepers (‘ties’); individual surfactants; chemicals for the food processing industry. There is a larger group of products whose ‘core ideas’ were developed in CC and then subsequently developed by centre partners or spin-offs.

Despite the difficulties of quantification and the limitations of the simple methods used here, the evidence suggests that the CC programme had economic impacts equivalent to many times the state’s investment. Our worst case estimate – based on a couple of handfuls of identifiable examples – is that by 2012 the programme was producing **annual** benefits of the same order of magnitude as the states’s entire 10-year investment. On a more optimistic view, the benefits could be several times that.

The economically most significant contributions have been through the improvement of existing products. Examples run into several billions of Crowns in increased sales where companies are already significant players in large markets. This underscores the importance of large firm participation in the programme: not only to the have the internal resources to define problems and understand and analyse technical results, but also to have the presence and power to bring new ideas to market. There are benefits from SME participation, but these seem to be much smaller in financial terms than those that can be ‘leveraged’ by the market power of larger industrial players.

From the evaluation perspective, it is much harder to discern the effects of incremental or sub-system innovation in large firms than of innovations in small ones. Attribution is difficult in that the responsibility for the innovation is clearly in some sense divided between the centre and the company. There is also a risk of ‘free riding’ where a company could have done the research in-house but chose to outsource it to a CC in order to obtain subsidy. We are, however, sceptical of the idea that there is much free riding in this programme. First, some of the companies involved have a strong culture of claiming to be able to do everything themselves. Second, and more important, especially in industries with a high rate of innovation and a short time to market (such as telecommunications), it would be foolhardy to outsource any development that is on the critical path; companies do not tend to do this.

In some of the impact examples we uncovered, benefits are expected to be large but have not yet been realised. In other cases, it was hard to separate out the specific contribution of the centre from that of the broader environment within which it is embedded. For example, Gothenburg has a large knowledge value collective with world-class skills in combustion, especially in relation to diesel. This spans CERC, KCK and other parts of Chalmers as well as the engine development activities in Gothenburg and Trollhättan. While it was in General Motors ownership, Saab Automobile led GM’s efforts in ethanol engine development but many of the benefits will have ‘leaked’ to GM worldwide and to Saab’s subsequent owners.

The CCs have had an impact not only in manufacturing industries but also in services – largely through the evolution of manufacturing companies to service provision (as in the famous ‘power by the hour’ example in aircraft engines). The programme as a whole has few pure services companies as participants. There is scope to explore the viability of the CC instrument in service sectors during future programmes.

They have also made significant contributions in process innovation, leading to new processes as well as cost-reducing improvements. The programme’s efforts in Life Cycle Assessment appear to have made a significant contribution to the innovation agendas of participating companies and hence to making processes more sustainable. CC work has also led to changes in company strategies, for example decisions to go into particular markets or to integrate Life Cycle Assessment into innovation more widely. There are also less visible strategic effects, such as the provision of information that rules out particular lines of R&D as being unfruitful. The ability to use the CCs to explore risky ideas in which the firms would not necessarily invest much of their own money changes the size of the ‘pipeline’ of new opportunities. While many risky ideas turn out not to be worth the bet, without exploration no such ideas can be exploited and there are examples of a minority of such risks paying off. Almost all firms appear to have used the CCs for high-risk projects, projects that were too costly to do in-house or that required competences not available within the firm. To this extent, the programme’s concern to include a fundamental element in its research portfolio is justified.

By training PhDs in relevant areas and linking masters students' final year projects to CC themes, the programme has helped increase the supply of relevant manpower as well as training that manpower in ways that make it more industrially useful. This is reflected in the high take-up rate of CC PhDs by industry in general and the CC partners in particular. Hence, a further key effect of the programme has been to help build capacity in participating companies and to build or strengthen the academic parts of those companies' networks. Capacity building has taken place also at higher levels within company R&D functions – the effect is not limited to new recruits. But the PhDs have another value: the general experience is that PhDs tend to recruit other PhDs, thus over time raising the capacity of their organisations through self-image recruitment. This is borne out by the presence of clusters of CC-trained PhDs in some of the partner firms.

The CCs have had an important effect on how companies innovate. First, they have learnt how to work in this more open and collaborative way. It took some time for this learning to take place, so there is a clear pattern of benefits appearing from the middle of the programme onwards. Second, they have learnt to cope with IPR issues in collaboration. In the early stages, especially when company legal departments were involved, IPR was seen as a significant obstacle. As in most experiences of collaborative R&D, once the lawyers go away the communications become more open and people develop routines to cope. Third, the programme has built not only know-how but 'know-who', strengthening knowledge value collectives and increasing the tacit ability of actors in the network to influence each others' agendas and cooperate.

While it would be surprising if we could untangle the effects of the CCs from other influences on the turnover of large multi-product companies, the simpler nature of small firms means that the link between the business and CC participation should be simpler. We therefore explored the trend in turnover for SMEs and micro enterprises participating in the programme. Overall the SMEs grew in real terms, while the micro enterprises as well as mean turnover in Swedish industry as a whole stagnated. This simple test does not allow us to attribute causality: it is not clear whether SMEs who work with CCs succeed or whether successful SMEs work with CCs. But it **is** clear at the case level that there are many examples of CC work having positive impacts on company sales and development, so we can reasonably attribute at least a part of the improvement in performance to the centres.

One of the things that **does** persist after the dissolution of a centre is the network of relationships among individuals. Generally, the company participants maintain relations with the university so many elements of the knowledge value collective remain in place. Where centres have worked in new fields (as was the case with CPM, SUMMIT and WURC) they therefore play a developmental role in building up new human capacities. Network building is not restricted to technology. Centres are often organised around supply chains (there are few examples where direct competitors work together). The same is true of the Framework Programme projects in which some companies participate. Not surprisingly, therefore, the centres play an important role in extending and strengthening business networks.

A further benefit for many – especially smaller – firms is the contribution of centre participation to ‘reputational assets’, which is to say that their ability to hold their own in the technologically demanding context of a CC is taken as proof of their quality and capability not only in product markets but also in the labour market.

Spillovers from the CCs occur (inter alia) through company spin-off, generation of IPR and publication. The pattern of spin-off is very uneven, with most occurring in ICT-related CCs and therefore in industries normally characterised by a high rate of firm formation. IPR was not a focus of the centres, and in many cases avoiding activities that would lead to patents was part of the modus vivendi that enabled collaboration. Patenting tended to be an activity ‘downstream’ of what the CCs were doing. Those CCs that did patent clustered in technologies that were closer to market and where product patenting is important. Generally, however, people involved with the programme believed that informal spillover mechanisms – especially labour mobility – far outweighed patents in importance.

While centre managers tended to see little influence on education below the masters level, in quite a number of cases the centres have influenced students’ choice of subject and career. The close industrial links of the centres were a key factor for many in choosing to do their PhD at a centre. The majority of the PhDs we were able to track down worked in industry. A common trajectory for those who remained in academia was to go to industry a few years later. We found a surprisingly high proportion of people who did their PhD, worked for a while in industry and then returned to work in the university sector. This is a relatively unusual trajectory that reflects well on the competence of the CC graduates. Whether in industry or academia, many of the CC PhDs found themselves in ‘gatekeeper’ roles in the links between the two sectors. About one fifth of the PhDs we could locate had been involved in a start-up technology company following graduation and about the same proportion had been involved in starting a consultancy.

The CCs play important roles in signalling – acting as ‘focusing devices’ that direct attention and R&D effort in both companies and universities to areas of problem and opportunity. This kind of agenda-setting can help change the pattern of industrial innovation, as seems to have been the case in extending the use of Life Cycle Assessment, or build capacity in new fields and technologies, as happened in Microsystems technology.

5.2 CCs in Policy

CCs stand out from other kinds of interventions in recent years in two respects: first, their high rate of subsidy; second, their apparent targeting of significant resources to particular branches and areas of technology.

5.2.1 Is there a theoretical justification for the high subsidy rate?

To understand why the high rate of subsidy is needed in competence centres we need to look a little into the economics of knowledge. The economics of knowledge are not intuitively obvious because knowledge is an unusual kind of good. It is 'non-rival' – meaning that many people can consume it at the same time. It is also 'non-excludable' – that is, it is hard to stop people getting access to it. Non-excludable, non-rival goods are 'public goods'. For the entrepreneur, there is little incentive to produce such things, which people can consume for free. In contrast, it makes a lot of sense for the state to invest in public goods because the returns can accrue to the whole of society. Thus, basic research is fully funded by the state in most countries.

The closer knowledge is to a specific application the fewer potential users it has and the more its application involves complementary investments, for example in doing specific designs and in production facilities. Because these things can be owned or monopolised, private investment becomes attractive. Hence, most industrial R&D is privately funded in the expectation that it will generate a private return. (Nonetheless, benefits from even private R&D tend to spill over to society over time – both through innovations generated by the R&D and through the 'leakage' of knowledge to others in form of information and through people changing jobs.)

This idea that companies are reluctant to invest in public goods underlies the conventional 'market failure' justification for government funding of research[68], which assumes that there is under-investment in research compared to a welfare-economic optimum, even if in practice there is no 'iron rule' that prevents companies from doing or paying for basic research. They sometimes do, and in the past they probably did to a greater extent than today[69].

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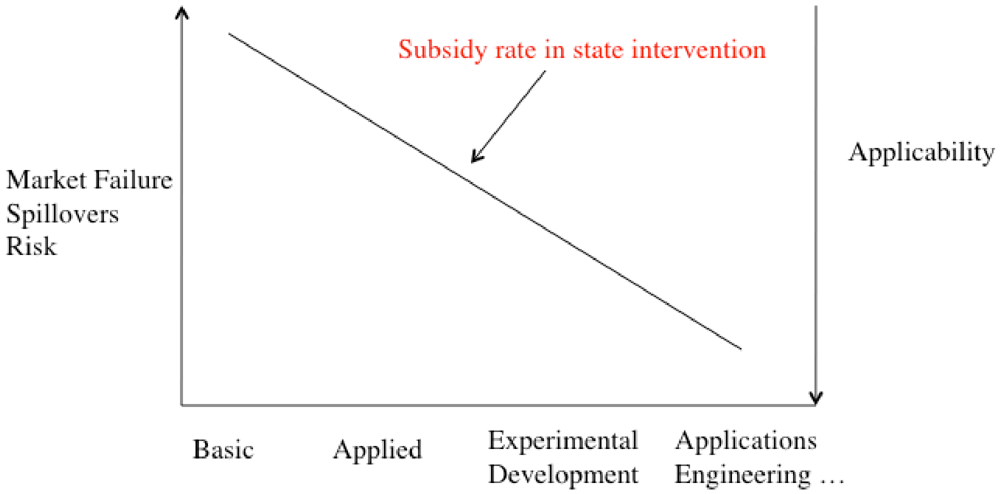
[68] Ken Arrow , 'Economic Welfare and the Allocation of Resources for Invention,' in Richard Nelson (Ed.) *The Rate and Direction of Inventive Activity*, Princeton University Press, 1962; see also Richard Nelson, 'The simple economics of basic scientific research,' *Journal of Political Economy*, 1959, vol 67, pp 297-306

[69] Nathan Rosenberg, 'Why do firms do basic research (with their own money)?' *Research Policy*, 19 (2), 1990, 165-174; RN Anthony, *Selected Operating Data: Industrial Research Laboratories*, Harvard Business School, Division of Research, 1951; cited from Benoît Godin, 'Research and development: how the "D" got into R&D', *Science and public Policy*, 33 (1), 2006, 59-76

Figure 42 Subsidy rates in state interventions for R&D



The market failure idea underlies not only state funding for basic research but also a range of other types of state R&D funding, which give companies incentives for doing or paying for research that is likely to have high spillovers. Such work is typically more risky than the R&D in which companies would normally prefer to invest. In principle, subsidy compensates companies for increased spillovers and risks. The higher these are, the greater the funding role of the state (Figure 42). The subsidy does not change the private investment rationality – rather, it adds a dimension that is expected to provide a social return. The higher-than-usual subsidy is the incentive for companies to tolerate more fundamental research as part of the centre portfolio. We would therefore expect that if the subsidy goes away then so too does the company's willingness to get involved in higher-risk research or research with high social spillovers. This is indeed the case with competence centres. Both US and Swedish experience is that when the funding runs out, they find new sources of subsidy or they shrink their activities towards shorter-term, less fundamental research or cease to exist.

Some funding instruments try to go beyond this logic and encourage beneficiaries to **learn** that there are benefits to them if they do higher risk research or research with high spillovers. The idea is to change their rationality, inducing 'behavioural additionality'. If this is achieved, then in future the company should not need the same subsidy in order to persuade it to tolerate higher levels of risk and spillover. There is some degree of behavioural additionality in the competence centres. Companies that did not already know the value of academic collaboration learnt that as well as the value of networking with other companies. The universities learnt about the power of centre-building and cooperation with industry as bases for setting new agendas in research and to a lesser extent in education, as well as the usefulness of industrial presence in order to attract various forms of research funding.

5.2.2 Competence centres, industry policy and networks

Competence centres represent very considerable investments by the state that are often specific to particular branches, supply chains or clusters. They can therefore trigger nervousness about whether the state is 'picking winners' or reverting to old-style industry policy.

Selectivity or 'picking winners' has had a fairly consistently bad press in OECD countries during recent years – largely in the light of past attempts in industrial policy to prop up failing industries and companies. The older policies could easily involve the state backing a firm against the market[70]. Nonetheless, successful examples of countries developing new branches often involve the state in making bets on particular clusters, technologies and infrastructures[71]. These policies differ from the 'national champion' policies pursued in the 1980s or the earlier attempts to save ailing companies in that they tend not to focus on a particular firm but on creating the conditions where a cluster can grow. The successful clusters often emerge 'bottom up', so that the role of the state is more to support potential winners than to pick them. In effect, selective industry policy has tended to be replaced by 'cluster' policy or – in the latest jargon – 'smart specialisation'. The Swedish CC programme was built 'bottom up' through a competitive process, which effectively tested whether there were actual or potential KVCs spanning industry and universities, their scientific and their industrial strength. It is therefore consistent with the newer style of industrial policy we describe that supports promising clusters rather than attempting to pick individual winners.

It is easy, also, to interpret the failure of individual, state-backed companies as evidence of the undesirability of selective policies. In practice, a result of building up these companies and of building other electronics and computing capacities is the creation of Knowledge Value Collectives. The policy lesson is clearly to pitch selective policies at the level of clusters and human capital and to leave the market to sort out who the company winners are.

Like other competence centre programmes, the Swedish one was launched through an open, non-thematic call. The call process itself was intended to identify areas of strong and matching capability in industry and academia. Offering an incentive in the form of centre funding was expected to encourage self-organisation in the innovation system, so that rather than doing a formal technology foresight exercise in order to identify attractive areas in which to establish centres, the call functioned as an "implicit technology foresight"[72].

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[70] Erik Arnold and Ken Guy, *Parallel Convergence: National Strategies in Information Technology*, London: Frances Pinter, 1986

[71] Erik Arnold, Malin Carlberg, Zsuzsa Jávorka, Flora Giarraccia and Sabeen Sidiqui, *A 'Reset' for Norwegian Industrial Development? What can we learn from fast developers?*, Oslo: Tekna, 2011

[72] Lennart Stenberg, Learning and policy development at SU/NUTEK: Competence centres as an example, Department of Policy Studies, Stockholm: NUTEK, 1997

Rogers and Bozeman have extended their KVC idea to identify ‘knowledge value alliances’ (KVAs).

> *A Knowledge Value Alliance is an institutional framework binding together, in a “knowledge covenant,” a set of directly interacting individuals, from multiple institutions, each contributing resources in pursuit of a transcendent knowledge goal (the basis of the covenant). Inherent in the KVA concept is the objective of generating multiple uses and multiple types of use (e.g. technology development, skill enhancement, understanding of fundamental phenomena). The KVA originates with the activation of a knowledge compact, usually, though not necessarily, through a formal alliance agreement … and terminates when resources are no longer brought to activities pertaining to the knowledge compact (or when resources are no longer shared among parties). The KVA is an interactive group but there is no necessity that each member interact directly with each other member; there must be links, however, among the members of the respective institutional representatives (those designated in the alliance agreement). The KVA acts as a selection mechanism parsing specialized information (e.g. understanding of phenomena, understanding of technologies’ product possibilities, skill in equipment operation or processes) for multiple knowledge uses.*[73]

KVAs can take a range of forms – it is not necessarily the case that the state is involved – but it is equally clear that competence centres can function as KVAs. A systematic exploration of their role as KVAs and the connection between these KVAs and the wider knowledge value collectives within which they operate is beyond the scope of this study. However, we have been able to indicate some of the human capital implications of the competence centres.

5.3 Lessons for future programme design

This evidence from the Swedish programme is in most places consistent with that from abroad. While two of the problems originally addressed by the programme – namely, fragmentation in the universities and lack of sufficient culture and experience of working with industry on a mix of applied and fundamental research – appear on a casual basis to have reduced since the early 1990s, there remain good reasons to carry on with this type of funding as part of the larger mix. We therefore offer the following recommendations for future programme design.

- Integrate CC programmes into the mix of R&D funding instruments. They provide an important way to stimulate development and growth
- Treat CC programmes as ‘focusing devices’ for supporting promising clusters and KVCs. Since they support existing and emerging areas, however, they need to be

[73] Jun D Rogers and Barry Bozeman, ‘Knowledge Value Alliances: An alternative to the R&D project focus in evaluation’, *Science, Technology and Human Values*, 26(1), 2001, 23-55

complemented by higher-risk, more radical funding instruments that can trigger changes in science and the emergence of disruptive technologies

- Continue to fund CCs in response to bottom-up applications. There is every reason to encourage interest from areas that are poorly represented in programmes but the act of building a committed consortium and a high quality proposal that will bear scientific and industrial scrutiny is a key test of viability
- Maintain competence centre style programmes with long funding horizons. These are needed in order to integrate Pasteur's Quadrant research and PhD education into academy-industry collaboration. It becomes increasingly possible to 'harvest' impacts after five years or so, suggesting that the extended funding period is important not only to the centre participants but also to obtaining a return on the societal investment involved
- Ensure that PhD education is integrated into the work of the CCs and encourage the centres to involve also the Masters and even the Bachelors level. The operational logic of a CC is focused on doing the research. A major component of the impact of the CC on the research and innovation system is through the generation of human capital
- Overall state funding should be a high proportion of the total budget, in order to compensate for market failure. Reducing this 'de-tunes' the centre away from fundamental and towards applied research. Within limits, this provides the programme designer (or, if a sliding scale of subsidy is offered, the proposal writer) the opportunity to tune the centre to the absorptive capacity of company consortium members
- Do not expect a kind of 'behavioural additionality' where companies learn themselves to pay for more fundamental research in competence centres. Companies will indeed from time to time find reasons to pay for some relatively fundamental research, but not on a large scale or in a way that can easily be programmed. Market failure is an economic phenomenon that does not go away. Some of the centres may survive the end of their funding but in a more applied form
- Be tactical about whether to extend competence centre funding beyond the normal period foreseen in the programme design. The semi-institutionalisation of the Energy Agency centres and of CHARMEC suggest that there are niches where it is useful to have a national resource of this type, but these need to be aggressively evaluated and if possible subjected to competition. The major role of competence centres is as change agents. They leave behind them new capacities, knowledge and networks, which will live or die according to need. Despite the sense of entitlement that beneficiaries understandably develop after a decade of funding, when the party is over it's time to go home
- Competence centres are to some degree 'scalable'. Be willing to fund both smaller and larger ones, where there is a clear case for doing so. CCs have start-up and overhead costs that involve some economies of scale, so overly small ones are likely to be inefficient. But size matters in the sense that there is a 'right' size for a given centre operating in its particular context. CC funding schemes should therefore tolerate reasonable diversity of size

- In general, a large part of the industrial contribution should be ‘in kind’ as this better integrates the work of the centre with that of the companies and makes the work more relevant and applicable in innovation
- In so far as competence centres act as change agents in science and technology, the ERC approach of integrating education down to the undergraduate level is the right one. Clearly, this will be more possible in some fields than in others. At a minimum, proposals that integrate education well should be assessed as being more fundable than ones that do not
- Large ‘Swedish’ companies as well as supply chains in general are becoming more international. Encourage international participation in future competence centres, where that has clear benefits for Swedish industry and universities
- The 1994 competition provided a ‘snapshot’ of promising areas for academy-industry collaboration in that year. VINNOVA’s current practice of launching fewer centres per year but doing so more often enables the programme to adapt to changing needs. This practice should be followed also in future
- Small companies can play important roles in competence centres, but their resources are limited so it is hard for them to play a significant role in the more fundamental work of the centres. Equally, their ability to translate technical into financial success is modest. Focus the majority of the effort in competence centres on the large firms that have the resources to engage in the research and exploit the results
- Include Swedish subsidiaries of transnational companies, in order to help ‘anchor’ them in Sweden and improve the attractiveness of Foreign Direct Investment
- Test the adequacy of leadership and governance arrangements when assessing proposals. These are critical success factors. If leaders are not seen as legitimate or if there is an imbalance of power among the academic and industrial participants, centres are unlikely to succeed
- Another importance imbalance of power is where a single large firm dominates a centre. This situation should be avoided because it hampers spillover and encourages abusive relationships between the large and small firms
- IPR arrangements do not drive CC behaviour. Funders should establish an IPR regime that participants view as fair and that is workable – typically respecting participants’ background knowledge while providing fair access to foreground knowledge generated in the centre. Once this is done, IPR is rarely a contentious issue in CCs

Appendix A Case studies, the specific role of CC in specific circumstances

In this chapter we look into a number of case studies, to be able to assess the significance and economic effects of participation at the level of the individual company, and also to understand the mechanisms by which the economic effects manifest themselves. The selection of cases is made to give examples and highlight similarities and differences between different types of companies, centres, approaches, activities and outcomes. Data from different sources are utilised to account for individual company ideas and motives for participation, their input into the different stages of the CC, both in cash and in kind, the involvement and the work they have put into the CC activities, what the networks looks like from the view of the individual company, results and effects, and what all these factors mean for the general impact from CC on society.

The case studies reveal a multitude of views; multiple motives for participation, multiple approaches to the research or R&D activities conducted in the CC, multiple uses of results from the different CC projects, multiple positions on how activities and results relate to the company's own (internal) development activities.

Despite this, there are several general features, and a fairly large amount of results that can be understood in the same way. The cases are presented in the same format, with thematic headings.

A1 Sandvik @ BRIIE (The Brinell Center of Inorganic Interfacial Engineering)

Sandvik describes itself as a high-technology engineering group with advanced products and a world-leading position within selected areas. Their worldwide business activities are conducted through representation in more than 130 countries. The group had 50,000 employees and sales of more than 94,000 MSEK in 2011. It has operations in five business areas with responsibility for research and development (R&D), production and sales of their respective products; Sandvik Mining, Sandvik Machining Solutions, Sandvik Materials Technology, Sandvik Construction and Sandvik Venture.

Sandvik was one of seven companies involved in the launch of BRIIE, following their interest in advanced development and research within a wide area of materials science. Many motives were involved, but the main ones were broader research from being part of a larger organisation, and an expected significant leverage of their own resources. They were interested in the possibility of recruiting people, and getting to know younger researchers. Sandvik hired some of the students that graduated.

A1.1 The company's relationship with the university

The company is seeking a broad interface with the university, as developments in research are rapid and coupled with the idea that an organisation cannot develop without collaboration. There were also areas where Sandvik had a number of very specific issues that they needed additional resources to solve and that were addressed in BRIIE, with Sandvik being very active in defining its enterprise.

A1.2 The company's financial contribution

The Sandvik total contributions to BRIIE can be seen in the table below, divided into the four different stages of the total CC period, and by the cash and in kind contributions respectively.

Sandvik	**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Total**	
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands	1 600	900	2 550	3 023	2 420	4 148	1 400	3 419	**7 970**	**11 490**

The table shows that the total contribution in cash has been close to 8 MSEK, and that this is exceeded by the in kind contributions which amount to nearly 11,5 MSEK. It also shows a variation in contributions over the years, as well as indicating an initial slowness to the start of the activities and use of the resources provided in the CC.

A1.3 CC problem solving and company development

In the case of Sandvik's participation in BRIIE, the issue of how the CC problem solving fits with the company's own development and innovation is very much a question of resources. The CC activities dealt with issues that the company could not handle itself, and were particularly suitable for the long-term development issues. To begin with, activities were more product development oriented, but towards the end more resources were invested in fundamental knowledge development.

This approach gives a larger common platform, and better possibilities to work with other companies. This was a lesson learned from the CC activities, one of many during the early years. All participating companies in BRIIE brought very product oriented projects to begin with, but later the projects became more and more research oriented.

To begin with the university was supposed to deliver goods and information, which later evolved considerably due to increased and better interaction. The successful projects were characterised by collaboration of major research effort among the companies. They were physically located in each other's premises. There was also mobility among the personnel, Sandvik recruited a number of the people graduating within BRIIE.

A1.4 Organisation of company R&D

In the company, R&D activities are organised in the different company divisions. The argument for participation come from the R&D manager, division managers and the researchers, while top management decides on the funding.

A1.5 Company benefit of CC participation

The benefit of Sandvik participation in BRIIE is clearly related to development of products and processes. The production of a ceramic material, which required extremely long milling times is a clear example. In BRIIE, it was possible to determine the causes of this, and to shorten the milling times by a factor of 10-20. This was actually not an issue that Sandvik brought into BRIIE, but something that emerged during the course of its research and development activities. Apart from this, the focus was on development of two different materials which were later commercialised in different products.

A1.6 Economic effects from CC participation

There is more than one economic effect as a result of these achievements. First, there is the energy efficiency following reduced milling times in the production of silicon nitride powder. The production process is modified and implemented, which, in total, gives a higher quality powder and lower scrap in the subsequent process steps. A reasonable estimate of saving is around 500 KSEK/year.

Secondly, there is the new sialon cutting tool material, which is mainly used in the aircraft engine industry. During the last ten years, three new varieties have been introduced which have been well received by customers. In sum, this has generated business of around 10-15 MSEK/year, depending on economic conditions or business cycles.

The third effect is by far the largest, and follows the development of a new hard metal which has become a corner stone in a new concept to cut rock with twice the strength as earlier. It enables the working of rock that has previously only been workable by drilling or explosion. This led to the ICUTROC system ("I cut rock"), which became a joint research and development project funded by the EU and launched in 1999. It has also become of great environmental and economical importance for mechanical excavation in harder rock conditions. This is a multi million business for Sandvik, and the system is still in production. One recent case where such a machine has been used is the Malmö City Tunnel Project.

A1.7 The market

All three examples also represent new to market solutions, all patented. Sandvik's market is clearly international. The market share has increased, not least as a consequence of the ICUTROCK system. The largest competitor is another Swedish company, and between them they are world leaders – the objective is to be number one in the world. For Sandvik as a whole, customers are mainly other companies, either manufacturing or extracting. The commodity for sale is productivity, not any single hard material component. This includes going through the customer's processes and providing complete solutions to its problems.

Developments like these have also led to a situation where Sandvik has a more or less complete line of cutting materials, which is a prime door-opener to other types of business activities with some of the really big actors, such as Rolls Royce or General

Electric. In other words, being innovative in this way brings so much more. This kind of business could be as much as 10-20 times bigger than for the individual products.

A1.8 Company strategy towards the university sector

Sandvik is very dependent on co-operation with the university sector. What was done in BRIIE, and the development it went through was typical for the kind of projects executed in the CC context. Initial collaborations were essentially product-oriented, but changed character after 7-8 years and became more focused on long-term knowledge and capacity building.

The company invests heavily in external R&D, since business and development requires a much greater breadth than is possible to have in one company. It also started to open up much more in relation to external partnerships in connection with the launching of the CCs. It is seen as important to have the competence domestically. This is crucial for the company's fortunes as Sandvik is not cheap, competing with low-cost Asian products.

A1.9 Additionality

Participation in BRIIE has given Sandvik greater value for money. The achievements came faster, there was a wider range of co-operation, and the work was done on a larger scale; though it cannot be completely ruled out that these things would have happened anyway. The company generally has significant exposure to the university sector. In the case of the ICUTROCK system, initial contacts had already been taken before the start of the CC.

As a consequence of the participation in BRIIE, Sandvik has made a number of strategic choices. The CC has been carried out within its traditional areas. The company is a manufacturer of materials with a significant knowledge in its area. The ambition has been to implement also the knowledge acquired in the CC in new applications. The competence among the personnel has also increased, which is regarded as highly important. Such a general increase in competence has undoubtedly led to a much larger absorption capability in the company.

Participation has not, however, led to any improved internal processes in the form of management and governance of R&D, which already existed in the company. Access to external resources, such as competence, networks and equipment, has also increased together with an extended contact interface with academia.

It is difficult to determine and rate the importance of the BRIIE participation for the strong brand that is Sandvik. The assessment is that it has at least not been negative.

A1.10 Spillover

There were no spinoff companies from the BRIIE competence centre. This is mainly due to the character of the projects, where much of it was product development highly controlled by the initiating companies. The likelihood of spin-off formation has, however, increased, since new materials or ideas that could be used outside the original companies can be created.

Capacity building, and the possibility to supply both companies and the university with skilled labour to continue the R&D work, is considered a very important effect. As mentioned before, Sandvik hired a number of the people who graduated within BRIIE.

A1.11 CC as focusing device

The operations of the CC have been both focusing and aligning, and needs and opportunities have been identified in collaboration with the CC researchers or departments with whom they had contact. The company always had extensive contacts with the university sector.

A2 ABB @ ISIS (Information Systems for Industrial Control and Supervision)

ABB describes itself as a leading supplier of industrial robots, modular manufacturing systems and service. By having a strong focus on solutions, manufacturers are helped to improve productivity, product quality and worker safety. ABB has installed more than 200,000 robots worldwide.

The company offers a variety of industrial robots (small, large, paint and special robots), as well as robot controllers (IRC5 Controller, RobotWare, SafeMove). There is also software for programming, simulation and applications, and application equipment and accessories, including standard global cells and solutions, among the offerings. The ABB robots are used in a number of applications and industries, such as automotive, foundry, metal fabrication, plastics, packaging and palletising, solar, wood, electrical, and electronics. In the area of service and support, the offers also include service contracts, parts, training, used robots and productivity programmes.

A2.1 The company's relation to the university

Back in 1995-1996, ABB Robotics had a lack of competence in areas like control engineering and system construction. Collaboration with the university then became a way to access international expertise. The possibility to recruit was also a main issue from the start; ABB has recruited several people from Linköping University. All existing types of collaboration have the same meaning in this context, whatever they are called in terms of programme names or headlines. The important thing is whether the different parties can work together.

The CC concept has the advantage that the contract comes from the public funding body, which forces the participating companies to live under the same terms and conditions.

A2.2 The company's financial contribution

The total contributions from ABB Robotics to ISIS can be seen in the table below, where it is also divided into the four stages of the total CC period, and by the cash and in kind contributions respectively. Contributions from both ABB Robotics and ABB Automation Technologies are included, since they concerned the same company.

ABB Robotics	Stage 1		Stage 2		Stage 3		Stage 4		Total	
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands	750	300	1 500	2 925	100	1 913	100	4 500	**2 600**	**11 925**

The total contribution in cash has been 2.6 MSEK, and the in kind contribution has been a little over 11.9 MSEK. Also this case shows a variation in contributions over the years, as well as indicating an initial slowness in starting the activities and using the resources provided in the CC.

A2.3 CC problem solving and company development

The areas in which ISIS has developed competence together with ABB Robotics are described as:

- Iterative Learning Control (ILC)
- System Identification for complex robot dynamics
- Model-based fault isolation in object oriented software
- Diagnosis of mechanical and electrical robot components
- Servo reference optimisation
- Servo loops optimisation

Since the CC director had experience of collaboration with another large Swedish company and ABB had experience of collaboration with other universities in Sweden and abroad, it was easy to get started and to find appropriate forms.

There is a general difficulty to find the balance between university research and company development. This was solved by dividing projects between the parties and letting graduate students literally sit in the premises of the company and take part in their development. The company had the opportunity to veto publications, but this was never used thanks to the working method which ensured that the company already knew everything about the content of the work.

All publications were co-written by authors from both the company and the university. The CC has been valuable for ABB mainly because it represents excellence in its area.

A2.4 Organisation of company R&D

Company participants in CC projects come from ABB development departments for software and motion control in robots, which is where graduate students from the university spent their time at the company. From the company perspective it is extremely important that these kinds of collaboration projects involve the company from the start, in everything that has to do with defining and formulating the research problem, to ensure the engagement of the company and its development.

For ABB, it is extremely important that the CC develops core competence and skills, as actually happened in the case of ISIS.

A2.5 Company benefit of CC participation

The benefit for ABB from participation in ISIS is estimated to be very high. It has been vital in building core competence for the company. According to the company, the best engineers in the field of motion control come from Linköping University, as a direct consequence of ISIS. The development of at least two products of high importance for ABB is described as a result of the collaboration in ISIS.

A2.6 Economic effects from CC participation

Two important products, involving new functionality through Iterative Learning Control and reducing robot cycle time respectively, are implemented in around 1,000 robots, and between 10,000 and 17,000 robots per year. This has clearly affected the company's turnover in a positive way.

One robot has a price of somewhere between 0.4 and 1 million SEK. Selling 1,000 robots will then generate revenue up to 1 billion SEK.

A2.7 The market

Within robotics, ABB is number three in the world, with a market share which is around 15 per cent. In its own opinion, the company has the world's best motion control for robots, which explains the position in the market. The estimate is that product development following participation in ISIS has generated around 150,000 new customers. Around 90 per cent is export.

A2.8 Company strategy towards the university sector

The overall results from CC involvement are very good, which has created interest among top management. ABB has joined projects in the EU research programme, which probably would not have happened without the involvement in ISIS. All results that generate earnings gives a chance to such outcomes.

The company remains involved in competence centre activities at Linköping University, in a new centre under the label Industry Excellence Centre.

A2.9 Additionality

The results from the ABB activities with ISIS are also very important for ABB's customers. Automation becomes available at lower cost, with higher quality: this also results in increased productivity and product quality. This way ABB actually also increases the competitiveness of the competitors of a number of Swedish companies, as most of the sales are abroad.

Strategy is continuously developed by all involved in the projects, identifying different possibilities, and a gradual shift in possibilities. ISIS has meant a lot for how ABB has developed its ideas and concepts in this respect.

Participation in ISIS has also undoubtedly led to an increased access to external resources, such as competence, networks and equipment. The numbers of personnel in R&D have grown, along with their competence,. The systems they are developing are so complex that they require more people, but without a loss of competence. The internal processes of management and control of the R&D have, however, not been subject to improvement.

A2.10 Spillover

There are no spinoffs from ABB, and furthermore there is no technology transfer. This applies also to the university, in the case of robots. There is competence in existing products, and also in the development of new ones. While much innovation takes place in large corporations like ABB, it is not visible externally but rather hidden in products, and surrounded by secrecy.

ABB puts little effort into patenting or IPR in this area. The production concerns software in embedded systems, where some kind of reverse engineering is not possible. There is one patent covering the Iterative Learning Control, but the rest is handled in privacy or confidential management.

There are substantial effects on the CC participants' development when it comes to scientific publication, participating in conferences, the use of methods, and so on. An interest in the long-term development has arisen, though there remains some question of how research is defined. Top management is, however, more interested, showing an understanding of how long it takes to achieve things as in ISIS.

The importance of the opportunity to recruit people with the right competence and background is hard to overestimate, although the company does not in any case pick just any graduate student. The right competence, together with the right attitude to industrial development is absolutely crucial.

A2.11 CC as focusing device

In the case of ABB @ ISIS, the CC activities have clearly had a focusing and directing function, in a way that both the company and the university have noticed and allocated resources to an area where knowledge needs have been identified. The CC had a pet project approach to help focusing. The idea was that the company mobilised resources itself, based on an interest in the entire organisation. This was actually formalised in ISIS. If the company failed to establish the pet project, fewer resources came through the programme.

A3 Ericsson @ CCCD (Competence Centre for Circuit Design)

Ericsson's vision is to be the prime driver in an all-communicating world, in its capacity as a world-leading provider of telecommunications equipment and services to mobile and fixed network operators. Over 1,000 networks in more than 180 countries use Ericsson network equipment, and more than 40 per cent of the world's mobile traffic passes through Ericsson networks.

The company is one of the few companies worldwide that can offer end-to-end solutions for all major mobile communication standards. The networks, telecom services and multimedia solutions all make it possible for many people, across the world, to communicate electronically. Ericsson also describes itself as playing a key role in the evolution regarding how communication changes the ways in which we live and work. This has to do with using innovation to empower people, business and society, and to work towards the Networked Society where everything that can benefit from a connection will have one.

A3.1 The company's relation to the university

For quite some time, Ericsson has supported the department of applied electronics at the university. CCCD was regarded a natural extension of this relationship. From the company there were individuals, who had been working at the department, and also a previous adjunct professor who contributed with a little general control and some research problem definitions that could maybe develop into projects.

The prime motive for Ericsson's participation was to promote undergraduate education, the second to promote a good graduate education, the third to get access to good research results. Technology development was therefore of secondary importance. The company had, however, a profound interest in embedded systems.

In most cases, the projects have been PhD projects, where Ericsson has served more or less as supervisor, and also provided some equipment. From the company, there was a wish that the university should take the lead in projects and research. Around five people from Ericsson were very involved in CCCD, and many more came in for shorter and smaller efforts.

A3.2 The company's financial contribution

The total contributions from Ericsson AB to CCCD can be seen in the table below, where it is also divided into the four different stages of the total CC period, and by the cash and in kind contributions respectively.

Ericsson		**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Total**
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands	4 700	1 850	7 050	3 000	4 500	4 631	3 000	2 000	**19 250**	**11 481**

The total contribution in cash has been 19,25 MSEK, and the in kind contribution has been close to 11,5 MSEK. As in previous cases, there is a variation in contributions over the years, and an apparent initial inertia at the start of activities in using the resources provided in the CC.

A3.3 CC problem solving and company development

At the time of the start of CCCD, Ericsson was developing mobile telephones. The types of problem dealt with in CCCD were then crucial to solve. The same was true for the development of Bluetooth, which was made in Lund and where Ericsson put in much effort for a long period. In 2002, SonyEricsson was formed, at a time when Ericsson was still doing technology development. Nowadays, that role has been taken over by ST Ericsson, a company which is half owned by Ericsson and half owned by ST Microelectronics. In Lund, around 2,000 people work on technology development within mobile telephony: this places high demands on education in Lund.

A3.4 Organisation of company R&D

Today Ericsson has its own global team of researchers, collaborating with university researchers to improve technology and create breakthroughs. Work is mainly in the areas of wireless access networks, broadband technologies, multimedia technologies, services & software, radio access technologies, packet technologies, global services research, security and sustainability & electromagnetic frequency.

A3.5 Company benefit of CC participation

For Ericsson, the university is an effective network hub. This way, the company can follow and monitor what goes on in research, and is able to embrace the latest research results. There are several examples where researchers have contributed with technology, not in the direct sense of inclusion in Ericsson's products, but in the form of key results that have been refined in the company.

A3.6 Economic effects from CC participation

It is difficult to single out specific economic effects for Ericsson resulting from specific research in CCCD. As indicated above, the research leads to key results which are refined by the company, and eventually become incorporated in the very complex product that the mobile telephone system constitutes. Consequently, the analogue-digital converter, which is a key component in mobile telephones builds to a large extent on research at CCCD, but not exclusively, and it is hard to say both exactly what the significance of that particular research is and to express how much of Ericsson's sales follow from qualities in the converter.

Some of the research at CCCD has also eventually resulted in active filters connected with Bluetooth, an extremely important feature. Bluetooth would not have happened at all without the connection to CCCD: it certainly started to evolve before CCCD, but it all came out of the same environment.

There is no doubt that Ericsson's products have been improved using results from CCCD. A research project in industry does not need to meet all requirements regarding standardisation and so on, but should really help developing an application. In academia, competence and concepts are developed, from which the companies benefit.

The overall improvement of the quality of Ericsson's products has helped to increase the company's turnover; it is however not entirely clear exactly how the specific research at CCCD made that happen.

A3.7 The market

The offering from Ericsson comprises services, software and infrastructure within information and communications technology for telecom operators and other industries. More than 40 per cent of the world's mobile traffic goes through Ericsson networks, and the company supports customers’ networks serving more than 2.5 billion subscribers. Ericsson operates in 180 countries and employs more than 100,000 people.

A3.8 Company strategy towards university

Ericsson has worked together with several research environments, but not in the area of circuit design where the only partners are Chalmers University of Technology in Göteborg and Lund University. CCCD is one of the most persistent and intimate collaborations Ericsson have had. Some minor collaboration takes place outside Sweden, with a shorter time horizon.

The company has the resources to have performed the research in-house, but there are qualities and possibilities in the academic research environment which are in favour of collaboration, such as new technologies. Added to this is the possibility to recruit: collaboration helps to foster and find researchers who can become a part of the organisation. Ericsson came to Lund because of the research, and its quality. To be able to recruit locally is important, and localisation partly follows from where the skills are.

Ericsson has focused on continued research co-operation with Lund University, which is a strategic choice. Investment in Bluetooth has also been a strategic choice, as is the choice of which radio circuits to go for. These things have all been influenced by the work in CCCD.

A3.9 Additionality

Having many companies involved in the CC is a positive feature, leading to a broader discussion, more varied approaches to projects, and additional skills brought into the work. The problems with having many companies involved are often associated with patent or IPR issues. Some of the industry representatives can also have difficulty understanding the benefits of scientific publication.

Ericsson did not directly receive any new partners through CCCD, but the centre was very important for the growing number of people in the company involved in R&D, and the development of their competence. CCCD had a relevant profile of the research, which also affects the supply and content of both undergraduate and graduate education. Ericsson recruited around half of the people that graduated within CCCD, though some of them are no longer with the company.

The department at the university has taken Ericsson’s help to develop radio courses and so on. Ericsson has also contributed by providing feedback on content, problem definition, supervision etc.

CCCD has also invited Ericsson to further research collaboration. The centre, and its successor, has an excellent network, while Ericsson cannot devote as much time to conferences and so on. The centre can arrange contacts which provide insight in the research frontiers, and there is a close dialogue between these actors. Ericsson also supports the centre brand: it is attractive for researchers to have the support from a company like Ericsson.

The centre has also helped to develop the competence of Ericsson's personnel, in that all courses have been open for the partner company staff, researchers and engineers. Many at Ericsson have taken courses, and also attended different conferences. Participation in CCCD has however not improved internal company processes, such as management and control of R&D.

There is no sign of increased access for Ericsson to competence, networks or equipment as a consequence of participation in CCCD, and the company brand is not considered to have been strengthened.

A3.10 Spillover

Today, Ericsson holds over 30,000 patents, considered to be one of industry's strongest portfolios. Also in CCCD quite a few results were patented. Later, Ericsson discovered that the contract was not very favourable, so the patent and IPR part of the activities were toned down; individual patents were probably not worth very much in themselves. Patents are taken long before it is possible to use results in a product. There is also a possibility to make money on licensing:, for instance, Ericsson makes money on the iPhone.

There is also one case where a spinoff-company was established. It was Ericsson itself which started a subsidiary concerned with some business connected with Bluetooth in 2001, but it was later closed down.

A3.11 CC as focusing device

CCCD has been able to create knowledge, competence and awareness in areas of importance for Ericsson's development, not least regarding the company's ability to focus and to select areas for its business. In the research projects it is possible to try different alternatives, and later decide on what actually works.

A4 Omnisys @ CHACH (Chalmers Centre for High-Speed Technology)

Omnisys Instruments was founded in 1992, with the main operations within development and production of high performance electronics hardware, mainly for the space industry but also for other scientific, security and medtech applications.

The company describes its competitive advantage in developing state-of-the-art technology solutions as enhanced through continuous research in collaborations with leading institutes. Among the clients and partners are European Space Agency (ESA), Swedish Space Corporation, Swedish National Space Board, Saab Space and European Southern Observatory (ESO). Omnisys has delivered space flight hardware for all three recent Swedish satellite projects: ODIN, SMART-1, and PRISMA.

The major business areas are power systems for satellites and THz range scientific radiometer instrumentation. The company makes a point of having a good understanding of scientific/user needs, which are translated to functional custom design hardware for its clients, and microwave laboratory facilities for test, breadboarding and space flight production.

A4.1 The company's relation to the university

At the time of the start of CHACH, Omnisys was unusual; there were not many SMEs at all in that particular sector. People in the company knew some of the university researchers personally, and found the whole thing promising. There was certainly potential in collaboration, in that a lot of good ideas in the scientific community could be commercialised.

From the beginning it seemed as if the university researchers regarded the centre mainly as a source of research funding, and industry's needs were almost neglected. The company struggled with that for a while. For instance, trying to include a systems perspective, making the researchers see beyond the component, and how the component could improve the system.

A mutual understanding of what was the idea of CHACH eventually grew. Participating companies had different ideas on what types of projects that CHACH would run. Some companies preferred projects that were relatively close to product development, while other companies, such as Omnisys, preferred to work with issues closer to research. There was however a gradual shift in these respects, and for the last three years of CHACH things were significantly improving as far as Omnisys was concerned. Today, in the centre which in some senses succeeded CHACH, things are considered better, more open and dynamic.

A4.2 The company's financial contribution

The total contributions from Omnisys to CHACH can be seen in the table below, where it is also divided into the four different stages of the total CC period, and by the cash and in kind contributions respectively.

Omnisys		**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Total**
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands		787	555	1 139		1 650	550	6 625	**1 105**	**10 201**

The total contribution in cash has been a little more than 1,1 MSEK, and the in kind contribution has been just over 10,2 MSEK. Also in this case, there is a variation in contributions over the years, and it looks like the Omnisys activities in CHACH, at least judging from the in kind contributions, really took off towards the end of the period. The last 18 months CHACH was also run without any government agency involvement.

A4.3 CC problem solving and company development

The hours put in by the company are, according to Omnisys, extremely important for the activities in the CC not to become commissioned product development. The CC is about generating knowledge. It should rather be understood as commissioned research; "is it possible to solve this problem?" Since industry needs to accept the problem definition, it has to be some kind of commission, the argument goes.

This balance has not always been easy. In the beginning of CHACH it happened that the university researchers went away and changed the problem definition on their own, and turned it more into academic research. On the other hand, the CC cannot get stuck in product development. They should for example not create some circuits that make up the core of a mobile telephone, but do the research on signal processing or the choice of technology to produce the circuits.

A4.4 Organisation of company R&D

Most of the staff, four to five people, at Omnisys were involved in the activities connected with the CC from the start. The company R&D was closely connected to all other activities in the organisation. The CHACH period was also the time when the company grew from five to fourteen. At the time of this study, there are 27 people in the company.

A4.5 Company benefit of CC participation

Participation in CHACH has been very useful for Omnisys, although it was difficult because of the above mentioned small staff. It is not possible to draw a perfectly straight line between participation in CHACH and success for Omnisys, but the collaboration has been tremendously important. There have been other projects, outside CHACH, but actually for the most times together with the same research group at Chalmers University of Technology, which in principle ran commissioned projects on the side of CHACH. This was possible because all parties concerned knew each other through CHACH, and had built confidence in each other's competence and loyalty.

The researchers in CHACH have gradually developed great respect for and understanding of the knowledge and competence held by industry. In, for instance, the case of Omnisys, the company sometimes know better than the researchers what can be done, and how. The mutual understanding has improved; the barriers have been dismantled.

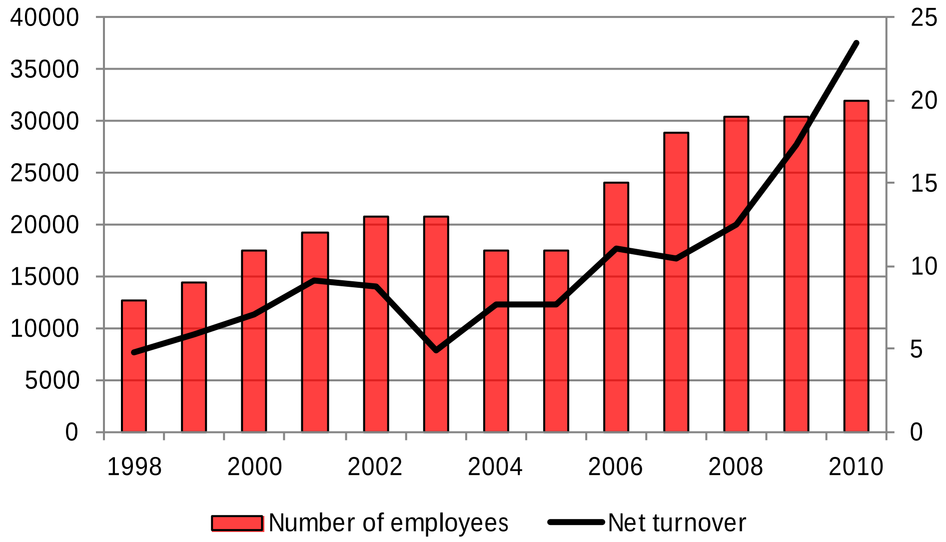
A4.6 Economic effects from CC participation

The company makes subsystems in microwave radiometers. It has developed more and more systems knowledge, from a situation of only knowing subsystems. In CHACH, Omnisys learned to understand the whole. This they did not learn from the larger companies; in the view of Omnisys it is the small companies who teach the large ones, not the other way around.

Market share has increased significantly as a consequence of participation in the CC. The first five to seven years did not see any extensive effects; it was too much work that could probably have been spent on something else yielding more revenue. The last years, however, generated more market benefit. Sales have increased some 30-50 per cent from participation in CHACH. This could have been much more, had the company really focused on it.

In Figure 43, we see the development in Omnisys of both the number of employees and the net turnover during the period 1998-2010.

Figure 43 Number of employees and Net turnover for Omnisys Instruments during 1998-2010



The figure shows that during this period, the number of employees rose by 150 per cent, from eight to twenty people. At the same time, the company's net turnover increased by nearly 400 per cent, from a little over 7,5 MSEK to around 37,5 MSEK. Although this is not entirely attributable to the participation in CHACH, Omnisys is clearly an example of a CC company which made use of research results from the centre to develop their product, and thereafter enjoyed some success in the market.

A4.7 The market

Omnisys Instruments is working in a completely internationalised market. The customers are all over the world, in the space industry, but also within other scientific, security and medtech applications.

A4.8 Company strategy towards university

Today Omnisys is working even more with the researchers at Chalmers, partly since they know each other even better, partly because the company has grown, and partly because no large company plays a dominating part in the collaboration. The company is more important to the university today, relatively speaking. They are, in other words, more mutually dependent.

Omnisys also has other research partners, mainly technical research institutes, both in Sweden and abroad.

A4.9 Additionality

To some extent, Omnisys ran projects together with other companies from CHACH, but it certainly was not much. From the company perspective it is not possible to share that much. Sweden is small and the electronics sector is broad. If you want to become a world leader, which is what is required, Swedish electronics industry automatically becomes dispersed or scattered. It is difficult to keep a centre of this type together, e.g.

getting to joint projects in the CC. Small businesses must choose small niches, with specialised technologies and products.

The context of the application is critical for which projects you are able to collaborate in as participating companies. There is almost always something that disturbs, for instance Omnisys wants to find the frequency of water vapour, while another company specifically wants to avoid that because that frequency is a disturbance. These seemingly little things can prevent co-operation if it concerns basic properties. CHACH did have some joint projects concerning manufacturing of circuits on a generic level, but they could never produce them because of differences in interest.

For Omnisys, participation in CHACH did not lead to any recruiting, but an industrial graduate student they had parallel to CHACH is now working for the company. No one left the company for CHACH. However, one co-worker left Omnisys to work for Saab, and that could have been a contact made in CHACH. Otherwise there was no mobility to speak of between participating companies. There are also some ongoing discussions about sharing graduate students between the company and Chalmers, who would spend two-three months in the company, then back to Chalmers and so on.

From the company's point of view, there is a general problem when university researchers in the CC start their own businesses. That makes them put in less time and effort on the CC company, following from a somewhat skewed incentive structure.

There has been no specific learning in the company when it comes to organising and/or managing R&D, or whatever projects. If any, it is the other way around; the university has learned a lot about how to run projects. However, it has been very valuable for Omnisys to have access to the laboratory at CHACH. Testing facilities and development tools, such as advanced CAD-systems, were at hand. By being able to test in that environment, the company could easier find arguments for later investments.

A4.10 Spillover

As far as Omnisys is concerned, there were very few further spillover effects visible. No spin-off companies, no specific case of IPR having a role in technology transfer or dissemination, and no visible effects on participants' behaviour in scientific publishing, conference attendance, or methods development. A fair interpretation could be that all these things were already quite developed in the different company contexts.

A4.11 CC as focusing device

Negative results, or failures, are considered very important by Omnisys, because they make them avoid bad investments. The company has learned a lot from participation in CHACH in that area. It is very much an issue of handling failures early in the process. Many of those are actually visible already in project descriptions and plans. By discussing the ideas with the researchers at CHACH it is possible to find out early what will not work,. These things really play an important part in reducing cost for the company. It also looks like the large corporations think very much the same way.

From the Omnisys idea of participation in a CC it follows that all participating companies should, once a year, write up a page telling why they are parts of that particular CC, instead of counting publications, patents and so on. In a publication you actually tell the whole world what you have been doing, or, in other words, you reveal to your competitors what you have achieved – and you do it for free. In a CC, the focus should rather be on the success of participating companies. Scientific quality is a rather poor measure of that kind of success.

A5 Saab @ CHACH (Chalmers Centre for High-Speed Technology)

Saab is represented in CHACH by what has lately been known as the business area Electronic Defense Systems, which is a merger between the two business units Saab Avitronics and Saab Microwave Systems, which Saab bought from Ericsson in 2006.

The operations in Electronic Defense Systems are based on Saab's interaction with customers who require solutions for surveillance and for threat detection, location and protection. This has created a competence in the area of radar and electronic warfare, and a product portfolio covering airborne, land based and naval radar, electronic support measures and self-protection systems.

For increased flight mission efficiency and flight safety, Saab supplies mission avionics and safety critical avionics computers for both civil and military customers.

A5.1 The company's relation to the university

The motive for Saab's participation in CHACH is simply that the company is in great need of Chalmers' competence and skills in the high-speed technology area. High frequency technology and microwave technology is at the core of Saab's products. They wanted to translate academic research into products, and also had an interest in finding skilled people to recruit.

A5.2 The company's financial contribution

The total contributions from Saab to CHACH can be seen in the table below, divided into the four different stages of the total CC period, and by the cash and in kind contributions respectively (actually all of these contributions were made while the company was still owned by Ericsson).

Saab		**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Total**
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands		3 995		5 779		5 760	1 500	1 562	**1 500**	**17 096**

The total contribution in cash has been 1,5 MSEK, and the in kind contribution has been just over 17 MSEK. There is a variation in contributions over the years, and it looks like the Saab activities in CHACH, at least judging from the in kind contributions, declined towards the end of the period. There is a contribution in cash from Saab in the last stage, but that is explained by the fact that the last 18 months CHACH was run without any government agency involvement.

A5.3 Organisation of company R&D

There was a total of 10-15 people from the company involved one way or the other in CHACH, around three at a time. The character of the projects varied a little. Sometimes most of the work was carried out at Chalmers, monitored by the participating companies. In other cases the company was more actively involved also in practice, e.g. by manufacturing small circuits that Chalmers developed further.

In most instances other companies were also involved, often three to six companies in each project. The company was practically never completely alone. It only happened once, in a specially ordered bilateral project towards the end of CHACH.

A5.4 Company benefit of CC participation

The company benefited from the participation in CHACH in more than one way. It has been a way to develop contacts with and knowledge about the entire area, as well as handling very specific problems. The primary aim, however, has always been to find new and improved solutions.

The companies and the researchers also learned a lot about how to collaborate in a centre. After the experience, they know a lot about how to optimise projects, what kind of projects to run, how new partners can become integrated and so on. In later centres all these things are much smoother.

A5.5 Economic effects from CC participation

The findings from the collaboration in CHACH definitely led to further development. In some cases, though, it was just a matter of learning to focus, and to reach good decisions in early stages. In other cases, the results were useful early in the process, but the technology has only just now begun to get exploited. Technology, materials and components are only at the time of this study starting to become parts in the company's products.

One specific case concerns some basic research done in CHACH in the 1990s, which now, in 2012, is starting to get commercialised. If that specific result had not been at hand, it could easily have taken another ten years or so. The research cycle is somewhere around ten years, and then adding the amount of time it takes for the company to transform the results into products gives unusually long development processes in this business.

The company never gives away exactly which components are parts of a product. That is a matter of principle. Therefore it is impossible to reveal exactly where the CHACH technology comes into products. It is, however, possible to say that CHACH technology is a part of a minority of the company's products. In 10-15 years from the time of this study it will probably be a part of a majority of the company's products. A technological shift has begun.

Consequently, not much of the company turnover so far is a result of the CHACH activities, but there is most likely an increase to come. That is how the significance of these results is assessed in the company.

The added value from a centre, in comparison with bilateral projects, is that the focus is clearly on the industry needs. They really had influence over the problem definition in CHACH. Having also other industrial partners in the centre was also a factor that contributed to the company reaching longer than would otherwise be the case. There is a leverage effect, with a larger outcome for every SEK the company puts in, if also other companies are willing to invest in the same project. It is also rewarding to learn what kind of problems other companies from the same technological domain or sector are struggling with from day to day..

It also seems clear that these achievements would not have been won, without the collaboration in CHACH.

A5.6 The market

In 2011, the company had sales worth 4,6 billion SEK. Around three quarters of the company's market is outside Sweden. The company is considered the fourth in the world in the radar area. In other areas it is smaller, and overall it is a small company compared with its major competitors.

A5.7 Company strategy towards university

Without the collaboration with Chalmers, the company would not have reached as far at all. There are other universities in other countries, but it is far from certain that the company would have been able to come as close to them. The industry in this sector is quite national, and there is a political dimension to it.

Some of the other companies involved were already acquainted, others were unknown. CHACH has helped to create a cluster and to make visible the area or sector of microwave technology. After CHACH some informal meetings have taken place. The growing network has been important. It has also led to some business collaboration, mostly after having learned who actually knows what, and from which companies it is possible to get consultancy support to deal with some specific small problems.

A5.8 Additionality

The company participation in CHACH has significantly contributed to the development of competence among its personnel. The dissemination to other parts of the company has, however, been limited. The number of people in the company involved in R&D activities has also increased. The sum of this is that the general absorption capability is higher as a consequence of participation in CHACH.

Also the internal competitiveness in relation to other companies in the Saab Group seems to be higher. There is much investment in the area, and it seems that the collaboration with Chalmers has strengthened the company in the internal distribution of funds and resources.

A5.9 Spillover

A large number of patents came out of CHACH projects (a total of 47); many of them in the microwave area. Following from the above referred principle of not revealing how components come into products, it is hard also to draw conclusions about the role of patents.

A5.10 CC as focusing device

In the radar business, there is a certain number of ways to, for instance, increase the scope of a product. It is important to understand the kind of different risks and opportunities associated with the possible measures to obtain that. CHACH has been crucial in helping the company to understand already in early stages what is sensible to invest in, how mature the technology is, what kind of difficulties or problems that might emerge, and so on.

A6 PHI @ CCCD (Competence Centre for Circuit Design)

The company Phase Holographic Imaging (PHI) specialises in holographic microscopy for non-invasive cell culture monitoring over extended periods of time. Cell culture monitoring combines simple automated cell counting and sophisticated live cell microscopy in a single device – which is called the HoloMonitor.

The founders of PHI, who saw the limitations of conventional optical microscopy and were inspired by the recent development of high resolution digital image sensors, started to develop a holo-graphic microscopy system in early 2001. A first functional prototype was built in collaboration with Lund University and CCCD, and then PHI was founded in 2004. A series of successively refined versions of the system have since been built and evaluated by local customers. The HoloMonitor was internationally launched in 2011, through a network of regional distributors.

A6.1 The company's relation to the university

Holographic microscopy is a new kind of microscopy, where a computer calculates a picture on the basis of a hologram. This makes it possible to focus through the software, instead of having to physically move something mechanical. It is also possible to measure the phase shift of light. The company is aiming at using microscopy on cells and cell cultures, where techniques are lacking to analyse cells in a non-invasive way, i.e. without destroying them. Several large companies have shown interest in this.

When the company started in 2001, there was an uncertainty whether an ordinary computer had enough capacity, and the founders had not themselves sufficient skills in the field of algorithms. That is when they contacted CCCD, and took on a graduate student who worked with them. CCCD funded the electronics part of the work, in the form of a base funding. Subsequently, the company funded more, and in 2004 they took in venture capital.

The sensors were not good in 2001, and neither were the digital cameras. A pilot study was completed together with an atomic physicist, and when they concluded that the whole thing could work CCCD came into the picture. It was the CC which made it possible to really start the activities. The graduate student was situated at the department, and actually so was the company. They rented their own room at the department, which was seen as a cheap and practical solution. They also knew the researchers well.

This is, however, history. None of the researchers in the CC is doing anything of significance for the company at the time of this study and the company describes itself as being in another phase.

A6.2 The company's financial contribution

The total contributions from PHI to CCCD can be seen in the table below, divided into the four different stages of the total CC period, and by the cash and in kind contributions respectively.

PHI	**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Total**	
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands								200		**200**

The total contribution is 200 kSEK, all of it in kind. The company came in late in the CCCD history, and were a part of the CC only in the last stage. From there, the activities in the company took off.

A6.3 CC problem solving and company development

The company's choice of application was made after a contact with an employee at Axis Communications in Lund, which was also a part of the CC. This person knew cell biologists and had some knowledge about their needs and problems. That is probably where the idea originally came from. This initial contact and discussion with the person at Axis did not, however, take place within the CC, but in another context. Lund is a small city, and Axis[74] is a significant actor.

A6.4 Organisation of company R&D

When there was any R&D in the company, it was done in very close connection with the researchers in CCCD. As mentioned above, the company was even located in the premises of the university department.

A6.5 Company benefit of CC participation

It would not have been possible to start the company at all, had the competence not been available in Lund, and where it so much was based on personal contacts.

The project could maybe also have been run on a bilateral basis, but since CCCD had such significant resources it was probably easier for them. The company could never have taken it by itself, that much is clear. The CC provided financial support, providing the graduate student salary, and for some time paying for other development.

[74] A world leading company in network video.

From the side of the company, the speculation is that the individuals in Lund are there anyway, and the money could have come from VINNOVA in some other form ... It is however all about the individuals, to somehow find the competence. The CC was a very good form and positive, but probably not entirely necessary.

In the company's views VINNOVA, as the funding agency, gets top marks for its efforts. It has been very good for the company, not least in later stages. Through the CC, PHI gained very good contact with VINNOVA, and when it ended there was still some money left that the company could have had for its activities. Instead, PHI suggested that the money go to the university, which could be use to buy one or two of the company's instruments to show to venture capitalists. This was very positive for the company, and their first instruments sold. It has also received support in another programme after the demise of the CC.

A6.6 Economic effects from CC participation

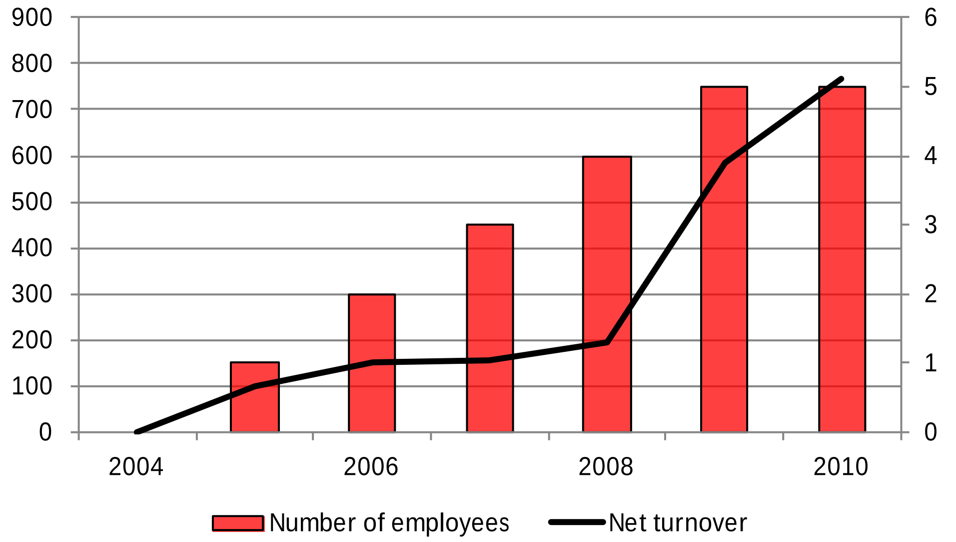
The very first instrument for the company was a programmable circuit that the graduate student made as a part of the education. It was a card, mounted in an instrument. The company had no capability to realise something of that type, in that they knew programming and optics, but knew nothing about circuits.

Then came the development of algorithms, partly by the graduate student but mainly through another researcher, close to, but never within, CCCD. This researcher helped them develop the algorithm, and they originally made contact through CCCD.

The company has had a product in the market around a year at the time of this study. It is being sold by roughly ten regional distributors. A new model, smaller and less expensive, is under development. An instrument costs about 250 000 SEK, and the company sold 15 of the so far. All the turnover the company has is a result of participation in the CC, since it is a start-up.

In Figure 44, we see the development in PHI of both the number of employees and the net turnover from the start in 2004, through 2010.

Figure 44 Number of employees and Net turnover for PHI during 2004-2010



The figure shows that during this period, the number of employees rose from zero to five people. The company's net turnover increased from zero to more than 750,000 SEK. Also PHI made use of research results in the CC, and it looks like it is about to enjoy some success in the market. PHI had 7 employees in 2012.

A6.7 The market

The product is used in health care, pharmaceutical industry, and beyond. The techno-logy improves the quality of the processes and has a great potential to develop further. The market is international, and the company is alone in the market offering this instrument. There are four companies in the world involved in this technology, but they are all aiming at different application areas.

The competition comes mainly from other companies with other technologies, but involved in the same kind of applications. That kind of competition is visible when customers are scanning the market, comparing performance between systems etc. At the time of this study, the company is discussing with large transnational American companies who are interested in the products, and maybe to acquire the company in the long term.

A6.8 Additionality

The company has not become part of any additional networks through CCCD. This is because it was a little odd in the CC, as the only one doing circuit design in that particular way. Participation in CCCD has not changed or developed the innovation behaviour or any internal processes such as the way management and control of R&D is done.

Being part of the KC has been very instrumental in the development of competence, while the engineers learned much by spending time in the department. The company held all its meetings there, for instance, amidst good opportunities for contact with the researchers

Later, nearly all the researchers at the university became partners in the company, although none of them is now active. The company would have liked to recruit researchers, but did not succeed, as the researchers prefer to stay at the university. The graduate student also moved on to another company.

The company uses university equipment infrequently, and normally through informal personal contacts with researchers

There is a general notion that the company brand has been strengthened by participation in the KC, though it is difficult to say exactly how. It is probably not in relation to the customers, biologists who do not know anything about the KC.

The company does not want to give an image of being too dependent on university researchers; it is in a phase where it likes to show they can stand on its own feet.

A6.9 Spillover

No patents have been filed through the CC. The company has applied for patent on the application, but will not try to protect the technology in itself, as the basic technology was published in 1967.

No spin-offs have been established as a result from the company's CC activities, and there are no examples so far where IPR has had a role in technology transfer or dissemination. The technology is, however, expected to spread widely within a few years. Others have the same or similar ideas in other parts of the world.

Company participation in the CC has also affected behaviour such as scientific publishing, conference attendance, methods development and so forth. Those who needed to merit themselves scientifically were free to do so. For instance, the graduate student kept on publishing for a while after graduating. There has not been any publication for other reasons, e.g. to block patents.

A6.10 CC as focusing device

The activities in the CC have been absolutely crucial to make the researchers and the company draw attention and devote resources to those areas where needs have been identified. The CC has certainly served as a focusing device in that sense.

A7 Saab Automobile @ Combustion Centres (CERC, KCK, CICERO, KCFP)

For a substantial part of the time of Saab Automobile's participation in a number of the CCs, it was owned by General Motors (GM, 2000-2010). The company has been active in a number of CCs, but the picture and conclusions presented here are mainly based on the empirical findings from its participation in the centres related to combustion. Saab Automobile was active also in other kinds of centres, but an account of the achievements made there is only very briefly touched upon.

Before Saab Automobile was acquired by GM, it was one of the very smallest car companies, selling approximately 120,000 cars annually. The engine development was situated in Södertälje until 2009, when some of it relocated to Trollhättan where the rest of the R&D was located. At that time Saab Automobile had around 5,000 employees, and was part of what had been the world's largest car manufacturer for 70 years.

A7.1 The company's relation to the university

In general, the company's relation to the university is about some kind of joint effort to build competence. This is what Saab Automobile had in common with a large number of companies that have participated in the CCs. In the case of the global development of vehicles, it is a very fast business and the competition is fierce. At the time of this study, this is particularly the case in the field of hybrid development. Before, the companies needed civil engineers, now they need technical doctors.

In other words, the CCs are about long-term knowledge development, without which the companies cannot cope. The model for this is very efficacious, it lays the foundation for a good dialogue with the agency and a good understanding on their part. It can otherwise be difficult for civil servants to see the industrial needs. Dialogue is crucial.

The model also stipulates both cash and in kind contributions from the companies, which can be described as another prerequisite for success. The university is a somewhat fixed and closed world, and there is a need to find the formula for making researchers work with industry relevant issues

University departments adjacent to, but not part of, the CCs shave also been of a high significance for what Saab Automobile has achieved from its activities.

A7.2 The company's financial contribution

The available figures on the total contributions from Saab Automobile to CERC and KCK can be seen in the table below, divided into the four different stages of the total CC period, and by the cash and in kind contributions respectively.[75]

Saab Automobile	**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Total**	
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands	1 230	640	1 350	729	2 400	3 400	1 600	2 658	**6 580**	**7 427**

The table shows that the cash and in kind contributions are almost evenly distributed, more than in any other case so far. The in kind contribution is just less than one million SEK higher. In most other case studies, either the cash or the in kind contribution predominates. Also in this case the contributions increased over the stages, but they

[75] Unfortunately the company contributions to CICERO and KCFP have proved impossible to obtain within the framework of this study.

peaked in the third stage when the company provided almost half of all the resources over the course of the CCs.

A7.3 CC problem solving and company development

In most cases, the research activities in the CC precede the company development operations, but this is not entirely conclusive. There are some very research intensive technical subcontractors, whose results can be applied in the CC.

A7.4 Organisation of company R&D

Most projects have involved an industrial graduate student, and in those cases the company has a problem for which it seeks a solution. The solution slowly emerges, more or less by itself, through the handling of what are considered urgent problems. In these phases, it mostly R&D-people involved from the company.

During the course of the CCs, the participating companies came to the conclusion that they wanted a better co-ordination and preparation before the research. This is regarded as desirable to bridge the gap between basic and applied research.

The role of the centre managers is also highlighted by the company. Their conceptions and their competence are considered to be very important for the success of the CC, or the possibility to obtain results that are really useful for the companies in their subsequent development efforts.

A7.5 Company benefit of CC participation

The participation in the CCs has led to Saab Automobile having a significant role, a global lead, within the GM-sphere in those areas. The American owners have not been over-enthusiastic about the participation, but at the same time not been able to really question it.

The number one benefit for the company has been the education of qualified people with current excellence in the relevant knowledge field. Benefit number two are the research results. After that follows the benefit of the collaboration and co-operation model, with the results from both basic and applied research as the foundation. The CC in itself is one important part and the surrounding university departments are another. Together they constitute critical mass.

Industry is interested in cost sharing, and the CC model offers leverage of the company’s investment. The open model generates a desire from companies to collaborate, something they do not voluntarily do under different circumstances. This is possible since the activities in the CCs concerned pre-competitive issues. Not even Ford or GM believed that competition was a problem under such conditions.

As indicated above, Saab Automobile specifically gained access to new research results for use in its own R&D projects. Important results were those related to coming combustion systems and the reduction of fuel consumption, and also those supporting the development of tools for future combustion configurations.

A7.6 Economic effects from CC participation

The economic effects of CC participation have been wide. Saab Automobile has been at the forefront in combustion systems development and engines. There are complete systems for alternative fuels. Saab Automobile has been innovative, using higher compression in the engines, which makes it possible to use pure ethanol as fuel. They were a ahead of the field in this respect. A variable compression engine is also being developed to run with different octane ratings. The company also had developed a semi-automatic gearbox, which requires knowledge in very advanced control technology.

It is hard to say how all this affected sales. Everything was implemented in the cars as it was mature and ready. There is a feeling that GM in the USA and Opel were those who took the greatest benefit of these findings. The benefit for Saab Automobile was perhaps less. This is also linked with the notion that the American owners never really focused on Saab, which probably would have done better with Volkswagen, which was always better at segmenting brands and models.

The achievements in the CC were also very important for the development in the entire market. Combustion technology is under very intense and constant development.

A7.7 The market

The market is totally international, but Saab Automobile has had its special problems, recently. General Motors and Opel seem to be the largest beneficiaries from the achievements made in the CC.

A7.8 Company strategy towards university

It is hard to imagine this kind of innovation without participation in the CCs. Going to the research institutes instead becomes much more expensive, and the risk is signify-cantly higher that the results end up in the hands of competitors. Saab Automobile would not have had the financial resources to benefit as much by itself. The funding model is crucial here, with its leverage effects.

The company was also always interested in maintaining a national centre, and finds it valuable to establish and maintain relations with a knowledgeable network of experts who can help solve all sorts of problems.

A7.9 Additionality

Saab Automobile’s group inter-company competitiveness has undoubtedly increased from participation in the CCs. The activities have also included collaboration with Fiat. During this time two new diesel engines were developed. Nothing like it existed in the USA, yet today they are with within GM and Fiat. The economic value of these things is very hard to assess, and maybe everything would have ended differently had the financial crisis in 2008-2009 not occurred.

The innovation behaviour in the company has developed, too. More collaboration has definitely taken place. There are some very good examples of openness in the starting up and early stages of projects. The traditional model is more fixed and closed. There are furthermore some recent examples of how key actors have come into the action, thanks to the model, its outline and conditions.

Lately, the companies have generally hired more people with research competence. This is leading to better absorption capacity and ability to take advantage of technological opportunities. The participation in the CCs, and using the centre approach, has also helped to develop the management view on what is possible and how to conduct the work. The CCs have helped to open up this way. The Swedish model is definitely a success, and it seems to have a future. Volvo, for instance, are very committed and show no signs of giving in.

Participation has also helped substantially in developing a network, which is of great importance for the possibilities to achieve anything in this field.

A7.10 Spillover

Several immaterial assets, patents or design, have followed from CC actitivities and results. It is, however, however difficult to assess their economic value. Facts, know-how and "know-who" have all been created, and are all very important for the companies involved. Again, different aspects of being a part of a network are held up as major achievements.

There was a general strengthening of the Saab company brand in relation to both the business community and the research community. Saab Automobile made itself known as a company that was interested in knowledge and research, and also knowledge and research intensive. This probably gave a lot back to the company, not least in terms of possibilities to recruit.

A7.11 CC as focusing device

In the way described in this section, the activities in the CCs where Saab Automobile has taken part has clearly have served to focus and define areas with knowledge needs and a need to allocate resources.

Someone may think that three combustion competence centres is at least one too many. They are, however, described as highly specialised and competent. They complement each other, and there is hardly any overlap.

A8 Ericsson @ ISIS (Information Systems for Industrial Control and Supervision)

Ericsson's vision is to be the prime driver in an all-communicating world, in its capacity as a world-leading provider of telecommunications equipment and services to mobile and fixed network operators. Over 1,000 networks in more than 180 countries use Ericsson network equipment, and more than 40 per cent of the world's mobile traffic passes through Ericsson networks.

The company is one of the few companies worldwide that can offer end-to-end solutions for all major mobile communication standards. The networks, telecom services and multimedia solutions all make it possible for many people, across the world, to communicate electronically. Ericsson also describes itself as playing a key role in the evolution regarding how communication changes the ways in which we live and work. This has to do with using innovation to empower people, business and society, and to work towards the Networked Society where everything that can benefit from a connection will have one.

A8.1 The company's relation to the university

Ericsson Research is generally involved in collaborations with universities, and such applications are considered positive. Criteria for participation are: 1) a sufficiently interesting topic, and 2) the collaboration takes place geographically close to some group at Ericsson. The main reasons for participation are: the specific results that come out of the projects, insight and understanding of important grounds for the company's ability to develop, and the possibilities to recruit highly competent people that are skilled in highly relevant areas.

The ISIS centre fits into all of this. There was an already established relationship with the centre director, and it felt very reasonable to deepen the collaboration. In other cases, the standard procedure is that the initiative comes from the university.

A8.2 The company's financial contribution

The total contributions from all Ericsson companies to ISIS can be seen in the table below, divided into the four different stages of the total CC period, and by the cash and in kind contributions respectively.

Ericsson	**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Total**	
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands	100	2 900	700	5 925	50	1 500	100	2 700	**950**	**13 025**

The table shows that the total cash contribution is a little under 1 MSEK, and the in kind contribution is a little over 13 MSEK. The contributions are very unevenly spread over the stages, with a significant peak in stage 2 where both the cash and in kind the contributions are clearly more than double that of any other stage. In fact, the cash contribution in the second stage is 74 per cent of the total for all stages, while the in kind contribution in the second stage is 41 per cent of the total.

A8.3 CC problem solving and company development

The problem solving activities at ISIS are described as fitting like a glove in relation to the development issues and needs in the company. Ericssons concern was within development of the 3G system, namely the so called stable uplink, which in short is the connection between the mobile telephone and the base station. Analysis of the uplink load situation is complicated, and a typical control problem to handle with the help of such algorithms that were developed at ISIS.

A8.4 Organisation of company R&D

The company's in kind contributions, and the actual time spent working in the projects, guarantees that its participation is well thought through, and that the problem at hand is something to engage in. The ideal approach would also include a genuinely common problem definition between the company and the researchers, which will also take place at the very beginning of the collaboration.

In the relation between Ericsson and ISIS, co-operation and co-production of the work and the publications were important and significant components. Actually, some people were employed part time at both places at the same time.

A8.5 Company benefit of CC participation

The company has absolutely benefited from the treatment of the problems addressed in conjunction with ISIS. Very important steps were taken in the development of the 3G system. This was made possible because the university had the courage to really let industry in, and gave them a real chance to influence and control. The board of the centre did have power over its activities and decisions. In this context, it is also important to understand the significance of organisation.

This is not always the case in collaboration with a university; sometimes companies feel like they are invited merely out of politeness or as an alibi for university researchers to attract funding for academically oriented research. In this case, both parties became really content, and felt truly comfortable with their collaboration. It is, however, seen as important not to cross the border to implementation. That is entirely company business.

Important things have also generally been done around the centre, by those actors who have been in contact with ISIS one way or the other. At the same time, this is not very clearly in focus. The company and ISIS give quite strict attention to the project(s) they have in common, in effect applying that somewhat limited perspective. From a general point of view, it is the company's contacts with the university that mean the most, not contacts with other companies. Nevertheless, useful contacts were no doubt made within the ISIS collaboration.

The participation in ISIS has also meant a lot for the competence building and the opportunity for the company to recruit both undergraduates and graduates with both high and relevant competence. Some mobility has taken place between organisations, at the time of this study the two seminal graduate students in the ISIS uplink project are working at Ericsson, for instance. This is of extreme importance for the company, and constitutes one of three really important outcomes.

A8.6 Economic effects from CC participation

The R&D projects resulted in a number of patents. Much of the activities circled around two people, both of which are employed by Ericsson Research at the time of this study. The results were most certainly used in the development of Ericsson's 3G product, which is a mature product that sells all over the world. The company has 40-50 per cent of the world market for these systems.

The product has generated revenue of more than 10 billion SEK. Ericsson may possibly be the participating company who gained most out of the participation in ISIS, even if the specific contribution into the development of the specific product was relatively lower compared with other companies, which addressed a larger proportion of their development problems within ISIS.

The innovation regarding the analysis of the uplink load would most probably have been made anyway, without participation in ISIS, even if it also is most likely that the work and the project would have been done in a smaller scale and taken longer to implement. The problem called for a solution anyway, and eventually Ericsson would surely deliver a mobile telephone network with a functioning uplink. The most significant factors in play have probably been the specific patents and the specific people performing the research, but the R&D resources are in principle available in the company. ISIS has added a broader perspective to the issues.

The product is mature and adds value to the company all through the 3G-era, and the success is connected with several patents related to the stable uplink. This is a feature of great importance for the entire 3G-development. The stability of the uplink makes it feasible to be as close to capacity as possible, without the whole system getting instable. Also the customers are highly dependent on this. To the extent 3G-services are used, it is also important for societal services, rescue services and so on. Probably no one has tried to estimate the total value of all of this.

A8.7 The market

As indicated above, the market for Ericsson is entirely global. The company is a world leading actor in its sector.

A8.8 Additionality

Results from research and insights from collaboration with the university are always essential in some general sense, i.e. not specific in relation to ISIS. The relation to the university is about being able to recruit for increased competence and qualifications, and to use the university as a probe to assess relevant conditions five years ahead. The activities in ISIS, on the other hand, were unusually close in time, unusually close to the company product development.

Ericsson is an organisation with approximately 500 researchers of its own, and well established collaboration forms with the university and research institutes. Participation in ISIS has thus not added much when it comes to development of the company’s innovation behaviour, through more co-operation, co-operation with more actors or more openness. The structure of these habits is probably both sector and company specific, since Ericsson is such a large actor.

The company cannot report any better absorption capacity, better ability to detect and make use of external technological opportunities, or higher competence to work close to the forefront, as a consequence of participation in ISIS. Neither has it led to more efficient internal management and control of R&D in the company.

There is no extended access to external resources, such as competence, networks and equipment, Ericsson already has all of that itself. In this case, software simulators. The company is already better than all universities at that, and they are constantly forced to update everything.

However, increased knowledge, competence and awareness, through fact finding, know-how and personal relationships ("know-who") are all well known outcomes too, for participants in the CC. It builds knowledge communities, which is very significant in the case of Ericsson @ ISIS.

Participation has also helped to strengthen the company brand in some general sense, towards the research community. This is important for Ericsson, who likes to think of itself and want to be seen as a knowledge organisation.

A8.9 Spillover

There are no spin-off companies directly related to the Ericsson area of R&D in ISIS.[76] From the Ericsson point of view, there are no examples of the creation of IPR which have had a role in some kind of technology transfer, within or between sectors. The company does not want to contribute to that. It does not have any small companies as subcontractors; this is Ericsson's own core business. There has possibly been some knowledge transfer through the university.

Ericsson is not aware of any effects on CC participants when it comes to scientific publications, conference attendance or methods development, either.

A8.10 CC as focusing device

The Ericsson participation in ISIS has also been both focusing and orienting, and thus made both researchers and companies aware of and allocate resources to areas where knowledge and human needs have been identified.

A9 NIRA Dynamics @ ISIS (Information Systems for Industrial Control and Supervision)

NIRA Dynamics is a company focusing on research and development of signal processing for the vehicle industry. Its products are based on signal processing, modelling and control, and it designs different vehicle applications, mostly to enhance safety. This is done through sensor fusion, which can be described as using information from several different physical sensors to compute new, virtual sensor signals.

The biggest selling product so far for the company is the Tire Pressure Indicator (TPI), which is an indirect tire pressure monitoring system to help reducing fuel consumption and enhance the life span of tires. Another product is the Map Aided Positioning (MAP), which uses a digital map and speed sensors.

[76] There are however spin-offs in neighbouring areas. One example is the company NIRA Dynamics. More on that elsewhere.

NIRA Dynamics is itself a spin-off company. Not exactly from ISIS, but from the close environment at the university. It was founded in 2001, and since 2003 it has been owned by Audi Electronics Venture GMBH.

A9.1 The company's relation to the university

When NIRA Dynamics was a part of ISIS, it was as a much smaller company. The main point of participation was to theoretically investigate potential products, before they were put into production. Other very important motives were to reach deep understanding of the company's products, and to get co-workers or employees with deeper expertise.

In the course of doing this, the company was quite focused on only few relations, and did not think of the CC as an arena for meeting other relevant actors in the first place.

A9.2 The company's financial contribution

The total contributions from NIRA Dynamics to ISIS can be seen in the table below, divided into the four different stages of the total CC period, and by the cash and in kind contributions respectively.

NIRA Dynamics		**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Total**
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands					50	450	100	1 650	**150**	**2 100**

The table shows that the company was an active part of ISIS only during its last two stages. The total cash contribution was no more than 150 000 SEK, and the in kind contribution amounted to 2,1 MSEK. However, the contributions rose significantly between the two stages. The cash contribution doubled, while the in kind contribution almost quadrupled.

A9.3 CC problem solving and company development

To the company, the activities at the CC are always seen as complementary activities. Delivering the products is number one at all times. Being in the academic environment is, however, very rewarding and fruitful in itself. For this one does need to literally be in place at the university a few days a week. That is when the ideas are created.

It is also quite fair to describe the context as a complex combination of companies, that all have some kind of idea connected with research. This drives the development, together with the demands from customers, and leads the companies to try to reach a deeper technical understanding. A lot of dialogue is included in this, which is also carried out in the networks.

A9.4 Organisation of company R&D

The typical situation in ISIS was that the participating companies had industrial graduate students, who were on location at the university on at least half-time basis.

This was generally seen by the participating actors as a prerequisite for any achievements. On the other part of their time, all of the graduate students fulfilled duties at company R&D departments, where they were working more or less close to product development, depending on which company. This was also very much the case for NIRA Dynamics.

A9.5 Company benefit of CC participation

From the NIRA Dynamics point of view, the largest benefits were a significantly deeper expertise among its personnel, and also more knowledgeable people. All people involved have increased their competence, and the contact network has also grown.

It is hard to compare with others, but there were a number of key industries involved, all of which had the opportunity to perform a little more long-term research and were able to make connections.

At the time of the company's participation in ISIS, it was most certainly crucial for the ability to lay the foundation for the innovation. The participation developed into much collaboration, and it is hard to see how it could have been created without it.

A9.6 Economic effects from CC participation

The tire pressure monitoring system is the big thing for the company. It is complex, and dependent on the development of rules and regulations in that area. In a couple of years time from when this study is made, there will be a much clearer outcome. The company is the world leader in its field of technology.

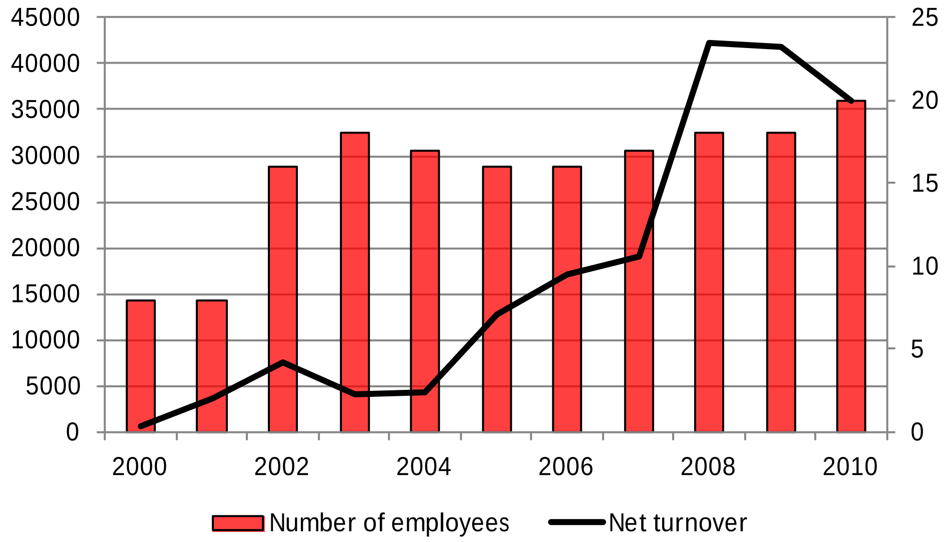
As mentioned above, NIRA Dynamics is owned by Audi and the business is thriving. The system is implemented in their cars. In the USA, there are regulations concerning active safety systems in vehicles already, and the prognosis is that this will also spread to Europe. The product did exist before ISIS, but was definitely subject to development there, which was extremely important.

After participation in ISIS, the really large effects occurred. They appear to coincide very well with the product life cycle, where the product is likely to be in an expanding, upward phase. It is not entirely clear what participation in ISIS meant for patenting. However, the company holds patents for key parts of the system, on which the entire company is dependent.

An active safety system, such as the TPI, has the potential to prevent a significant amount of accidents, even if it is difficult to estimate how many. There is also an environmental effect of driving cars with the correct tire pressure, which constitutes a potentially huge profit for society. The company is not able to estimate that, either.

In Figure 45, we see the development in NIRA Dynamics of both the number of employees and the net turnover from its registration in 2000, through 2010.

Figure 45 Number of employees and Net turnover for NIRA Dynamics during 2000-2010



The figure shows that the activity in the company has increased steadily during the period, with one exception 2003-2004, which was when Audi acquired the company, and another exception in connection with the financial crisis in 2008-2009, which ended a tremendously positive development during the preceding four years. Since 2002, the number of employees has also been fairly constant, which indicates a raise in productivity during the period.

A9.7 The market

The market is completely international. The company is owned by Audi, which also makes it a part of the Volkswagen Group. Furthermore, the market is new and emerging, and an example of how active safety systems see a growing demand as a consequence of how traffic safety rules and regulations develop in society.

A9.8 Company strategy towards university

The CC has been very important for the knowledge and competence building, and for the opportunity for NIRA Dynamics to recruit skilled people. The mobility that the company has experienced is also rather typical for what it has looked like within and around ISIS, which is also quite substantial. To point at just one likely example, we can think of a person who started a career working for a large manufacturer in the defence sector, went through university to a smaller technical consultancy, and lately is back again with one foot at the university.

A9.9 Additionality

It does not seem that participation in the CC has had a strong impact on the company's strategic plans and choices. They were apparently rather clear when the collaboration with the university started. The collaboration itself, and how the company valued it, have more likely been subject to change or development, but when it comes to the products it is doubtful. Some really significant things have nevertheless happened. New employees have started and helped to raise the competence; the company has been bought by Audi, and so on.

In the company, people have become more and more competent. though the absorption capacity has always been quite strong. It has not necessarily increased, since the company always had many PhDs. For the same reason, the internal processes to manage and control R&D have probably not become better.

The company's innovation behaviour has gone through some development, but at the same time it is possible to conceive of it as more focused and consolidated. There are still very close connections between the company and Linköping University. There are also close connections with Germany. Audi is the owner, they have a larger automotive industry, and there are even more connections with the Volkswagen Group.

One of the most important achievements is clearly the increased access to external resources, such as competence, networks and equipment. It seems also that the participation in the CC has helped to create conditions that have proved important for the development of the company, in the form of opportunity to graduate, to work with others in knowledge and competence building, and to make contacts and create the networks together with other researchers and companies. These things would probably not have happened if it were not for ISIS, and its role as a platform.

The way that participation has helped to strengthen the company brand is by the company getting a bit more known in academic circles. It makes good advertising, and the system is quite easy to explain and to show for students and people who get employed. For recruitment those things have proved to be valuable. People from the company are giving guest lectures, supervising undergraduate theses, and so on.

A9.10 Spillover

NIRA Dynamics is a spin-off company, but, as mentioned before, not from ISIS, but from a very close environment at the university department. All the people from the outside working at ISIS were already in their companies, very typically as industrial graduate students. Of course ideas emerged. NIRA Dynamics is a fairly typical example of a company that has been acquired because of ideas.

Some technology transfer has probably also taken place on the basis of ideas that have been under development and discussion in the CC. In such cases it would have been building on the notion that one idea can be transferred to and tested within another, neighbouring problem area. It has been described as quite amusing when such things happen, and a clear consequence of knowing each other quite well.

Most people at the company are graduates. They are thus used to working and publishing scientifically and to attending conferences. The extent to which these things are actually done is probably a function of education and training. Most of the development of methods and so on is effected through recruitment.

A9.11 CC as focusing device

ISIS as a CC has really functioned as a focusing device. Although very free and open, the industry needs always came through, at the same time as the scientific quality was sufficient. The balance between these two demands is sometimes hard to keep. The companies are always product centred, while it is equally important to keep the long-term perspective in knowledge building.

A good mix of academy and industry interests is always complex and difficult to obtain. It is hard to find a completely generic approach. Judging from ISIS, it seems that most companies are able to ensure the relevance and their benefit through the industrial graduate student model.

A10 Lucchini @ CHARMEC (Chalmers Railway Mechanics)

Lucchini Sweden (previously Adtranz Wheelset) has a long tradition in the production of railway wheels, axles and full wheel sets. Today the company is the only manufacturer of these products in Scandinavia. The main production is focused in the machining of wheels, tyres and wheel sets. All wheel sets are designed for low cost utilisation and maintenance.

The development of new products focuses on wheel sets for heavy haul and for high speed trains in Scandinavian climate with down to -50° degrees centigrade. The plant is equipped with a machining shop for wheels, tyres, axles and for the assembly of complete wheel sets and with two test rigs, one for brake experiments and one for noise measurements.

The company participated in CHARMEC since the start, all through the four stages.

A10.1 The company's relation to the university

Participating in CHARMEC was an initiative of the former CEO of the company. It is a small company, with around 60 employees, but, as mentioned above, the only supplier of wheels and axles in the Nordic countries. Being a part of a CC is the only possibility for the company to keep up skills and competence, to be able to compete. It actually concerns a competence that otherwise would have been impossible for the company to obtain.

Within the Lucchini Group, there is certainly both R&D and competence, but that is not very close at hand.

The research issues of significance for the company are about wheels, damage to the wheel design, thermal forces, and so on. A core competence area for CHARMEC is the contact area between wheel and rail, which is completely right for this company.

Lucchini Sweden has practically no bilateral collaboration with any other R&D provider. At CHARMEC, the competence is assembled, and maybe something very specific is sometimes done together with a single individual, on a separate bill.

A10.2 The company's financial contribution

The total contributions from Lucchini Sweden (and Adtranz during the first two stages) to CHARMEC can be seen in the table below, divided into the four different stages of the total CC period, and by the cash and in kind contributions respectively.

Lucchini Sweden	**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**			**Total**
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands	1 600	1 165	3 000	2 813	3 000	2 918	1 950	1 826	**9 550**	**8 722**

The company was active in CHARMEC through all of its stages. The total cash contribution was a little over 9,5 MSEK, whereas the in kind contribution landed on just over 8,7 MSEK. This is, in other words, also one of the very few cases where there is a fairly even distribution between cash and in kind contributions. Also in this case, however, it looks like it has been a bit if a slow start, and there is a peak in the second and third stages.

A10.3 CC problem solving and company development

The activities in CHARMEC represent a very obvious complement to the development activities in the company. From the company perspective, the CC exists to maintain the long-term general competence, and it has had great benefit from exactly that particular competence.

A10.4 Organisation of company R&D

The participation in CHARMEC has especially been executed by the CEO himself, who is actually also the company's R&D and the sales executive at the same time. In effect, CHARMEC is the company's R&D department.

The company has mainly provided support for a PhD project, but also one on a bilateral basis, where it has the opportunity to control which help to get from the research. It could concern issues on designs, proposed solutions or getting help to explain different outcomes. The company's customers also use CHARMEC for damage analyses or investigations.

A10.5 Company benefit of CC participation

CHARMEC has been working exactly with those issues that are of interest to the company. It has been an almost perfect match. There is, however, not a perfectly clear link between what is done in a PhD project and what the company does in its workshop. Instead, spin-off effects follow. Via Chalmers other customers show interest in wheel issues. The Iron Ore Line is an example, which is a very tough application.

The larger and growing network is another very important effect. In the CHARMEC board the company meets representatives for the entire railroad sector. This is not seen as mere industry support by the company, but a way to effectively disseminate research results so they may benefit development and growth. It is actually also a genuine public private partnership, since it is a joint effort between the partners.

Being part of CHARMEC is definitely perceived to be good for Lucchini Sweden's company brand. Without participation it would only be a mechanical workshop, but by participating it moves along on the highest levels of research. That gives another punch. The company becomes updated on the latest findings in research, also in adjacent areas. In the next phase, that may be used in the company's own business.

In the longer run, the company's customers are the ones who benefit from the development of the products, together with the company itself. The problems of the customers are the ones being solved. Again, the Iron Ore Line is a good example. The smallest problems are seen directly. They have changed the grade of steel many times, and are always on the limit.

Productivity and efficiency in the customer's activities is in the balance. The company does not hold any patents.

The participation in CHARMEC has thus increased competence, but none of it is through mobility or by recruiting people educated at the CC. The company does not recruit for these purposes, but, as mentioned above, uses CHARMEC as its R&D department.

A10.6 Economic effects from CC participation

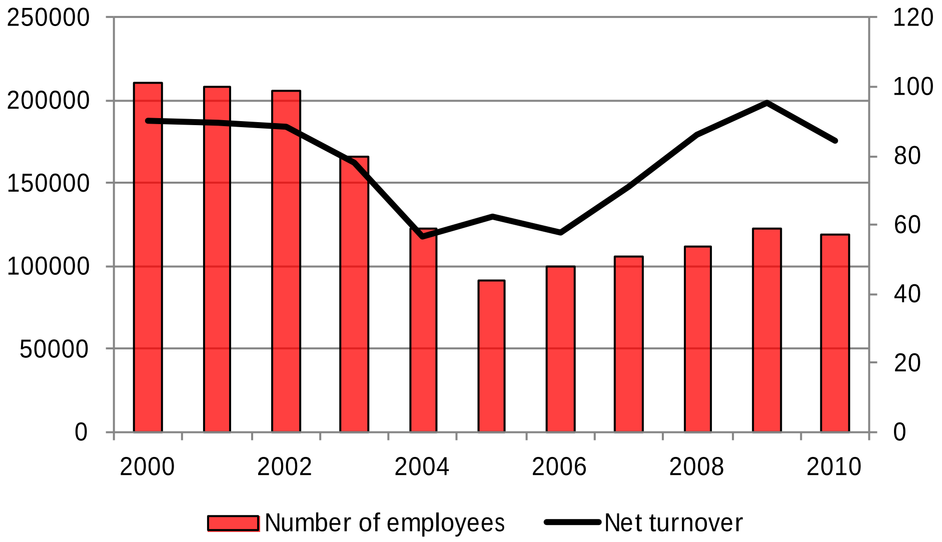
Like many Swedish companies, Lucchini Sweden must compete on other than price. It needs to complement the products with services, but also to have presence and represent competence. The company should provide flexibility, the right quality, the right product, be able to discuss with the customer, not least with reference to climate which affects the properties of the product.

The company has had a lot of support in the wheel design area. At the time of this study there are some parts of the EU standards that are considered overlooked. Crushing on railway wheels in the winter creates considerable forces, stronger than anyone has imagined. The standards do not take this into account. There is a hope that the results from the CC can help influence them as well.

The CHARMEC work has also been of great benefit in the work of improving production techniques. Development is continuous, where Lucchini, CHARMEC and the customer jointly find solutions and develop the product.

Figure 46 shows the development in Lucchini Sweden of both the number of employees and the net turnover during the period 2000, through 2010.

Figure 46 Number of employees and Net turnover for Lucchini Sweden during 2000-2010



From Figure 46 it is clear that the company has been able to recover the net turnover from a dip in 2004-2006, a development that actually started after 2002. After that, the number of employees has also seen a slight but steady increase, up until after the financial crisis in 2008-2009 which obviously also affected Lucchini Sweden, both in terms of a decreasing net turnover and the reduction of a couple of employees.

A10.7 The market

Lucchini Sweden is only working in the Nordic market. The company is large in Sweden, and has around 60-70 per cent of the market. In Denmark the share is even larger, close to 100 per cent, but in Finland and Norway the share is lower.

Should the EU standards change, or if it was possible to reason with the customers, that would be important to handle the above mentioned winter problems. The company would be one of the very few actors able handle the problem. Production and sales would certainly be affected by that, but these effects are difficult to quantify in advance. It would, however, be very important.

A10.8 Company strategy towards university

Without the company’s participation in the CC, the issues would most likely be handled somewhere else in the Lucchini Group. Without CHARMEC, the Swedish branch would only be a company who manufactures train wheels. The CC is also of support in for instance technical dialogue with customers.

In the case of Lucchini Sweden, it is a question of either or. Participation in CHARMEC makes activities possible, which otherwise should not have been performed at all.

A10.9 Additionality

The company cannot become a low-cost supplier, but must live on quality, technical competence and both development and choice of materials. Mechanical forces and metallurgy are both of high relevance. The causes of the winter damages are still a bit of a mystery. The Italian metallurgists have also been involved, there is a collaboration all along the line.

Participation in the CC has not led to a heavy increase in the number of collaborations or collaboration with more actors. There is only CHARMEC, or else the dialogue is with the Group people in Italy.

There are no R&D personnel employed by the company, and hence no specific internal processes for management and control of R&D that could have been affected by the participation in CHARMEC. Access to external resources, such as competence, networks and equipment, has increased in the ways described above.

A10.10 Spillover

Not much spillover has been visible from the company's point of view. No spin-off companies or intellectual rights that have had a role in technology transfer, within or between sectors. A vague speculation would be that brake systems developed for trains could be relevant for manufacturers of trucks and buses.

A10.11 CC as focusing device

The activities at CHARMEC has very clearly functioned to focus and orient participating parties in a way that they have given attention to and put resources into areas where needs have been identified. They have actually sat down together, to discuss and decide on problems and areas they would like to research.

A11 Södermalms talteknologiservice (STTS) @ CTT (Centre for Speech Technology)

Södermalms talteknologiservice (STTS – speech technology services) is one out of seven start-up companies that were founded during the course (1996-2006) of the Centre for Speech Technology (CTT) at the Royal Institute of Technology (KTH). It was founded in 2002, during the third stage of CTT. During the fourth stage it was also a partner of CTT.

STTS focuses on computational linguistics and speech technology. The company offers speech technology counselling, general and custom-made synthetic voices, lexicon development, annotation of speech and language data, and other consultancy services in speech technology, including software development.

The founders have years of experience of research and development in computational linguistics, speech technology and dialogue systems. Their university education covers linguistics, computational linguistics, speech technology, phonetics, programming, Swedish, English, German, Irish and Finnish.

Since the foundation, STTS has primarily worked with development of pronouncing dictionaries for a number of European languages, recording and annotation of speech data for unit selection speech synthesis, and transcriptions and semantic labelling of speech data to be used in dialog systems.

A11.1 The company's relation to the university

The motive for participation in CTT was largely to be part of what was believed to be a valuable network, and the opportunity to attend useful seminars. At least to begin with, the solving of specific problems was not the main point.

The founders of the company started their business, and were asked to join CTT. This was received positively since the company was planning to do things that were very closely related to CTT and its activities. The contacts with the people who were active in the CC remain. Some contacts have also been established and maintained with other departments, for undergraduate thesis work, and to find people who are skilled at languages.

At the time of this study the company also frequents international conferences from time to time, many of which are commercially oriented. Technological development is the main interest. With that comes the opportunity to sell, which is also the raison d'être for any commercial actor.

A11.2 The company's financial contribution

The total contributions from STTS to CTT can be seen in the table below, divided into the four different stages of the total CC period, and by the cash and in kind contributions respectively.

STTS	**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Total**	
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands								485		**485**

The total contribution is 485 kSEK, all of it in kind. The company was founded during the third stage of CTT, and was a part of the CC only in the last stage, even if the people in the company were working in CTT. That is when and where the activities in the company started.

A11.3 CC problem solving and company development

The company is convinced that it would have been active in the same area, even without participating in CTT, but there has definitely been product development in STTS following directly from this collaboration. Everything that is done in the company comes from CTT, one way or another.

Participation in CTT has created knowledge and competence building important for the development of STTS through acquisition of facts and know-how. The company tries to keep itself updated, also in terms of basic research, even if the knowledge is otherwise very practical.

The company has increased the networks for both its business and the technological development both by participation in the CC, and through former employers. They do perceive themselves as part of some sort of knowledge community. The company brand is strengthened from participation. People know what CTT is, when participation is mentioned. It serves as some kind of very general proof of quality in these people's eyes.

A11.4 Organisation of company R&D

Everybody at STTS was involved in the CTT activities. The company is very small, it is actually a spin-off from CTT, and all personnel were actively involved in project work, of co-writing articles and so on.

A11.5 Company benefit of CC participation

The benefit of networking is significant for STTS. The company has been able to take advantage of CC resources, and learned a lot of useful things in that context. One thing was lexicon development in new ways. Competence development and experience are key words.

A11.6 Economic effects from CC participation

All products in STTS build on results from CTT. A large product has been a foreign lexicon for GPS, where the company has been the largest supplier to the largest supplier in the business. At the time of this study the company is dependent on the possibility to take part in a project for a completely new concept in the GPS area.

Pricing is very competitive in the industry; it is practically not possible to deliver to the low prices that are required. New functionality has to be introduced at all times, everything needs to be available. All conceivable points of interest must be included.

The company claims that many new goods and services are in the pipeline, all of which also have their grounds in results from CTT. Talking magazines and talking books is one area in which things are expected to happen.

The innovation created in the company would hardly have seen the light of day without participation in the CC. Possibly at some former employer, but none of them would probably show any interest.

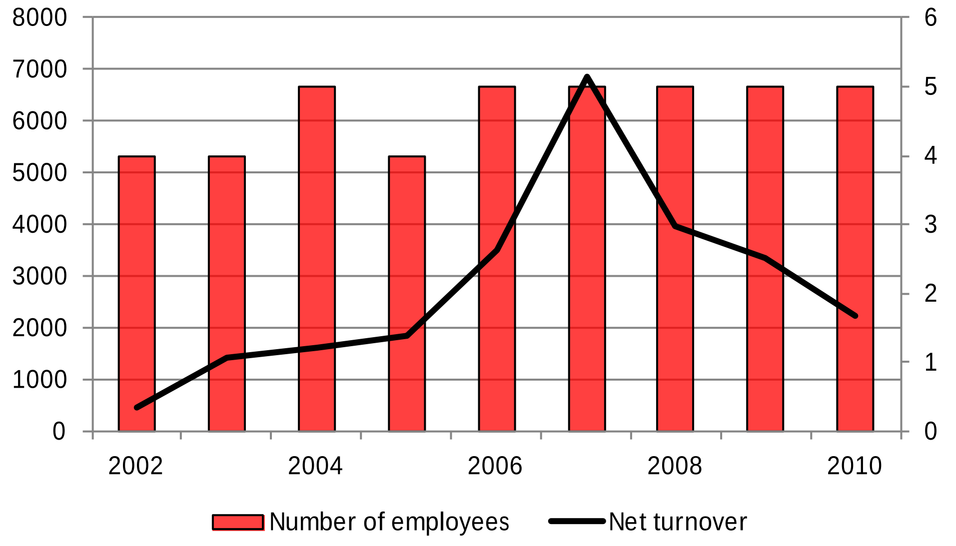
The products in the company have a life cycle for about 7-8 years, before the low-cost competition is catching up.

At STTS they have considered patenting one small part of what they are doing. However, software cannot be patented by STTS, and it is moreover a matter of craft. The company uses open source, which is seen as essential for the possibilities to collaborate. At CTT, that was not fully implemented, which has been perceived as a bit annoying. There were several companies which simply protected their own interests.

There are not very many suppliers in this sector. In the products are built in rules and tests which are both language and client specific. The product represents high value for the customer. Their products are dependent on what is done at STTS.

Figure 47 shows the development in STTS of both the number of employees and the net turnover during the period 2002, through 2010.

Figure 47 Number of employees and Net turnover for STTS during 2002-2010



In Figure 47 we see that the company had a peak in net turnover in 2007. In 2010 it was back to a little over 2 MSEK, after having been up touching almost 7 MSEK in 2007. The number of employees, however, has been fairly constant, between four and five people during the period.

A11.7 The market

The market is international, but both in Sweden and other countries it fluctuates quite heavily. Sometimes competitors suddenly turn up as clients, and sometimes as some kind of subcontractor.

A11.8 Additionality

The participation in CTT has not only affected the company's strategic choices, but it has also made its business possible at all. Customers have come indirectly from CTT. Again, the network is crucial.

The company has developed its absorption capacity, and a better ability to discover and make use of technological possibilities, and to work at the forefront in the business. The basic competence to perform R&D also comes from participation in the CC.

Participation has also led to access to networks, and, sometimes, to some equipment.

A11.9 Spillover

The company itself is a spin-off company, and there are actually six more of them originating from the CC.

There are international conferences which the company attends, many of which are commercial. Some representatives for other companies attend too. There have been no international equivalents to the CC visible to STTS, anyway. The company has been at workshops with, among others, the Language Council, in the area of a language bank. They often meet the same kind of companies that were partners in CTT.

A11.10 CC as focusing device

To a high degree the participation in CTT has been focusing and orienting. That is actually where the company's business idea comes from in the first place.

The CC concept is generally held as very valuable by STTS. In the company they regret that there is no equivalent to CTT at the time of this study.

A12 ABB @ FaxénLaboratoriet (Centre for the Fluid Mechanics of Industrial Processes)

As a CC, the FaxénLaboratoriet had the aim of developing experimental, numerical and theoretical fluid mechanics for use in industrial processes. This was to be achieved through interdisciplinary research, and by joint graduate school programmes that were carried out between different departments at the Royal Institute of Technology (KTH).

The research at the centre concerned applications of Fluid Mechanics in the fields of Electrochemistry, Materials Processing and Paper Technology. For each of the three fields, there was a research programme. "Applications" in this context refers to what is perceived as genuine interdisciplinary projects, rather than slightly modified exercises in academic Fluid Mechanics. Projects were designed in close collaboration with the industrial partners.

A main objective of the centre was also the transfer of results and knowledge to the industrial partners, which was carried out in a number of ways. The approach included:

- direct involvement of partners in the projects as members of guidance and working groups, co-advisors or active researchers at the industrial site
- participation of partner staff in the graduate programme (industrial graduate students)
- providing the partners with methods, models and tools developed by the centre
- recruitment of graduates from the centre by the industrial partners

Successful transfer of results from the centre to the industrial partners took place in projects where closely related activities were carried out by a research group at the centre and the partner's research organisation, and where the graduate student eventually became employed by the partner.

As a large manufacturing company with numerous industrial processes, ABB had several entrances to the centre, and were involved in a number of its projects. There was, for instance, a development of both a methodology and equipment delivered for experimental investigation of mechanical properties of cables subject to movements. Another example concerns analytical methods and numerical tools provided for an engineering analysis of the influence of different parameters on the life-time of a cable. Further, the company worked on a complete modelling approach in design of cables for industrial robots.

The case described in this section will, however, be the company's efforts to develop simulations of the movements of steel melt, to handle the problem of magnetic swirls which caused systematic errors in the calculations.

A12.1 The company's relation to the university

At the time of its participation in the CC, ABB found it too difficult to improve the models of movement in steel melt on its own. The company perceived the problem as more of a research problem. At ABB, they were also keen on strengthening the relation with KTH, and maybe also be able to attract new recruits. There were no established contacts with the research groups in question, only to some extent with the centre director.

The project was carried out by a doctoral student at KTH, who was in fact not an industrial graduate student from the company. The CC model was very rewarding in this case. The supervisor came from the company and was very experienced, and the graduate student also had an industrial background. The dialogue with ABB was very extensive, and concerned also other some matters not directly handled within the project. This context gave shape to the insight that for this to be successful, the graduate student and the supervisor at the university must think strategically. Is it possible to add undergraduate thesis work to this? Is there a way to increase contacts with the company? What else would the company be interested in? These things will not fall out by themselves.

The exchange within the centre, however, was perceived to be limited. From the company perspective the FaxénLaboratoriet seemed a little too fragmented to be able to function as a broad coherent platform. It also seemed divided between academic departments, where some professors had a bit too academic an approach to be really interested in a fruitful dialogue with industry. This seemed to work better on the paper side of the centre, where ABB was never active. For their part the projects were bilateral in practice, with one single company and a group of researchers involved.

A12.2 The company's financial contribution

The total contributions from ABB to the FaxénLaboratoriet can be seen in the table below, divided into the four different stages of the total CC period, and by the cash and in kind contributions respectively. The table shows contributions from all ABB companies involved.

ABB	**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Total**	
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands	500	500	2 050	2 551	1 535	1 280	1 133	450	**5 218**	**4 781**

The total contribution was very close to 10 MSEK, quite evenly distributed. A little more than half of the resources were in cash and a little less than half in kind contributions. Also in this case the comparatively smaller contributions in the beginning would indicate a somewhat slow start, which could have to do with needing to put everything in place in terms of defining projects, installing people to do the work and so on. The smaller contributions in the last stage would also indicate declining activities from the company's side.

A12.3 Organisation of company R&D

The project in this case concerned a very specific problem, involving the graduate student, his supervisor and a few more people – some R&D manager at ABB, and an additional couple of engineers. One calculation engineer in particular put in quite some time on the project.

The problem at hand was very suitable for a collaboration project with the university, because the practical application was clear, but, at the same time, the level of the project a little too distant and related to basic research for the company to motivate an investment internally.

A12.4 Company benefit of CC participation

The calculations are implemented in electromagnets that are used to melt steel. The role of the magnets is to dampen the turbulence in the steel melt, but they can also have some unintended and unwanted side effects, such as the swirl which was the specific problem in this case.

The project eventually turned out quite well. The graduate student managed to develop a turbulence model that was possible to implement in the simulation code used by ABB back then, and to some extent still is at the time of this study.

A12.5 Economic effects from CC participation

Implementation of the model could result in ABB selling more products, especially because the company is able to show to its customers that their personnel is involved in basic research, that the employees are competent and that they are interested in developing the products further. These things give credibility.

Maybe the customers do not care particularly about this or that specific calculation made in some project, but it is important for them that these kinds of projects are executed at all. The project has been promoted in many contexts and displayed to customers. Several years after graduation, at a time when he did not even work for the company, the graduate student was invited to a tour between Japanese steel manufacturers.

It is very difficult, or impossible, to calculate what the innovation has specifically meant for the product, or its sales. The project could probably not have been more successful, it generated several good publications, a very good postdoc period, and a researcher who also became a valued dialogue partner in the area. In addition, ABB succeeded in integrating the solution into the intended product.

To ABB it is important that collaboration projects generate networks and invites to new recruitment. In this case, the graduate student got a large network. He chose, together with the company, to present the research at conferences where the customers might appear, and to publish in those journals that the customers might read.

Through the project, the graduate student also got to show himself closely to the company, which played a part in its subsequent recruitment of him. At the time of this study he is also hired by KTH for 10 per cent of his time, to build networks and to make the company visible.

The electromagnet is a niche product in ABB. It occupies around 100 employees; researchers, administrators and manufacturers. The innovation has probably to some extent helped to increase sales. It has been used in the product since the project ended in 2000, but probably also been somewhat modified during the period.

There are no patents involved in this development. It is impossible to patent mathematical models. There are also other profits in this, since the process uses less energy, and it costs less both to invest in it and to operate it.

A12.6 The market

As indicated above, the market for this product from ABB is completely international, and it is probably only marginally affected by the innovation made in the project.

A12.7 Company strategy towards university

It is sometimes tricky to make competitors sit down and speak to each other. In the metallurgy sector, however, the exchange between actors seems to be unusually good, maybe thanks to Jernkontoret (the Swedish Steel Producers' Association). In the CC, ABB was the only metallurgy company.

The innovation was not likely to have been made without the participation in CC, as it did not actually fit in with ABB and the company would not have invested that kind of money by itself. The added value of the CC was significant, it brought much more attention to interaction and that the academics started to look at problems with industrial relevance. The notion is that if the researchers get to choose the research problems by themselves, they might just as easily turn to unrealistic methods or conditions that are not applicable. They are, however, good for publication in scientific journals.

ABB seems to have developed a taste for this kind of collaboration. The project became something of a symbol or example project and a successful case, which made the company inclined to invest in similar, open projects performed in close collaboration.

The company nowadays has a demand that it should be the owner of the problem definition, and also working actively in the project at hand. It has become more selective when it comes to choice of projects in which to engage, and does not even support all of what is considered good. ABB wants to make at least an implicit, statement that a specific project and/or approach is more crucial than others in the same area, even if almost everything in the area would be potentially interesting. When the company does invest, it demands large influence and to contribute with many working hours. It is not entirely clear what kind of role the project in this case has had, but it seems to have influenced the company's way of thinking in that direction.

A12.8 Additionality

In a very direct sense, the effects on the networks for business and technological development appear to be rather small. The project did not have a subsequent project in the centre. The graduate student himself has been recruited as a consequence of the project. Nobody else has been recruited the same way, but he sees that as more of a coincidence. People from the surrounding department at KTH have been recruited by ABB. No mobility the other way has been detected.

The project definitely helped to strengthen the company brand. It became a good platform for dialogue, the competence and the understanding of the problem in the project increased, but it is hard to say anything about how that might have spread.

There has been no influence from the project over the number of people doing R&D in the company. The money for R&D is not distributed in a way that a good project can increase the number of employees for that particular purpose. There are no visible effects there. It is an unrealistic expectation. The goal for ABB is to spend 2.1 per cent of turnover on R&D, and it has around 130,000 people employed. Where shall it invest to get returns?

A12.9 Spillover

The only spillover visible from the point of view of this project is that the people involved to some extent have increased their tendency to publish their work at conferences and in journals where they expect customers to take note of it.

A12.10 CC as focusing device

The main experience for ABB from this case is on how to design and run projects. This includes how to generate internal activities in the company. The challenge is to create some kind of contextual learning, so it does not end up with just a thesis to read and understand. In such case, the gap to the practical application will be too wide.

If the general ambition is to support research of relevance for industrial development, in close collaboration between academy and industry, the focus should be the active involvement of companies. This would for instance be important when evaluating applications. There are several projects out there, not least in the EU system, where it looks good on paper, but no real, practical collaboration will ever take place. Administrators and evaluators need to become good at seeing through those things.

How large is the industry ownership of problem definition? Have participating companies allocated any resources to work with project management? And so on. With such heavy investments, it is bound to become good. If completely managed by the university, it is more difficult to make an impact in industry.

In the case of this project, focus was also on getting graduate students with an industry background into the centre, as well as supervisors employed by industry. This way a completely different climate for collaboration is created.

A13 AstraZeneca @ SNAP (Centre for Surfactants based on Natural Products)

The competence centre SNAP (Surfactants Based on Natural Products) was active from the end of 1995 until June 2006. It was created due to the vision that the industrial use of natural raw materials will and should increase and that surfactants derived from natural products will become common products, with unique properties compared with petroleum based surfactants.

A total of 13 industrial companies and 6 academic departments have participated in SNAP. The core competence within SNAP included deep knowledge in organic chemistry, physical chemistry, surface chemistry as well as biochemistry. Besides this cross-disciplinary nature of the centre, it was also cross-technological since the industrial partners included raw material producers, surfactant producers and end-users of surfactants.

From the AstraZeneca point of view, SNAP provided a wealth of data on the physico-chemical and biological characteristics of novel surfactants, primarily such based on carbohydrates. The results constitute a foundation on which future developments can be built. In a sense, the work within SNAP can be described as a concept test of novel surfactant technology.

A13.1 The company's relation to the university

The product developers at AstraZeneca had problems with chemical degradation when using the then existing technology. There was an expectation that SNAP could help in developing sugar based surfactants, and gain better understanding of how the surfactants work on the product and how they interact with live cells. They wanted to design an optimal surfactant to develop drugs for inhalation.

The company was very product oriented in this case. Developing networks was hardly an issue at all, and they already felt they had very good links to those involved.

A13.2 The company's financial contribution

The total contributions from AstraZeneca to SNAP can be seen in the table below, divided into the four different stages of the total CC period, and by the cash and in kind contributions respectively.

AstraZeneca	**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Total**	
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands	80	300	265	1 749	880	2 607	600	1 193	**1 825**	**5 849**

The total contribution is close to 7.7 MSEK, most of it in kind. Also in this case, smaller initial contributions might indicate a slow start, and they peaked in the third stage of the CC when nearly half the investment occurred.

A13.3 Organisation of company R&D

A graduate student at SNAP did most of the actual work, with a supervisor from the company, which also had a postdoc working for them. Nobody else from AstraZeneca in Lund was involved, but two people from AstraZeneca, Mölndal were. In Mölndal, they were working with another focus, and should almost be regarded as another company according to the people from Lund.

A13.4 Company benefit of CC participation

The company would not have invested in anything like this project in-house. Maybe there could have been a low-intensity project, but that would probably have failed quickly.

For the company, to run the project in the CC context represented a very large added value. There was a very good assembly of companies active in SNAP; they represented a more or less complete value chain. The pharmaceutical industry is very rigid, partly because of regulatory and toxicological requirements. The input from, for instance, AkzoNobel was very useful. They really knew surfactants, understood what was working and the functioning of the market. It never resulted in any formal co-operation, just a very good dialogue and discussion.

It was a good thing that AstraZeneca was the only pharmaceutical company in the CC, because that resulted in a very open climate with free discussion. There was no internal sector competition, which was probably just a happy circumstance, and happened totally by coincidence. The positive outcomes from the specific projects had probably less to do with the form of the CC, though. The environment was, however, stimulating for the graduate student.

There is also a quite tangible environmental benefit from the project. The result is a green surfactant, benign and water based. The manufacturing process is also more energy efficient.

A13.5 Economic effects from CC participation

The findings and the results from the project have generated a new start-up company, i.e. not anything inside AstraZeneca. The participants managed to understand how it all works and how it interacts with cells, and were able to design a dream molecule. After SNAP, they managed to get funded to develop the finding some more, after they realised that they could not produce the molecule in some already established way. When the person who supervised the graduate student left AstraZeneca, he made AstraZeneca sign over the rights to Intenz Biosciences, where he is one of the owners.

The start-up process was complicated, especially concerning the ownership over Intenz Biosciences. The researchers involved waived from the ordinary intellectual property rights of academic staff. One company was started, which later converted into Intenz Biosciences. AstraZeneca gave them the rights, since it is not interested in manufacturing that kind of product, but definitely to use them and has therefore acquired the rights to use the product in Intenz Biosciences if it succeeds. The university researchers remain involved.

Intenz Biosciences is still developing, and does not make any money yet. It needs to raise another 10-15 MSEK to be able to work on a more long-term basis. The product needs maybe three years to reach the market at the time of this study. The market potential is huge; the product would be used in cosmetics, ice-cream and pharmaceuticals. The focus is on the latter, and then cosmetics and shampoo will follow.

Secondly, participation in SNAP had a large impact on Astra Zeneca. The method that was developed in SNAP to analyse surfactants was possible to apply also in other contexts. AstraZeneca applied it to a key process that was part of a product on which it made money. By introducing the process, AstraZeneca made at least 10 MSEK a year. This learning was also applied to other processes, but the effects from that were not as vivid.

A13.6Additionality

The person at AstraZeneca responsible for the project in SNAP still has contacts with the researchers at the department where he is adjunct. The contact with KTH is sporadic, and the person at AkzoNobel is retired.

It was an open climate and good dialogue already from start in SNAP, partly because of lack of competition from the company's own sector, but also since the participants did not have commercial application immediately in view. In later projects that became more of a problem, which inhibited discussions, but SNAP was more characterised by pre-competitive activities.

The company definitely increased the absorption capacity and the ability to work closely to the forefront of knowledge and competence production in its field. SNAP is considered a very good way of working, which led to great learning. Companies need to have the courage to invest time and money in that kind of programme, which can pay off very well. A lot of knowledge could be implemented in the company, with methods for analysis and a general increase in competence.

Just as network building was never really an issue for AstraZeneca in this project, they also already had the resources in the form of equipment.

A13.7 Spillover

No patents were involved on AstraZeneca's part in SNAP. That became an issue in later projects.

The only evident spillover effect visible from the project is the establishment of the spin-off company Intenz Biosciences, which is working directly with the further development of the results from AstraZeneca's participation in SNAP.

A13.8 CC as focusing device

There is a need to be extremely persevering and focused to be a part of the kind of development made by AstraZeneca in SNAP. The success in this case was also partly thanks to sheer luck, to have the results from SNAP in such a form that it was possible to get funding from another actor in the later project.

There must be some kind of overlap between generations of projects or programmes, with different but overlapping foci. Today, these things seem more unplanned or *ad hoc*. Five years is not a long time for this kind of project. Sometimes new constellations of partners are also needed as the development progresses and new kinds of issues need to be taken care of, as a research problem becomes a development problem becomes a marketing problem or whatever the sequence in different cases.

A14 RUAG Space @ CHACH (Chalmers Centre for High-Speed Technology)

RUAG Space AB in Sweden specialises in reliable on-board satellite equipment including computer systems, antennas and microwave electronics and adapters and separation systems for space launchers. The headquarters and location for design and manufacture of digital electronics, microwave electronics and antennas is in Göteborg. Design and manufacture of launcher adapters, satellite separation systems, satellite structures and sounding rocket guidance systems is performed in Linköping.

A14.1 The company's relation to the university

According to RUAG Space, there are three main reasons to be a part of collaboration with researchers at the university, or in a CC:

6 Enhancing competence. Staff need to develop and to have insight in the research frontier. In the long-term, also recruitment of, for instance, graduate students, even if that was not the most important in relation to CHACH.

7 Minimising risk. The university can take technological risks that the company cannot. A mistake would cost the company a lot of money, but at the university that sort of mistakes is the same as learning, and moving the research frontier. When the stability is acceptable also from a company perspective, RUAG can go in. This could for instance concern testing of circuit designs.

8 New technical solutions, which RUAG, after some modification, can implement in its products.

A14.2 The company's financial contribution

The total contributions from RUAG Space to CHACH can be seen in the table below, divided into the four different stages of the total CC period, and by the cash and in kind contributions respectively. The contributions were made when the company was still Saab Ericsson Space.

RUAG Space	**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Total**	
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands		766		1 180		1 200	1 200	1 175	**1 200**	**4 321**

The total contribution is a little over 5.5 MSEK, also in this case mostly in kind. There are also in this case indications of a slow start, with smaller initial contributions. The largest contributions were made during the last stage, with twice the amount of any other stage. This is explained by the fact that the last 18 months CHACH was run without any government agency involvement.

A14.3 CC problem solving and company development

The problem solving in the CC has been important for most products within the relevant product fields at RUAG. Around half of its products benefit from CHACH, which corresponds roughly to half of the company's turnover.

A14.4 Organisation of company R&D

In total, there were six people in the company who were in contact with Chalmers, one of them in a co-ordinating role. The details were sorted out by the chief engineer, and the work was carried out by the construction section, by 3-4 designers and their boss.

The projects were joint projects, together with Chalmers, where the different organisations carried out various work packages on their home turf, and then met. Often a graduate student at Chalmers was involved, with whom RUAG had relatively close interaction.

Most cases had the form of bilateral projects. In some occasions, other companies were also involved, but that was rare.

A14.5 Company benefit of CC participation

The company makes constructions on semiconductor chips, and wants to know what material combinations and processes suit them best. There is a complete jungle of semiconductor technologies, and Chalmers is both interested in and skilled at orienting it.

The collaboration can also concern whole concept solutions, where it is very expensive to explore all existing variants. RUAG can get the support to make the right choices, using the competence at Chalmers.

Development of personnel is important for RUAG. People have learned to become better engineers as a result of both gathering facts and developing methods. They also probably learned something about who knows what, but much of that was most likely already known.

Building business and technology networks was not a main priority for RUAG in CHACH. This has become more important in later centre activities. Mostly because it has been a requirement, but also after the company learned that it can be rewarding.

There has not been any mobility to or from the company as a consequence of the collaboration in CHACH.

A14.6 Economic effects from CC participation

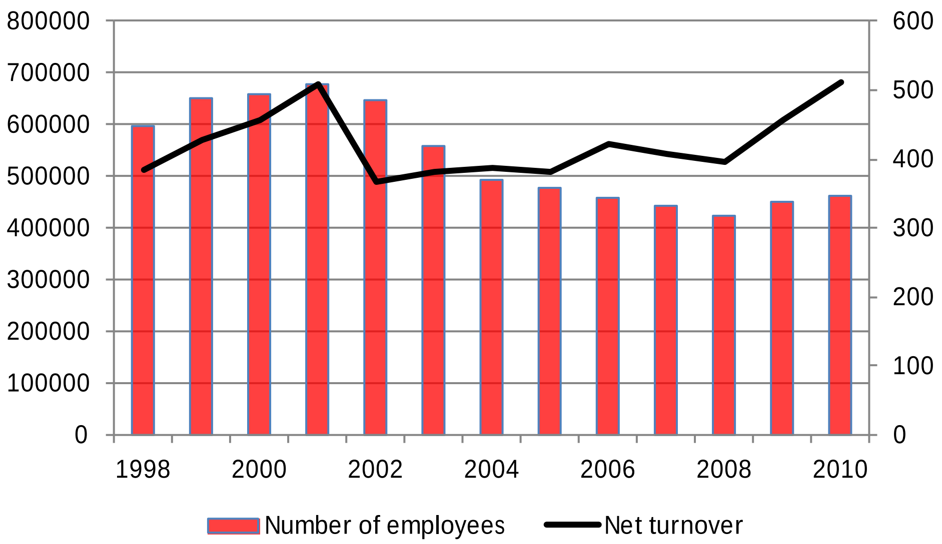
The company is using a microwave mixer which is developed at, and builds on a patent owned by, Chalmers, which RUAG has the right to use. The microwave mixer is a crucial component in the company's products; it is completely dependent on it. It has affected the company's market share significantly, which has grown from 10 per cent to 30-40 per cent of the world market for those products. Indeed, the growth is not entirely due to Chalmers, but the component is a key component and the company would have had a hard time to grow without it.

This 30-40 per cent of the world market is worth around 130 MSEK a year. The increase in company turnover follows to a large extent from the company's participation in the CC.

The company's products are used in communication satellites. These have been easier, safer and cheaper to launch, partly thanks to the company's products. It is, however, difficult to estimate how much better and cheaper.

In Figure 48 the development of the number of employees and the net turnover is shown for RUAG Space during the period 1998, through 2010 (before 2007, the company was Saab Ericsson Space).

Figure 48 Number of employees and Net turnoverfor RUAG Space during 1998-2010. Before 2007, the company was Saab Ericsson Space



The figure shows that the company's net turnover has been relatively stable during the period, varying between around 500 MSEK and 700 MSEK, with a small but steady increase during recent years. At the same time, the number of employees has decreased from a level around 500 people to a level around 350 people.

A14.7The market

The company's market is entirely international, and the customers exclusively outside Sweden.

A14.8 Company strategy towards university

There are also other forms for collaboration between the company and Chalmers, for instance through the Swedish National Space Technology Research Programme and in a programme subsequent to CHACH called the GHz centre. The former is complementary to CHACH and the latter builds on CHACH, but for RUAG it concerns other technologies.

There are also collaborations with other universities, but that is mostly done by other groups in the company.

A14.9 Additionality

The collaboration in CHACH has led to prioritisation of the product area, since the product has done so well. There are no other parts of the company group that have the same products, so that kind of competition is not an issue. Strengthening this product area would instead probably lead to financial effects when it comes to distribution of resources within the company group.

This is an important aspect for the company, as a part of an international company group. Since success breeds success, the group management will be more inclined to invest in units that have succeeded before.

The company is very open and tells about its collaborations in several different contexts. That kind of openness has not changed. The space sector is inherently open. The customers are interested in all details of the solutions, since there is no second chance of doing that. The companies in the sector let them see it, but not read about it.

Participation in CHACH has definitely developed the competence in the company. The internal processes have been somewhat affected, too. The company has been able to align the efforts to make sure they work in the production. There is less focus on early research.

A14.10 Spillover

None of the spin-off companies from CHACH has been started in close proximity to the projects RUAG were involved in. No intellectual rights have been used for technology transfer; they have rather built up some product unit.

The participation in CHACH *per se* has probably not strengthened the company brand. However, the good results have, since the products have become better. Once, the company even brought a professor to convince a customer.

A14.11 CC as focusing device

From the company’s perspective the activities in the CC has clearly helped to focus and orient so the company has placed both attention and resources on areas where needs have been identified. The graduate education has been improved at Chalmers, and the quality of the undergraduate education has increased. The company however observes that the students have rarely noticed that, which it finds regrettable.

RUAG plays some part in the education, by giving a guest lecture every year, by participating in student career and recruitment days, and so on.

A15 Södra Cell @ WURC (Wood Ultrastructural Research Centre)

Södra Cell is the world's third largest market pulp supplier, with a total annual production of more than two million tonnes. The company’s raw material comes mainly from the forests of Södra's members, where spruce and pine dominate. Consequently, 90 per cent of the production consists of softwood pulp. Besides that hardwood pulp from birch and eucalyptus is produced. The birch wood comes from the members' forests as well as from import, while the eucalyptus is all imported.

WURC´s focus has primarily been on pre-competitive fundamental research. Therefore the success of WURC cannot be measured in terms of new products but rather the advances in useful understanding of fibre ultrastructure that has been generated. WURC can be regarded as a focused effort on fibre ultrastructure research with strong industry involvement.

A15.1 The company’s relation to the university

Fibre is the absolute core competence for Södra. The company has to be in the forefront in that area. It is unthinkable for it not to take part in a Swedish centre with the approach of WURC’s. The motive for participation was to a large extent to be able to develop already existing products. The centre has given great insight into what different processes actually does to the fibre, and how the fibre is not getting destroyed. Recruitment of personnel was not a motive in itself for participation, but the opportunity to build networks with university researchers certainly was.

WURC was a completely new kind of effort. There was nothing like it before, where the companies in the sector were gathered this way around basic knowledge production. From the Södra point of view, this was a very good way of competence building in the Swedish sector.

The company was interested in general knowledge about fibre, and did not bring any specific research problem. WURC was about rather basic research. This particular partner is not entirely clear on why WURC came to have that approach, but suspects that it had to do with many of the partner companies being competitors.

A15.2 The company’s financial contribution

The total contributions from Södra Cell to WURC is shown in the table below, divided into the four different stages of the total CC period, and by the cash and in kind contributions respectively.

Södra Cell	**Stage 1**		**Stage 2**		**Stage 3**		**Stage 4**		**Total**	
Contributions	Cash	In kind	Cash	In kind	Cash	In kind	Cash	In kind	**Cash**	**In kind**
SEK, thousands	475	54,4	970	570		241	361	183	**1 806**	**1 048**

The total in kind contribution is a little over 1 MSEK. This is surpassed by the cash contribution, even though we do not exactly know how large it is since it has proved to be impossible to obtain the number for the third stage. Already the sum of contributions from the other stages is, however, larger.

A15.3 Organisation of company R&D

The company participation in WURC involved two people at the time: the R&D manager was in the programme board, while a researcher was deeply involved in the WURC activities for quite a large proportion of his or her time. The company was able to bring home many of the results from WURC and refine them in relation to the own company's processes.

The knowledge the company attained in the CC also made it possible for the company to better help its customers. Laboratory personnel were also involved, and even more people in the company attended seminars and so on.

The projects mostly involved all the participants in the centre, since the activities concerned research so basic that it was genuinely pre-competitive. For instance, Södra came to work very close to its competitor SCA in the centre.

A15.4 Company benefit of CC participation

The added value in the format of the CC was that the basic projects could use competence from several different sources, which provides diversity.

It is also of great importance that industry is actively involved. That gives much more benefit to the companies, compared with when they only read the reports. The projects become more applied than when the researchers decide for themselves. They do not really know what is relevant in industry. Furthermore, industry is forced to take part in a more concrete way. Everybody in industry is very busy, but if they get to work actively it means that they really are thinking it through and learn deeply. That is, compared with if they are sitting in reference groups and just put in the money.

Where product development and innovation are concerned, it is not possible to sit so many competing companies around the same table. The work must be more divided between actors who hold different places in the value chain than was the case in WURC.

Without WURC, the company would not have been able to immerse itself in the knowledge, nor would it have had access to the analysis equipment at the university laboratories. That would have constituted a lot of extra work, and not as much money and efforts could have been put into it. The company would thus not have come as far.

There were no patents involved from Södra's side. The company did not apply for patents at all at that time. That goes for the whole sector. WURC gave more basic knowledge, which helped the company make better choices in earlier stages. On the basis of WURC it has, for instance, been able to choose the right equipment in new investment, so that expensive apparatus of a certain kind could be avoided.

A15.5 Economic effects from CC participation

The centre led to great insight into how pressure, temperature, alkali content and mechanical impact affect fibre, and into the improvement of processing conditions to minimise fibre destruction. Some characterisation methods later used in the company's laboratory were also developed.

The company's processes have been improved from this insight. This also connects to some improvement of the products that have been made. There has, however, not been any development of new products, and hence no innovation in that sense.

All pulp products have been improved as a result of participation in the CC: that has been a clear effect. Södra also gives courses in fibre knowledge to its customers. A lot of that also started in WURC.

The company is mainly competing with other companies not manufacturing their own paper, and most of them are found abroad. The worst competitors were thus not a part of WURC.

It is very difficult to see if any market share was gained. Södra is considered to be a company which makes a good pulp with high-quality parameters, but the price means a lot in the business. It is therefore hard to see if quality affects market share. And the insight from WURC did not affect the price of the company's products.

However, a leaner production of paper is also a public good, optimising the use of the fibre, and using less material.

A15.6 The market

The company sells pulp for papermaking in the European and Asian markets. The Swedish share of the company's market is around 40 per cent.

A15.7 Additionality

The participation in WURC has clearly changed the way the company collaborates. It has tried to apply the WURC approach in all collaborations thereafter, i.e. active involvement.

The forestry industry has always had tightly knitted networks. No new networks in the business sector have emerged through WURC, but new contacts with the research community have been created. The company is working a lot with researchers in Sweden, also outside the CC. The creation of other relationships is not linked to WURC, even if the company still works with some researchers from there.

The company has recruited more people to do R&D, but that is a strategic choice unconnected with WURC, and has not involved anyone from WURC.

Access to the right equipment is crucial to be able to participate in centres and to have other collaborations with researchers. The company is not able to buy electron microscopes and such, and were not able to use any other company's equipment since they too do not have such advanced equipment.

The company participation in the CC, together with the researcher network, strengthens the company brand in customers' eyes.

A15.8 Spillover

There are no known examples where intellectual property has been created, with a role in technology transfer.

Suppliers of equipment for pulp mills might also have benefited from participation in WURC, and Södra has now taken the initiative to collaborate with other companies in procurement to make demands on the suppliers.

A15.9 CC as focusing device

The CC activities have certainly helped to focus and draw attention and resources to areas where needs have been identified. WURC also taught the university what was pertinent to industry, which may have helped the researchers to discard irrelevancies.

When it comes to the design and execution of projects, the company believes that WURC was probably also helpful for several researchers. The wide problem areas and the complexity might have made the start a bit slow, but it was very instructive for the university. University researchers often like to work within their own group, raise funds for the group and keep the money there. To get good leverage on the funding, larger constellations of groups with participants from several different sectors and universities are often needed.

Appendix B Abbreviations

ASTEC	Advanced Software Technology
BRIIE	The Brinell Centre Inorganic Interfacial Engineering
CAP	Centre for Amphiphilic Polymers from Renewable Resources
CBioPT	Swedish Centre for Bioprocess Technology
CBioSep	Swedish Centre for BioSeparation
CCCD	Competence Center for Circuit Design
CERC	Combustion Engine Research Centre
CHACH	Chalmers Center for High-Speed Technology
Charmec	Chalmers Railway Mechanics
CID	Centre for user-oriented IT Design
CPM	Competence Centre for Environmental Assessment of Product and Material Systems
CTT	Center for Speech Technology
EKC	Competence Centre in Electric Power Engineering
FaxénLab	Faxén Laboratory, Centre for Fluid Mechanics of Industrial Processes
HTC	Competence Centre in High Temperature Corrosion
ISIS	Information Systems for Industrial Control and Supervision
KCFP	Competence Centre for Combustion Processes
KCK	Competence Centre for Catalysis
MiMeR	Minerals and Metals Recycling Research Centre
NIMED	Non-Invasive Medical Measurements
PolhemLab	The Polhem Laboratory, Competence Centre in Integrated Product Development
PSCI	Parallel and Scientific Computing Institute
KI Rad. Ther.	Karolinska Institute Research Centre for Radiation Therapy
SNAP	Centre for Surfactants based on Natural Products
S-Sense	Centre for bio- and chemical sensor science and technology. The Swedish Sensor Centre
SUMMIT	Surface & Microstructure Technology
VoxénCentrum	WoxénCentrum, Competence Centre for Lean and Agile Production/ Competence Centre for Customer-Driven High Performance Production Systems
WURC	Wood Ultrastructure Research Centre

Appendix C Our sources

Ailes, C.P, I. Feller & H.R. Coward, (2001), The Impact of Engineering Research Centers in Institutional and Cultural Change in Participating Universities, Science and Technology Program, Arlington, VA: NSF.

Allen Consulting, (2005), The Economic Impact of Cooperative Research Centres in Australia: Delivering Benefits for Australia, Melbourne: Allen Consulting.

Allen Consulting Group, (2012), The Economic, Social and Environmental Impacts of the Cooperative Research Centres Programme, Melbourne: Allen Consulting Group.

Anthony, R N, (1951), Selected Operating Data: Industrial Research Laboratories, Harvard Business School, Division of Research; cited from Benoît Godin, 'Research and development: how the "D" got into R&D', Science and public Policy, 33 (1), 2006, 59-76.

Arnold, E & K. Guy, (1986), Parallel Convergence: National Strategies in Information Technology, London: Frances Pinter.

Arnold, E, J. Clark and S. Bussillet, (2004) Impacts of the Swedish Competence Centres Programme, 1995-2003, VA 2004:3, Stockholm: VINNOVA.

Arnold, E, N. Busch, J. Deuten, G. Fayl & K. Guy, (2006), Pilot Monitoring of Centres in the Pázmán Péter and Asbóth Oszkár Programmes, Report to NKTH, Brighton: Technopolis.

Arnold, E, K. Männick, R. Rannala & A. Reid, (2008), Mid-term Evaluation of the Competence Centre Programme, Report to the Estonian Ministry of Economics, Brighton: Technopolis.

Arnold, E, M. Carlberg, Z. Jávorka, F. Giarraccia & S. Sidiqui, (2011), A 'Reset' for Norwegian Industrial Development? What can we learn from fast developers?, Oslo: Tekna.

Arrow, K, (1962), 'Economic Welfare and the Allocation of Resources for Invention,' in Richard Nelson (Ed.): The Rate and Direction of Inventive Activity, Princeton University Press.

Baras, J & P. Stenius, (2004), 'Third evaluation of competence centres: overall impressions and programme-wide issues,' note to VINNOVA and the Swedish Energy Agency.

Bozeman, B & J. Rogers, (2002), 'A churn model of scientific knowledge: Internet researchers as a knowledge value collective,' Research Policy, Vol 31, pp 769 – 794.

Charmec, (2009), Charmec, Triennial report 2006–2009.

Edler, J, S. Huuhrer, V. Lo, C. Rainfurth & S. Kuhlmann, (2004), Assessment, 'Zukunft der Kompetenzzentrenprogramme (K plus und K ind/net und Zukunft der Kompetenzzentren', Fraunhofer-ISI and KMU Forschung.

Ekberg, A & B. Paulsson, (2010), Concluding Technical Report: INNOTRACK. International Union of Railways.

Ekberg, A, (2011), Forskningsprocessen – hur man får en effektiv järnvägsforskning. Memo, Charmec, Chalmers University of Technology.

Elforsk, (2006). Elanvändningen i Norden om 10 år.

Feller, I, C.P. Ailes & J.D. Roessner, (2002), Impact of research universities on technological innovation in industry: evidence from engineering research centers, Research Policy, 31, 457-474.

Harman, K, (2004), Producing 'industry-ready' doctorates: Australian Cooperative Research Centre approaches to doctoral education, Studies in Continuing Education, 26 (3).

Hjorth, S, (1998), The Nutek Competence Centre Programme: An effort to build bridges between science and industry in Sweden, (mimeo) Stockholm: Nutek.

Hjorth, S, (2000), The Nutek Competence Centre Programme: An effort to build bridges between science and industry in Sweden, Stockholm: Nutek.

Hjorth, S, (2002). The Swedish Competence Centres Programme. Country Report Sweden. The STRATA Thematic Network "MAP-TN". 5th MAP meeting, Bilbao, Spain

Howard Partners, (2003), Evaluation of the Cooperative Research Centres Programme, Barton, ACT: Howard Partners.

Insight Economics, (2006), Economic Impact Study of the CRC Programme, Melbourne: Insight Economics.

Ministry of Economic Affairs, (1996), 'Op weg naar Technologische topinstituten', The Hague, Netherlands.

Nelson, R, (1959), 'The simple economics of basic scientific research,' Journal of Political Economy, vol 67, pp 297-306.

Nutek, (1993), Inbjudan till forskare och forskargrupper vid universitet och högskolor, industriforskningsinstitut och svensk industri: Industri- och energirelevanta kompetenscentra i anslutning till universitet och högskolor, Stockholm: Nutek.

OECD, (2004), Public-Private Partnerships for Research and Innovation: An Evaluation of the Austrian Experience, Paris.

Parker, L, (1997), The Engineering Research Centres Programme: An Assessment of Benefits and Outcomes, Arlington, Va, NSF.

Productivity Commission, (2007), Public Support for Science and Innovation: Research Report; cited from Allen Consulting 2012.

Rank, D, (2002), Evaluation of the Networks of Centres of Excellence, Ottawa: Industry Canada.

Rogers, J D & B. Bozeman, (2001), ‘Knowledge Value Alliances: An alternative to the R&D project focus in evaluation’, Science, Technology and Human Values, 26(1), 23-55.

Rosenberg, N, (1990), ‘Why do firms do basic research (with their own money)?’ Research Policy, 19 (2), 165-174.

Statistics Sweden (SCB), (2010), Structural Business Statistics.

Stenberg, L, (1997), Learning and policy development at STU/Nutek: Competence centres as an example, Department of Policy Studies, Stockholm: Nutek.

Swedish National Agency for Higher Education (2010). Doktorsexaminerades etablering på arbetsmarknaden. Rapport 2010:21 R.

van der Veen, G, E. Arnold, P. Boekholt, J. Deuten, J. v Giessel, M. d Heide and W. Vullings, (2005), Evaluation Leading Technology Institutes, report to the Ministry of Economic Affairs, Amsterdam: Technopolis.

Williams, JE jr & C.S. Lewis, (2010), Post-Graduation Status of National Science Foundation Engineering Research Centres: Report of a Survey of Graduated ERCs,, Grand Rapids, MI: SciTech Communications LLC.

Appendix D General data description SME analysis

Figure 49 Number of active enterprise, by class size

Year	Large (250 employees or more)	Small and Medium (between 10 and 249 employees)	Micro (less than 10 employees)	Not classified	Total
1998	135	35	19	7	**196**
1999	136	40	20	7	**203**
2000	137	51	20	7	**215**
2001	144	53	23	8	**228**
2002	148	56	27	5	**236**
2003	148	57	29	5	**239**
2004	147	60	30	1	**238**
2005	140	65	26	1	**232**
2006	141	67	22	2	**232**
2007	134	64	25	1	**224**
2008	123	62	26	1	**212**
2009	122	63	24	3	**212**
2010	122	64	22	4	**212**

Source: Performance data (Bokslut Data), 1998-2001

Figure 50 Distribution of active enterprise, by class size

Year	Large (250 employees or more)	Small and Medium (between 10 and 249 employees)	Micro (less than 10 employees)	Total
1998	71%	19%	10%	**100%**
1999	69%	20%	10%	**100%**
2000	66%	25%	10%	**100%**
2001	65%	24%	10%	**100%**
2002	64%	24%	12%	**100%**
2003	63%	24%	12%	**100%**
2004	62%	25%	13%	**100%**
2005	61%	28%	11%	**100%**
2006	61%	29%	10%	**100%**
2007	60%	29%	11%	**100%**
2008	58%	29%	12%	**100%**
2009	58%	30%	11%	**100%**
2010	59%	31%	11%	**100%**

Table 11 Total resources per CC and stage (MSEK)

CC	Stage 1 Cash	In kind	Stage 2 Cash	In kind	Stage 3 Cash	In kind	Stage 4 Cash	In kind	All stages Cash	In kind	All stages Total
CHACH	8.2	12.8	21.5	56.5	22.3	56.6	20.8	29.0	72.7	154.8	**227.4**
WoxénC	11.1	18.9	29.2	44.0	16.5	47.5	21.0	24.3	77.7	134.6	**212.3**
PSCI	10.1	6.7	35.4	34.8	38.8	34.9	26.5	24.2	110.7	100.6	**211.4**
Charmec	11.7	9.4	34.6	25.0	41.0	26.8	36.1	24.2	123.3	85.5	**208.7**
CID	7.5	6.2	29.7	29.5	43.7	30.7	32.1	24.0	112.9	90.4	**203.2**
ISIS	8.0	23.5	23.6	45.7	20.6	18.5	15.4	44.0	67.6	131.5	**199.2**
PolhemLab	11.8	15.0	30.5	24.5	36.3	25.1	23.8	16.6	102.4	81.4	**183.8**
CERC	15.9	3.8	32.2	31.0	31.2	27.5	22.2	19.5	101.4	81.8	**183.3**
SUMMIT	7.9	12.5	18.3	47.0	18.3	36.9	12.0	24.8	56.5	121.2	**177.7**
CBioSep	7.4	10.9	19.8	32.8	22.5	37.1	15.2	31.9	64.9	112.6	**177.6**
KCK	7.6	10.4	21.1	34.4	24.8	35.7	16.3	23.8	69.6	104.3	**174.0**
CBioPT	12.2	7.8	27.3	29.5	21.0	34.3	14.5	24.7	74.8	96.3	**171.2**
KCFP	9.3	10.1	27.2	26.1	34.2	26.1	20.5	15.9	91.2	78.2	**169.4**
S-Sence	10.6	9.7	26.0	26.8	33.9	24.4	18.9	18.2	89.3	79.1	**168.4**
CCCD	13.7	10.3	30.6	19.9	26.1	28.6	17.0	18.2	87.4	77.0	**164.4**
SNAP	11.0	9.6	19.2	20.7	25.3	37.8	16.9	21.8	72.3	89.9	**162.3**
CTT	8.6	5.0	22.4	32.2	19.5	35.7	13.1	24.3	63.7	97.3	**160.8**
WURC	9.8	8.0	25.1	22.6	29.7	29.8	19.8	16.0	84.4	76.4	**160.8**
CAP	10.7	12.0	23.4	19.9	24.9	26.7	17.2	24.3	76.3	82.8	**159.1**
EKC	8.3	9.0	27.1	22.6	26.6	27.3	18.4	19.7	80.4	78.5	**158.9**
MiMer	12.4	7.6	26.5	17.1	37.7	16.3	27.1	12.5	103.6	53.5	**157.0**
NIMED	10.0	6.2	30.7	20.6	34.2	19.0	21.2	14.8	96.1	60.6	**156.7**
FaxénLab	12.0	6.0	38.5	16.2	37.7	18.5	18.9	8.4	107.3	48.9	**156.2**
ASTEC	5.7	12.1	20.3	23.0	19.0	32.8	16.3	26.7	61.3	94.6	**155.9**
CPM	8.5	17.8	23.8	22.9	25.5	21.7	17.3	17.4	75.0	79.8	**154.9**
BRIIE	10.3	8.2	25.6	27.2	24.9	24.3	16.1	17.7	76.9	77.5	**154.3**
HTC	5.2	8.5	25.9	20.5	30.6	27.7	18.4	15.0	80.1	71.8	**151.9**
KI Rad. Ther.	6.3	10.7	15.1	27.3	19.1	32.8	12.3	28.4	52.8	99.1	**151.9**
All 28 CCs	**271.6**	**288.8**	**730.4**	**800.1**	**785.6**	**841.0**	**545.3**	**610.2**	**2332.7**	**2540.0**	**4872.6**

Note: The available data on industry contributions to EKC for stage two were not separated on cash and in kind. As an approximation, the industry contributions to EKC stage two have here been listed as 50% cash and 50 % in kind.

Table 12 Resources from industry per CC and stage (MSEK)

CC	Stage 1 Cash	In kind	Stage 2 Cash	In kind	Stage 3 Cash	In kind	Stage 4 Cash	In kind	All stages Cash	In kind	All stages Total
WoxénC	2.3	14.5	3.7	29.3	0.7	30.2	0.5	12.8	7.1	86.7	**93.8**
PSCI	2.9	4.2	10.6	21.6	11.3	20.5	8.5	14.1	33.2	60.4	**93.6**
ISIS	2.0	17.8	3.6	28.3	1.6	14.1	1.4	24.3	8.6	84.5	**93.2**
Charmec [77]	5.8	4.0	15.9	8.5	20.7	8.6	18.8	6.2	61.2	27.4	**88.6**
CCCD	5.7	4.2	12.6	7.7	8.1	16.6	5.0	9.8	31.4	38.3	**69.7**
CHACH	0.5	7.0	1.8	17.2	2.0	24.2	2.9	12.8	7.2	61.3	**68.4**
CPM	1.7	11.1	4.2	16.4	4.5	15.7	1.6	10.7	12.0	53.9	**66.0**
PolhemLab	2.3	6.3	6.2	12.8	8.3	14.1	5.9	9.2	22.7	42.4	**65.1**
SUMMIT	0.4	7.2	0.3	22.9	0.3	18.0	0.0	12.3	1.0	60.4	**61.4**
EKC	2.3	4.8	9.1	9.1	8.6	12.3	5.0	9.7	25.0	35.8	**60.7**
KCFP	3.3	3.3	9.2	8.4	16.2	7.5	8.5	3.5	37.2	22.7	**59.9**
S-Sence	3.5	4.8	6.3	13.6	7.3	11.6	4.4	7.8	21.5	37.8	**59.3**
CID	1.4	3.7	2.2	14.3	3.6	17.7	1.9	14.3	9.1	50.0	**59.0**
CBioPT	3.3	5.0	4.5	13.1	2.1	16.6	1.7	10.8	11.5	45.5	**57.0**
CERC	6.8	0.9	11.9	7.4	10.9	6.8	6.8	5.3	36.4	20.4	**56.8**
SNAP	2.3	6.9	3.7	10.8	5.2	14.3	4.1	9.2	15.2	41.2	**56.4**
ASTEC	0	6.3	5.1	11.5	2.1	14.0	2.2	14.1	9.4	45.9	**55.3**
CTT	3.1	1.5	2.4	15.6	0.7	18.4	0.6	12.8	6.9	48.4	**55.2**
CAP	4.7	3.3	7.8	7.0	6.9	11.2	5.2	8.8	24.7	30.3	**55.0**
BRIIE	3.3	4.8	6.7	9.2	6.1	11.9	3.6	9.3	19.7	35.2	**54.9**
NIMED	3.3	2.7	8.2	10.0	7.8	10.2	3.4	8.8	22.7	31.7	**54.4**
MiMer	2.4	4.2	4.1	10.5	4.9	13.7	3.8	10.8	15.2	39.2	**54.3**
CBioSep	1.6	4.4	3.6	13.1	4.5	14.6	3.2	9.3	12.9	41.3	**54.3**
KCK	1.6	4.4	3.4	11.7	4.5	14.4	2.8	10.8	12.2	41.3	**53.5**
KI Rad. Ther.	0	5.5	0.9	14.8	1.1	16.9	0.3	13.3	2.3	50.5	**52.8**
FaxénLab	2.1	3.9	7.4	10.9	9.2	10.1	4.2	4.8	23.0	29.6	**52.6**

[77] Charmec data includes 31.3 MSEK in contributions from Swedish Rail Administration, of which 26.0 MSEK was contributed in cash and 5.3MSEK in kind.

CC	Stage 1 Cash	In kind	Stage 2 Cash	In kind	Stage 3 Cash	In kind	Stage 4 Cash	In kind	All stages Cash	In kind	All stages Total
HTC	2.1	4.7	8.3	7.6	9.3	9.1	4.6	6.0	24.3	27.5	**51.8**
WURC	4.6	1.2	9.7	5.7	11.7	6.6	7.8	4.4	33.8	17.9	**51.7**
All 28 CCs	**75.2**	**152.8**	**173.3**	**368.9**	**180.0**	**400.1**	**118.7**	**285.9**	**547.2**	**1207.7**	**1754.6**

Note: The available data on industry contributions to EKC for stage two were not separated on cash and in kind. As an approximation, the industry contributions to EKC stage two have here been listed as 50% cash and 50 % in kind.

Table 13 Resources from host universities per CC and stage (MSEK), based on reports from the CCs to the funding agencies

CC	Stage 1 Cash	In kind	Stage 2 Cash	In kind	Stage 3 Cash	In kind	Stage 4 Cash	In kind	All stages Cash	In kind	All stages Total
CHACH	0.9	5.8	2.3	39.3	2.3	32.4	5.6	16.2	11.0	93.5	**104.5**
CBioSep	0.0	6.5	0.0	19.7	0.0	22.5	0.0	22.6	0.0	71.3	**71.3**
CERC	3.1	2.9	2.3	23.6	2.3	20.7	1.5	13.5	9.1	60.7	**69.8**
KCK	0.0	6.0	2.5	22.7	2.3	21.3	1.5	13.0	6.2	63.0	**69.3**
Charmec	0.0	5.4	2.3	16.5	2.3	18.2	4.7	18.0	9.2	58.1	**67.2**
PolhemLab	2.7	8.7	6.3	11.7	10.0	11.0	5.9	7.4	24.9	39.0	**63.9**
SUMMIT	1.5	5.3	0.0	24.1	0.0	18.9	0.0	12.5	1.5	60.8	**62.3**
CBioPT	2.9	2.8	4.8	16.4	0.8	17.7	0.8	13.9	9.2	50.8	**60.1**
WoxénC	2.0	4.4	3.3	14.7	3.2	17.3	2.4	11.5	10.9	47.9	**58.8**
WURC	0.0	6.8	0.0	16.9	0.0	23.2	0.0	11.6	0.0	58.5	**58.5**
SNAP	2.7	2.7	2.0	9.9	2.1	23.5	0.8	12.6	7.6	48.7	**56.4**
KCFP	0.0	6.8	0.0	17.7	0.0	18.6	0.0	12.4	0.0	55.5	**55.5**
CID	1.0	2.5	3.5	15.2	3.9	13.0	5.1	9.7	13.4	40.4	**53.8**
CTT	1.0	3.5	2.0	16.6	0.8	17.3	0.5	11.5	4.3	48.9	**53.1**
CAP	0.0	8.7	0.5	12.9	0.0	15.5	0.0	15.5	0.5	52.5	**53.0**
HTC	0.0	3.8	1.9	12.9	3.2	18.6	3.3	9.0	8.4	44.3	**52.7**
MiMer	4.0	3.4	8.0	6.6	14.9	2.6	11.3	1.7	38.2	14.3	**52.5**
ISIS	0.0	5.7	2.0	17.4	1.0	4.4	2.0	19.7	5.0	47.0	**52.0**
ASTEC	0.0	5.8	0.0	11.5	0.0	18.8	0.0	12.6	0.0	48.7	**48.7**
FaxénLab	3.9	2.1	12.9	5.3	7.9	8.4	4.5	3.6	29.3	19.3	**48.6**
KI Rad. Ther.	0.0	5.2	0.0	12.5	0.0	15.9	0.0	15.1	0.0	48.6	**48.6**
NIMED	0.7	3.5	4.5	10.6	8.4	8.8	5.8	6.0	19.4	28.9	**48.3**

CC	Stage 1 Cash	In kind	Stage 2 Cash	In kind	Stage 3 Cash	In kind	Stage 4 Cash	In kind	All stages Cash	In kind	All stages Total
PSCI	1.5	2.5	1.7	13.2	2.2	14.4	1.5	10.1	6.9	40.2	**47.2**
BRIIE	1.0	3.4	1.5	18.0	0.8	12.4	0.5	8.4	3.8	42.3	**46.0**
S-Sence	0.3	4.9	1.7	13.2	0.1	12.8	1.0	10.4	3.0	41.3	**44.3**
EKC	0.0	4.2	0.0	13.5	0.0	15.0	1.3	10.0	1.3	42.7	**44.1**
CCCD	0.0	6.1	0.0	12.2	0.0	12.0	0.0	8.4	0.0	38.7	**38.7**
CPM	0.8	6.7	3.6	6.5	2.3	6.0	1.5	6.7	8.1	25.9	**34.0**
All 28 CCs	**29.8**	**136.2**	**69.4**	**431.1**	**70.5**	**441.1**	**61.5**	**323.5**	**231.3**	**1331.8**	**1563.1**

Table 14 Resources from Nutek, VINNOVA and Swedish Energy Agency, per CC and stage (MSEK)

CC	Stage 1 Cash	In kind	Stage 2 Cash	In kind	Stage 3 Cash	In kind	Stage 4 Cash	In kind	All stages Cash	In kind	All stages Total
PSCI	5.5	0	18.0	0	19.5	0	13.1	0	56.1	0	**56.1**
CCCD	8.0	0	18.0	0	18.0	0	12.0	0	56.0	0	**56.0**
PolhemLab	6.8	0	18.0	0	18.0	0	12.0	0	54.8	0	**54.8**
S-Sence	6.8	0	18.0	0	18.0	0	12.0	0	54.8	0	**54.8**
CHACH	6.8	0	17.4	0	18.0	0	12.3	0	54.5	0	**54.5**
WoxénC	6.3	0	18.0	0	12.0	0	18.0	0	54.3	0	**54.3**
CBioPT	6.0	0	18.0	0	18.1	0	12.0	0	54.1	0	**54.1**
EKC	6.0	0	18.0	0	18.0	0	12.1	0	54.1	0	**54.1**
CERC	6.0	0	18.0	0	18.0	0	12.0	0	54.0	0	**54.0**
ISIS	6.0	0	18.0	0	18.0	0	12.0	0	54.0	0	**54.0**
KCFP	6.0	0	18.0	0	18.0	0	12.0	0	54.0	0	**54.0**
NIMED	6.0	0	18.0	0	18.0	0	12.0	0	54.0	0	**54.0**
SUMMIT	6.0	0	18.0	0	18.0	0	12.0	0	54.0	0	**54.0**
BRIIE	6.0	0	17.4	0	18.0	0	12.0	0	53.4	0	**53.4**
Charmec	5.9	0	16.4	0	18.0	0	12.6	0	52.9	0	**52.9**
CTT	4.5	0	18.0	0	18.0	0	12.0	0	52.5	0	**52.5**
CID	5.1	0	17.0	0	18.0	0	12.0	0	52.1	0	**52.1**
CBioSep	5.8	0	16.2	0	18.0	0	12.0	0	52.0	0	**52.0**
ASTEC	5.7	0	15.2	0	16.9	0	14.1	0	51.9	0	**51.9**

CC	Stage 1 Cash	In kind	Stage 2 Cash	In kind	Stage 3 Cash	In kind	Stage 4 Cash	In kind	All stages Cash	In kind	All stages Total
CPM	6.0	0	16.0	0	17.8	0	12.0	0	51.8	0	**51.8**
KCK	6.0	0	15.2	0	18.0	0	12.0	0	51.2	0	**51.2**
FaxénLab	6.0	0	18.2	0	18.0	0	9.0	0	51.2	0	**51.2**
CAP	6.0	0	15.1	0	18.0	0	12.0	0	51.1	0	**51.1**
WURC	5.2	0	15.4	0	18.0	0	12.0	0	50.6	0	**50.6**
KI Rad. Ther.	6.3	0	14.2	0	18.0	0	12.0	0	50.5	0	**50.5**
MiMer	6.0	0	14.4	0	17.9	0	12.0	0	50.2	0	**50.2**
SNAP	6.0	0	13.5	0	18.0	0	12.0	0	49.5	0	**49.5**
HTC	3.1	0	15.7	0	18.1	0	10.5	0	47.4	0	**47.4**
All 28 CCs	**165.8**	**0**	**471.2**	**0**	**498.3**	**0**	**341.7**	**0**	**1477.0**	**0**	**1477.0**

Table 15 Resources from other organisations

CC	Stage 1 Cash	In kind	Stage 2 Cash	In kind	Stage 3 Cash	In kind	Stage 4 Cash	In kind	All stages Cash	In kind	All stages Total
CID	0	0	7.0	0	18.2	0	13.1	0	38.3	0	**38.3**
PSCI	0.2	0	5.1	0	5.8	0	3.4	0	14.5	0	**14.5**
S-Sence	0	0	0	0	8.5	0	1.5	0	10.0	0	**10.0**
WoxénC	0.5	0	4.2	0	0.6	0	0.1	0	5.4	0	**5.4**
FaxénLab	0	0	0	0	2.6	0	1.2	0	3.8	0	**3.8**
CPM	0	0	0	0	0.9	0	2.2	0	3.1	0	**3.1**
CERC	0	0	0	0	0	0	1.9	0.7	1.9	0.7	**2.7**
CAP	0	0	0	0	0	0	0	0	0	0	**0**
CHACH	0	0	0	0	0	0	0	0	0	0	**0**
ASTEC	0	0	0	0	0	0	0	0	0	0	**0**
BRIIE	0	0	0	0	0	0	0	0	0	0	**0**
CBioPT	0	0	0	0	0	0	0	0	0	0	**0**
CBioSep	0	0	0	0	0	0	0	0	0	0	**0**
CCCD	0	0	0	0	0	0	0	0	0	0	**0**
Charmec	0	0	0	0	0	0	0	0	0	0	**0**
CTT	0	0	0	0	0	0	0	0	0	0	**0**

CC	Stage 1 Cash	In kind	Stage 2 Cash	In kind	Stage 3 Cash	In kind	Stage 4 Cash	In kind	All stages Cash	In kind	All stages Total
ISIS	0	0	0	0	0	0	0	0	0	0	**0**
KCK	0	0	0	0	0	0	0	0	0	0	**0**
KI Rad. Ther.	0	0	0	0	0	0	0	0	0	0	**0**
MiMer	0	0	0	0	0	0	0	0	0	0	**0**
NIMED	0	0	0	0	0	0	0	0	0	0	**0**
PolhemLab	0	0	0	0	0	0	0	0	0	0	**0**
SNAP	0	0	0	0	0	0	0	0	0	0	**0**
SUMMIT	0	0	0	0	0	0	0	0	0	0	**0**
WURC	0	0	0	0	0	0	0	0	0	0	**0**
EKC	0	0	0	0	0	0	0	0	0	0	**0**
HTC	0	0	0	0	0	0	0	0	0	0	**0**
KCFP	0	0	0	0	0	0	0	0	0	0	**0**
All 28 CCs	**0.7**	**0**	**16.3**	**0**	**36.6**	**0**	**23.5**	**0.7**	**77.1**	**0.7**	**77.8**

Appendix F Detailed accounts of organisational participation

This appendix contains detailed accounts of all company participations per CC. All figures are in kSEK.

F1 ASTEC

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
ABB AB	Engineering						600			**600**
ABB Automation Products AB	Engineering				300					**300**
ABB Automation Technologies AB	Engineering							600	1400	**2000**
Absint Angewandte Informatik GmbH	Unknown								2000	**2000**
Arcticus Systems AB	Services								100	**100**
Cross Country Systems AB	Microelectronics & Telecom						300		100	**400**
Ericsson AB	Microelectronics & Telecom					1700	2800	1500	3500	**9500**
Ericsson Radio Systems AB	Microelectronics & Telecom		600							**600**
Ericsson Telecom Systems AB	Microelectronics & Telecom		200	900	500					**1600**
Ericsson Utvecklings AB	Microelectronics & Telecom			4200	700					**4900**
I.A.R. Systems AB	Software & Engineering consultancy		400		5800		5100		700	**12000**
Mecel AB	Automotive		1200		1000					**2200**
Mobile Arts	Services						800		1000	**1800**
OSE Systems AB / ENEA Embedded Technology AB	Software & Engineering consultancy						800		300	**1100**
Prover Technology AB	Services		900		900		2300		3500	**7600**
Rational Software Scandinavia AB	Software & Engineering consultancy		1000		300					**1300**
Telelogic AB	Services				200					**200**
Telelogic Sverige AB	Services						200			**200**
Telia AB	Microelectronics & Telecom		2000							**2000**
Telia Validation AB / Validation AB	Software & Engineering consultancy				1600		600			**2200**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Tidorum OY	Unknown								600	**600**
T-Mobile Ltd (Storbritannien)	Microelectronics & Telecom					400				**400**
Virtutech AB	Services						300		800	**1100**
VM-Data Validation AB	Software & Engineering consultancy							100	100	**200**
Volvo Teknisk Utveckling AB	Automotive				200		200			**400**

F2 BRIIE

Company	Sector	**Stage 1 Cash**	**Stage 1 In kind**	**Stage 2 Cash**	**Stage 2 In kind**	**Stage 3 Cash**	**Stage 3 In kind**	**Stage 4 Cash**	**Stage 4 In kind**	**Total**
Atlas Copco Secoroc Aktiebolag	Mining, steel & metal	100	300	450	591	450	1073	300	974	**4238**
Celsius Materialteknik (CMT) AB	Unknown	200	900							**1100**
Erasteel	Mining, steel & metal	600	1500	1275	1990	1275	2807			**9447**
Ericsson Cables	Microelectronics & Telecom				460					**460**
Höganäs Aktiebolag (publ)	Mining, steel & metal	600	600	1275	1382	1275	2064	850	1529	**9575**
Kanthal	Mining, steel & metal	100	300	450						**850**
Nobel Biocare AB (publ)	Pharmaceuticals & medical devices							600	1689	**2289**
OFCON	Engineering				600					**600**
Sandvik Coromant	Mining, steel & metal	1600	900	2550	3023	2100	3634	1400	3419	**18626**
Sandvik Hard Materials	Engineering					320	514			**834**
Seco Tools Aktiebolag (publ)	Mining, steel & metal	100	300	675	1138	675	1816	450	1701	**6855**

F3 CAP

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Akzo Nobel Surface Chemistry AB	Chemicals	1080	1050	1800	1912	1800	2046	1200	1250	**12138**
Astra Hässle AB	Pharmaceuticals & medical devices	720	393	1950	1938					**5001**
AstraZeneca AB	Pharmaceuticals & medical devices					1950	4973	1300	3552	**11775**
CEN	Unknown							600	1323	**1923**
Eka Chemicals AB	Chemicals	280	464	420	885	420	1035	280	775	**4559**
Fortum	Unknown				81					**81**
LyckebyStarch / Sveriges Stärkelseproducenter	Unknown	900	728	1200	1083	900	1497	600	844	**7752**
NoHy	Unknown					75				**75**
SCA Hygiene Products AB	Paper, pulp & forestry					900	415	600	264	**2179**
SCA Research Aktiebolag	Paper, pulp & forestry			1410	459					**1869**
SCA	Paper, pulp & forestry	900	284							**1184**
Tetra Pak Research & Development AB	Paper, pulp & forestry	860	390	1030	629	900	1264	600	810	**6483**

F4 CBioPT

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
AbSorber AB	Pharmaceuticals & medical devices					150	435			**585**
Active Biotech AB	Pharmaceuticals & medical devices					150	500			**650**
Amersham Pharmacia Biotech AB / Amersham Biosciences AB / GE Healthcare Biosciences	Chemicals	650	928	367	3929	300	2023	225	875	**9297**
Assi Domän AB	Paper, pulp & forestry	100	60	450	590					**1200**
Astra Arcus AB	Pharmaceuticals & medical devices	200		100						**300**
Astra Biotech AB / AstraZeneca AB	Pharmaceuticals & medical devices			300	120	300	3632	200	2532	**6664**
BiaCore AB	Pharmaceuticals & medical devices	100	101	100	724					**1025**
BioInvent AB	Pharmaceuticals & medical devices			570	1055	150	1451	413	150	**2164**
Biovitrum AB	Pharmaceuticals & medical devices			50	90	300	2908	225	2870	**6303**
Carbamyl	Other	50	24							**74**
DNP Sweden AB	Paper, pulp & forestry			100	64			100	200	**300**
KaroBio AB	Pharmaceuticals & medical devices	100	163			150	2930	113	2012	**5468**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Korsnäs AB	Paper, pulp & forestry	100	66	150	499					**815**
MoDo AB	Paper, pulp & forestry	100		300	660					**1060**
Multiferm AB / BioGaia	Unknown	214	640	300	775					**1929**
Novozymes Biopharma AB	Chemicals					150	1851	113	700	**2814**
Pharmacia & Upjohn AB / Pfizer AB	Pharmaceuticals & medical devices	1100	1820	1050	3368	300	718	225	1420	**10001**
Pharmacia & Upjohn Diagnostics	Chemicals	347	1145	200	255					**1947**
Recopharma AB	Pharmaceuticals & medical devices							113		**113**
SBL Vaccin AB	Pharmaceuticals & medical devices	100	72	150	679	100	157			**1258**
Stora Corporate Research AB	Paper, pulp & forestry	100	11	300	310					**721**
Other	Unknown	1								**1**

F5 CBioSep

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Active Biotech	Pharmaceuticals & medical devices			188	895	300	1567			**2950**
Alfa Laval Separation	Engineering	0	106	0	498					**604**
AnaMar Medical	Pharmaceuticals & medical devices					50	59			**109**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
AstraZeneca	Pharmaceuticals & medical devices			375	460	600	1650			**3085**
Biacore	Pharmaceuticals & medical devices			0	466	150	856			**1472**
BioInvent International	Pharmaceuticals & medical devices	0	258	113	231	150	1810	100	679	**3341**
Biora	Pharmaceuticals & medical devices					150	522	150	2252	**3074**
BioSwede	Other	0	200	0	150					**350**
Biovitrum	Pharmaceuticals & medical devices	1236	609	938	2376	300	2257	200	349	**8265**
Carbamyl	Other	0	329	0	457					**786**
Centritech	Unknown	0	202							**202**
Eka Chemicals	Chemicals	100	705	281	1189	300	1295	200	337	**4407**
Excorim	Other			0	445					**445**
GE Healthcare	Chemicals	200	751	939	1767	1800	2403	700	1215	**9775**
Genovis	Pharmaceuticals & medical devices							100	518	**618**
Gramineer International	Pharmaceuticals & medical devices	0	1087	0	3229	83	363			**4762**
MonoGel	Microelectronics & Telecom			0	300					**300**
Novozymes Biopharma	Chemicals	100	152	314	288	150	827	100	319	**2250**
Percell Biolytica	Chemicals			0	200					**200**
Pfizer Health	Pharmaceuticals & medical devices					300	918	1550	1533	**4301**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Polypeptide Lab. Sweden	Pharmaceuticals & medical devices			188	107	125	79			**499**
Protista Biotechnology	Pharmaceuticals & medical devices							100	2074	**2174**
Teknopol	Services			300						**300**

F6 CCCD

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Agro Vision AB / Pharma Vision AB	Pharmaceuticals & medical devices		200	400	35					**635**
AXIS Communications AB	Microelectronics & Telecom			720	990	300	2265	200	1070	**5545**
Cadence Design Systems AB	Software & Engineering consultancy		2000		3000		3000		3000	**11000**
Ericsson Components AB (Ericsson Microelectronics AB)	Microelectronics & Telecom	700	150	1050	290					**2190**
Ericsson Mobile Communications AB / Ericsson AB in Lund	Microelectronics & Telecom	2000	1300	3000	1745	3000	1767	2000	1200	**16012**
Ericsson Radio systems AB / Ericsson AB in Kista	Microelectronics & Telecom	2000	400	3000	965	1500	1064	1000	800	**10729**
Ericsson Technology Licensing AB	Microelectronics & Telecom						1800			**1800**
Infineon Technologies Sweden AB	Microelectronics & Telecom					900	113	600	100	**1713**
Perlos AB	Microelectronics & Telecom					300	1265	200	1000	**2765**
Phase Holographic Imaging AB	Microelectronics & Telecom								200	**200**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
St. Jude Medical AB	Pharmaceuticals & medical devices			1400	50					**1450**
SwitchCore AB	Microelectronics & Telecom			1500	20					**1520**
TeliaSonera AB	Microelectronics & Telecom	1000	150	1500	600	1500	600	1000	400	**6750**
United Microelectronics Corporation	Unknown					612	4720		2000	**7332**
Ångpannestiftelsen	Software & Engineering consultancy							23		**23**

F7 CERC

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
ABB Automation Products AB	Engineering					2610	990	1520	900	**6020**
ABB Industrial Systems AB	Engineering			1620	1350					**2970**
Aspen Petroleum AB	Software & Engineering consultancy	200	20	300	90	300	20			**930**
Husqvarna AB	Engineering	730	140	750	511					**2131**
Mecel AB / Hoerbiger Control Systems	Automotive	100	20	300	200					**620**
SAAB Automobile / GM Powertrain	Automotive	830	40	750		1500	1000	1000	1058	**6178**
Scania CV	Automotive	1305	80	1446	227	1200	255	800	258	**5571**
Statoil AS / Statoil Hydro AS, Norge	Chemicals	300	40	380	352	323	135	200	330	**2060**
Volvo Car Corporation	Automotive	1330	270	3000	1200	3000	1200	2000	557	**12557**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Volvo CV / Volvo Powertrain	Automotive	1505	245	2880	3275	1650	3160	1100	2107	**15922**
Volvo Penta	Other vehicles			300		300	50	200	100	**950**
Wärtsilä NSD Sweden AB	Other vehicles	100	20	150	215					**485**
Övriga	Unknown	400								**400**

F8 CHACH

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Allgon systems	Microelectronics & Telecom			90	663		1500	0	0	**2253**
Comheat Microwave	Microelectronics & Telecom					225	870	200	868	**2163**
Ericsson AB	Microelectronics & Telecom						5445	150	4263	**9858**
Ericsson Microwave Systems	Microelectronics & Telecom		3995		5779		5760	1000	920	**17454**
Gigatech	Microelectronics & Telecom			534	1116			0	0	**1650**
Infineon	Microelectronics & Telecom	215	585	200	6051		330	0	1223	**8604**
Omnisys Instruments	Microelectronics & Telecom		787	555	1139		1650	0	2315	**6446**
Optillion	Unknown						2845	0	0	**2845**
Radians Innova	Microelectronics & Telecom						660	0	0	**660**
Ranatech	Microelectronics & Telecom		209		380			0	0	**589**
SAAB Ericsson Space	Microelectronics & Telecom		766		1180		1200	800	650	**4596**
SAAB Rosemount	Microelectronics & Telecom					450	1200	300	200	**2150**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
SAAB Tech AB	Microelectronics & Telecom	300	700	440	625	645	1500	400	400	**5010**
Zarlink Semiconductor AB	Microelectronics & Telecom				315	650	1240	0	1940	**4145**

F9 Charmec

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Abetong Teknik AB	Other	1700	635	2550	984	2100	187	800	459	**9415**
Adtranz	Other vehicles	1600	1165	3000	2813					**8578**
Banverket	Public sector, cooperatives & NGOs	1500	1835	5960	2174	7985	969	10577	342	**31342**
Bombardier Transportation Sweden AB	Other vehicles	0				3000	1517	2000	547	**7064**
Cardo	Other vehicles	0		1500	691					**2191**
Duroc Rail AB	Unknown	0		900	605	1050	842	500	725	**4622**
Faiveley	Other vehicles	0						900	305	**1205**
Green Cargo AB	Services	0				1440		480	14	**1934**
Inexa Profil	Mining, steel & metal	0		501	264	150	173			**1088**
Lucchini Sweden AB	Other vehicles	0				3000	2918	1300	1217	**8435**
SAB Wabco Group AB	Other vehicles	0				1500	449			**1949**
SJ	Services	1000	400	1500	953					**3853**
SL Infrateknik AB / SL AB Teknikenheten	Software & Engineering consultancy	0				200		800	107	**1107**
TrainTech Engineering Sweden AB / Interfleet	Software & Engineering consultancy							100	591	**691**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
TrainTech Engineering Sweden AB / Interfleet	Software & Engineering consultancy	0				300	1546			**1846**
voestalpine Bahnsysteme GmbH	Mining, steel & metal	0						1300	1941	**3241**

F10 CID

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Apple	Software & Engineering consultancy	125	175		300					**600**
Ateles	Software & Engineering consultancy							100	308	**408**
Bollnäs kommun	Public sector, cooperatives & NGOs							30	400	**430**
DataDoktorn AB	Software & Engineering consultancy				300		735		480	**1515**
Enator Informationsystems AB / TietoEnator	Software & Engineering consultancy			75	1020	75	1044			**2214**
Ergolab	Software & Engineering consultancy						130		200	**330**
Ericsson AB	Microelectronics & Telecom	325	2100	300	4350	600	1100			**8775**
Grafiska Företagen	Unknown	25								**25**
Guide	Software & Engineering consultancy							100	200	**300**
Handikappinstitutet / Hjälpmedelsinstitutet	Other			60	90	60	720	40	576	**1546**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Handikappombudsmannen	Public sector, cooperatives & NGOs							20	176	**196**
IBM	Software & Engineering consultancy	60	415							**475**
ICL	Unknown	125	100							**225**
IconMediaLab	Software & Engineering consultancy					100	576			**676**
Lentus	Services					75	690			**765**
Lernia	Other					90	810			**900**
LO	Other	25		150	450	150	720	120	1140	**2755**
MadeInSthlm	Unknown								304	**304**
Metamatrix	Software & Engineering consultancy							20	450	**470**
Myndigheten för skolutveckling	Public sector, cooperatives & NGOs							150	900	**1050**
Nationellt centrum för flexibelt lärande	Public sector, cooperatives & NGOs							100	1080	**1180**
No Picnic Industrial Designers AB	Services				225				240	**465**
Nomos Management AB	Services	25	100		495		500			**1120**
Riksförsäkringsverket	Public sector, cooperatives & NGOs	75								**75**
Riksskatteverket / Skatteverket	Public sector, cooperatives & NGOs	75		300		450	480	200	116	**1621**
Riksutställningar	Public sector, cooperatives & NGOs							100	348	**448**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Silicon Graphics AB	Software & Engineering consultancy				695					**695**
SIT Läromedel	Unknown					150	450			**600**
Skolverket	Public sector, cooperatives & NGOs			300		600	900			**1800**
Statens maritima muséer	Public sector, cooperatives & NGOs								500	**500**
Statskontoret	Public sector, cooperatives & NGOs							50	576	**626**
Stiftelsen Svensk programvaruindustri	Unknown	25								**25**
Sun Microsystems AB	Software & Engineering consultancy				750					**750**
Sverige Direkt	Unknown!					60	630			**690**
TCO / TCO Development	Services	25		150	225	60	375	60	750	**1645**
Tekniska muséet	Other								924	**924**
Telia Group AB / TeliaSonera	Microelectronics & Telecom	450	800			450	3600	300	2400	**8000**
Telia Koncern IT	Microelectronics & Telecom				338					**338**
Telia Nättjänster	Microelectronics & Telecom			300	3600					**3900**
Telia Research AB	Microelectronics & Telecom			150	225					**375**
Telia TeleCom AB	Microelectronics & Telecom			300	394					**694**
Teracom	Microelectronics & Telecom					150	750			**900**
Terminologicentralen	Software & Engineering consultancy								200	**200**
TimeCare	Services					90	450			**540**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
tobii	Services								808	**808**
UI Design AB	Software & Engineering consultancy	25			150					**175**
Usability Partners	Other							200		**200**
Utbildningsradion	Services					150	360	100	400	**1010**
Vattenfall	Energy			90	675	300	2700	200	800	**4765**

F11 CPM

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
ABB	Engineering	140	1023	300	2070	450	1085	190	1236	**6494**
Akzo Nobel	Chemicals	140	902	300	1492	450	1252	190	3695	**8421**
Avesta Sheffield	Mining, steel & metal			210						**210**
Bombardier Transportation	Other vehicles					450	1814	190	786	**3240**
Cementa	Other			300	3289	450	2305			**6344**
Duni	Paper, pulp & forestry			300	366	450	2119	190	336	**3761**
Electrolux	Engineering	140	475	300	448					**1363**
Ericsson	Microelectronics & Telecom	140	860	300	949					**2249**
IKEA	Services							190	1713	**1903**
ITT Flygt	Engineering					300	1024	190	913	**2427**
MoDo / Holmen	Paper, pulp & forestry	140	665	300	926					**2031**
Norsk Hydro	Unknown	140	755	100						**995**
Perstorp	Chemicals	140	810	300	1162					**2412**
SAAB	Automotive			300	207	450	990			**1947**
SCA Hygiene Products / Mölnlycke	Paper, pulp & forestry	140	1230	300	1129	450	886	190	1058	**5383**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Schenker	Services								458	**458**
Stora Enso	Paper, pulp & forestry	140	1105	300	2232	450	1687	190	284	**6388**
Telia	Microelectronics & Telecom	140	860							**1000**
Tetra Pak	Paper, pulp & forestry							95	181	**276**
Vattenfall	Energy	140	1207	300	948	150	256			**3001**
Volvo / Volvo Cars	Automotive	140	1228	300	1209	450	2321			**5648**

F12 CTT

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
ABB Automation Technology Products AB	Engineering					741	1731	84		**2556**
Acapela Group	Software & Engineering consultancy								1345	**1345**
Babel-Infovox AB	Software & Engineering consultancy						2269			**2269**
Englishtown Limited, Hong Kong	Unknown								80	**80**
Ericsson Radio Systems AB	Microelectronics & Telecom	650	1350	600	900					**3500**
Flextronics Design	Unknown						750			**750**
GN ReSound AB	Pharmaceuticals & medical devices							350	95	**445**
Hjälpmedelsinstitutet	Other				750		1104		533	**2387**
HoneySoft	Other						828		692	**1520**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Icepeak AB	Software & Engineering consultancy								1876	**1876**
Just Direct	Unknown						1079			**1079**
Labyrinten Data AB	Services								130	**130**
Levande Böcker i Norden AB	Unknown				1785					**1785**
Luftfartsverket	Public sector, cooperatives & NGOs				1950					**1950**
Phoneticom AB	Software & Engineering consultancy						460		243	**703**
PipeBeach AB	Unknown				600		495			**1095**
Polycom Technologies Aktiebolag	Software & Engineering consultancy				480		431		158	**1069**
Saab AB	Other vehicles				900		790			**1690**
Saab Systems	Unknown								781	**781**
SaabTech AB	Microelectronics & Telecom						1027			**1027**
SpeechCraft AB	Software & Engineering consultancy								47	**47**
Svenska Handelsbanken	Services			750	155					**905**
Sveriges Radio Aktiebolag	Services	150	150	195	105		588	198	302	**1688**
Sveriges Television Aktiebolag	Services						1416		297	**1713**
Södermalms Talteknologiservice (STTS) AB	Services								485	**485**
Talboks- och punktskriftsbiblioteket, TPB	Public sector, cooperatives & NGOs								2262	**2262**
Telia Promotor	Engineering				1871					**1871**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Telia Research	Microelectronics & Telecom	2000			3150		2200			**7350**
TeliaSonera Sverige AB	Microelectronics & Telecom								2200	**2200**
Trio AB	Other				1500					**1500**
Vattenfall Aktiebolag (publ)	Energy	300			1500		2430		500	**4730**
Voice Provider Sweden AB	Software & Engineering consultancy								801	**801**
Volvo Teknisk Utveckling AB	Automotive			833						**833**
Voxi	Services						813			**813**

F13 EKC

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
ABB	Engineering	700	2100	3750	3750	1800	5700	1200	3290	**22290**
ABB Automation	Engineering							200	210	**410**
ABB Motors	Unknown	400	400	900	900	750	750			**4100**
ABB Refrigeration	Unknown	140	400							**540**
API Elmo	Unknown					315	450			**765**
Atlas Copco Controls	Unknown	260	600	967	968			200	260	**3255**
Danaher	Unknown							200	520	**720**
Elforsk	Energy					3450	2550	2300	4030	**12330**
Elmo Industrier	Unknown	140	200	382	383					**1105**
Höganäs	Mining, steel & metal					900	900	200	360	**2360**
InMotion Techn.	Unknown					300	450			**750**
ITT Flygt	Engineering	400	400	900	900	900	900	600	650	**5650**
Programma	Unknown					150	450	100	300	**1000**
Sabroe Refrigeration	Unknown			300	300					**600**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Stockholm Energi	Energy	20	40	300	300					**660**
Sura Magnets	Unknown			60	60	0	120	0	30	**270**
Sydkraft	Energy	90	210	600	600					**1500**
Vattenfall	Energy	180	420	900	900					**2400**

Note: The available data on industry contributions to EKC for stage two were not separated on cash and in kind. As an approximation, the industry contributions to EKC stage two have here been listed as 50% cash and 50 % in kind.

F14 FaxénLab

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
ABB AB	Engineering							683		**683**
ABB Automation Systems AB	Engineering			1000	1588					**2588**
ABB Corporate Research	Engineering		250	525	613	750	540			**2678**
ABB Industrial Systems AB	Engineering	500	250							**750**
ABB Power Technology Products AB	Engineering					150	150	225	225	**750**
ABB Process Industries AB / ABB Automation Technology	Engineering					500	500	225	225	**1450**
ABB Switchgear AB	Unknown			525	350	135	90			**1100**
ABB, Said Zahrai	Engineering					315				**315**
AGA AB	Chemicals	400	200	350	175	300	225	150	113	**1913**
Albany Nordiskafilt AB / Albany International AB	Other			263	525	450	450	225	225	**2138**
Alfa-Laval Separation AB / Alfa Laval Tumba AB	Engineering	100	640	175	1330	150	1140	25	100	**3660**
Assi Domän AB	Paper, pulp & forestry		200		250					**450**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Avesta Sheffield AB	Mining, steel & metal			613	700					**1313**
Borealis AB	Chemicals					450	450	75	75	**1050**
CDT Nordic	Microelectronics & Telecom							225	225	**450**
Comsol AB	Software & Engineering consultancy								225	**225**
Eka Chemicals AB	Chemicals	240	240	420	600	750	750	375	375	**3750**
Elektrokoppar	Unknown							225	300	**525**
Elkem	Mining, steel & metal							300	250	**550**
Ipsen International GmbH	Unknown			50	100	300	600	150	300	**1500**
Korsnäs AB	Paper, pulp & forestry		200		250					**450**
Metso Paper, Inc	Paper, pulp & forestry					2475	900		450	**3825**
MetsäSerla	Paper, pulp & forestry					375	375			**750**
Mitrion	Microelectronics & Telecom							150	150	**300**
MoDo AB	Paper, pulp & forestry		200		250					**450**
Norzink AS	Unknown	100	860							**960**
Outokumpu Fabrication Technology AB	Mining, steel & metal							225	375	**600**
Outokumpu Partner AB / Outokumpu Copper Partner AB	Mining, steel & metal			525	875	450	750			**2600**
Permascand AB	Mining, steel & metal	160	160	280	280					**880**
Process Flow Ltd. OY	Software & Engineering consultancy						1400			**1400**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
SAPA	Engineering					300	600			**900**
SCA Packaging Sweden AB	Paper, pulp & forestry					300		150		**450**
SCA Research AB	Paper, pulp & forestry		200	350						**550**
SKF Engineering & Research Centre B.V.	Engineering			700	700					**1400**
SSAB Oxelösund AB	Mining, steel & metal							300	550	**850**
Stora Corporate Research	Paper, pulp & forestry	400		350	350	300	300			**1700**
StoraEnso Research	Paper, pulp & forestry							150	150	**300**
Valmet Corporation	Automotive			613	700					**1313**
Vattenfall Utveckling AB	Energy	200	500	350	1050	750	900	375	450	**4575**
Volvo PV Komponenter AB	Automotive			350	175					**525**

F15 HTC

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
ABB Alstom Power	Unknown			645	1148					**1793**
ABB STAL	Unknown	100	0							**100**
Avesta Sheffield	Mining, steel & metal	330	36	1065	287					**1718**
Birka Värme	Energy			855	118					**973**
Daros AB	Unknown					0	69	100	144	**313**
Demag Delaval Industrial Turbines	Engineering					569	1168			**1737**
Duroc AB	#SAKNAS!			75	170	56	49	50	141	**541**
Elforsk	Energy							1190	340	**1530**
Fortum	Energy					1073	70			**1143**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Kanthal	Mining, steel & metal	330	130	1050	1089	1138	1307	750	1722	**7516**
Kvaerner Enviropower	Unknown	100	2600							**2700**
Kvaerner Power	Unknown							470	670	**1140**
Kvaerner Pulping	Unknown			425	1602	748	1237			**4012**
Metalock AB	Unknown			75	38	0	0			**113**
Outokumpu Stainless	Mining, steel & metal					1024	1659	620	433	**3736**
Sandvik Materials Techn.	Mining, steel & metal					1040	702	650	943	**3335**
Sandvik Steel	Mining, steel & metal	330	190	1038	314					**1872**
Siemens	Unknown							350	1153	**1503**
Stockholm Energi	Energy	125	60							**185**
Sydkraft	Energy	280	114	855	154	1073				**2476**
Sydkraft SAKAB	Energy					81	288	50	50	**469**
Tekniska Verken i Linköping	Energy					81	0			**81**
Vattenfall	Energy	390	60	1094	328	1203	288			**3363**
Volvo Aero	Other vehicles	100	1500	525	1269	569	581	350	422	**5316**
Volvo Lastvagnar	Automotive					650	1724			**2374**
Volvo Technology	Automotive			600	1116					**1716**

F16 ISIS

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
ABB Automation Products	Engineering			150	2287					**2437**
ABB Automation Systems / ABB Automation Technologies	Engineering			50	900	50	750	100	4500	**6350**
ABB Corporate Research	Engineering			50	843	50	1125	100	2250	**4418**
ABB Industrial Systems	Engineering	100	1425							**1525**
ABB Industry Solutions	Engineering					50	900			**950**
ABB Robotics / ABB Robotic Products	Engineering	750	300	1450	2025	50	1163			**5738**
Ericsson AB	Microelectronics & Telecom	100	4500			50	1500	100	2700	**8950**
Ericsson Radio Systems	Microelectronics & Telecom			600	1050					**1650**
Ericsson Utveckling	Microelectronics & Telecom			100	4875					**4975**
Mecel AB	Automotive	100	1500	150	2250	50	825	100	1650	**6625**
NIRA Dynamics	Automotive					50	450	100	1650	**2250**
SAAB AB	Other vehicles			150	3450	500	900	100	1800	**6900**
SAAB Automobile AB	Automotive	100	1275	150	2250	50	750	100	2700	**7375**
SAAB Dynamics	Mining, steel & metal							100	2400	**2500**
SAAB Military Aircraft	Other vehicles	100	2550							**2650**
SAAB Missiles AB / SAAB Bofors Dynamics	Mining, steel & metal	100	1613	150	3733	50	1050			**6696**
Unknown		634	4657	634	4657	634	4657	634	4657	**21161**

F17 KCFP

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
ABB Alstom Power Sweden AB	Unknown					300	3100			**3400**
ABB Stal AB	Unknown	400	400	2400	2200					**5400**
Atlas Copco Berema AB	Unknown	300	300							**600**
Caterpillar Inc	Automotive					1600	0	500	0	**2100**
Cummins Engine Co	Engineering					1600	0	500	0	**2100**
Demag Delaval Industrial Turbomachinery AB	Engineering							500	1400	**1900**
Fiat-GM Powertrain	Automotive							200	0	**200**
Hino Motors Ltd	Automotive					900	0	500	0	**1400**
Husqvarna AB	Engineering	600	600							**1200**
Mecel AB	Automotive					200	200			**400**
Nissan	Automotive							1100	0	**1100**
Saab Automobile AB	Automotive					200	200			**400**
Scania CV	Automotive			500	400	1000	500	300	300	**3000**
Sydkraft AB	Energy	700	700	2500	2300	3100	700	2300	400	**12700**
Toyota Motor Corp.	Automotive					1600	0	500	0	**2100**
Vattenfall Värmekraft AB	Energy	100	100	600	600	500	400			**2300**
Volvo AB, Teknisk Utveckling	Automotive	200	200	500	500	0	1000	0	700	**3100**
Volvo Aero Corporation AB	Other vehicles	200	200	300	300	1000	400	200	300	**2900**
Volvo Lastvagnar AB	Automotive	100	100	700	600	1100	300	300	0	**3200**
Volvo Penta	Other vehicles					400	0	100	0	**500**
Volvo Car Corporation	Automotive	700	700	1500	1300	2500	500	1500	400	**9100**
Wärtsilä	Other vehicles			200	200	200	200			**800**

F18 KCK

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
ABB Fläkt Industri AB (nedlagt alt namnbyte)	Engineering	100	450	100	300					**950**
EKA Chemicals / Akzo Nobel / Albemarle Catalysts / Akzo Catalyst AB	Chemicals			200	300	600	900	400	600	**3000**
Perstorp Specialty Chemicals AB	Chemicals	100	450	300	2565	900	2400	400	1400	**8515**
Saab Automobile AB / Saab Automobile Powertrain AB / GM Powertrain Sweden AB	Automotive	400	600	600	729	900	2400	600	1600	**7829**
Swedish Space Agency / Swedish Space Corporation	Software & Engineering consultancy					600	900	400	1000	**2900**
Svensk Bilprovning / MTC / AVL-MTC AB	Software & Engineering consultancy	4	196		492	300	900	200	600	**2692**
Svensk Emissionsteknik AB / Johnson Matthey CSD	Software & Engineering consultancy	500	1300	950	3700		3900		2600	**12950**
Volvo	Automotive	450	1450	1200	3600	1200	3000	800	3000	**14700**

F19 KI Radiation Therapy

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Applied Medical Imaging	Unknown				67					**67**
Comair	Pharmaceuticals & medical devices		530							**530**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
C-RAD Imaging	Microelectronics & Telecom								568	**568**
C-RAD Innovation	Pharmaceuticals & medical devices					125	1 095		390	**1610**
C-RAD Positioning	Microelectronics & Telecom								1270	**1270**
CTI PET Systems (CPS)	Unknown						3 724		200	**3924**
Elekta Instrument	Microelectronics & Telecom		716	228	3 810	166	1 689	138	1 627	**8374**
IBA-Scanditronix	Pharmaceuticals & medical devices		983	472	6 277	373	4 021	150	5 013	**17289**
Latronix	Microelectronics & Telecom		247	136	1 600					**1983**
Nucletron Scandinavia	Software & Engineering consultancy		2 705	99	2 736	186	921		2 260	**8907**
RaySearch Labs	Pharmaceuticals & medical devices					81	3 889		1 485	**5455**
ScandiNova Systems	Pharmaceuticals & medical devices								150	**150**
SECTRA-Imtec	Services		300		315					**615**
SenseGraphics	Software & Engineering consultancy								298	**298**
Studsviks Medical	Pharmaceuticals & medical devices					146	1 604			**1750**

F20 MiMeR

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
ASKANIA AB	Unknown	70		120	52					**242**
Avesta Sheffield AB/Avesta Polarit AB/Outokumpu Stainless AB	Mining, steel & metal	140	801	240	1080	390	1855	160	3602	**8268**
Boliden Mineral AB	Mining, steel & metal	200	1283	240	193			240	786	**2942**
Cementa AB	Other					130		80	105	**315**
Erasteel Kloster AB	Mining, steel & metal			120	83	130		80		**413**
Fundia Special Bar AB/Ovako Bar AB	Mining, steel & metal	140	64	240	325	260	22	160	78	**1289**
Gotthard Nilsson AB/Stena Gotthard AB	Mining, steel & metal	140		120	54	130		120		**564**
Heckett MultiServ Nordiska AB	Other	140								**140**
Höganäs AB	Mining, steel & metal	160	473	300	720	260		240	148	**2301**
Linde AG	Unknown					130	469	120	250	**969**
LKAB	Mining, steel & metal	190	162	300	953	460	3408	240	13	**5726**
Lulefrakt/BDX Industrier AB /BDX Företagen AB	Other					260	164	160		**584**
Montanus Holding AB/Begslagens Stålservice AB/Multiserv AB	Other	70		120	893	260	202	240	6	**1791**
Outokumpu Stainless Oy	Mining, steel & metal							160	760	**920**
Ovako Steel AB	Mining, steel & metal	140	30	240	611	390	739	240	880	**3270**
Partek Nordkalk AB	Unknown	70	21	120	197	130	150			**688**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
RagnSells Elektronikåtervinning AB	Unknown					50				**50**
Rautaruukki Oy/Rautaruukki Steel Oy	Mining, steel & metal					260	430	240	294	**1224**
RECI Industri AB	Unknown	70								**70**
Sandvik Steel AB/AB Sandvik Materials Technology	Mining, steel & metal	140		240	176	260	169	240		**1225**
Scandust AB	Unknown	160		120		130				**410**
SSAB Merox AB	Other	190	808	300	955	260	192	160		**2865**
SSAB Tunnplåt AB	Mining, steel & metal	190	496	300	3444	260	4993	240	2646	**12569**
Stena Metall AB	Mining, steel & metal			240	3					**243**
Svenska Mineral AB	Mining, steel & metal	70	47	120	105	130		120		**592**
Uddeholm Tooling AB	Mining, steel & metal	70	1	120		260	933	240	281	**1905**
Vattenfall Utveckling AB	Energy	70	3	240	607	260		240	674	**2094**
Vattenfall Utvecklings AB	Energy			240				80	280	**600**
Östra Sörmland Bilfrakt AB	Unknown					50	11			**61**

F21 NIMED

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Althin Medical AB	Pharmaceuticals & medical devices	500	698	1430	1592					**4220**
Amersham Health A/S	Pharmaceuticals & medical devices					1625	898			**2523**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Astra Pain Control AB	Pharmaceuticals & medical devices	600	281	900	796					**2577**
Atos Medical AB	Pharmaceuticals & medical devices	168	100	750	552	750	524	600	1650	**5094**
Baxter Health AB	Pharmaceuticals & medical devices					2128	2177			**4305**
Bruker SA	Unknown			140	1149					**1289**
Elekta Instrument AB	Microelectronics & Telecom	500	585	750	715	1425	1898	929	2475	**9277**
Flodafors Lego	Engineering							277	550	**827**
Gambro	Pharmaceuticals & medical devices							661	1650	**2311**
GE VingMed AS	Pharmaceuticals & medical devices							400	1100	**1500**
Lisca Development AB	Pharmaceuticals & medical devices			750	682					**1432**
Lund Instruments AB	Unknown	30	100							**130**
Mamea Imaging AB	Unknown					240	1300			**1540**
Mezona Instruments AB	Pharmaceuticals & medical devices	800	563	600	1040					**3003**
Nycomed Imaging AS	Unknown			788	800					**1588**
OptoQ AB	Microelectronics & Telecom					215	2000			**2215**
Optovent AB	Pharmaceuticals & medical devices	88	0	1140	1576					**2804**
Perimed AB	Pharmaceuticals & medical devices			50	66	1425	1396	500	1375	**4812**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Siemens Elema AB	Pharmaceuticals & medical devices	600	394	900	1040					**2934**

F22 PolhemLab

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
ABB Atom AB	Unknown			900	958					**1858**
ACCRA Teknik AB	Software & Engineering consultancy					60	128			**188**
Aerodyn AB	Mining, steel & metal					90	200	40	50	**380**
Alimak AB	Engineering		982							**982**
Banverket N:a Regionen	Public sector, cooperatives & NGOs	420	358	450	468	400	452			**2548**
Branschsystem AB	Unknown		100	150	604					**854**
Ferruform AB	Automotive					750	121	500	53	**1424**
Hägglunds Drives AB	Engineering	200	446	450	897	750	910	400	573	**4626**
Indexator AB	Engineering				264	75	27			**366**
Inexa profil AB	Mining, steel & metal	200	400	450	805	200	150			**2205**
Kiruna Industrial Dev.AB	Unknown		80							**80**
Land Systems Hägglunds AB	Other vehicles							400	1000	**1400**
Metso Panelboard AB	Paper, pulp & forestry					900	3157	500	2002	**6559**
Msc Software Nordic	Services					600	544	400	177	**1721**
Sandvik Coromant AB	Mining, steel & metal	300	394	450	1207	450	1276	300	396	**4773**
SKF Sverige AB	Engineering							400	102	**502**
Ursvikens Mekaniska verkst.AB	Unknown	200	119							**319**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Vattenfall Vattenkraft AB	Energy	800	978	1200	1855	1350	2010	1000	1419	**10612**
Volvo Aero Corporation	Other vehicles		1880	900	2850	1350	3310	1000	2220	**13510**
Volvo Lastvagnar AB	Automotive			600	1370					**1970**
Volvo Personvagnar AB	Automotive			600	1507	1350	1800	1000	1200	**7457**
Volvo Technical Development AB	Automotive	150	587							**737**

F23 PSCI

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
ABB AB	Engineering			345	750					**1095**
ABB Corporate Research	Engineering	200	400							**600**
ABB Fläkt Industri AB / ABB Ventilation Products AB / Fläkt Woods AB	Engineering			600	1500	150	490			**2740**
Aerotech Telub AB	Software & Engineering consultancy						2000	1400	1050	**4450**
Alfa Laval Separation AB	Engineering	240	1300	360	2100	360	1390	200	420	**6370**
Allgon Systems AB	Microelectronics & Telecom					225	716			**941**
Avesta Polarit AB / Avesta Sheffield AB	Mining, steel & metal					600	472			**1072**
Biovitrum AB	Pharmaceuticals & medical devices						1020	500	0	**1520**
Bofors AB / SAAB Bofors Dynamics AB	Mining, steel & metal	100		300	900	600	535	500	250	**3185**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Computer Solutions Europe AB (Comsol)	Software & Engineering consultancy	300	200	150	270	300	300	250	125	**1895**
Digital Equipment AB / Compaq Computer AB	Software & Engineering consultancy			150	150	150				**450**
Ericsson Microwave AB	Microelectronics & Telecom			3000	3000	600	3981	800	1192	**12573**
Ericsson SAAB Avionics AB / SAAB Avionics AB	Microelectronics & Telecom			840	1590	1720	1300			**5450**
Flygtekniska Försöksanstalten (blev FOI)	Public sector, cooperatives & NGOs	50		150	300					**500**
FOA (blev FOI)	Public sector, cooperatives & NGOs	100	300							**400**
FOI	Public sector, cooperatives & NGOs					1050	3295		2373	**6718**
Höganäs	Mining, steel & metal					330	345	500	125	**1300**
IBM Svenska AB	Software & Engineering consultancy	100	100	150	150	450	728	100	0	**1778**
ITT Flygt AB	Engineering			150	300					**450**
Mitrionics AB	Microelectronics & Telecom							100	50	**150**
Parallel Systems Scandinavia AB	Unknown	200	200							**400**
Pharmacia Pharmaceuticals AB / Pharmacia & Upjohn AB	Pharmaceuticals & medical devices	260	600	390	450	600				**2300**
Pyrosequencing AB / Biotage AB	Pharmaceuticals & medical devices							500	30	**530**
SAAB AB	Other vehicles			1095	2220	1050	2147	500	250	**7262**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
SAAB Ericsson Space AB	Microelectronics & Telecom							100	0	**100**
SAAB Military Aircraft AB	Other vehicles	100	1300							**1400**
SAAB Tech Systems AB	Software & Engineering consultancy					600	712	500	284	**2096**
Sandvik Steel	Mining, steel & metal	50								**50**
Silicon Graphics AB	Software & Engineering consultancy			150	150					**300**
SMHI	Public sector, cooperatives & NGOs	400	300	300	600			100	50	**1750**
Sun Microsystems AB	Software & Engineering consultancy					3240	570	2112	158	**6080**
Svenska Rotormaskiner AB (SRM)	Engineering					150	1081	500	681	**2412**
Unknown	Unknown	483	-870	2125	6789	-1367	-1300	-304	7000	**12556**
Wiglaf AB	Software & Engineering consultancy					150	150	100	50	**450**
Volvo Aero Corporation AB	Other vehicles	300	400	345	360	300	605			**2310**

F24 SNAP

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Akzo Nobel Surface Chemistry AB	Chemicals	1710	4049	2430	3631	1500	5457	700	3508	**22985**
Arizona Chemical AB (i NL etapp 4)	Chemicals	80	227	150	200	180	378	200	365	**1780**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Astra Hässle AB*	Pharmaceuticals & medical devices	80	300	265	1749					**2394**
AstraZeneca*	Pharmaceuticals & medical devices					880	2607	600	1193	**5280**
Castrol	Chemicals	80	150							**230**
Karlshamn	Other	80	99	210	454	600	542	400	463	**2848**
Kemira	Chemicals	80	271	50						**401**
Kullgrens	Chemicals					100				**100**
Scotia Lipidteknik AB	Pharmaceuticals & medical devices	50	1348		3050					**4448**
Snowclean	Chemicals	80	153	150	114	180	53	120	34	**884**
Svenska Lantmännen	Other	80	350	165	897	600	962	500	1201	**4755**
Unilever	Other					845	3890	1339	2303	**8377**
UPM Kymmene Kaukas	Unknown			250	666	300	382	200	163	**1961**

F25 S-Sense

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
AppliedSensor (f.d. NST)	Microelectronics & Telecom			1050	1449	1575	846	700	665	**6285**
Asko Cylinda	Engineering			450	1286	600	2262	400	350	**5348**
Assi Domän Carton	Paper, pulp & forestry			450	1804	300	991			**3545**
Biacore	Pharmaceuticals & medical devices			0	542	850	1269	100	513	**3274**
Billerud	Paper, pulp & forestry							400	799	**1199**
BiosensorApplications	Microelectronics & Telecom							300	1200	**1500**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Duni/Finess	Paper, pulp & forestry			450	1894	262	819			**3425**
Eka Chemicals	Chemicals	400	100							**500**
Ford	Automotive							800	1200	**2000**
Global Hemostasis Institute MGR AB	Software & Engineering consultancy			300	943	250	417			**1910**
Iggesund Paperboard	Paper, pulp & forestry	300	842	600	458					**2200**
Mecel	Automotive	300	569	350	1278					**2497**
NIBE	Engineering							400	476	**876**
Otre	Unknown					750	1908			**2658**
Pharmacia & Upjohn	Pharmaceuticals & medical devices	1500		900	474					**2874**
Senset	Software & Engineering consultancy							200	837	**1037**
Statens kriminaltekniska laboratorium	Public sector, cooperatives & NGOs		720							**720**
StoraEnso	Paper, pulp & forestry	300	1048	600	825					**2773**
Svenska Lantmännen	Other	400	772	200	1291					**2663**
Tekniska verken i Linköping AB	Energy					750	672	500	510	**2432**
Tetra Pak Processing Systems AB	Paper, pulp & forestry					425	441			**866**
Vattenfall	Energy			600	349	900	807			**2656**
Volvo PV / Volvo Powertrain	Automotive					600	600	600	1200	**3000**
Volvo TU	Automotive	300	739	350	1012	0	616			**3017**

F26 SUMMIT

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Biacore	Pharmaceuticals & medical devices				1662		3349			**5011**
Biosensor Applications	Microelectronics & Telecom						603		801	**1404**
Celsius Tech	Microelectronics & Telecom	200								**200**
Engström Medical AB/Datex-Engström AB / Instrumentarium AB	Microelectronics & Telecom		17	300		300	20			**637**
Ericsson AB	Microelectronics & Telecom		6028		11929		7550		894	**26401**
Kitron Development	Software & Engineering consultancy								554	**554**
Network Automation MXC AB	Software & Engineering consultancy								1290	**1290**
Pondus Instruments	Mining, steel & metal								800	**800**
Quartz Pro	Software & Engineering consultancy		122							**122**
Radi Medical Systems	Pharmaceuticals & medical devices		132		1472		425			**2029**
Replisaurus Technologies	Software & Engineering consultancy								794	**794**
Saab Ericsson Space	Microelectronics & Telecom						414			**414**
Saab Training Systems	Microelectronics & Telecom								647	**647**
SaabTech	Microelectronics & Telecom				263					**263**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Sandvik Coromant	Mining, steel & metal		739							**739**
Sensaire	Microelectronics & Telecom		117		422		613		2301	**3453**
Siemens-Elema	Pharmaceuticals & medical devices	200								**200**
Spectrogon	Microelectronics & Telecom				6643		3200		1050	**10893**
SWEMA Instruments AB	Microelectronics & Telecom		35							**35**
XaarJet	Software & Engineering consultancy								1118	**1118**
Åmic	Pharmaceuticals & medical devices				525		1843		2060	**4428**

F27 VoxénCentrum

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
ABB AB	Engineering	85	1265	124	1556	105	4440	60		**7635**
ABB Automation	Engineering								1150	**1150**
ABB Power	Engineering								300	**300**
AlfaLaval Separation AB	Engineering	60	1400	90	1568	82,5	3315	60	2000	**8576**
Atlas Copco Tools AB	Engineering	60	320	90	125					**595**
Bofors	Mining, steel & metal	60	370							**430**
BT Products AB	Engineering	60	190	90	0					**340**
Celsius Tech Electronics AB	Microelectronics & Telecom	60	250	90	1313					**1713**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Electrolux	Engineering	60	1495	90	1077	82,5	1590	60	1000	**5455**
Enator	Services	60	250							**310**
Ericsson Radio Systems AB	Microelectronics & Telecom			90	3303	60	7950			**11403**
ESAB Welding Equipment AB	Engineering			90	0					**90**
Eurostep AB	Services			90	375					**465**
ITT Flygt	Engineering	60	480	90	257	30		60	2150	**3127**
Mecman / AB Rexroth-Mecman	Engineering	60	260	90	168					**578**
Modig Machine Tool AB	Engineering	60	435	315	0					**810**
NEOS Robotics AB	Engineering	60	150	170	405					**785**
NPU	Unknown			60	0					**60**
Posten Sverige AB	Services			60	850	82,5	3240	60	3128	**7421**
SAAB Military Aircraft / SAAB AB	Other vehicles	60	188	112	122					**482**
Sandvik Automat	Unknown	60	105							**165**
Sandvik Coromant	Mining, steel & metal	60	345	100	323	100				**928**
Scania CV AB	Automotive	414	825	447	5386	52,5	3300	60	2000	**12485**
SECO Tools AB	Mining, steel & metal	60	232	90	15					**397**
SKF-LMT	Engineering	85	1700	354	5455					**7594**
SlipNaxos	Other	60	111	110	105					**386**
SMT Machine AB	Engineering	60	380	90	488					**1018**
System 3R International AB	Engineering	60	420	90	578					**1148**
Volvo LV	Automotive	85	380							**465**
Volvo PV / Volvo Car Corporation	Automotive	388	1590	60	3856	52,5	6315	60	500	**12822**

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Volvo PVS	Automotive	60	1010							**1070**
Volvo Teknisk Utveckling AB	Automotive			447	1795					**2242**
VPUC AB	Unknown			60	0					**60**
ÅF-Industriteknik AB	Software & Engineering consultancy	60	335	90	156	36		60	600	**1337**

F28 WURC

Company	Sector	Stage 1 Cash	Stage 1 In kind	Stage 2 Cash	Stage 2 In kind	Stage 3 Cash	Stage 3 In kind	Stage 4 Cash	Stage 4 In kind	Total
Assi Domän AB	Paper, pulp & forestry	900	72,14	1843	1083					**3898**
Eka Nobel AB / Eka Chemicals	Chemicals	100	14,8	194	116		171	262	183	**1041**
Holmen Paper / M-real Corporation	Paper, pulp & forestry						211	361		**572**
Kappa Kraftliner	Paper, pulp & forestry						255	223		**478**
Korsnäs AB	Paper, pulp & forestry	650	122,186	1358	792		230	335	183	**3670**
MoDo AB / M-real	Paper, pulp & forestry	840	99,46	1746	1024		223	720	367	**5019**
SCA AB	Paper, pulp & forestry	630	243,425	1358	798		361	595	368	**4353**
Stora / StoraEnso	Paper, pulp & forestry	1050	813,547	2231	1311		854	720	367	**7347**
Sveaskog	Paper, pulp & forestry						212	223	183	**618**
Södra Cell	Paper, pulp & forestry	475	54,4	970	570		241	361	183	**2854**
Unknown			-220			11700	3842	4000	2566	**21888**

Appendix G Performance of CCs as reported

This appendix lists the most important impacts of CCs in industry as reported in the final reports (in the cases of CERC, EKC, HTC, KCFP and KCK: stage reports) and in the interviews and other empirical material in the present study.

G1 ASTEC

- ASTEC had specific competence in the programme language Erlang. Erlang was developed by Ericsson and Swedish Telecom (Televerket) and later tailored for mobile communication networks, and the reason why Ericsson joined ASTEC in 1995. In 1998 Ericsson decided to release Erlang as open source. University researchers in ASTEC made several important contributions within Erlang. The open source has led to the spread of Erlang into other large companies and the creation of quite a few start-ups globally. Ericsson follows closely the development of the Erlang community and the language has during the last years had a revival at Ericsson.
- Typechecking of Erlang resulted in the Dialyzer tool which became part of the Erlang/OTP product. Dialyzer has been used in several development projects within Ericsson and is described as a very valuable tool in finding error in early phases (before function test), which saves significant costs during development. Many small ideas regarding SMP (Symmetrical Multi-processing) support in the Erlang emulator was implemented in the product. The SMP support is regarded a real important feature since it allows Erlang programs to take advantage of multi-core technology very easily.
- At Prover Technology AB the work has resulted in a tool (FixIt) which scales up better than classical BDD-based techniques on several classes of systems. The work is described as an implementation of known theoretical “formal method” results into a “practical tool”, and considered by the company as a good example of technology transfer from academia to industry.
- IAR-systems reports that the industrial partners of the centre have contributed to their understanding of the end-user problems when using their products. During the first years of co-operation the centre was also reported to be a good way for the company to recruit skilled students.
- The techniques developed have been used by CC-systems in industrial pilot studies together with ESAB and Rolls-Royce Marine, and were later used at CC-systems to develop new embedded control systems.
- At Ericsson results from ASTEC projects have been integrated into products like: Improved Garbage Collection, Native code generation for SPARC and Intel X86 (for evaluation in real products), Compiler improvements and optimisations, Packages, and a hierarchical module system.
- Enea Embedded Technology was able to try out, and influence the development of, what they describe as some of the most advanced real time analysis tools on this planet. Participation also led the company to actively taking part in the European

level research community, with many interesting contacts with researchers from UK, Germany, France and Finland.

- Virtutech was helped in exploring interesting issues that they would otherwise not have the competence to pursue on their own.
- The collaboration with ASTEC on development of Tidorum's WCET tool was described as useful both directly – much of the work on a tool version for the Renesas H8/300 processor was completed in 2004 – and indirectly as it exposed the tool's architecture to outside review and comment. The contact with ASTEC contributed to Tidorum joining the ARTIST2 Network of Excellence, cluster on "Compilers and Timing Analysis" which started in 2004. The ASTEC/WCET work on improved modelling of the arithmetic computations in a program (interval analysis, pointer analysis) was described as very interesting to Tidorum and there was a feeling of a clear need to add such functionality to Tidorum's WCET tool in the future.

G2 BRIIE

- Sandvik AB has with assistance from BRIIE developed a new hard metal for cutting rock, which has become a corner stone in a new concept – the ICUTROC system – launched in 1999. The ICUTROC system is a multi million business for Sandvik.
- Sandvik has also developed three new varieties of sialon cutting tool material, which has generated business of around 10-15 MSEK/year over ten years.
- A new procedure which led to improved dispersion of powders, which is both economic and environmentally-friendly, has led to a patent published by Seco Tools.

G3 CAP

- Akzo Nobel Surface Chemistry has pointed out that knowledge built up within CAP has been very useful in the development of new associative cellulose derivatives (HM-EHECs) and in the formulation of new PUR thickeners. The investigation of new tools and development for methods for characterisation of amphiphilic polymers has also been a useful complement to the company’s internal work.
- For AstraZeneca, the participation has led to improved characterisation of polymers employed in pharmaceutical dosage forms, leading to increased knowledge regarding product functionality and, ultimately, decrease of lead times and production costs. It has also resulted in improved understanding of polymer films, gels and drug release from polymer tablets, as well as to recruitment of one PhD from CAP.
- Celanese Emulsions Norden AB has obtained detailed knowledge on polymer dispersions, including core-shell particles, functionalised particles and their interactions with surfaces, mixtures of particles, effects of added inorganic nano particles, and the drying of polymer dispersions.
- At Eka Chemicals, participation inspired development of new amphiphilic starches in a joint project with Lyckeby. It also led to improved basic understanding of adsorption mechanisms of retention polymers, leading to a broadened product range (2nd generation of amphiphilic polymers), and to new or improved methods for characterisation of polymers with respect to charge distribution and molar mass. Also, some characterisation of silica products was useful.

- Lyckeby Starch AB has as a result of participating in CAP developed a new product based on amphiphilic polymers for use in emulsions in food products such as mayonnaise and dressings. The product has brought the company into new markets. The company also developed film formation/controlled release as a new area of starch applications. It launched a project with Eka Chemicals, including a number of patents, and recruited new personnel with a special responsibility to take care of research results.
- SCA internal seminars held by CAP researchers both opened the mind and solved problems in the company. Senior researchers at CAP have as members of project reference groups in SCA internal projects and by other forms of consultancy strengthened its work. Reportedly, CAP management has very successfully bridged the gap between the academic way of working and industrial culture and business interest.
- Tetra Pak increased its competence on properties of renewable polymers, and on film formation and barrier properties of polymers, which was a crucial knowledge base for decisions on continuation or termination of internal development projects. They also had valuable input of ideas relevant to improving the functionality of new and existing packages, and recruited two PhDs.

G4 CBioPT

- Pfizer in Strängnäs believes that links to CBioPT and CBioSep helped the unit to attract an internal investment of around 1500 MSEK to the production plant in Strängnäs, opened in 2009. Although such a venture depends on many factors, Pfizer in Strängnäs observed that its ability to show high competence and good links to leading research environments was a key factor.
- Sobi/Pharmacia/BioVitrum was able to ‘productify’ into new services some of the capacity building it acquired in CBioPT and CBioSep. The company then sold the services as consultancy to other biotechnology firms.
- One new company has been established as a result of a patent filed, dealing with a new analysis technique for measurement of endotoxin i.e. a lipid which is present in several membranes in organisms.
- Another new company is a contract manufacturer and a process development company. The initiative for start-up of this company is taken from CBioPT and the School of Biotechnology and builds on a combination of the large scale equipment of KTH and knowledge generated in the centre.

G5 CBioSep

- BioInvent International has, with the help of CbioSep, been able to implement a range of new techniques and statistical methods in its production processes, which have both improved quality and reduced costs. Most input from BioInvent has concerned pharmaceuticals that are (still) not on the market. BioInvent estimates that the CC inputs will save hundreds of MSEK for a pharmaceutical product on the market.
- Pfizer in Strängnäs believes that links to CBioPT and CBioSep helped the unit to attract an internal investment of around 1500 MSEK to the production plant in Strängnäs, opened in 2009. Although such a venture depends on many factors,

Pfizer in Strängnäs observed that its ability to show high competence and good links to leading research environments was a key factor.

- Protista, a small company, claims that participation in CBioSep, where they were mostly surrounded by large corporations, has given them respect – both among companies and researchers – they would otherwise not have. That partly symbolic aspect has improved their sales. It has also led to new collaborations with researchers and companies in Sweden and internationally.
- Sobi/Pharmacia/BioVitrum learned in CBioSep that a core method – "two-phase systems" – it hoped to implement would not be possible to use and therefore decided to opt for another method. That decision was largely by the help of a researcher in CBioSep who was an expert in the area.
- Sobi/Pharmacia/BioVitrum was able to 'productify' into new services some of the capacity building it acquired in CBioPT and CBioSep. The company then sold the services as consultancy to other biotechnology firms.

G6 CCCD

- AXIS Communications in CCCD. A PhD student in CCCD supervised bv AXIS developed a technology that will become a key component in products representing at least 75 per cent of AXIS projected sales in the coming years; equivalent to sales that in 2011 amounted to 3 000 MSEK and which AXIS expects to grow by around 25 per cent per year during the coming years. AXIS sells network cameras for security supervision.
- Ericsson AB. CCCD has assisted Ericsson in the development of analogue-to-digital converters, which are key components of all mobile telephones. The participation has been crucial for the development of high-performance power amplifier linearisation architectures and circuits, provision of mixed signal circuits, both in-house developed and at procurement of external solutions, and the projects have been at the centre on echo cancelling, space time trellis coding, two dimensional FFT etc. The projects have been the starting point for much in-house circuit development at Ericsson. The centre has also delivered highly skilled PhDs to Ericsson (branches in Lund, Gothenburg and Stockholm).
- Perlos AB experienced the impact of participation as mainly long-term. One person was able to concentrate on a research task. The company's network within the university improved, which also generated partners for possible joint projects and evaluations of technology/theory, as well as access to new research facilities.
- Phase Holographic Imaging is an academic spin-off that was "incubated" in CCCD. The company was started in 2001 and was at that time lacking crucial competence in algorithms. CCCD helped them with the algorithms and also with circuit design. The company has had products on the market since 2011. This far they have sold about 15 instruments, which each cost around 250 kSEK.
- TeliaSonera has worked to understand the technology state-of-the-art and the potential for advanced circuits to be included in network nodes and end-user devices. It had an overall strategy for cooperation with leading competence centres contributing to the successful information and communications technologies (ICT) domain in Sweden and the Nordic market. The technical progress of integrated system on chip and applications specific integrated circuit design was regarded a key towards future access independent personal communication services.

G7 CERC

- Volvo Car Corporation and Saab Automobile improved their combustion engines as a result of participating in CERC. In particular Saab claims significant use of the centre.
- Volvo Powertrain has as result of participating in CERC learned how to burn DME in large diesel engines. DME is a biofuel from black liqueur. With the input from CERC, Volvo has been able to reduce emissions of carbon monoxide by 90 per cent and the fuel consumption by 20 per cent. This far Volvo has developed about ten test vehicles.

G8 CHACH

- Gotmic AB is a spin-off from CHACH. The company develops and sells high-speed circuits based on wireless LAN (WLAN) for very high frequencies. In 2011 Gotmic reported three employees and an annual turnover of 2.2 MSEK. The technology is developed partly in CHACH with special collaboration with Ericsson.
- Omnisys Instruments AB has had close collaboration with CHACH – most of the time the entire R&D staff has worked with the CC. With the help of CHACH the company has developed all its products, which the company estimates has increased its sales with around 30-50 %. In 1998 Omnisys Instruments had a net turnover of 7.5 MSEK; in 2010 it was 37.5 During the CC-period the company grew from five to 14 employees, today it employs 27 people.
- RUAG Space in CHACH. The company has developed a new microwave mixer. The mixer is a key component in the company's products and has been the most important reason behind the company's growth from ten to 30–40 per cent of the global market. The current market share is worth around 130 MSEK per year. RUAG expects to use the mixer in their products for a long time. As a consequence of the successful development and the increased sales, the product area and unit has become prioritised in the RUAG Group.
- SAAB Electronic Defence Systems has together with CHACH developed materials and designs for semiconductors. Implementation is expected to lead to a shift in semiconductor technology at SAAB. At present the technology is used only in a minority of the products and has therefore only had little economic impact, but Saab estimates that in 10-15 years the technology will be used in a majority of its products

G9 Charmec

- Between 1995 and 2011, Charmec has altogether strongly contributed to an economic impact for society and industry that can be estimated to between 1035 and 1430 MSEK per year, which not only includes the examples below. Charmec's contributions have been made on noise reduction, wheel pressure, corrugated rails, software programs, support in the introduction of new technologies and in preventing the accidents and breakdowns.
- Abetong AB has with the help of Charmec developed a new type of railway sleeper in concrete, which also led the company partly to rebuild its manufacturing plant. The new product has contributed significantly to Abetong signing a new contract with Swedish Transport Administration. With the new contract Abetong controls 60

per cent of the market segment in Sweden, which equals sales of around 135 MSEK per year. Abetong has also filed a patent application for the new sleeper.

- LKAB and StoraEnso have together saved 700 MSEK per year between 2006 and 2009 due to increased axle loads on around 40 per cent of the Swedish railway net, including the Iron Ore Line. The savings are partly a result of Charmec's collaboration with LKAB, Lucchini and the Swedish Rail Administration, which both led to improved wheel design of LKAB's iron ore wagons and subsequently to increased axle loads and thereby more loads in each wagon. The Swedish Rail Administration calculated the savings for LKAB and StoraEnso in 2009. If the same figures apply also for 2010–2012, the total savings for the two companies this far amount to 4200 MSEK. Also other companies using the railways for their freight have been able to increase their loads.
- Lucchini in Charmec has with the help of Charmec gained new insights into cracks in railway wheels caused by winter conditions. Lucchini have together with LKAB, Bombardier and Swedish Rail Administration been able to upgrade the Iron Ore Line (Malmbanan) in the North of Sweden to allow higher axle loads. Lucchini changed the wheel design; they found out that the wheels did not fit well enough with the rails, which caused costly damages. LKAB has saved about 8 MSEK on the wheel maintenance. The earnings due to more efficient transportation are unclear.
- Voestalpine GmbH, Vossloh Cogifer, Swedish Rail Administration and Deutsche Bahn have together with Charmec in an EU-programme, INNOTRACK optimised rail switches and crossings. The result is switches and crossings that are expected to have 24 per cent lower lifecycle costs than existing ones. Improvements include 10.2 per cent savings connected to changed design and new material choices, 11.7 per cent savings due to more efficient driving and locking devices and 4.2 per cent lower costs when monitoring can be decreased. The calculation also includes costs for expected train delays. The project was formally not carried out in Charmec as a CC; it was mainly carried out at a later stage, when Charmec's base funding came from the Swedish Rail Administration. The new switches and crossings today only exist as a few demonstrators. Charmec estimates that the improved switches and crossings will, when implemented in larger scale, save at least 100 MSEK per year in e.g. railway maintenance and traffic disturbances in Sweden.

G10 CID

- CID focused on user oriented design in ICT and human–computer interaction and seems to have made a valuable impact among some of its participants on the general awareness of the potential of the field. The CC mostly worked with highly applied projects, often with actors that are normally not part of this type of centres.
- Ericsson reported that it had been easy to use results from CID in the form of methods, which occurred at several places and eventually several development methods and usability labs came into production. CID research were directly or indirectly transformed into commercial services or products, e.g. the VideoCafé, which was initiated early with Ericsson Media Lab and carried through at CID. Internally at Ericsson it was commercialised into a system for telemedicine.
- Another relevant research area is Smart Things, where CID and Ericsson started common research in 1998 around services, tools and methods for smart things. Ericsson had a parallel track for commercialising a system for simple connection of

web services to physical objects. This was an activity in the spin-off company ConnectThings, which started in 1999 and was bought by AirClic. It was financed by Symbol, Ericsson, Motorola and Goldman-Sachs. AirClic later sold company solutions for tracking, e.g., persons, assets or processes on the move over large distances.

G11 CPM

- ABB has in close cooperation with university researchers at CPM developed Environmental Product Declarations for about 100 key products and systems. Life Cycle Assessments lie at the core of this work. The work with CPM has also led ABB to develop internal protocols for monitoring sustainability impacts of all products under development. In addition, the company has been able to develop a comprehensive database to better assess environmental impacts of the products. ABB considers itself leading in the application of Life Cycle Assessments.
- AkzoNobel has with the help of CPM developed Eco-Efficiency Assessments for 330 key products throughout the whole corporation and developed methods that the whole corporation must use when making investments. In 2005 the corporate management decided that the Sustainable Development-group in Gothenburg would be responsible for introducing Eco-Efficiency Assessments within the whole AkzoNobel corporation.
- SKF has, most probably thanks to CPM, selected Chalmers University of Technology as its partner university for sustainability, which beside participation in CPM also includes funding of the SKF-Chalmers University Technology Centre for Sustainability, inaugurated in March 2012 with more or less the same topics as CPM and led by former CPM staff.
- AB Volvo has with the help of CPM developed both basic and applied research and integrated Life Cycle Assessment into all parts of the corporation. The company claims to that it thanks to CPM is the only producer of heavy duty lorries that can offer a complete Life Cycle Assessment of a lorry.

G12 CTT

- Södermalms Talteknologiservice (STTS) is built entirely on its participation in CTT. STTS is a small privately owned SME, founded in 2002, that in 2011 had about five employees and an annual turnover of 8MSEK.
- The Infovox company, originally started by senior members at CTT in the 1980s, joined forces with the Babel company in Belgium. The new company, Babel-Infovox, subsequently merged with the Elan company in France forming the Acapela Group. Acapela Group became a major European company in the field of speech technology. The research and projects run at CTT opened new business opportunities for the company. As a result of the collaboration, new advanced cutting edge technologies were introduced to the company. Thanks to the CTT co-operation the company was planning an expansion to new markets where Acapela Group was not earlier present. Thanks to research results from CTT Acapela Group has been able to highly improve the quality of the latest generation of text-to-speech products.
- CTT and Telia had an active co-operation ever since the start of CTT, especially in the fields of Spoken Dialog Systems and Multimodal Synthesis. TeliaSonera R&D

was very active in the creation of the multimodal dialog system AdApt at CTT. The system has been demonstrated at many occasions at TeliaSonera and played an important role to show future possibilities for new advanced services in the company. The TeliaSonera group expanded with two PhDs educated at CTT, and it was successful in creating an international reputation of high quality research and development. CTT played a role for the progress of the group by joint projects, education and personal interaction.

- ABB carried out work to expand the ABB Aspect Integrator Platform with speech interaction possibilities, which resulted in a paper that was presented at the 2003 International Conference on Auditory Display. One initiative at ABB focused on mobile applications, primarily within the area of Process Automation. During 2003 a project called WiseTech (Wireless Service Technician) was started at ABB Corporate Research in which CTT was involved. Among other things, the project tried to find out the customer value of speech technology.
- The Swedish Television joined CTT to push forward the idea of exploring speech synthesis as an alternative way to present subtitles in television. Positive results led to the introduction of this service in the digital terrestrial television network in 2004.

G13 EKC

- ABB has with the help of EKC developed diagnostic tools for cables, transformers and rotating machines. ABB can now quickly diagnose the functionality and change the parts only when needed. The methods are only used internally. The economic impacts have not been calculated
- EKC has developed a range of models, methods, schemes and algorithms to control, monitor and regulate power networks
- EKC has contributed to development and regulation of models, analytical tools and computation models for analysis of electricity markets and regulation of electricity power networks
- The CC has developed so called permanent magnet drives for industrial tools, which makes engines more energy efficient. The technology has been implemented in e.g. ITT Flygt’s pumps and mixers, which is believed to strengthen ITT Flygt’s market position over time, for example on the U.S. market

G14 Faxén Laboratory

- ABB has based on the project in FaxénLab developed an algorithm that simulates turbulence caused by electromagnets in melted steel. It is unclear if the project has led to more electromagnet sales, but ABB notes that it is important to show an interest in innovation in order to sell products of this type. ABB often presented the project to customers and other parts of ABB as a prime example of successful collaboration with university researchers.
- ProcessFlow Oy developed a simulation model for flow in pulp for paper making as a result of participating in FaxénLab. The project at FaxénLab directly led to a large project with a paper producer, and the product has later been used in collaboration with Metso and other paper producers.
- Design and construction of an apparatus for the development of a new method for water purification using ion-exchanging textile fibres. This is an example of

hardware developed at the Centre; the apparatus went into use at Vattenfall Utveckling AB.

- In the Material Processing program, a physical model was developed for the air gap formed between the mould and the solidified metal shell in casting processes. In addition, an extensive experimental program was carried out to measure certain material data and air gap characteristics for a number of Al- and Cu-based alloys. Data and mathematical models were used by Outokumpu Fabrication Technologies AB and SAPA AB.
- A working Group with AGA AB and Ipsen International GmbH was formed, in which advanced numerical modelling was used for the global optimisation of gas quenching chambers used for quenching of metal objects of different shapes. Experimental studies of heat transfer from geometrically simple bodies were used for verification of models and numerical schemes. The project was executed in parallel with development and experimental work at Ipsen International GmbH. In a post-graduate project, financed explicitly by Linde Gas, the technology was adapted and made available for Linde Gas.
- Methodology and equipment was developed and made available for ABB Automation Technology AB and Belden CDT Nordic AB (previous CDT Nordic) for experimental investigation of mechanical properties of cables of interest for applications where the cable is subject to movements. In addition, analytical methods and numerical tools were provided for an engineering analysis of the influence of different parameters on the life-time of the cable. These tools were delivered to the partners. ABB Corporate Research worked further for establishment of a complete modelling approach in design of cables for industrial robots.

G15 HTC

- Sandvik has with the help of HTC developed two or three completely new metal alloys for high temperatures and discovered a new application. None of them has however yet been implemented in products; the development process for new high temperature materials is often 15 years
- The partner firms have been consistent on emphasising that HTC should focus on basic, long-term research to build capacity in the sector over time. This is HTC’s main contribution to industry this far
- HTC has worked extensively with fireside corrosion when burning municipal waste for energy extraction. The problem has been very complex and of significant interest to several of the largest partner companies; much money and environmental savings can be made once a good solution is found. At the end of the investigated period HTC had gained important insights, but no implementation had been realised at that time

G16 ISIS

- ABB has based on ISIS developed control technology for industrial robots. ABB considers itself world-leading in control technology for robots, largely due to ISIS. The company estimates that the ISIS input has generated 150 000 new customers and been the most important factor explaining the company’s current global market share of 15 per cent. The technology is included in robots which ABB sells for at least 4 BSEK, possibly 10 BSEK, per year.

- ABB Corporate Research included results from ISIS in the multi-variable Model Predictive Controller ”OptimizeIT Predict & Control” from ABB. It addressed a common objection to the use of state-space models in Model Predictive Control: that prior knowledge about non-existent dependencies between inputs and outputs has been hard to use when identifying a multivariable process. Another project on model predictive control for non-linear processes contributed to the general knowledge build-up that was expected to be exploited in further product enhancements. ABB developed a rather general tool to detect and isolate faults in the process industry, used in pulp & paper mills. Some of the important basic ideas and solutions to problems for the tool can be attributed to ISIS.
- Ericsson AB. ISIS has made significant contributions to algorithms that regulate the signals between mobile telephones and base stations in 3G networks. Ericsson's occupies 40–50 per cent of the global market and sells products in this market that are worth more than 10 BSEK annually.
- For Mecel AB the co-operation with ISIS played an important role for the ability to build relevant competence within its core-business, i.e., ion-sense based diagnosis and engine control. The company works with cutting edge technology in this area. Customers turn to them in order to benefit from know-how, and the applications are demanding. An example of Mecel's customers is Ferrari Sportiva, the formula one racing team. In March 2003, it was announced that Mecel became an official partner to Ferrari. Specifically, ISIS and Mecel together have applied for and received a patent in the area of model based signal processing applied to ion sense signals. The patent has been used in a project for a paying customer. Other examples of application areas of interest for Mecel that are studied within ISIS are model based diagnosis, detection, combustion engine modelling and control, and non-linear signal processing.
- NIRA Dynamics AB has as a result of participating in ISIS developed a method to measure the pressure in car tyres. The innovation made NIRA Dynamics world leading in the area, which resulted in Audi, Volkswagen Group, buying 95 per cent of the company in 2006.
- SAAB AB has, as a result of participating in ISIS, improved several functions in JAS Gripen military aircraft. Improvements particularly concern the navigation system, where algorithms developed in ISIS solved the problem of locating the horizon when flying in poor weather conditions. In connection with this, a number of applications have their roots in the research performed within ISIS.
- SAAB Bofors Dynamics had a direct use of ISIS results in the development of products, especially some of the Terrain navigation systems. The manifold filters in combination with Bayesian statistics was also expected to be a powerful tool to evaluate approximations in sensor-fusion and adaptive filtering among a number of products. The theory developed in this projects also increased the knowledge level for the company's employees so they can understand and use more advanced theory in later projects and products.
- SAAB Automobile reported that the project at Vehicular Systems on model based diagnosis and detection of very small air leakages was instrumental when deciding on the route for future development of functionality: The approach and the use of models became a natural method used for development of new algorithms in engine control system (Trionic) both for diagnosis and control. The basic modelling

specifically directed towards turbo engines and the utilisation of these models in function development are directly coupled to the development process towards future advanced control systems. This included for example directed projects on driveline resonances and joint projects on implementation of experimental platforms.
- Volvo Car Corporation has had secondary use of ISIS. The fundamentals of the technology that ISIS developed for military aircrafts at SAAB were later used in a PhD project partly funded by the IVSS-programme (outside ISIS), which formed the basis for an automatic brake system for cars.

G17 KCFP

- Volvo Car Corporation and Saab Automobile improved their combustion engines as a result of participating in KCFP. In particular Saab claims significant use of the centre
- KCFP has for most part of the period focused on the so called HCCI engine, (HCCI stands for Homogeneous Charge Compression Ignition), which has included extensive studies within e.g. kinetic computations, laser diagnostics and engine analyses and attracted a range of large automotive corporations, including big multinationals such as Toyota, Nissan and Caterpillar

G18 KCK

- Volvo Car Corporation and Saab Automobile improved their combustion engines as a result of participating in KCK. In particular Saab claims significant use of the centre.

G19 MiMeR

- Höganäs observes clear links between the capacity it has built in MiMer and strategies for waste products.
- Outokumpu Stainless AB, in co-operation with MiMeR and Mefos in Luleå, has developed a method where hydroxide slurry can be used as new raw material in the production of stainless steel. This way, a material that has been disposed of can be completely re-circulated, which provides environment benefits as well as economic benefits for the manufacturing companies.
- Uddeholm Tooling decreased its environmental costs by 80 per cent through a method from MiMeR for recycling of dust in steel manufacturing.

G20 NIMED

- The development of the Tissue Viability Imager (TiVi) and start-up of the company WheelsBridge AB in the fall of 2004 has the roots in the long-term research activities in biomedical optics at the department of biomedical engineering (IMT) at Linköpings Universitet.
- The company LB Index AB was founded in 2006 as a result of activity within NIMED, expecially emerging from the collaboration with the industrial partner Siemens Elema AB and later on due to funding by VINNOVA and support by University Holding, Linköping.

G21 Polhem Laboratory

- Volvo Aero's (now a part of the British company GKN Aerospace) participation in the Polhem laboratory, and the useful results achieved from it, is associated with the company's growing interest in functional sales during the 1990s. The specific content in the projects run in the Polhem laboratory was within product development and computer simulation. The innovation developed upon results from the centre is a light-weight concept which became world leading. The company roughly doubled its share of the world market. The activities in the Polhem laboratory and other publically funded R&D initiatives laid the foundation for the company's backlog for the next 30 years valued around 120 billion SEK.
- Hägglunds Drives AB has been able to improve the efficiency for Integrated Product Development. Hägglunds Drives turnover grew from 600 MSEK in 1995 to 900 MSEK in 2002. The company's sales have changed from selling components during the 1980s to selling more systems and looking at function sales.
- Volvo Car Corporation has accessed new ideas and technologies that enabling it to integrate and automate some virtual analysis software, making these processes more efficient, e.g. the prototype system for structural dynamic and aero-acoustic integrated numerical analyses. The Polhem Laboratory provided a good ground for the future employment of graduated engineers. It gave the opportunity to exchange experience, knowledge, and competence with different academic research groups, and other industrial partners and international expertise. Many of the designs from one of the projects have resulted in patents or have been implemented in vehicles.
- AB Sandvik Coromant's participation in the Polhem Laboratory and finite element simulations has provided a deeper understanding of the cutting process. Sandvik Coromant's R&D team uses this knowledge to provide a strong evaluation basis for future technologies and also to predict influences on the cutting process and work piece more accurately. The finite element simulation of the cutting process has successfully been used in training to demonstrate the mechanisms of cutting.
- MSC.Software Nordic has increased the number of direct work with other partners. The most important input received from these industrial partners is in which direction they would like to go and what future needs they have in welding and cutting simulations. In addition to the direct support the code development has gained, input and detailed knowledge from the centre (and the industrial partners participating) of the need for different simulation capabilities have been obtained.
- Through its involvement in the Polhem Laboratory Ferruform AB started the evaluation of the forming process using finite element simulations, started a number of projects together with different partners to create new demands in the product development process, and developed and registered the patent for a new laser welding method, used to produce the future shafts. Ferruform also started the R&D department, installed equipment for distributed engineering, provided systems for FEM-analysis, participated in DITRA and EVOnet projects, joined Complab at Luleå University of Technology, and strengthened the collaboration with other industrial partners, e.g., Daimler-Chrysler, M.A.N., and Volvo.

G22 PSCI

- Comsol, a company based in Stockholm collaborated with PSCI throughout the ten-year period, a time during which it went from being almost entirely a distributor of the software MAT-LAB to developer of a sophisticated software product FEMLAB/COMSOL MultiPhysics for solution of partial differential equations with scientific and engineering applications. PSCI played a role in this development. The main software system was named Comsol Multiphysics and the company grew to over 150 employees and SEK 200 million in sales.
- The company Efield was started directly as a spin off from the PSCI project GEMS. It developed software systems for electromagnetic simulations with applications, for example, in antenna design and to radar signature evaluations.
- Wiglaf was started as a small company by a group of PSCI graduates. Its focus was consulting and CFD in connection to building computer clusters.
- Pharmacia developed a table for dose planning, and Höganäs designed a metal powder atomisation nozzle.
- GEMS, the largest PSCI project, a software simulation system for electromagnetic simulations had a strong impact on Ericsson, Saab and FOI, the Swedish Defence Research Institute.
- ABB Fläkt developed optimisation in the design of fan blades for large tunnel fans, which minimised the efficiency penalty.
- Other co-operation projects at PSCI included screw compressor simulation in collaboration with Svenska Rotormaskiner and after-burner simulation on IBM SP2.

G23 KI Radiation Therapy

- The development of a new technique for producing narrow scanned photon beams for efficient delivery of intensity modulated radiation therapy.
- The development of a new fast laser, scanner for 3-dimentional patient imaging for integration with high accuracy tumour diagnostics and treatment delivery systems (patent pending).
- The development of a high resolution, high sensitivity detector array for portal imaging in radiation therapy (patent).
- The development of a new radiation dosimeter of unprecedented geometrical resolution and negligible angular dependence.
- The development of a new synergistic treatment technique where high intensity ultrasound is producing X-raylike DNA-damage.
- The development of a dedicated low energy treatment unit for intensity modulated con-formal radiation therapy (patent pending).
- Bayesian method for fast update of new treatment results into radiobiological treatment optimisation algorithms.
- The development of a new approach to light ion therapy employing Deuterium, Lithium, Beryllium, Boron, Oxygen and Fluorine ions in a biologically optimised treatment.
- The development of new transport codes for electron and light ion transport in tissue.

- The development of new low-noise high-resolution methods for MRI, SPECT, PET and CT.
- The development of a dedicated diagnostic high energy treatment unit for intensity modulated conformal radiation therapy and in vivo dose delivery monitoring.

G24 SNAP

- AkzoNobel Surface Chemistry AB has with the help of SNAP developed a set of low-foaming alkyl glucosides sold as hydrotropes and wetting agents in alkaline or high electrolyte applications. The sales of the products amount to about 40-60 MSEK per year.
- AstraZeneca has with the help of SNAP saved at least 10 MSEK per year by making the production process of one of its products more efficient.
- Intenz Biosciences AB is a biotechnology spin-off based on an innovation that AstraZeneca made in SNAP. Intenz Biosciences does in October 2012 not have a product on the market and had in the end of 2011 no reported employees, but has attracted venture capital.
- Kemira previously produced surfactants for washing detergents. Knowledge gained in SNAP enabled the company to offer better arguments in selling situations, for example to better point at how the potential customer could implement the product most efficiently, or how the customer and Kemira could organise a common project around a product.

G25 S-SENCE

- The voltammetric electronic tongue, developed within S-SENCE led to the foundation of a spin-off company, Senset AB, in 2001. The commercialisation led to a method for the determination of the environmentally important parameter chemical oxygen demand (COD) and on-line analytical systems were installed in the paper and pulp industry, e.g. at the S-SENCE partner Billerud. These systems have proven very reliable, with a minimum of maintenance.
- A silicon carbide based sensor system was developed together with NIBE industrier for control of domestic boilers. The sensor system, which also included a commercial temperature sensor, was used to control the primary and secondary air inlet of the wood fuelled boiler. The combustion efficiency increased considerably and the emissions were drastically lowered. Both wet wood and very dry wood could be used as fuel, still with good result. The project led to the formation of a spin-off company, SenSiC AB, launched in 2007, with NIBE as the first customer. SenSiC is now commercialising SiC sensors e.g. for NIBE and other domestic boiler manufacturers and as an oxygen sensor for the automotive industry.
- In 2004 it was reported that the SiC based NH3 sensor successfully detected 10 ppm NH3 in diesel exhausts. It was taken as proof of concept by AppliedSensor and technology transfer was performed for the application control of SCR in diesel trucks. The SCR, Selective Catalytic Converter, process means that NOx is reduced in the catalytic converter by NH3, which is injected as urea in the exhaust system. The commercialization of the SiC based NH3 sensor was, however, stopped in the company in 2006. The SiC based sensors are now commercialised by SenSiC.

- SiC-FET ammonia sensors were successfully tested on two Volvo trucks during a 10 days excursion in Spain. The two trucks were equipped with urea injection systems in order to reduce the nitrogen oxide emissions.
- Already in stage I it was shown that SiC based gas sensors can be operated at 1000 °C for a short time and show time constants below a few milliseconds when operated at temperatures ≥ 550 °C. These properties facilitated cylinder-specific monitoring tests on the exhaust gases from real engines at Mecel AB in Åmål.
- AppliedSensor (formerly NST) is not a real spin-off company from the activities of S-SENCE since it was started before the start of S-SENCE. However, it is a spin-off company of the research on metal-insulator-semiconductor field effect transistors, MISFETs, that was used in the electronic noses that constituted the scientific base for the establishment of S-SENCE at that time. S-SENCE has been important for the development of the company and the company has been important for the development of S-SENCE.
- AppliedSensor has carried out development on a hydrogen sensor for safety applications in the automotive segment. In 2007 it was announced that AppliedSensor's hydrogen gas detection module is incorporated in the BMW Hydrogen 7 which was the first hydrogen driven car in the luxury performance segment. The connection between AppliedSensor and BMW was initiated in 2002. The development was then carried out at AppliedSensor, including former employees at LiU/S-SENCE employed by AppliedSensor, in collaboration with BMW.
- New types of biosensor surfaces have been developed both for Biacore and Biosensor Applications. The detection of small molecules, explosives and narcotics was successfully demonstrated using imaging surface plasmon resonance and selective immobilised antibodies. Discrimination of different drugs in a mixture (heroin, ecstasy, cocaine, ...) was obtained.
- An electronic tongue was implemented in the product line in a dairy industry (Skånemejerier). The electronic tongue could follow milk qualities, change of milk sources, and cleaning efficiency for over six months without any need of servicing.
- A method for monitoring water quality at a water production plant of Tekniska Verken was introduced. Successful measurements of the water quality have been performed. Also, an automatic sample handling system has been developed and run for four months.

G26 SUMMIT

- SUMMIT made an important achievement by gathering significant parts of the Swedish industry interested in the emerging field of micro systems technology, disseminating research and supporting the firms in applications. Several successful firms have participated in or in other ways benefitted from SUMMIT. Successful members include Radi Medical Systems (today St Jude Medical Systems) and Åmic. Åmic, bought by Johnson & Johnson in 2009 and then relocated to the U.S., has spun out several small companies often listed among promising start-ups, such as Gyros AB and Sigolis AB. Åmic's technology also connects to technology in Q-Linea, listed by Sweden's leading technology newspaper Ny Teknik as one of the 33 hottest Swedish firms in 2012. Also Rolling Optics, on Ny Teknik's top-33 list for three consecutive years, 2010, 2011 and 2012, has worked with SUMMIT and uses technology developed in the CC. Sweden's prime 'success story' in the field, Silex Microsystems AB, founded in 2000 and with 190 employees in 2011, was never part of the CC but has benefitted indirectly for example by recruiting a number of PhDs from SUMMIT

G27 VoxénCentrum

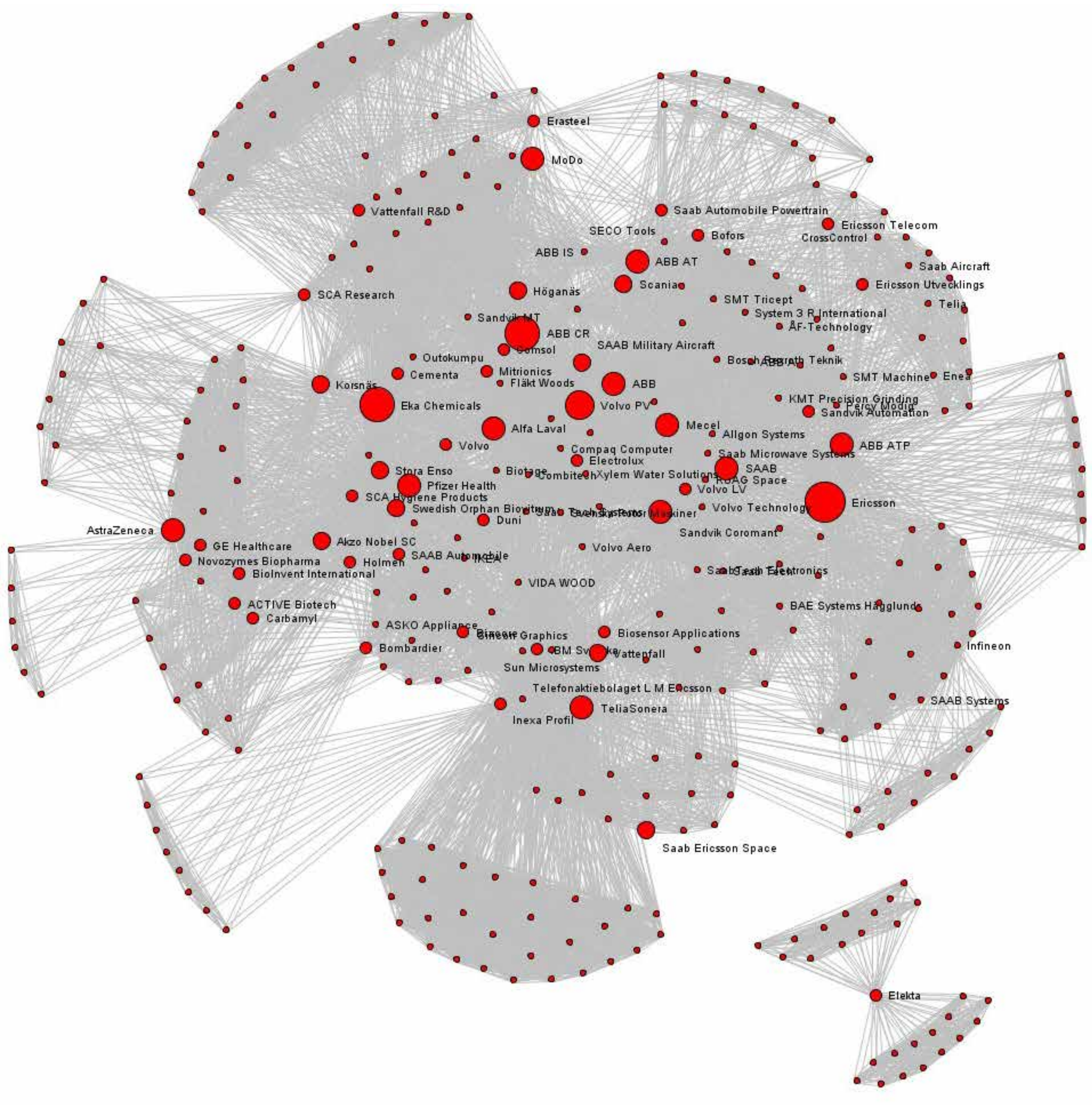
- The software vendor Delfoi has made a commercial software tool based on the results of the DFA2 (Design for Automatic Assembly) project.
- Eurostep Commercial Solutions AB's product Share-A-space™ is a "product data portal" for collaborative development. The development of the product was partly based on research work at WoxénCentrum. The Share-A-space™ product came into use in production by companies like Hägglunds Vehicle, Volvo and FMV. It was also used by KTH and CTH in their research and educational programmes.
- A patent was filed as a result of a research project in WoxénCentrum: 'SKAPA' (Skiktvis Kvasiisostatisk Additiv PulverApplikation), 'SQAPA' (Sheetwise Quasi-isostatic Additive Powder Application).
- An extension was developed to the web browser for viewing and traversing related product, process and resource data and documents in the Product Data Technology Network project, PDT Net. The goal was to realise a communication scenario between Scania and ABB when developing a manufacturing system. The communication is based on Step AP 214 and XML. It was demonstrated at the International Symposium on Robotics (ISR 2002). It was also been presented and demonstrated at the Swedish final event for Product Data Technology Network seminar and at the Interest Group meetings at ProStep in Germany.
- A framework for concurrent specification of manufacturing systems was also developed on the basis of a case study at Scania. This framework consists of a generic information model, in which applicable processes to manufacture are defined.
- The Alfa programme regarding reformulating the business strategy of the company into a concrete production strategy, i. e. plan for development of the production system engaged five companies. It was planned to be published as an industrial guideline manual and distributed through several channels during spring 2007.
- All 'classic' PhD students were employed by industrial companies after examination.

G 28 WURC

- WURC was established to increase competence in the paper and pulp industry of the properties of the wood fibre. Wood fibres are fundamental in the sector. At the beginning of the CC, there was a significant gap between the level (and possibilities) of university research and the level of competence in industry on the field. Initially WURC therefore provided relatively basic research, presented to build capacity and promote the field in industry. During the second half of the CC, industry's capacity to absorb WURC's research was higher, and the character of the projects could therefore shift towards more applied research. WURC has clearly made an important contribution to the sector: all five responding firms praise the CC for proving highly useful capacity building in the sector. WURC has also formed the basis for much of present collaboration between the paper and pulp industry and universities.

- SCA has with insights from WURC been able to develop new methods to make its production of mechanical pulp consume less energy.
- Södra Cell in WURC. Södra Cell is a leading producer of pulp for paper-making, with specific strengths in high quality pulp and fibres, today recognised as world leading on wood fibre knowledge and gives courses on the topic to its customers; much of that competence has been developed as a result of participation in WURC.

Appendix H Network of CC participation



Appendix J Interviews with company representatives

Eva Ahlner	Naturvårdsverket	CPM
Björn Andersson	Elekta	KI Radiation Therapy
Gunnar Bark	Ericsson	ISIS
Tomas Berns	Ergolab AB	CID
Harald Berthelsen	STTS Södermalms taltekn	CTT
Tommy Björkqvist	SICEC prev SAAB Automob	CERC, KCK, KCFP
Rikard Bolmsvik	Abetong	Charmec
Gunnar Brandt	Sandvik	BRIIE
Torgny Brogårdh	ABB	ISIS
Johan Carlert	SAAB AB	CHACH
Lisbeth Dahllöf	Volvo Technology	CPM
Gunnar Edwall	prev Ericsson	SUMMIT
Peter Egelberg	Phase Holographic Imaging	CCCD
Bengt-Olof Elfström	Volvo Aero/GKN Aerospace	Polhem
Daniel Elvin	AXIS Communications	CCCD
Karin Emilsson	Södra Cell	WURC
Anders Emrich	Omnisys Instruments	CHACH
Sonja Enestam	Metso Power	HTC
Kennet Eriksson	Process Flow	Faxén
Cristina Glad	BioInvent	CBioSep, CBioPT
Börje Grandin	Volvo Cars	CERC, KCFP
Jan-Gunnar Gustafsson	prev Biovitrum AB	CBioSep, CBioPT
Ulla Gytel	Kemira Kemi AB	SNAP
Björn Haase	Höganäs	MiMer
Klas Hallberg	Akzo Nobel	CPM
Tommy Hedberg	Atos Medical AB	NIMED
Björn Holmgren	ABB	EKC
Paul Häyhänen	Ruag Space	CHACH
Susan Iliefski Janols	SCA Hygiene	CPM
Ove Ivarsen	Swe Trade Union Conf (LO)	CID
Mats Jarekrans	prev Pfizer Health	CBioSep, CBioPT
Pia Jour	Eka Chemicals	WURC
Hans Jungvid	Protista Biotechnology	CBioSep
Rickard Karlsson	NIRA Dynamics	ISIS
Bengt Kasemo	Insplorion AB	KCK
Erik Kihlberg	Lucchini	Charmec
Bengt Larsson	Alfa Laval Lund AB	Woxén
Mats Lundberg	Sandvik	HTC
Kennet Lundin	Ericsson AB	ASTEC

Birger Löfgren	SKF	CPM
Sven Mattisson	Ericsson	CCCD
Anders Moberg	StoraEnso	WURC
Thomas Nordmark	LKAB	Charmec
Joakim Oberhammer	KTH, on Network Automation	SUMMIT
Jan Palmqvist	SAAB AB	ISIS
Predrag Pucar	NIRA Dynamics	ISIS
Jan Qvick	Seco Tools	BRIIE
Anders Rydahl	AB Electrolux	Woxén
Peter Sandström	SCA	WURC
Richard Stock	Voestalpine	Charmec
Lars Strandberg	Biovitrum AB/Sobi	CBioPT
Stefan Sundin	Erasteel	BRIIE
Anders Sunesson	Perlos/Lite-On	CCCD
Lennart Swanström	ABB	CPM
Lasse Tenerz	prev Radi Medical Systems	SUMMIT
Jan Tengzelius	Höganäs	BRIIE
Peter Thormählen	Ecaps AB	KCK
Claes Tjäder	Swe Inst of Assistive Techn	CTT
Helena Tufvesson	Korsnäs	WURC
Stefan Ulvenlund	AstraZeneca, Intenz Bioscience	SNAP
Heije Westberg	Volvo Technology	KCK
Ola Widlund	ABB Corporate Research	Faxén
Olle Wikström	Lyckeby Starch	CAP
Lars Wrangensten	Elforsk	HTC
Eva Österberg	Akzo Nobel Surface Chemistry	SNAP

Appendix K Interviews with CC managers and university representatives

Fritz Bark	Royal Institute of Technology	Faxén
Bo Björkman	Luleå University of Technology	MiMer
Anders Brahme	Karolinska Institute	KI Radiation Therapy
Per Martin Claesson	Royal Institute of Technology	SNAP
Geoffrey Daniel	Swe Univ of Agricultural Sci	WURC
Anders Ekberg	Chalmers Univ of Techn	Charmec
Björn Engquist	Royal Institute of Technology	PSCI
Mats Eriksson	Linköping University	S-Sence
Jan Grahn	Chalmers Univ of Techn	Chach
Björn Granström	Royal Institute of Technology	CTT
Roland Grönroos	Uppsala University	ASTEC
Klas Hjort	Uppsala University	SUMMIT
Lars-Gunnar Johansson	Chalmers Univ of Techn	HTC
Bengt Johansson	Lund University	KCFP
Bengt Jonsson	Uppsala University	ASTEC
Lennart Karlsson	Luleå University of Technology	Polhem
Bengt Kasemo	Chalmers Univ of Techn	
Per-Olof Larsson	Lund University	CBioSep
Gen Larsson	Royal Institute of Technology	CBioPT
Mark Linné	Chalmers Univ of Techn	CERC
Lennart Ljung	Linköping University	ISIS
Roger Lundén	Chalmers Univ of Techn	Charmec
Thomas Lundholm	Royal Institute of Technology	Woxén
Lars Nordström	Royal Institute of Technology	EKC
Lennart Piculell	Lund University	CAP
Emma Rex	Chalmers Univ of Techn	CPM
Magnus Skoglundh	Chalmers Univ of Techn	KCK
Folke Snickars	Royal Institute of Technology	
Bengt Steen	Chalmers Univ of Techn	CPM
Göran Stemme	Royal Institute of Technology	SUMMIT
Tomas Strömberg	Linköping University	NiMed
Yngve Sundblad	Royal Institute of Technology	CID
John Ågren	Royal Institute of Technology	BRIIE
Viktor Öwall	Lund University	CCCD

Appendix L Graduate students' career survey

Välkommen till denna enkät som utgör en del av den pågående effektutvärderingen av Kompetenscentra finansierade av VINNOVA och Energimyndigheten under 1995-2007. På uppdrag av de två myndigheterna genomförs utvärderingen av Technopolis Group.

Du som mottagare av enkäten har enligt uppgift doktorerat inom något av de 28 aktuella Kompetenscentra.

Du kan svara på några frågor i taget, lämna enkäten och sedan återkomma vid ett senare tillfälle. Var dock noga med att alltid trycka på "Nästa" innan du lämnar enkäten för att sidan ska sparas. När du trycker på "Klar" lämnar du in enkäten. Svaren kommer endast att presenteras på aggregerad nivå, så att enskilda individer och mindre grupper inte kan identifieras.

Vi uppskattar att enkäten tar 8-10 minuter att fylla i. Vi vill ha dina svar senast fredag den 31:a augusti 2012.

Om du har några frågor om enkäten eller om vårt uppdrag, kontakta Tobias Fridholm, tobias.fridholm@faugert.se, 08- 55 11 81 15 eller Peter Stern, peter.stern@faugert.se, 08 55 11 81 06.

1 Vilket år är du född?
Välj födelseår i rullgardinen

2 Vilket år disputerade du?
Välj disputationsår i rullgardinen

3 Vilken typ av arbetsgivare och arbetsuppgifter har du haft efter din disputation?
Vänligen börja med din första arbetsgivare efter disputationen och ange sedan resten i kronologisk ordning.
Organisationstyp; Huvudsakliga arbetsuppgifter; Var du ansvarig för samverkan mellan industri och lärosäte/institut?; Fick du anställningen genom kontakter från Kompetenscentret?

4 Här har du möjligheter att lämna kommentarer och övriga synpunkter på fråga 1-3:

5 Vilken betydelse hade förekomsten av Kompetenscentret i ditt val av forskningsmiljö att disputera i?
- Ingen betydelse
- Liten betydelse
- Stor betydelse
- Avgörande betydelse

- Vet ej

6 Var vänlig gör en bedömning av hur du uppfattar att den forskningsmiljö du disputerade i skilde sig från andra forskningsmiljöer inom samma fält.

Gradera från 1-7 där 1 betyder ”mycket mindre” och 7 betyder ”mycket mer”; Vet ej.

- Kontakter med industrin
- Kontakter med framgångsrika forskningsmiljöer vid universitet/högskola
- Effektiv organisation av forskningsmiljön
- Ditt inflytande över ditt avhandlingsprojekt
- Dina möjligheter att skriva en avhandling av hög akademisk kvalitet
- Dina möjligheter att skriva en avhandling med hög industriell relevans

7 I vilken utsträckning tror du att Kompetenscentret påverkat följande, jämfört med om du disputerat i en mer traditionell forskningsmiljö?

Gradera från 1-4 där 1 betyder ”i mycket liten utsträckning” och 4 betyder ”i mycket stor utsträckning”; Vet ej.

- Din vilja att utföra forskning (”hands-on”)
- Din vilja att leda forskning
- Din vilja att arbeta vid universitet/högskola
- Din vilja att arbeta vid institut
- Din vilja att arbeta i industrin
- Din vilja att initiera/delta i samarbeten mellan universitet/högskola och industri

8 Vad tror du att du haft för nytta av att disputera i ett Kompetenscentrum, jämfört med en mer traditionell forskningsmiljö vad gäller följande faktorer?

Gradera från 1-4 där 1 betyder ”inget mervärde” och 4 betyder ”stort mervärde”; Vet ej.

- Nätverk i universitet/högskola
- Nätverk i industrin
- Kunskap om hur man bedriver industriell FoU
- Kunskap om hur man kan kombinera hög akademisk nivå med industriell relevans

9 Hur viktiga anser du att nedanstående kunskaper/resurser är för en nydisputerad doktor?

Gradera från 1-4 där 1 betyder ”inte alls viktigt” och 4 betyder ”mycket viktigt”; Vet ej.

- Nätverk i universitet/högskola
- Nätverk i industrin
- Kunskap om hur man bedriver industriell FoU
- Kunskap om hur man kan kombinera hög akademisk nivå med industriell relevans

10 Sammantaget, hur mycket mervärde tror du att fått av att disputera i ett Kompetenscentrum jämfört med om du disputerat i en mer traditionell forskningsmiljö?

Gradera från 1-7 där 1 betyder ”mycket negativt” och 4 betyder ”mycket positivt”; Vet ej.

11 Här har du möjlighet att lämna kommentarer och övriga synpunkter på fråga 5-10:

12 Till dig som efter disputationen arbetat i industrin: I vilken utsträckning har det/de företag du arbetat i dragit nytta av följande?

Gradera från 1-4 där 1 betyder ”i mycket liten utsträckning” och 4 betyder ”i mycket stor utsträckning”; Vet ej.

- Den tekniska/metodmässiga/teoretiska expertis (ditt humankapital) du skaffade dig under doktorandtiden
- De tekniska lösningar du utvecklade under doktorandtiden (analysresultat, koncept, algoritmer, etc)
- Din kunskap i hur man effektivt samverkar med universitet/högskola
- Dina nätverk inom universitet/högskola

13 Arbetar du idag med problem närliggande de problem du arbetade med under doktorandtiden?

Gradera från 1-4 där 1 betyder ”i mycket liten utsträckning” och 4 betyder ”i mycket stor utsträckning”; Vet ej.

14 Hur många patent har du?

- Totalt?
- Till följd av doktorandarbetet?

15 Har du efter disputationen varit delaktig i att starta något företag?

Ja/Nej

- Eget/egna konsultföretag för att lättare hantera specifika uppdrag
- Ett/flera företag för att utveckla/kommersialisera nya teknologier/motsvarande

16 Vilken kontakt har du med deltagarna i Kompetenscentret idag?

Gradera från 1-4 där 1 betyder ”ingen kontakt” och 4 betyder ”mycket tät kontakt”.

- Handledaren/Närmaste akademiska kollegorna
- Andra akademiska forskare i centret
- Industrirepresentanter du samarbetade med i centret
- Andra industrirepresentanter i centret

17 Här har du möjlighet att lämna kommentarer och övriga synpunkter på fråga 12-16:

18 Har du något övrigt att tillägga?

Stort tack för din medverkan!

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May 2013

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10 Long Term Industrial Impacts of the Swedish Competence Centres. *For brief version see VA 2013:11*

11 Summary - Long Term Industrial Impacts of the Swedish Competence Centres. *Brief version of VA 2013:10. Only available as PDF*

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VERKET FÖR INNOVATIONSSYSTEM – SWEDISH GOVERNMENTAL AGENCY FOR INNOVATION SYSTEMS

VINNOVA, SE-101 58 Stockholm, Sweden Besök/Office: Mäster Samuelsgatan 56
Tel: +46 (0)8 473 3000 Fax: +46 (0)8 473 3005
VINNOVA@VINNOVA.se www.VINNOVA.se