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SUMMARY

LONG TERM INDUSTRIAL IMPACTS OF THE SWEDISH COMPETENCE CENTRES

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SUMMARY

Long Term Industrial Impacts of the Swedish Competence Centres

by

Peter Stern, Erik Arnold, Malin Carlberg, Tobias Fridholm,
Cristina Rosemberg & Miriam Terrell

technopolis |group|

Preface

The Swedish Competence Centres programme was launched in 1993 by NUTEK, the predecessor of VINNOVA and the Swedish Energy Agency.

This publication is a summary of the second impact study of the programme done 2012-2013 "*Long Term Industrial Impacts of the Swedish Competence Centres*" (VINNOVA Analysis VA 2013:10). The main goal of the study is to present direct and indirect long term effects in the companies participating in the Competence Centres as well as providing recommendations regarding competence centres programme design in future policy.

The Swedish Competence Centres Programme was an effort to build bridges between science and industry in Sweden by creating excellent academic research environments in which industrial companies participate actively and persistently in order to derive long-term benefits. The mission was to strengthen the very crucial links in the Swedish National Innovation System between academic research groups, industrial R&D and public sector actors.

A Competence Centre has two main goals:

- To become a productive, academic Centre of Excellence by actively involving a number of companies and research groups in joint multidisciplinary research
- To promote the introduction and implementation of new technology and to strengthen the technical competence in Swedish industry.

A basic idea underlying the Competence Centre concept is that active involvement from industry in academic research brings about mutual benefits. From more than 300 applications 28 Centre consortia were selected to receive 10 years of funding, starting from 1995. The programme involved most of the largest companies and corporate groups in Sweden. By the final stage, there were about 200 companies involved, with the proportion of SMEs growing over time.

The study was led by Prof Erik Arnold, Technopolis group, and was carried out together with his colleagues in the Swedish subsidiary Faugert&Co.

VINNOVA and the Swedish Energy Agency wish to express our sincere thanks to all persons in participating companies and the universities, especially present and former Centre Directors, for providing time and efforts to prepare and participate in interviews with facts and experiences. We also express our thanks to the former Director for the Competence Centres programme, Staffan Hjorth, who contributed to the study with experiences and facts, collected during the lifetime of the programme. Without high quality contributions in these efforts by so many, this study would not have been possible.

Stockholm in May 2013

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

Contents

1 Introduction

This document summarises key parts of a large study of the impacts of the Swedish Competence Centres (CC) programme, which was commissioned by VINNOVA and the Swedish Energy Agency. The full report is available from the VINNOVA web site[1].

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 research and development (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 than other government-funded R&D support, to encourage more fundamental research to be done, and they involve PhD education. The Swedish CC programme is described in more detail in section 5.

The study forms one in a series looking at the longer-term impacts of R&D funding by VINNOVA and its predecessor agencies and extends an evaluation of the centres done in 2004[2]. 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.

The empirical input to the analysis comes mainly from five 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.

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[1] Peter Stern, Erik Arnold, Malin Carlberg, Tobias Fridholm, Cristina Rosemberg, Miriam Terrell, *Long Term Industrial Impacts of the Swedish Competence Centres*, VINNOVA Analysis VA 2013:10, Stockholm: VINNOVA, 2013

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

2 Industrial impacts of the competence centres

The primary focus of this study was on industrial impacts and the main study provides quite a lot of detail about these. We found seven kinds of industrial impact.

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

Direct impacts on industry, through generating directly usable outputs in the form of products, processes or services. These include a wide range of new and improved products, services and processes – some of which have been realised; others are on the way to realisation.

Longer-lasting, more environmentally friendly railway sleepers

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 significantly reduced maintenance.

World-beating robots

ABB Robotics has based its products on control technology for industrial robots generated at the ISIS centre. 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 with a sales volume of between 4 BSEK and 10 BSEK, per year.

Powering trucks from paper mill residues

Volvo Powertrain produces drive line components for all companies in Volvo Group, the world's second largest producer of trucks[3], and has learned how to burn DME

[3] Since 1999 Volvo Car Corporation is not part of Volvo Group.

(dimethyl ether) in large diesel engines as result of participating in the CERC centre. DME is a biofuel that can be made from the ‘black liquor’ processing residues from paper mills, other kinds of biomass or natural gas. The basic problem was to combine low emissions with low fuel consumption. A CERC project enabled the company to adjust the system for fuel injection and develop a new piston. DME is comparably environmentally friendly since it does not produce soot and can generate 95 per cent less carbon dioxide than diesel. With the input from CERC Volvo was able to reduce emissions of carbon monoxide by 90 per cent and fuel consumption by 20 per cent and has built ten demonstrator trucks. Market introduction of trucks with engines for DME, however, would require a relatively stable supply of DME as well as infrastructure for refuelling.

Speech and language technology

Södermalms Talteknologiservice (STTS) entirely builds on its participation in the CTT centre. 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.

Direct impacts through behavioural additionality such as learning the value of more open innovation forms, more networking and recruitment of technical specialists. Effects were visible on company strategy, changes in the ‘innovation models’ used by firms and their ability to network and co-publish with other firms and academics, development of human capital, more sophisticated R&D management and improved ability to access external facilities useful in R&D.

Bluetooth

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.

Life Cycle Assessment

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. The study focused on companies, which we had reason to believe were likely to have experienced positive results from CC participation. About half the companies we interviewed had managed to make a major 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 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. Very few companies could put a number to the value of the impacts of CC participation. Nonetheless, if the earnings and cost savings that we could identify as resulting from the CC programme are counted, the total impact of programme *at the very least* amounts to somewhere between 5.3 and 11.8 BSEK per year as of 2012 (Table 1). 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. Omitting 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. But however we count, the long-term effects are very large and we are clearly only able to quantify a part of the total impact.

Table 1 Economic impacts from products and processes 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**

Unusually among the centres, Charmec has been careful to track its economic impacts. Table 2 summarises its findings. (Note that we have not cross-checked these in detail.)

Table 2 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[4]
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**

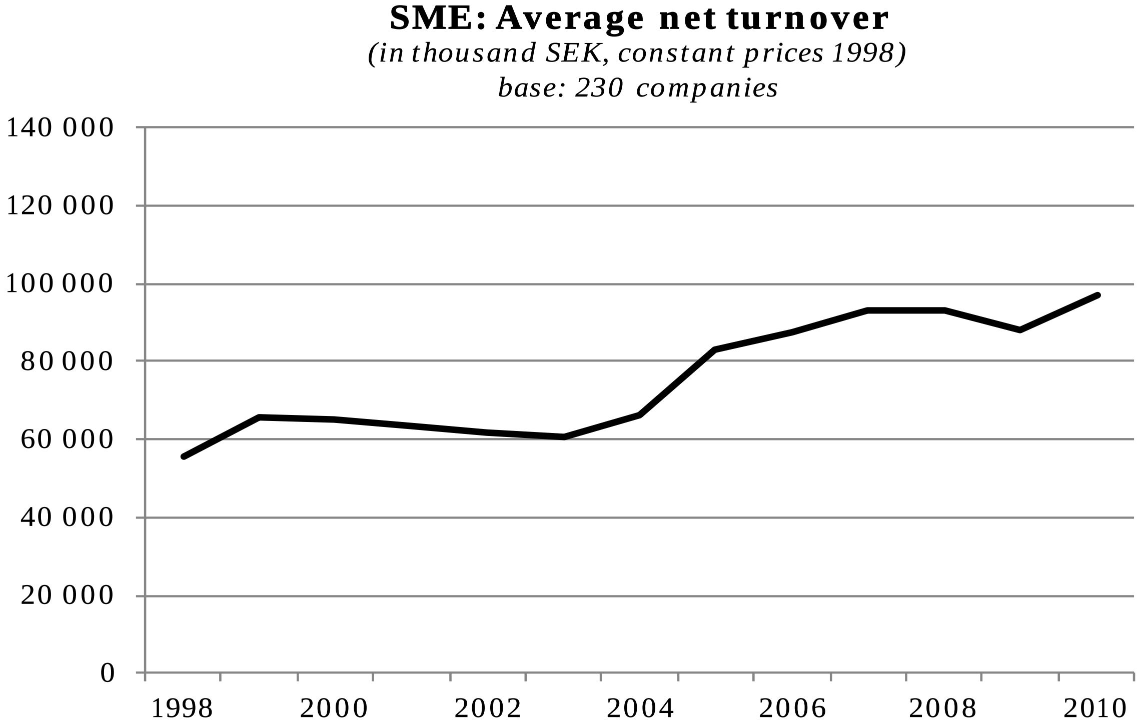
Economic development of individual SMEs participating in CCs. While the biggest economic impacts occur in large companies, which can exploit new knowledge across big production volumes, development of SMEs is also important. Impacts upon them include improved economic performance through internal efforts and the development of better networks for technology and business as well as the positive effects of participation on firms' reputations for technological capability.

Our tracking of small and medium sized enterprises (SMEs) involved in the programme indicated that their collective economic performance is stronger than the average in the economy. We cannot test whether CC participation causes the good performance or whether it is the other way round. But 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.

Figure 1 shows the trend in average net turnover for participating SMEs, indicating an upward trend in net turnover from 2003 to 2009.

[4] Not yet introduced at large scale; the technology only exists in successful demonstrators

Figure 1 Participating SME's performance 1998-2010



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 easily be tied to specific innovations but which nonetheless has or will lead to improved productivity and improved technological capability. Internal resources affected 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.

Three CCs stand out as efforts to introduce relatively recent technologies and practices 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

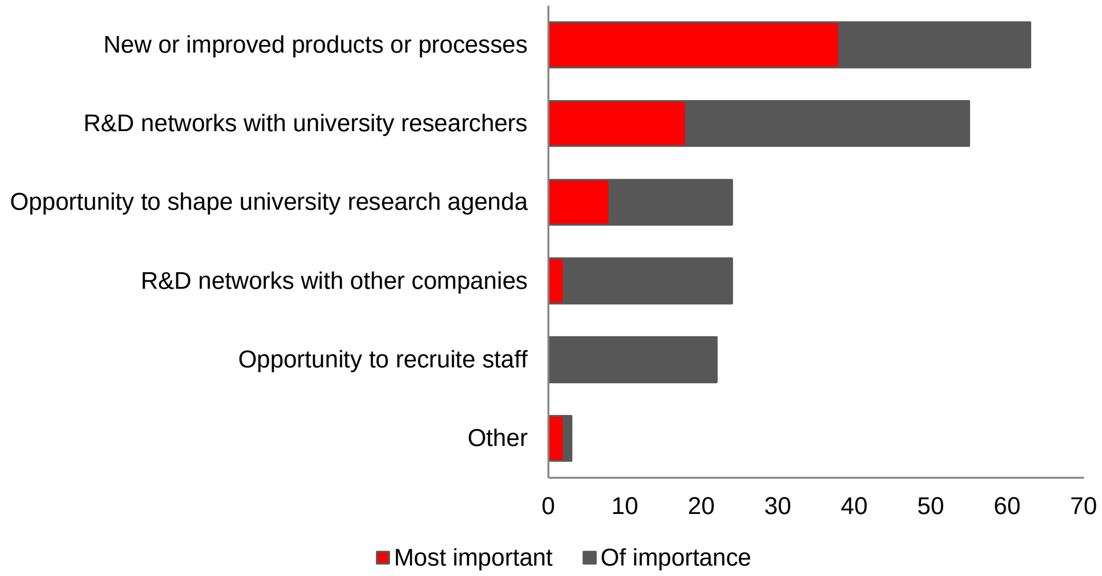
Spillovers from the participating firms and universities to other knowledge users. The majority of the PhDs went into industry, taking skills with them. There were also large numbers of scientific outputs in the form of papers, conferences and dissemination events. So the programme produced a lot of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

Indirect effects, via the university system, such as access to more, more relevant graduates. A total of 520 people did their PhDs in the Swedish CCs. The centres not only increased the supply of postgraduate recruits with relevant technical skills for participating companies but also influenced undergraduate and masters-level curricula. This means that they acted as 'focusing devices', leading to a larger build-up of human resources in areas in which the centres worked – areas that through the CC competition had been identified as having clear scientific interest as well as importance to Swedish industry. This kind of agenda setting can help change the pattern of industrial innovation.

Figure 2 shows that the opportunity to develop new or improved products was the most important reason for the companies interviewed to join a CC, 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 less important than the first 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 of interest to large companies. Since large companies are over-represented among respondents, responses to the latter two alternatives are therefore probably skewed.

Figure 2 Reasons to participate in CC



Note: N=68

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 do they have the internal resources to define problems and understand and analyse technical results, but they also 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 persist even 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.

3 Competence centres in future policy

Competence centres should continue to form part of VINNOVA's repertoire of funding instruments. The CC programme 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 their 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.

Intellectual property rights (IPR) disputes can stop a CC in its tracks. An arrangement that protects participants' existing background knowledge and provides access on fair terms to the foreground knowledge generated in the consortium is needed and should be imposed in a standard form on the whole programme.

Designers of future CC programmes should consider the following lessons that derive from Swedish and international experience.

- 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 networks of people involved in particular technologies. 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 suggests 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

4 Competence centres internationally

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

CCs involve an unusually high rate of state subsidy, compared with many other programmes. In general, companies are reluctant to invest in generating knowledge that they cannot monopolise because this basically means giving their investment away to others. The more fundamental the knowledge generated, the harder it is to monopolise. The high rate of subsidy in CC programmes is needed to encourage industry to participate in projects that involve a greater degree of fundamental research than is normal in industry-university cooperation. This allows PhD training to be brought into the programme, with beneficial effects, and allows the R&D done in the CCs to be more fundamental and in at least some cases to have more significant impacts than shorter-term, more applied efforts.

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.

5 The Swedish competence centre programme

The Swedish CC scheme ran from 1995 to 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.

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

[5] One was subsequently closed after stage 1

Table 3 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-Sense Information Systems for Industrial Control and Supervision, ISIS Non-invasive 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

The CCs were in important respects a ‘flash photograph’ of the high points in the Swedish industrial economy in the mid-1990s. Industrial participation remained relatively stable in terms of number of participants throughout the programme period. The microelectronics and telecom sector was the largest, with between 29 and 42 participations. Pharmaceuticals and medical devices, mining, steel and metals and the engineering sectors were well represented. Two service sectors grew notably: software programming and engineering consultants; and services, including for example publishers, logistics and also some software companies. Participation by paper, pulp and forestry companies and the automotive sector decreased slightly towards the end of the period. The engineering sector also decreased, owing to reorganisations of subsidiaries among certain large firms.

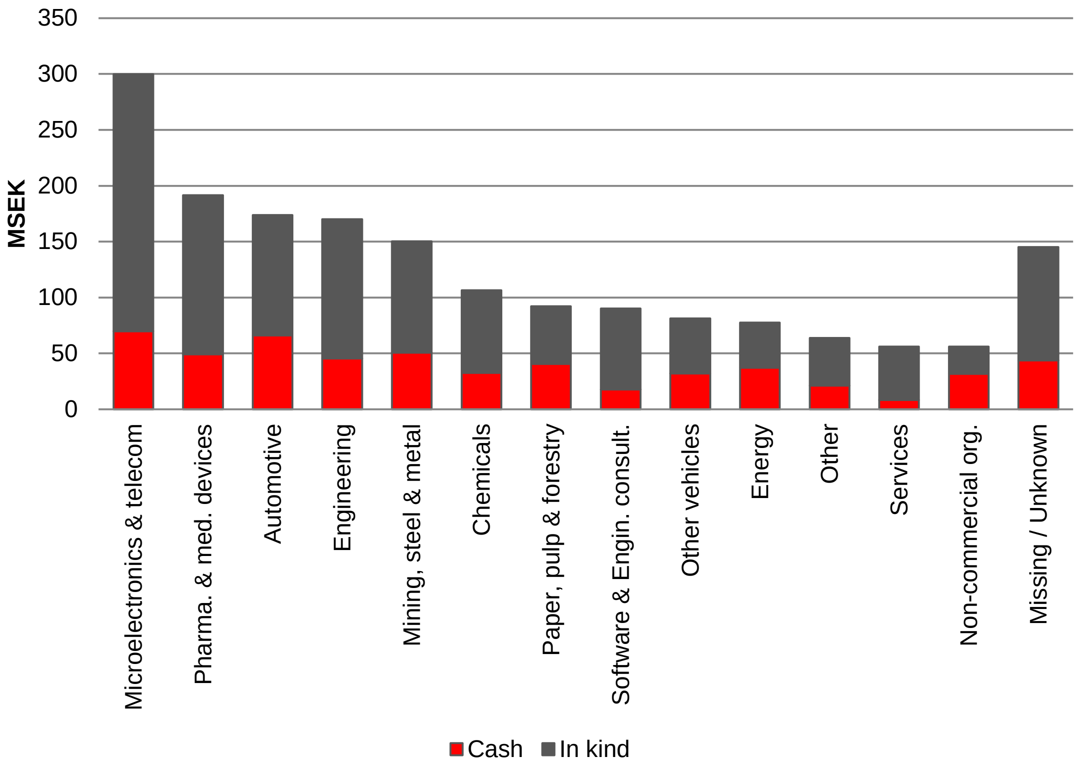
In total, the CC programme cost around 4.9 BSEK, split almost evenly among the funding agencies, industry and the participating universities (Table 4).

Table 4 Overview of contributions to the CC program

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 %**

The sectors that dominate in number of participants also dominate the industrial contributions (Figure 3). The microelectronics and telecom sector was by far the 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 fairly weakly represented, but energy-related issues were of concern also for many companies in the other sectors.

Figure 3 Cash and in kind contributions per industrial sector, all stages



By the final stage, there were about 200 companies involved, with the proportion of SMEs growing over time. However, 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 were 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.

The CC programme involved most of the largest companies and corporate groups in Sweden. Table 5 Top 20 corporate funders 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 28 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.

Table 5 Top 20 corporate funders

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

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.

Network analysis reveals clusters of firms from the same branches, usually involving more than one centre and networks of individuals working with related technologies and problems across industry and academia. 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.

Past assessments of the quality and impacts of the CCs have been very positive. For example, the third scientific evaluation of the 28 centres 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]

At the end of the ten-year funding period of the CC programme the Energy Agency decided to continue funding for its 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.

Of the centres funded by VINNOVA, eight centres continue: Charmec and CPM, with the same name as in the CC period but in smaller format; six former CCs 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.

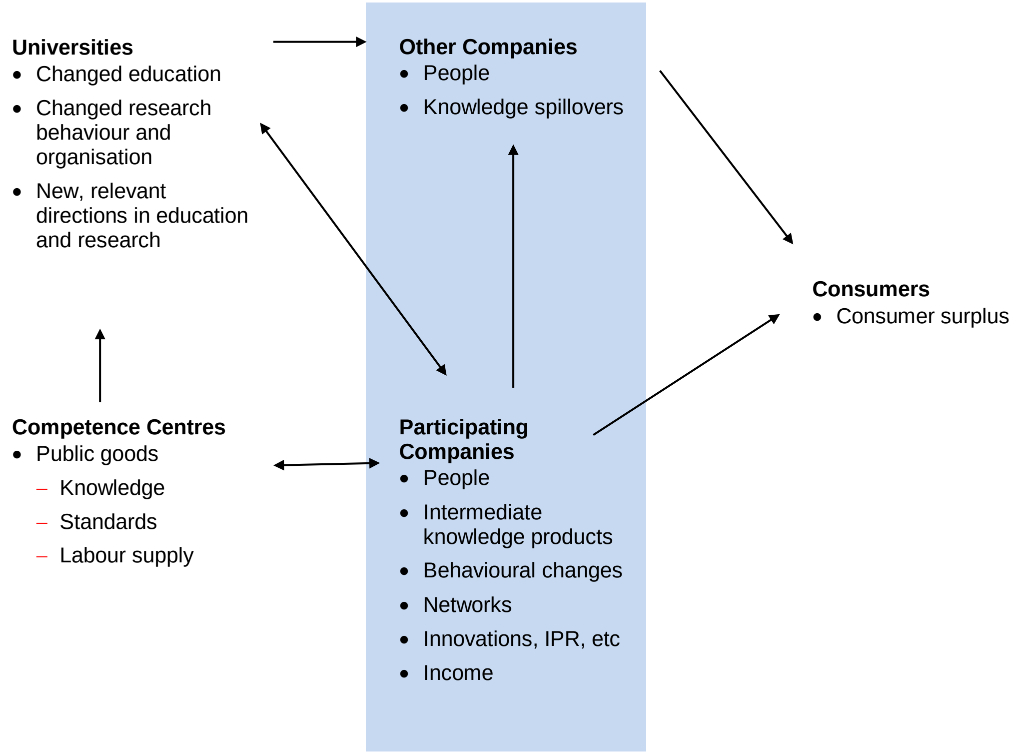
In addition, several CCs that did not continue as new centres have to various degrees formed parts of new VINN Excellence Centres. ASTEC and SUMMIT form much of the basis for WISENET. Researchers in S-Sence have split up on a couple of new centres, including FUNMAT. Two research groups from SNAP are part of SuMo Biomaterials. By and large therefore, centres pave persisted where comparable funding has been available but withered where it has not.

[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

6 Broader impacts of the centres

While the focus in this study was on industrial impacts, CCs also have wider effects. Figure 4 shows the broader impact paths of the CC programme. The centres themselves generate public goods that go into the public domain through the university system as well as knowledge and other resources that are in the first instance captured by the participating companies. They affect research and education processes cultures and themes in the universities and these changes in turn not only benefit participating companies by also spill over to others. Ultimately, benefits spill over directly to consumers in the form of consumer surplus (benefits such as improved quality goods for which producers cannot extract full value and turn it into profits), but many of them arise through changes in competitiveness, employment and wealth creation.

Figure 4 Impact paths of the Swedish competence centres



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