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Mid-Term Evaluation of the Competence Centre Programme

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Mid-Term Evaluation of the Competence Centre Programme

Final Report

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Foreword

Collaboration is one of the most essential keys to secure competitiveness in the contemporary world. We can see collaboration everywhere – between people, between enterprises, between states, etc. However, is it possible to conduct successful collaboration with dissimilar partners that frequently serve opposing purposes?

In 2002, based on the Estonian Research and Development Strategy Knowledge-Based Estonia 2002-2006, the Estonian Ministry of Economic Affairs and Communication commissioned a feasibility study to analyse the potential of Competence Centres as an effective tool for the co-operation between science and industry in the Estonian innovation system. By that time Competence Centres as a co-operational instrument between science and industry had been evolving for 20 years all over the world.

The study was executed by Technopolis and Technologie Impulse Gesellschaft. The study pointed out the potential of Competence Centres to stabilize R&D planning, public and private R&D funding and to strengthen industrial R&D capabilities in a mid- and longer-term perspective. Competence Centres may be used to create critical mass and sizeable research groups for applied R&D. Competence Centres can also be visible and attract foreign partners, they may contribute to the improvement of research management skills and changes in the research culture in R&D institutions.

In 2002 the Competence Centre programme was approved by the Estonian Government and launched by the Enterprise Estonia in 2003.

Competence Centres originated by the programme are R&D collaborations in the form of private legal entities. They are founded, managed and financed together by scientific and industrial partners receiving public support against the joint R&D plan consisting of collaborative R&D projects focused on applied research.

Through a competitive call five centres were selected for funding: Competence Centre in Electronics, Information and Communication Technologies; Competence Centre of Food and Fermentation Technologies; Estonian Nanotechnology Competence Centre; Competence Centre for Cancer Research; and Bio-Competence Centre of Healthy Dairy Products.

At present, following the first funding period of Competence Centre programme, it is of great importance to learn from the past and to assess whether the steps taken so far have been adequate, to address the most pressing problems, and also to identify necessary improvements for the forthcoming years.

The present evaluation project "Midterm evaluation of the Competence Centre programme" has been initiated by the Estonian Ministry of Economic Affairs and Communication and undertaken by the consultancy Technopolis Group Ltd. The aims of the current evaluation were to assess the rationale, appropriateness and objectives of the Competence Centre programme and to make recommendations for the next funding period.

Division of Technology and Innovation
Estonian Ministry of Economic Affairs and Communication

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The Programme and its Context

This is a rather early (mid-term) evaluation of a long-term measure. We can therefore assess directions of change and suggest alterations in the programme design that we judge likely to improve its performance, but not at this stage identify evidence of social impacts. Nonetheless, based on the extensive international experience of competence centres and an understanding of the Estonian context as well as the evidence collected here, we believe we can draw conclusions and make recommendations that are well founded.

The Competence Centres programme was among the earliest of the new measures introduced to improve the performance of the Estonian innovation system in the run-up to EU membership and was then integrated into the wider package of measures made possible by European Regional Development Funding (ERDF). It represented a modified form of an instrument used in a range of other countries to foster long-term co-development of R&D in universities and industry. It funded five Competence Centres (CCs) for three years in a process that was made complex and bureaucratic by the shift from solely national to ERDF co-funding. In July 2008, a new call was launched for a seven-year successor programme.

The rationale of the CC programme is to tackle weaknesses in the Estonian innovation system, especially its low R&D capability. By improving this, it aims to create areas of technological strength in research and human capital that will support increased research and innovation capabilities and position Estonian industry to become technologically more competitive.

Through Enterprise Estonia (EAS), the Government (and the ERDF) provides generous subsidies to the CCs. According to plan this should have covered 80% of costs. However, the final public contribution was 75% and three of the centres have managed to increase significantly their industrial income above expectations, thus a significant success. The need, in some cases, to change the partnership pattern and the highly different cost structures implied by operating in different specialisations was tackled by allowing the centres great flexibility in the way they spent their budgets rather than imposing a uniform model. A drawback of the degree of decentralisation involved is that – despite the rather detailed reporting required by EAS – it remained difficult for the evaluation team to have access to the basic data on how many people had been employed, under what conditions, to do what. Some have chosen to build up a committed core team – which is a precondition for the long-term success of the centres – while others have maintained a slim core and a very fragmented periphery of people who have only briefly been involved. In the light of the funding uncertainties imposed on the programme, the latter is a rational response, which nonetheless undermines performance.

The CCs have served to focus research attention and effort on specific areas of technology and thereby to increase the number of PhD students working in the given areas. There is an important and useful knock-on effect to MSc and BSc education, providing human resources to strengthen both the university and the industrial systems. At this early stage, the centres' aggregate publication and patent outputs are growing, however, remain lower than they should be once the centres become mature and initial writing and publication lags have been overcome.

Policy Context

Estonia shifted towards a proactive, Western-style innovation policy only at the start of the present decade and despite some progress in strengthening the innovation system many of the economic fundamentals such as productivity remain weak. While policy has headlined 'knowledge-based' activities and these need to be given some policy priority, it is important also to work with the potential for improvement across other sectors of the economy, low-tech as well as high-tech. The continuing tendency to 'brain drain' from the Estonian poorly paid higher education sector, despite improved investments, is a cause for concern as is the growing tendency in the universities to focus on traditional measures of research output and to undervalue applied research and industrial linkage. These issues are partly addressed by the CCs, however, the centres alone are not sufficient to resolve them. The lack of infrastructural investment in the HEIs at the start of the CC programme meant there was a risk that universities would treat it as an opportunity to boost infrastructure rather than support research and innovation, though this has been reduced since a dedicated R&D Infrastructure programme was launched. While European Social Fund co-financed doctoral schools have begun to increase the attractiveness of post-graduate study, neither this nor the CC scheme is sufficient to tackle the disincentive to PhD studies provided by the present doctoral stipends, which need to be further improved. Intra-university

barriers to industry cooperation also need to be removed through clearer university strategies and improvements in administration, overheads, accounting and the universities' ability to tackle IPR and innovation issues. On the industrial side, too little has so far been done to raise the technological capabilities of 'lower-tech' clusters and a more complete set of financing instruments is needed to support high-tech entrepreneurship. In the absence of a well-developed policy context – and in particular of other measures that support the development of absorptive capacity on companies – there will continue to be barriers to the effectiveness of the CCs in addressing their own specific mission.

The Centres

ELIKO has established a large but shifting group of partners and is doing highly relevant applied research and advanced engineering while also producing significant numbers of research outputs and trained people. However its activities like its client base are rather fragmented and it has yet to develop a sustainable long-term vision, owing to the lack of large technologically capable partners.

At the time of interviews for the present report in spring 2008, the Food and Fermentation centre's industrial consortium seemed more stable but still has opportunities to develop and become more inclusive. The centre has established an excellent research infrastructure and begun to produce graduates and industrially useful results. The present structure of two very senior professors and a large but young staff needs to be strengthened through more permanent centre commercial and scientific management. This will allow it to increase its publication output, establish more clearly its unique specialisation and establish better links to international science and industry.

The Nano centre extends a strong tradition of physics research at Tartu University and has helped to build research capacity in aspects of nanotechnology such as carbon nano-tubes. It has a strong production of postgraduates and research results and transferred some findings to industry, however, the consortium is very unbalanced with only a few, small companies. Longer-term centre staffing is minimal and the centre is acutely in need of strong industrial partners able to work in this high technology. Within Estonia, the prospects of finding them appear poor and the sustainability of the given centre uncertain.

The Dairy centre builds on expertise at the Tartu University and the Estonian University of Life Sciences to support a strong industrial consortium representing several stages in the dairy supply chain, which recognises that important limits in productivity and quality are being reached and can probably be bypassed only through research. The publication record so far is acceptable and the centre is contributing to graduate education. Having established a solid base, it is now beginning to diversify into related themes and – especially if the number of partners is increased – the centre has excellent prospects.

The Cancer centre builds on an established Estonian research tradition and brings together cancer researchers within the country. The industrial consortium largely comprises SMEs, however, is not directly involved in the research and aims to establish strong IPR in the field and to use this to valorise the research. Scientific and education outputs appear to be good and human resources are moving between the universities and industry. The consortium lacks the market or financial clout needed to move significantly further into pre-clinical or clinical trials but is reluctant to extend the partnership, which would dilute its IPR ownership. Yet without a wider partnership, it would appear to require a great deal of luck for the given centre to be sustainable in a globally highly competitive field.

The centre visions were all ambitious however need to be tempered with realism abut the prospects of long-term survival without continued subsidy. The centres have all become credible research suppliers but generally need to strengthen their core team – and to do this, longer-term funding stability is required. Some need to address the balance of power between industry and the academic side. While most centres have strong industrial consortia, a more balanced mix of long- and short-term work will allow movement towards larger project teams.

The choice of an 'Austrian model' (the centre created as a distinct legal entity as opposed to integration in a university as in the Swedish model) for the legal form of the centres has had unexpected and undesirable consequences. There is scope for EAS to be more active in supporting the centres as well as administering the programme, which needs to devote further effort to overcoming the push towards fragmentation caused by Estonia's small size and the need to internationalise.

Stakeholder Perspectives

Despite initial worries that the centres might prove to be competitors, all the universities involved now strongly support the CCs, which strengthen university focus in certain areas and increase industrial contacts but have yet to exert a more profound influence on university strategy. Longer-term funding commitment and a wider portfolio of R&D funding instruments, including technology programmes and better post-graduate funding, were needed if the CCs were to play fully their potential role.

Company partners are almost all small firms, though their mean size has grown a little in the last few years. Two thirds of them are exporters. They have made strategic decisions to partner with the CCs but their aims are mainly to get rather short-term help with product and process development. In practice, the CCs tend to function somewhat as 'industry platforms' where members network and get business as well as technological benefits and – as in most collaborative R&D – the results participants actually take away are more likely to be 'intermediate knowledge outputs' than results they can put directly into development. At the same time, there is also evidence that a lot of near-to market technology transfer is happening and there is also variation among the centres.

Companies tend to see their centre participation as related to their core technologies and business areas, similarly as strategically important in connection with their longer-term innovation effort and thus also internal effort, and as reducing both technical and commercial risks. The majority saw the benefits of participation as outweighing the costs and most said their activities were additional: without the CC they would not be able to achieve as much as they could with its help. Human resources produced via the centres were important to the companies. Among the 'soft' effects was that the centres were often a source of internal 'inspiration' to the companies – training their and their employees' technical ambitions.

Most of the researchers who responded to our survey were only involved with the CCs part-time, reinforcing the impression that a stronger core of more full-time people is needed. Their goals in participating were highly varied and reinforced the impression that the funding was a major influence and that correspondingly few other research-funding opportunities were available. This is similar to the situation of the early Irish CCs (the Programmes in Advanced Technology), which were enthusiastically received by the universities as they represented a unique source of new research money. Researchers tended to work close to their core technologies but did not see the CC research as risky. On the other hand, it was comparatively long term and far from the market – which is consistent with industry's view that it was getting intermediate knowledge products a fair proportion of the time and seldom the close-to-market outputs it wanted.

Lessons from Abroad

Competence centres have been evolving internationally over the past 20 years or so. While they share common characteristics of long-term commitment by industry and academic to common R&D programmes, interdisciplinary problem focus, engagement with postgraduate education and undertaking more fundamental types of R&D than is usual for the partners involved, they are implemented in a range of ways that should be context dependent. Generally, they should be one component in a more comprehensive policy mix that tackles both researcher-driven research and the needs of lower-capability clusters in industry that would benefit less from the relatively advanced work done in competence centres.

Since the CCs tackle a significant market failure, it is not realistic to expect them ever to become fully self-financing. They can be refocused on issues closer to the market but then their impacts become not only shorter term but probably also smaller. The extent of absorptive capacity among industrial partners is a crucial determinant of CC design. Design must also take account of the extent to which university behaviour needs changing and their institutional preparedness for working with industry and tackling issues such as IPR.

Findings, Conclusions and Recommendations

The competence centre instrument is appropriate in the Estonian context because it is employed to extend the quantity, quality and time horizon of the innovative activities of a nationally important consortium, while focusing research and education activity on areas of national need. The instrument works best where university management is sophisticated. It depends upon the state acting as a reliable long-term funding partner and benefits from being part of a well-developed range of policy instruments.

Adopting competence centres requires a great deal of institutional and personal learning and while EAS helped with this, even more activity would have been helpful. At the same time there is a need to ensure transparency and accountability in an un-bureaucratic way. The decision to require the centres to be independent legal entities was rational at the time of the initial programme design given that the only other solution would have been to adopt a model based on their integration in academic structures. The necessary conditions for the latter option in terms of the modernisation of university structures and professional management of research-industry relations were not in place at the time and remain inadequate today. However, the adoption of for-profit structures in a majority of cases by the CC had unexpected and negative consequences for the programme, encouraging behaviour likely to maximise private rather than public benefits.

All the centres have progressed towards their goals – some further than others. Three of the centres appear rather robust for the longer term; the other two, less so. The CC programme has encouraged universities to begin concentrating research and educational resources in areas of national need and improve links with industry. Companies increased their R&D capabilities and were better prepared to tackle high-risk innovation. The research community also benefited from increased funding and produced significant numbers of research outputs – some directly useful to industry; others longer term in nature.

The evaluation was able to confirm that the rationale for the programme was and is valid and that it fits wider policy objectives – though additional research and innovation support instrument are needed to complete the policy mix. There is an initial positive impact on both the industrial and research communities and experience with running centres is being built up. A key success factor is to find a workable balance between industrial and academic interests in steering the direction of the centres. Programme management has largely worked well but the repeated need to refund the programme imposed a needlessly high bureaucratic load on both the administration and programme participants, diverting effort away from research and the learning activities that could have improved common performance more quickly.

We recommend that the CC programme continue but with greater continuity of funding and a guarantee of seven years of funding for the next round of centres. Pressure on the centres to perform and to maintain quality standards should be applied through mid-term evaluation and there should also be a final impact-focused evaluation. More flexible consortium membership arrangements should be permitted in order to allow entry and exit in the rapidly changing circumstances of the Estonian economy. There need be no presumption that future CCs are 'high tech', though by their nature they should be knowledge intensive. Greater internationalisation should be fostered through international scientific committees and making part of the CC funding contingent upon international membership of the consortium. Improved 'corporate governance' is required to take account of the fact that the centres are funded by public funds and a shift towards not-for profit arrangement to reduce the incentives for opportunism would be the optimal solution. The need, in either the for-profit or not for profit case, to meet accepted international standards of good corporate governance and to ensure an appropriate use of public funds in the broader 'public interest' leads the evaluation team to propose the introduction of performance based agreements and enhanced centre management and supervisory functions in the CC before EAS commits further funds in favour of existing or new CCs. There should also be a register of interests in which policymakers and policy implementers must reveal actual and potential conflicts of interest. The Ministry should amend all research and innovation support contracts to make cooperation in official monitoring and evaluation a condition of funding. In parallel, Estonia needs to launch a range of complementary funding instruments aimed at increasing institutional, technological and human capabilities in innovation and research.

1 Introduction

The Competence Centres (CC) programme was announced in November 2002, as a component in the implementation of the 'Knowledge-based Estonia' programme of 2002-6. Its general objective is to improve the competitiveness of enterprises through strategic cooperation between the science and industry sectors in Estonia. This reflected perceptions that Estonian industry tended to lack absorptive capacity while science was fragmented and weakly linked to national and international industry.

The programme has now reached the end of its first period and a new call for proposals was issued on 1 July 2008. The Ministry of Economic Affairs and Communications commissioned this mid-term evaluation in order to learn the lessons from the experience so far that can be fed forward into the second period. While we are naturally interested in what can be said at this stage about the outcomes and impacts, our emphasis in the present study is therefore on learning (in evaluation jargon, it is a 'formative' rather than a 'summative' evaluation). The key evaluation issues are therefore the

- Rationale, appropriateness and objectives of the programme
- Role and compatibility of the programme within the wider policy mix and with regard to national innovation policy objectives
- Impact of the centres on the national innovation system
- Experience at the centre level – especially about the centres' compatibility with stakeholders' objectives and their influence upon stakeholders' strategies, behaviour and structure
- Management of the programme and the value added by the programmatic approach.

Given the uncertainties and risks of bias involved with individual evaluation tools, we proposed to tackle these questions using the following range of techniques. Employing several techniques at once, it is possible both to 'cover all the angles' better by looking at the programme via different perspectives and to look for consistency among the results of different techniques. Where there is such consistency, our confidence in their findings is increased. The methods we used were

- Analysis of documents, which range from the programming documentation and monitoring reports of the programme to evaluations of competence centre systems outside Estonia
- Interviews with
  - The Ministries of Economic Affairs and Communications and Finance
  - Programme management
  - Representatives of universities at department and university level
  - Company partners
- Self-evaluations by all five competence centres
- Centre reviews by a three-person international panel (Sten Ljungström, Berghold Bayer and Erik Arnold) with strong competence centres experience
- A survey of researchers to explore their motivations and experiences in working at the centres

The present report sets out the evidence and synthesises the results obtained using the different techniques. It begins with a description of the programme, its objectives, history and composition and the way it fits into the wider policy mix (Chapter 3). It continues to describe (Chapter 4) the results of the panel review before exploring the perspectives of the universities, companies and individual academic researchers involved (Chapter 5). Chapter 6 considers what lessons the programme can draw from experience of competence centres abroad. The last Chapter draws conclusions, answers the key evaluation questions and makes recommendations for the future of the programme.

We are grateful to the centre managers and personnel, members of EAS and the Ministry who helped us with the evaluation. It was clear from the centre managers that the evaluation was seen as an irritation and a burden, especially in the light of the previous three years when they had annually been required to produce substantial proposals for funding and continued funding and in the light of the parallel scientific evaluation process. Most of them were nonetheless polite and welcoming. We also gratefully acknowledge the help of our other interviewees (listed in the Appendix) and all those who took the trouble to respond to our surveys.

2 The Programme and its Context

The Competence Centres programme was among the earliest of the new measures introduced to improve the performance of the Estonian innovation system in the run-up to EU membership and was then integrated into the wider package of measures made possible by European Regional Development Fund (ERDF) funding. It represented a modified form of an instrument used in a range of other countries to foster long-term co-development of R&D in universities and industry. It funded five Competence Centres (CCs) for three years in a process that was made complex and bureaucratic by the shift from national to ERDF funding. On 1 July 2008, a new call was launched for a seven-year successor programme.

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The CCs have served to focus research attention and effort on specific areas of technology and thereby to increase the number of PhD students working in the given areas. There is an important and useful knock-on effect to MSc and BSc education, providing human resources to strengthen both the university and the industrial systems. At this early stage, the centres' aggregate publication and patent outputs are growing but remain lower than they should be once the centres become mature and initial writing and publication lags have been overcome.

2.1 Background

The CC Programme was launched as part of the first Estonian R&D Strategy "Knowledge-based Estonia" for 2002-2006. However, in practice the programme idea was developed earlier than the R&D strategy during a period of policy innovation at the start of the present decade that produced a number of comparatively free standing programmes, e.g. the R&D Projects Financing Programme and the SPINNO Programme (formerly by ESTAG – the technology agency of the Ministry of Economic Affairs; presently by Enterprise Estonia). The process of planning "Knowledge-based Estonia", followed by the writing of the first Single Programming Document for implementing EU Structural Funds subsequently brought these and other initiatives together within a coherent overall policy framework.

In 2001-2, the Ministry of Economic Affairs and Communications commissioned a feasibility study for a competence centres programme from Technopolis Group in collaboration with the programme manager of the Austrian competence centre programme (K-Plus) and an expert from the Catholic University of Leuven (Belgium). The team studied not only Austrian but also Swedish practice in some detail and surveyed a range of similar programmes in other countries, partly via the Multi Actors and Programme (MAP) network (managed by the Austrian agency Technologie Impulse Gesellschaft – TIG – now part of the Austrian Research Promotion Agency, FFG). The given international work underlined the importance of national context in determining the detailed characteristics needed for CC programmes in any given country. The study also emphasised the need to treat a CC programme in Estonia as a component of a wider, coherent research and innovation support portfolio. It could not function as the only measure for addressing all the weaknesses of R&D in Estonia.

The original programme document developed by the Ministry of Economic Affairs and Communications in 2002 set out the main principles of the scheme, stressing that what should distinguish the competence centres from other public R&D programmes was their focus on research and the fact that they would have a medium-term research programme carried out by a group of researchers and engineers from both the research and the enterprise sector. They were to focus on one or a small number of areas of technology. Long-term co-operation between enterprises and R&D institutions would make it possible to harness existing R&D potential and generate new knowledge in the Estonian innovation system, satisfying the needs of the market economy.

The programme document specified the eligibility and evaluation criteria that should be used to establish the centres as well as a set of financing rules. The CC Programme was aimed at institutions in the 'knowledge infrastructure' able to do applied R&D work and at companies with R&D competence or potential. A competence centre had to comprise at least one leading R&D institution and three companies. In their proposals the CCs had to set out a detailed programme of work, in which at least half of the R&D projects would involve no less than one research institution and two industrial partners. The research consortium was open to institutions from abroad, however, the core group had to be formed by Estonian R&D institutions and companies.

CC applications had to define clearly their objectives, proposed outcomes and to demonstrate the link between the CC objectives and intended outcomes and impacts on increased industrial competitiveness. The proposals had to include both a scientific dimension and an economic rationale. They had to distinguish between long-term (5-7 years) and mid-term (1-3 years) objectives. Further, the proposal had to indicate the expected distribution of work among fundamental research, industrial research and pre-competitive development projects. The competence centre's overall focus was required to be on applied research supporting the needs of both research and industry partners. The proposals thus aimed to build a basis for strategic research co-operation between research and industry partners.

The proposal assessment process therefore contained not only scientific quality criteria but also criteria about intended outcomes and impacts as well as a number of process criteria that aimed to ensure consistency between the proposed centre and the objectives of the scheme, notably relating to the structure of the consortium, its work plan and financial plan. Each CC was required to have a core group of researchers and engineers with a shared vision (at least three full-time people when the centre was launched).

The programming document and the call for proposals were not prescriptive about the legal form that the centres would adopt. They were free to act either as autonomous structures within the leading (research) institution (on the Swedish model) or as independent legal persons in private law, e.g. as limited liability companies (Austrian model). Later, during the programme call phase, the Ministry of Economic Affairs and Enterprise Estonia opted for an approach similar to the Austrian model, adding the limitations that the shareholders should include at least one research and three industrial partners registered in Estonia and that at least 51% of the stock capital of the centre must belong to private companies registered in Estonia.

The first call in 2003 was a two-stage process with short proposals being evaluated and the winners being invited to make full proposals. This allowed EAS to fund visits to Swedish and Austrian centres by CC applicants making full proposals. In total 14 full applications were submitted and assessed by separate scientific (composed entirely of foreign experts) and 'core' expert panels (half of which were foreign). Expert opinions were used to make final financing decisions. Financing negotiations were held with six tenderers and five of them were funded. The evaluation criteria used for assessing proposals were derived directly from the original programming document, namely: quality of the consortia; the centre strategy and research programme; human resource development plan; organisation; and sustainability. The five CCs selected for funding were as follows (the abbreviations we use in the present report follow their full names)

- Competence Centre of Electronics, Info and Communication Technologies (ELIKO)
- Competence Centre of Food and Fermentation Technologies (FF)
- Competence Centre of Healthy Dairy Products (Dairy)
- Estonian Nanotechnologies Competence Centre (Nano)
- Competence Centre of Cancer Research (Cancer)

The second call in 2005 was similar to the first but was open only to the existing centres and introduced explicit weighting of the different criteria. The research plan provided 50% of the total score, the financing plan 25% and the performance of competence centres to date (organisational performance, ability to implement the research plan, research and industry partners' experience of collaborative research and implementation of the research plan) 25%.

The original intention was to sign three-year funding agreements with the CCs. However, it was then decided that from the second year the programme should be co-financed by the EU Structural Funds (ERDF) rather than solely from national money. This had the advantage of insulating the programme from the ups and downs of the national budget but it also meant that the programme had to be accommodated to the ERDF rules. The winning centres found at the outset that they only had money from national funds for one year and that they had to reapply to EAS for money for a second two-year period, imposing a very large bureaucratic burden on them.

In 2007, as the first three-year periods began to expire, complementary state funding was allocated to all five competence centres for the period up to the end of June 2008, when a new call allowed them to apply for funding, this time in competition with other potential new centres, for a seven-year period.

Five competence centres have therefore been in place for the last three years with around 30 companies being involved. On the basis of the information from EAS, about 60 full-time equivalent researchers are involved, over 100 Bachelor, Master and PhD theses have been written or are in preparation and the first three spin-off companies have been established. External investors have made additional investments in five CC related companies, CCs have initiated five new product development projects (financed under the R&D Projects Financing Programme of Enterprise Estonia) and three EU projects.

Three-year external scientific peer review assessments of all the CCs were intended to be in place by June 2008. The ones that have become available we have taken into account in the present evaluation.

In the next seven-year programming period, Enterprise Estonia will co-finance each CC annually with maximum 20 million EEK (1.28m), within a limit of 70% of centres' budgets (exceptionally up to 50% for IPR related costs). The first four-year budget may include 20% of reserve funding for new sub-projects. A description of the three last funding years is not required in the project proposal.

2.2 The Competence Centres Programme

2.2.1 Rationale

The programming document sets out the intervention logic described in Figure 1.

Sub-objectives	*Mechanisms*
1. Facilitation of concentration of R&D in a specific field of technology or on the basis of different fields	1.Creation of a critical mass of R&D in a specific field of technology or in cooperation between different fields. Extended R&D base (in the form of material and immaterial assets) for R&D institutions and enterprises; Increased importance of ideas and knowledge with applied orientation for R&D
2. Enhancement of mid-term R&D planning and management capabilities in the science and industry sectors	2.1. Shared understanding and strategic aims emerging in the cooperation between the science and industry sectors in a specific field of technology or in cooperation between different fields 2.2. Improved planning and management skills and knowledge in the science and industry sectors
3. Growth of the number of R&D specialists oriented to industry needs and increased mobility between the science and industry sectors	3.1. Growth of the number of R&D specialists meeting the requirements of the industry sector 3.2. Growth of mobility of R&D specialists between research institutions and enterprises
4. Increased internationalisation of R&D	4. Greater involvement of enterprises with international participation and international R&D institutions and enterprises in R&D activities in Estonia as a result of the attractiveness of the competence centres

Figure 1: Programme Sub-Objectives and the mechanisms by which it should reach them
Source: Programming document

The programme was intended to have clearly specified effects on both the scientific and the industrial partners (Table 1).

Table 1: Intended Effects on Scientific and Industrial Partners

Source: Programming Document

Intended Effects for Science	*Intended Effects for Industry*
1. Reorientation from project-based R&D planning to a programme-based approach 2. Implementation of traditions characteristic of company culture (incl. result-orientation of activities, planning, management, etc) 3. Enhanced awareness of research staff of the problems of enterprises and their greater involvement in the solution of the given problems 4. Improved attractiveness of certain areas for R&D cooperation within Estonia and internationally	1. Realisation of strategic aims of enterprises through cooperation with R&D institutions 2. Emergence of R&D cooperation between enterprises (upon achievement of a critical mass in a certain area) 3. Orientation of R&D work in the Estonian R&D institutions so as to meet the requirements of enterprises 4. Training and application of R&D specialists meeting the requirements of enterprises 5. Improved international cooperation with other enterprises and R&D institutions. Source: Programming Document

2.2.2 The financial conditions

Table 2 below summarises the financial data for the programmes as provided by Enterprise Estonia. The data highlights that compared to the initial proposals, the proposal appraisal and contract negotiation phase led to the outcome that the consortiums received 68% of the original budgets requested, reflecting, amongst other factors, that a number of projects considered as non-core were dropped on the advice of the proposal evaluators.

Table 2: Programme funding and partner funding per centre

Source: Enterprise Estonia, data received on 3 October 2008, Technopolis calculations.

	in EEK	*Initial proposal*	*Plan*	*Actual/EAS*	*actual/ERDF*	*Actual total*	*Shares*
ELIKO	*Public funds*	*62 929 000*	*28 193 537*	*13 461 030*	*14 456 423*	*27 917 453*	*73,9%*
	Partners	*24 586 000*	*9 935 076*			*9 869 758*	*26,1%*
	Total	*87 515 000*	*38 128 613*			*37 787 211*	*100%*
FF	*Public funds*	*27 892 000*	*32 291 247*	*11 538 864*	*20 155 147*	*31 694 011*	*84,4%*
	Partners	*16 468 000*	*6 004 307*			*5 872 225*	*15,6%*
	Total	*44 360 000*	*38 295 554*			*37 566 236*	*100%*
Dairy	*Public funds*	*23 825 000*	*18 538 372*	*8 777 479*	*9 737 165*	*18 514 643*	*65,0%*
	Partners	*23 825 000*	*9 982 201*			*9 961 285*	*35,0%*
	Total	*47 650 000*	*28 520 573*			*28 475 929*	*100%*
Nano	*Public funds*	*23 440 000*	*23 787 807*	*10 916 874*	*12 088 277*	*23 005 150*	*80,1%*
	Partners	*13 677 000*	*5 892 193*			*5 727 066*	*19,9%*
	Total	*37 117 000*	*29 680 000*			*28 732 216*	*100%*
Cancer	*Public funds*	*43 670 000*	*39 659 839*	*21 295 693*	*18 204 952*	*39 500 645*	*72,8%*
	Partners	*17 544 000*	*14 869 015*			*14 767 777*	*27,2%*
	Total	*61 214 000*	*54 528 854*			*54 268 422*	*100%*
		181 756 000	*142 470 802*		*Public funds*	*140 631 903*	*75,3%*
		96 100 000	*46 682 792*		*Partners*	*46 198 111*	*24,7%*
		277 856 000	*189 153 594*		*Total*	*186 830 015*	*100%*

The final public contribution (EAS plus ERDF) for the three-year programme has been just above 75% in line with plan. However, one centre, dairy, had a public-private financing ratio of 65:35, while Nano and Food and Fermentation centres received over 80% of their budget from public funds.

Moreover, according to the detailed reports submitted by the centres to EAS[1] and examined by the evaluation team, it is clear that the capacity of the centres to attract additional sources of funding (e.g. EU research framework programme, other EAS schemes or commercial projects) has varied.

Additional industrial income has been attracted in ELIKO, the Food and Fermentation Centre and – especially – in the Dairy Centre. Neither the Nano Centre nor the Cancer Centre has attracted significant additional income. In the case of the Nano Centre it partly reflects a lack of industrial demand and partly a reluctance to modify or extend the university's research programme. Despite the suggestions of the proposal assessors, who argue that a major pharmaceutical partner was needed in order to complete the consortium and provide a channel to market, the Cancer Centre's strategy is to follow a medium-long term research plan and to exploit the results within the initial consortium.

ELIKO's founder partners have been able to attract additional funding sources. ELIKO works in a very fast-moving set of industries, where product life cycles can be short and the fortunes of companies (large as well as small) can change quickly. Clearly, if the CC programme is to operate in such dynamic areas then the rules must be able to accommodate changes in centre structure and partnership.

Figure 2 and Figure 3 show the CCs' cost structures to date, indicating that there are considerable differences in the way the centres operate. ELIKO buys in many of services from its partner companies, who collectively had received twice as much income from the centre as they had paid to it (at the time of analysis). The TUT also gets a considerable income from the centre, not only for academics' time but also because the centre pays for access to university equipment rather than buying its own. This makes sense both in terms of sharing costs and also as the equipment needed has a short useful life.

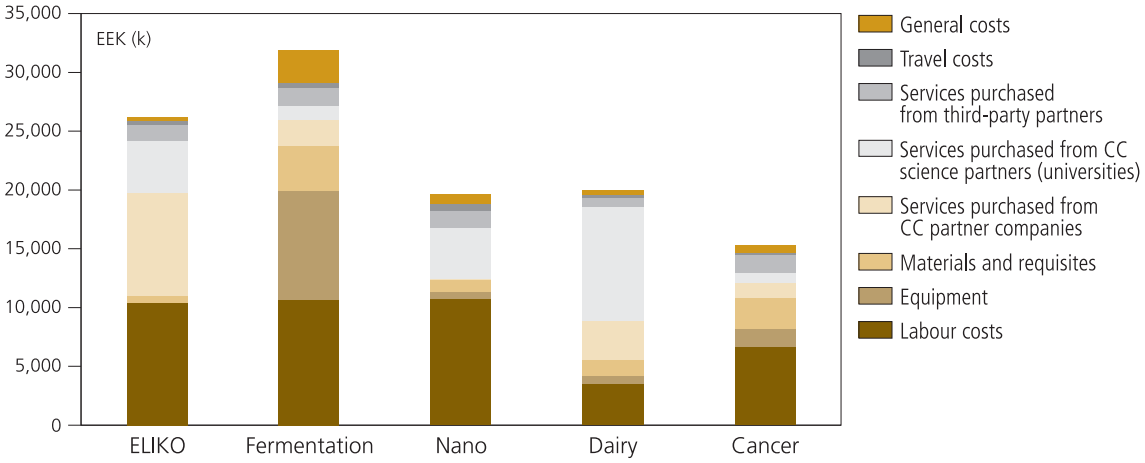

Figure 2: Centres' Costs to Date

Source: EAS

In contrast, the Food and Fermentation centre has invested heavily to equip its laboratories – reflecting the lack of pre-existing university infrastructure in the given area. Most of the equipment needed by this and the remaining three centres has a much longer life than that needed by ELIKO. The Nano centre has an unusually high proportion of labour in its total costs, which appears to be fragmented across a very large number of part-time contributions (many from postgraduate students). It also spends a good proportion of its income paying for access to university facilities. However, it is the Dairy centre that passes the most income over to the universities involved, reflecting its strategy of being an organising device to bring together existing strong university capabilities and to place them at the disposal of its industrial partners. The Cancer centre is very self-contained: its largest external expenditure is for materials and requisites.

[1] *That is for ELIKO 21.12.07; FF 19.11.07; Nano 27.03.07; Dairy 27.03.08 and Cancer 09.05.07. In subsequent figures showing information "to date', these are the applicable dates.*

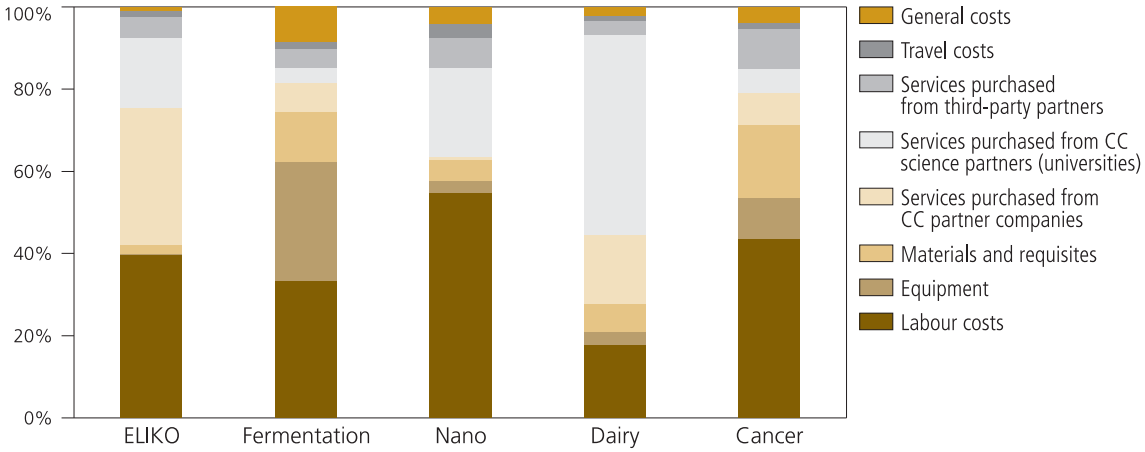

Figure 3: Centre Cost Structures to Date
Source: EAS

Table 3 shows the staffing of the CCs towards the end of 2007. Unfortunately, the reporting to EAS does not help us to understand how much of the overall effort is contributed by contract staff. It is clear that the centres follow somewhat different human resource strategies, however. ELIKO, the Food and Fermentation and Cancer centres focus strongly on permanent staff while the Nano centre has a small core of permanent people and a large periphery of contract staff. The Dairy centre makes considerable use of both permanent and contract staff. Clearly, the commitment of permanent resources to the centres is necessary in order to build something sustainable over the longer term.

Table 3: Human Resources in the CCs
Source: Progress reports to EAS (see details in panel review chapter)

	Permanent		*Other*	*Total*
		People	*FTEs*	*People*
ELIKO	22	11	1	23
Food	40	31	5	45
Nano	4	3	35	39
Dairy	12	10	14	26
Cancer	40	28	12	52
Total	118	82	67	185

2.2.3 Research outputs

Influencing and contributing to university education is an important function of competence centres everywhere. Table 4 shows the centres' latest reports about the given activities. The significant cadre of PhD students attached to the centres is an especially important contribution by the programme to national capacity. Since a PhD takes a long time to research and write, it needs to be done in a stable context. While the state funding for the competence centres remains, in practice, short term, it is difficult to attach PhD students very strongly to the centres. If the 2008 Call for proposals in reality produces a seven-year programme, the links between the PhD students – and their thesis topics – and the centres may become tighter and yet more industrially focused.

Table 4: Degree Activity Reported by Centres
Source: Latest available centre reports to EAS (dates shown in the last column)

	BSc		*MSc*		*PhD*		*Report*
	Defended	*Ongoing*	*Defended*	*Ongoing*	*Defended*	*Ongoing*	*Date*
ELIKO	20	2	15	7	3	13	21.12.07
FF	0	4	9	5	3	3	19.11.07
Nano		5	0	11	2	14	27.03.07
Dairy	0	0	4	7	0	8	27.03.08
Cancer	0	4	0	8	0	2	09.05.07
Total	20	15	28	38	8	40	

The centres also have a substantial number of publications to their credit (Table 5) with a good mix of peer-reviewed journal papers with conference participations. As the longest-established centre, it is not surprising that ELIKO has the largest overall number of publications and the importance of conference papers in its output is typical of its field. Given the 82 FTE staff shown in Table 3 who will have been working for 2-3 years, and allowing for the fact that this effort is in practice fragmented into more people, the centre's work must produce about one third of a reviewed journal paper per FTE year – a figure that should be improved towards a target of perhaps one paper per FTE **scientist**[2] per year on average as the centres mature. Both the youth of the centres and normal lags involved in producing and publishing papers mean it is hard to reach high scientific productivity at the start of new centres.

Table 5: Centres' Publication Outputs to Date

Source: Centre reports to EAS; additional list from Cancer Centre

	ELIKO	*FF*	*Nano*	*Dairy*	*Cancer*	*Total*
Reporting date	21.12.07	1.11.07	27.03.07	27.03.08	04.06.08	
Refereed journal papers	15	9	13	24	14	75
Conference papers	68	16	24	28	20	156
Others (books, monographs, PhD theses)	4	6	11	11	6	38

The centres have also begun to produce patents, as indicated in Table 6. The number of patent applications remains limited at this stage but gives optimism for the future once further research activities reach a more mature stage. It may also be expected that the centres would increasingly patent with the European patent office or the US equivalent, since the strategic value of Estonian patents now that Estonian is a member of the EPO is lower.

Table 6: Patent Applications Reported by 2007

Source: Reports to EAS

Centre	*Estonian*	*International*	*IPR Owners*
ELIKO	2	2	ELIKO, TTU
Food and Fermentation	1	0	LDI
Nanotechnology	0	3	TTU, TU, Nano Centre
Dairy	1	1	Dairy Centre
Cancer	1	3	Cancer Centre, TTU, Prosyntest, Kevelt, InBio

An important future indicator of success of the centres, which can be measured by monitoring annual account data, is the importance of immaterial capital held by the partner companies.

[2] *The human resource figures quoted above include all categories of labour.*

3 The Policy Context

Estonia shifted towards a proactive, Western-style innovation policy only at the start of this decade and despite some progress in strengthening the innovation system many of the economic fundamentals such as productivity remain weak. While policy has headlined 'knowledge based' activities and these need to be given some policy priority, it is also important to work with the potential for improvement across other sectors of the economy, low-tech as well as high-tech. The continuing tendency to 'brain drain' from Estonia's poorly paid higher education sector, despite improved investments, is a cause for concern as is the continuing tendency in the universities to focus on traditional measures of research output and to undervalue applied research and industrial linkage. These issues are partly addressed by the CCs but the centres alone are not sufficient to resolve them. The lack of infrastructural investment in the HEIs at the start of the CC programme meant there was a risk that universities would treat it as an opportunity to boost infrastructure rather than support research and innovation, though this has been reduced since a dedicated R&D Infrastructure programme was launched. While European Social Fund co-funded doctoral schools for research with industrial relevance have begun to increase the attractiveness of post-graduate study, neither this nor the CC scheme is sufficient to tackle the disincentive to PhD studies provided by the present doctoral stipends, which need to be further improved. Intra-university barriers to industry cooperation need also to be removed through clearer university strategies and improvements in administration, overheads, accounting and the universities' ability to tackle IPR and innovation issues. On the industrial side, too little has so far been done to raise the technological capabilities of 'lower-tech' clusters and a more complete set of financing instruments is needed to support high-tech entrepreneurship. In the absence of a well-developed policy context – and in particular of other measures that support the development of absorptive capacity on companies – there will continue to be barriers to the effectiveness of the CCs in addressing their own specific mission.

The Competence Centre Programme was launched during the first period of policy development in the field of innovation in Estonia. This shift towards a more pro-active, or interventionist, policy agenda was only initiated from 2000 onwards, after the negative macro-economic effects of the Russian crisis in 1999 created a 'policy-shock' by underlining that economic growth could not be sustained indefinitely on a low-cost, low-value added, low tax and free trade model. The need to shift towards a 'knowledge-based Estonia' (as outlined in the 2002 R&D strategy) became widely accepted. Since 2000, the country has experienced high rates of economic growth, due to a mix of foreign investment, domestic demand fuelled by favourable credit conditions and low tax, and the positive effects (credibility and investment including public investment via the Structural Funds) of entry to the EU.

The economic fundamentals, the enterprise base and the strengths and weaknesses of the national innovation system have certainly evolved in the last eight years. However, if anything, the pending sense of crisis of the current 'economic model' has only accentuated in the last couple of years. A report in 2008 for the Estonian Development Fund is the most up to date and authoritative examination of recent trends and future prospects of Estonian competitiveness[3] and concluded that the economy faces a series of challenges:

- The productivity of knowledge-intensive service and industry sectors is still several times lower than in highly developed countries[4]
- Estonian enterprises are largely engaged in those stages of the value chain where productivity in knowledge-intensive fields is comparatively low, and export orientation is low
- Estonia's economic structure by no means resembles a contemporary knowledge-based economy; it has rather an industrial structure still based on cheap labour and services.

The report concluded, "Estonia needs to pay much more attention to developing knowledge-intensive and high-productivity services oriented towards external markets". It suggests that it is imperative to change the structure of industry towards increasing the relative importance of sub-branches with higher productivity (for example, production of precision instruments, medical equipment, sophisticated electronic components and equipment); and that the importance of knowledge-intensive services in the economy must increase. In its most dramatic statement, the report suggests that the "Estonian economic structure is becoming Greece-like" rather than say following a Danish or Finnish trend.

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3 *Varblane Urmas, (2008) Estonian Economy Current Status of Competitiveness and Future Outlooks, Report to the Estonian Development Fund.*

4 *For example, in the field of business services, productivity is only 21% of that in Ireland and Denmark, and 30% of the level of Finland, which overrides the view that Estonia has caught up with the developed EU countries in the business services sector.*

The report is also critical of the strategic management and organisational capacities in Estonian enterprises as a key 'system failure' arguing that "there are too few enterprises that are actively looking for opportunities to increase added value and achieve a better position in the value chain. Very few entrepreneurs have a global ambition". Finally, it notes that the creation of cooperation and collective knowledge, as well as the joint use of resources is insufficient.

Equally, a series of recent reports and surveys on the 'innovation system' suggest that the weaknesses identified in the early part of the decade have at best been reduced but certainly not overcome[5]. This is not thoroughly surprising given that a pro-active innovation policy has only been pursued since 2002, and indeed only with adequate financial resources since 2004 and the arrival of EU Structural Funds. It would have been surprising for policy intervention to turn around entirely the situation in only five years. The 2007 OMC policy mix report[6] argues that

> there is a need for a coherent discussion on the relationship between the future development of Estonian industry and the needs for R&D within industry and in the knowledge institutions. This discussion should not be misled by the dichotomy between high-tech and low-tech industries. The term "high-tech" denotes a company that invests more than 4% of its turn-over in R&D. It is essentially an R&D indicator. Given that companies can be knowledge-based, innovative and profitable without these levels of R&D investments, the development of high-tech industries cannot be put up as a political goal in its own right. Relevant Estonian business areas that could benefit from such incremental and knowledge-intensive innovation could for instance be food production, textile production, building materials, pulp and paper, furniture, manufacturing and electronics. The strong growth of the Estonian service sector indicates a need for a more systematic approach towards this heterogeneous part of the economy, including tourism (which is the only sector where there is an explicit sectoral policy), health and social work and financial services.

From the higher education and research sector side, a recent review of tertiary education in Estonia for the OECD[7] points outs that despite increasing funding going to higher education in general, and the research activities of the HEIs in particular, this sector continues to face a number of 'internal' difficulties which influence its capacity to co-operate with the enterprise sector in programmes such as the competence centres. For instance, the report highlights that the brain drain is a real issue for Estonia as very few research institutions can offer internationally competitive research environment. "*Due to the issue of limited funding over the years, infrastructure investments enforcing international cooperation on equal footing have been possible only in a few cases. Hence, in many institutions or subunits academic culture could be described as inward looking. It is not rare to notice that there is a tendency for a pressure to increase fragmentation*". Certainly, increased funding of infrastructure through the Structural Fund co-financed R&D infrastructure and Centres of Excellence programmes are helping to reduce this gap and disincentive to carry out research in Estonia or for international students, postgraduates and researchers to come to Estonia.

As the 2007 TrendChart report highlighted, Estonia needs to generate a significantly larger number of researchers and engineers (despite a positive trend, the average is 5/1000 population compared to 5.5 in the EU25); yet, the number of new science and engineering graduates in Estonia is relatively low (64 % of the EU average). However, while the current challenge is to orientate sufficient students to science and engineering courses (particularly at doctoral level), the country faces a demographic crunch which will lead to a significant decrease in the student population[8]. A main challenge faced by the higher education sector in a tightening labour market is clearly to compete for the "best people". As mentioned in the OECD report on Tertiary Education, the student support system in Estonia is limited and grant support that is available is small and allocated on the basis of academic performance. Even at doctoral level, the grant is limited (6000 eek/month approx. 380, compared with the official minimum wage, monthly 278) and only paid during 10 months per year (the student is also not covered for pension or social/health insurance). As will be seen later, this issue of making doctoral studies attractive, both financially and in terms of industrially orientated PhD, is one that the competence centre programme appears to be addressing.

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5 *See for instance: Katrin Männik, INNO-Policy TrendChart – Policy Trends and Appraisal Report, ESTONIA, 2007*

6 *Wolfgang Polt et al, Evaluation of Estonian RTDI Policy Mix, Results of OMC Peer Review Report 2007, Country Report for Estonia*

7 *OECD Thematic Review of Tertiary Education, Country Background Report for Estonia, Estonian Ministry of Education and Research, November 2006*

8 *It is predicted that due to the downward demographic trend, the number of potential students starting their studies in higher education will diminish by almost 60% between 2004 and 2016. Consequently, this decrease will have a very negative impact on the labour market over the coming decades.*

Even if it were possible to boost the number of graduates, keeping them in the R&D sector is a further challenge. The average monthly salary in the R&D sector in 2005 was around 8242 EEK, which is slightly less than the average salary but much less than in comparable engineering, service and management jobs in private secondary or tertiary sectors. This is amongst the lowest levels in the EU27 and it is one reason explaining the unattractive nature of a career in the local R&D system (RDI Strategy Progress Report 2007).

Finally, the Estonian academic incentive system is based on a well-established system of international peer review largely influenced, as in most EU27 countries, by publication records in international journals. Given the limited human and financial resources, allocating resources towards contract research, research commercialisation and management of IPR portfolios is still something that is a secondary objective of the university sector. The evaluation of the SPINNO programme (SQW, 2007) noted that while the legal and management issues of intellectual property and research commercialisation had been largely improved and targets in terms of patents, contract research improved, the absolute levels of the indicators measuring 'knowledge transfer' or research commercialisation are low. The report noted that "the financial and traditional academic incentives for institutions to engage in knowledge transfer are limited. They all attach higher priority to knowledge transfer than previously, and several have it as an explicit component of strategic plans but demand from Estonian businesses is still limited and the financial returns are not attractive when compared to the costs of engaging in knowledge transfer". 'Mainstream' activities such as teaching and conventional research are better rewarded. In particular, the research funding system does not give explicit weight to applied research and knowledge transfer and favours conventional research outputs (publications in academic journals).

In short, the Estonian economy needs to shift radically and rather rapidly towards knowledge intensive sectors, both in niches of manufacturing and in services. However, continuing weaknesses on both the enterprise side (strategic focus of investments, management weaknesses, labour skills, co-operation culture and innovation management) and on the academic side, continue to create an unfavourable climate for either knowledge transfer in the form of spin-offs or joint R&D activities between enterprises and academic scientists.

Hence, the evidence suggests that there was and is certainly an underlying rationale for the competence centre programme within a 'policy-mix' in favour of innovation and competitiveness (and indeed, promotion of economically relevant research in higher education). The questions that need to be considered given the policy context are to what extent the model proposed by the original feasibility study and then transposed into the programming documents adequately took account of a) the structural differences between the Estonian enterprise sector and that of more advanced economies; b) the absorptive capacity and organisational and strategic management skills of Estonian enterprises; c) the specialisation profile of the Estonian research base and its alignment with the needs of the enterprise sector, the existence (or not) of critical mass (financial and human) in the given fields of research and the barriers to research commercialisation (academic incentive system, low know-how on IP portfolio management, limited venture capital, small size of national market, etc.).

From a policy-mix perspective, it is important to consider the place of the programme both in terms of intended or unintended complementarities with other programmes, as well as in terms of possible gaps in public support which may hinder or diminish the expected effects of the programme. Obviously, it is not the place of this report to analyse the entire policy mix[9], however a simplified approach can be adopted by analysing three 'blocks' or 'streams' of public support vis-à-vis intended targets.

Knowledge production: capturing first and foremost public investment into either human capital or basic and pre-competitive research.

- High-quality research infrastructure: the competence centre programme was not intended to be a surrogate for basic flows of investment in research equipment in the academic research institutes partnering with the enterprises. Given the above noted, and well established, under-investment for over a decade in the Estonian research infrastructure, there was clearly a risk or a temptation prior to the launch of the programme that academic partners would see it as such. To some extent this risk was diminished during the lifetime of the programme through the launch of the R&D infrastructure programme (co-financed by the ERDF and managed until 2008 by EAS). The competence centres may, or should indeed, lead to a leverage effect where the group of partners combine financial funding sources (private, public, academic) to share facilities and equipment of an advanced, or at least industrially relevant, nature.

[9] *For a more thorough examination of the policy-mix (2006) see: Männik Katrin Monitoring and analysis of policies and public financing instruments conducive to higher levels of R&D investments: The "Policy Mix" project; Country Review: Estonia; and Polt Wolfgang et al (2007), op. cit.*

These new 'nodes' of embodied technology in the Estonian research landscape may in turn attract the interest of other funders (for instance, foreign investors seeking to relocate research activities towards relatively lower staff cost locations). An issue here is the extent to which the partners are budgeting sufficiently for depreciation and replacement of the equipment purchased. At the present time, at least on the university side, this remains a poorly managed issue.

- Investment in human capital: the well noted difficulties in ensuring a sufficient flow of young people into science and engineering education and thereafter careers in Estonia cannot be solved by a single initiative such as the competence centres. However, as noted in the intervention logic of the programme boosting interest in undertaking doctoral and post-graduate research with industrial relevance was an expected goal of the programme. Doctoral Schools, co-financed by the European Social Fund (2004-2006), as well as the above mentioned infrastructure improvements are clearly complementary measures. However, the key issues appear to be linked to boosting doctoral stipends and benefits and while the competence centres can be expected to assist in attracting or maintaining students to pursue PhDs, etc., they can only do so in a limited way. Wider funding of doctoral and post-doctoral research, for instance through broader technology programmes would seem more likely to boost doctoral numbers than the competence centre approach per se.

- Funding of pre-competitive research: the need to focus and target funding of research in Estonia has been highlighted in a number of reports and is a concern being addressed by on-going adjustments to the system of targeted financing and Estonian Science Foundation Grants being prepared by the Ministry of Education and Research. Clearly, the competence centres primary focus is not to contribute to structuring the academic research base. The centres of excellence programme and eventually the oft-mooted national technology programmes (an energy research programme has recently been approved) are more appropriate instruments, and indeed in the end the responsibility lies with the strategic choices made by the academic authorities. Nevertheless, the competence centres could be expected to contribute to structuring groups of private and academic research teams and given the scale of the Estonian economy and research system could over time have a more appreciable effect on building up 'critical mass' than in larger national innovation systems.

Knowledge exchange:

- Various routes exist for exploiting IPR developed in public or academic research and the Competence Centre model is one which contributes to this process, while it is again not the primary goal (co-R&D and hence sharing of IP generated being the model here). As noted above, the SPINNO programme has served, according to a recent evaluation, to put in place the basic skills sets and capacities within the public research universities to manage their IPR portfolios. Yet absolute levels of patenting and licensing as well as revenue generated from contract research, consulting and testing services remain limited. The interviews carried out for this evaluation highlight a number of continuing impediments in the academic sector to the provision of services to companies (which for many companies is the most sought after form of support and hence knowledge transfer, given the limited in-house capacities to undertake R&D in the industrial sector). These barriers include administrative burdens (contracting delays), overhead charges of the universities on such contracts, absence of cost accounting in the university sector, etc. The independent legal structure of the competence centres appears (from interviews) to allow them to act more flexibly and at lower cost and in a more business-friendly manner than the academic sector.

Innovation (finance and skills for product/service development, innovation management and absorptive capacity of enterprises, etc.)

- Funding for industrial R&D carried out within enterprises or by academic research institutes on behalf of enterprises is supported through Enterprise Estonia. This is done on non-targeted, first-come, first served basis (individual proposals being selected on their merits). The advantage, or complementarity of the competence centre approach is thus self-evident, in that it structures industrial R&D activities into 'strategic portfolios of projects'. At the present time, this approach is the only 'sectoral' orientation of enterprise R&D and innovation funding; although a cluster support mechanism is being designed at present by the Ministry of Economic Affairs and Communications. The cluster-based concept and initiative may favour to increase innovation capabilities more in less knowledge- and technology-oriented and traditional economic sectors as the interlinks between companies are more developed in those sectors (although there is not any sectoral limitations for the programme based on its draft legal act). This clearly requires careful consideration in the future, as the competence centres in the 'lower-tech' fields (e.g. food) may run some risk of overlapping with the nascent cluster policy.

- As the competence centre programme involves existing firms (working with the research-performing institutions), there may be no pressing need to access equity capital for start-up firms or for commercial exploitation of the R&D results in existing firms. Innovation finance in Estonia remains limited but has been boosted since the launch of the competence centre programme by the creation of the Estonian Development Fund. This fund aims to co-invest with the private sector financiers in knowledge-intensive firms. The competence centres in more speculative research-intensive areas (e.g. cancer) or some areas of R&D of other centres (e.g. bio-electronics in Eliko) may, however, generate potentially interesting cases for the launch of new companies. To what extent the competence centres programmes will serve as precursors for this type of more targeted support aimed at the shift up the ladder of knowledge-intensive production and services restructuring of the Estonian economy called for in the above mentioned recent report of Varblane is clearly an issue.

4 Panel and Peer Review Findings

ELIKO has established a large but shifting group of partners and is doing highly relevant applied research and advanced engineering while also producing significant numbers of research outputs and trained people. Its activities like its client base are rather fragmented, however, and it has yet to develop a sustainable long-term vision, owing to the lack of large technologically capable partners.

The Food and Fermentation centre's industrial consortium is more stable but still has opportunities to develop and become more inclusive. The centre has established an excellent research infrastructure and begun to produce graduates and industrially useful results. The present structure of two very senior professors and a large but young staff needs to be strengthened through more permanent centre commercial and scientific management. This will allow it to increase its publication output, more clearly establish its unique specialisation and set up better links to international science and industry.

The Nano centre extends a strong tradition of physics research at Tartu University and has helped to build research capacity in aspects of nanotechnology such as carbon nano-tubes. It has a strong production of postgraduates and research results and has transferred some findings to industry, however, the consortium is very unbalanced with only a few, small companies. Longer-term centre staffing is minimal and the centre is acutely in need of strong industrial partners able to work in the given high technology. Within Estonia, the prospects of finding them appear poor and the sustainability of this centre is uncertain.

The Dairy centre builds on expertise at the Tartu University and the Estonian University of Life Sciences to support a strong industrial consortium representing several stages in the dairy supply chain, which recognises that important limits in productivity and quality are being reached and can probably only be bypassed through research. The publication record so far is acceptable and the centre is contributing to graduate education. Having established a solid base, it is now beginning to diversify into related themes and, especially if the number of partners is increased, the centre has excellent prospects.

The Cancer centre builds on an established Estonian research tradition and brings together cancer researchers within the country. The industrial consortium largely comprises SMEs but is not directly involved in the research and aims to establish strong IPR in the field and to use this to valorise the research. Scientific and education outputs appear to be good and human resources are moving between the universities and industry. The consortium lacks the market or financial clout needed to move significantly further into pre-clinical or clinical trials but is reluctant to extend the partnership, which would dilute its IPR ownership. Yet without a wider partnership, it would appear to require a great deal of luck for this centre to be sustainable in a globally highly competitive field.

The centre visions were all ambitious but need to be tempered with realism abut the prospects of long-term survival without continued subsidy. The centres have all become credible research suppliers but generally need to strengthen their core team – and to do this, longer-term funding stability is required. Some need to address the balance of power between industry and the academic side. While most centres have strong industrial consortia, a more balanced mix of long- and short-term work will allow movement towards larger project teams.

The choice of the 'for-profit' ('Austrian model') for the legal form of four out of five of the centres has had unexpected and undesirable consequences given that the centres are administering public funds. There is scope for EAS to be more active in supporting the centres as well as administering the programme, which needs to devote further effort to overcoming the push towards fragmentation caused by Estonia's small size and the need to internationalise.

4.1 ELIKO

ELIKO is the oldest of the CCs, mainly working with embedded networks and Digital Signal Processing (DSP) applications in embedded systems.

At the outset, the core experts who assessed ELIKO's proposal regarded it as 'average'. They argued that the fact this is a virtual centre was a problem that would undermine the commitment of key staff and meant that the centre had high management costs. A large international partner was needed, if the centre was to establish an international reputation. The strategy was overly driven by company needs, and therefore lacked research focus.

The mid-term peer review rated the work as 'good to very good' but fragmented to such an extent that there was even duplication across two projects. The range of work expanded the academic to the very close to market. The importance of industry in specifying the work meant that it was highly likely to be implemented in practice. While the centre's capabilities were very wide, industrial needs were wider – so there was a need to focus. At the same time, the centre was short of software engineering capability. The lack of a major international partner with significant internal absorptive capacity was an important brake on the centre's development.

In the proposal, ELIKO articulated a vision and mission at the 3- and 7-year levels. In the first period, it would establish itself, hire 30 staff and by the end of the period win 30% of its income from international orders. By the end of the seventh year, it would have 40 staff, 30 external partners and be 80% self-financing. On the basis of its first three years of experience, the centre now regards these ambitions as too demanding and expects to set itself more realistic goals when it reapplies for funding this year.

The centre has produced a strong list of publications and seven patent applications. We have no information on the number of postgraduate degrees produced. Given the youth of the centre, its work is more likely to contribute to MSc than PhD education and to produce partial inputs into such degrees. It has so far involved 13 PhD and 18 MSc students. It has two successful Framework Programme (FP) proposals out of seven submitted, which is impressive, especially for such a young centre.

Table 7 indicates that the centre has established a significant team based on permanently employed senior researchers and researchers but in our view it is undermined by the fact that ELIKO operates as a virtual centre. It has neither territory nor its own visibility at the University and largely exploits equipment acquired by the University for other purposes. The centre's strategy has not yet stabilised – in part because it faces fragmented demand. Many of its projects are 'advanced engineering' so that it is effectively substituting for this capability among its industrial partners.

Table 7: ELIKO Centre Personnel

Source: report to EAS, 21.12.07

	Permanent		*Other*	
ELIKO	*People*	*FTEs*	*People*	*Total*
Research personnel	**18**	**8.1**	**1**	**19**
Main activity and subproject managers	4	2.1	1	5
Senior researchers, researchers	14	6.0	0	14
Other	0	0.0	0	0
incl. Bachelor students	0	0.0	0	0
incl. Master and PhD students	4	0.0	1	5
Administration	**4**	**2.5**	**0**	**4**
Project managers	1	1.0	0	1
Other administration	3	1.5	0	3
Engineers/technicians/laboratory technicians	**0**	**0.0**	**0**	**0**
Total	**22**	**10.6**	**1**	**23**

Table 8 shows the partnership involved at the time of the original proposal. Those companies highlighted are shown in the most recent progress report to EAS as contributing financially to ELIKO. As the second row of the table indicates, all the companies are small or micro-firms. Regio and EMT did not get involved as initially planned in the original proposal since the expert assessment excluded projects 3.1-4.4 from the research plan. Regio (70 employees) has recently started work with the centre however, even along with a new partner, Modesat (10 employees), plus spin-offs Smartfid and Smartimplant, this does little to change the picture of weakness in the industrial partnership. While there is no reason to question the quality or enthusiasm of the companies involved, it is hard to expect such small organisations to be able to deliver long-term commitment – especially to the more fundamental types of research that characterise CCs abroad. Until ELIKO can find stronger industrial partners (perhaps from outside of Estonia assuming this is of a strategic interest for Estonian companies) it will be forced to continue to work rather close to market in almost a 'contracting' mode.

Table 8: ELIKO Original Partnership

Source: CC Proposals, EAS

Project Type			*Artec*	*ELI*	*D-codex*	*GIRF*	*Emros*	*RIKS*	*EMT*	*Regio*	*Cyber*	*M&T*	*Elvior*	*Ibeks*	*TTU*	*No of Participants*
No of Employees			*32*	*7*	*8*	*5*	*4*	*70*	*295*	*47*	*Science*	*2*	*9*	*5*	*Science*	
1,1	A	SAI			X	X							X		X	4
1,2	A	ITM			X	X		X							X	4
1,3	A	AMMI			X	X								X	X	4
1,4	B	DSG-1	X									X			X	3
1,5	A	DSG-2	X		X	X									X	4
2,1	B	USME	X	X	X	X					X	X			X	7
2,2	A	UMTDA	X								X	X			X	4
2,3	A	MTDM	X								X	X			X	4
2,4	A	MIK-2		X		X	X								X	4
3,1	A	AVATEP	X						X	X					X	4
3,2	B	VAPOS-1	X							X					X	3
3,3	A	VAPOS-2	X						X	X					X	4
3,4	A	CONTEX	X						X	X					X	4
3,5	B	AR	X	X						X					X	4
4,1	B	KAV-1			X	X									X	3
4,2	A	KAV-2			X	X									X	3
4,3	B	PT-1	X	X											X	3
4,4	A	PT-2	X	X											X	3
		No of Participations	12	5	7	8	1	1	3	5	3	4	1	1	18	

While Table 8 suggests there are many multilateral projects, these appear largely to be modular, so that the amount of firm-firm cooperation is limited – which is also typical of close to market activities. However, some 20 industrial engineers are involved, so the cooperation is very active. ELIKO has started selling projects to industry as well as to funding bodies, which is a positive indication that the centre can have its own life beyond the CC programme.

There is a good mix of projects that the centre regards as 'basic research' ('B' in the second column of Table 8) and others that it sees as applied ('A'). However, this is essentially an engineering-oriented centre so its centre of gravity is close to applications rather than fundamental research.

ELIKO appears well managed, enjoying clear commercial as well as scientific leadership. There is scope to increase leadership at the level of the two themes on which the centre focuses. The supervisory board, however, seems to add little beyond the level of individual members being interested in their own projects and might benefit from more scientific members to counterbalance the industrial members' tendency to focus on individual projects.

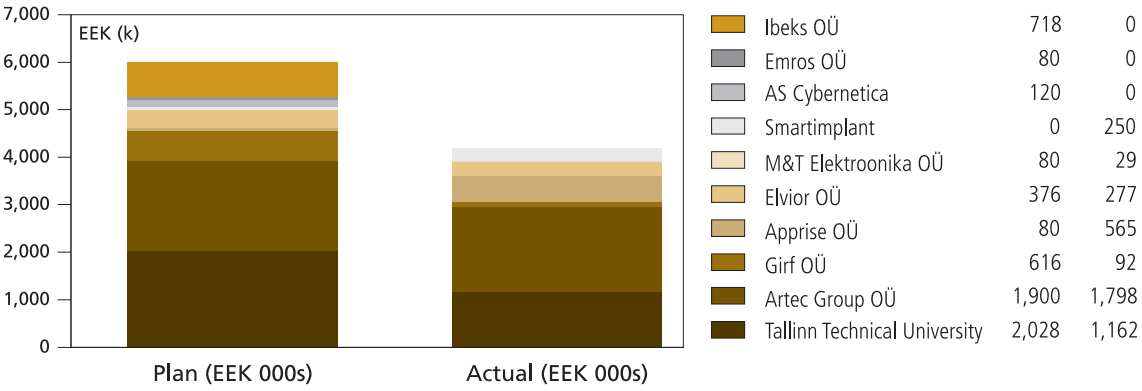

Figure 4: ELIKO Partner Contributions

Source: EAS (Apprise incorporates the former D-Codex)

The University appears strongly committed to ELIKO, providing both space and access to equipment. Most of the company partners are actively engaged in the projects and are both adding new capabilities (for example, in how to use RFID) and putting project results into production.

The centre has also had a beneficial effect on the University, triggering new courses on embedded software and involving 13 PhD and 18 MSc students in project work. New educational tools have been developed and the amount of research activity in the relevant university department has increased.

The long-term sustainability of the centre is an open question at this early stage. Its initial self-funding ambitions are clearly exaggerated and in the existing industrial environment of small firms it is difficult to see the centre operating without a continued and high level of subsidy, albeit declining over time. In the absence of subsidy, ELIKO would in effect have to become an industrial consultancy, and it is not clear that its customers would be willing or able to pay the full cost of its work.

Overall, ELIKO appears to be doing a useful job in a fragmented but developing industry. It continues to need at least one large industrial partner who can take a longer-term industrial view and more international exposure as well as stronger internal management to bring together a project portfolio that risks fragmentation. Until the industry matures to a greater degree and some larger companies emerge, it is unlikely that this centre can do the kind of more fundamental research seen in CCs abroad, but what it is doing today in raising industrial and universities is already valuable.

4.2 Food and Fermentation

The Food and Fermentation centre had a vision of becoming firmly established as a CC after three years and has the intention to establish a position as an internationally recognised research centre generating 70% of its costs at the end of year seven. It was originally intended to be a part of TUT but took on the legal form of a (non-profit) company at the insistence of EAS. The other CCs are legally for-profit companies.

The core panel reviewed this centre's application as a 'strong average'. The scientific peer reviewers pointed out that while the proposed work was industrially relevant, the research group was not as well in touch with international developments in science as necessary and the mid-term peer review underlined this by recommending the centre establish an international scientific committee.

The centre has two themes, which reflect the respective interests of the founding professors

- Technology, stability, quality and health aspects of food
- New fermentation technologies.

The vision involves the centre not only in developing strong sales of research to industry but also developing and exploiting its own IPR so as to generate a significant income stream towards the middle of the next decade. This will be hard to do – partly because the partner companies have rights to use IPR generated in the centre and partly for the normal reason that only a very small fraction of IPR generated or protected is ever commercially exploited. The centre is depending on a significant amount of luck in relying on this – and that may not be the best way to plan.

The centre's publication output is modest – about 20 papers and one patent – in part as a result of the effort that has gone into setting itself up and owing to the fact that most of the researchers are young, many being postgraduate students. Eight people – mostly at MSc level – have already moved on to industry and the research sector. Investing in a new cadre of researchers is an important precondition to increasing the amount of research and development capacity available in these areas to universities and industry alike. Table 9 shows that 60% of the centre's effort comes from students and as many as 60 (primarily post-graduate) students have already worked at the centre.

Table 9: Food and Fermentation Centre Personnel

Source: Report to EAS, 19.11.07

		Permanent		Other	
Food		*People*	*FTEs*	*People*	*Total*
Research personnel		35	26.3	5	40
Main activity and subproject managers		7	5.3	0	7
Senior researchers, researchers	4	2.0	0	4	
Other		24	19.0	5	29
incl. Bachelor students		2	1.5	0	2
incl. Master and PhD students	22	17.0	0	22	
Administration 2			2.0	0	2
Project managers		2	2.0	0	2
Other administration		0	0.0	0	0
Engineers/technicians/laboratory technicians		3	2.5	0	3
Total		40	31.0	5	45

The centre has devoted much of its first three years to establishing a new set of well-equipped laboratories and to postgraduate education, providing a step change in the size and quality of the facilities available to the university as well as a capacity not found in Estonian industry. Table 10 shows the original partnership. Those companies still making contributions (Figure 5) in 2007 are highlighted in yellow. The partnership is a mix of technology-based SMEs and larger food producers. The presence of Lallemande's Estonian subsidiary provides an important link to the global fermentation industry while Laser Diagnostic Instruments is a strong technology partner with high absorptive capacity that provides both measurement and instrumentation skills needed by the centre and a commercialisation outlet for some of he knowledge produced. While there has been some drop-out from the original consortium, new partners are being found in food, fermentation and logistics.

Table 10: Food and Fermentation Original Partnership

Source: Proposal, EAS, Nb: the projects 1.1 and 1.4 were excluded from the research plan following the expert assessment.

Project Type			*Kalev*	*Kohuke*	*Tallina Piimatööstus*	*Sakutaguse Pärmitehas (Lallemand)*	*Bio-expert*	*Pro-ekspert*	*LDI*	*Animal Recording*	*Dagotar*	*Valio R&D Centre, Finland*	*Applikon BV, NL*	*TTU*	*No of Participants*
No of Employees			*560*	*75*	*193*	*30 (MNC)*	*8*	*21*	*30*	*69*	*389*			*Science*	
1,1	A	Water in food stability	X	X					X					X	4
1,2	A	Fermentation and milk gelation			X				X	X		X		X	5
1,3	B	Functional food engineering	X	X	X	X			X			X		X	7
1,4	A	Fish Quality, Stability							X		X			X	3
2,1	A	Yeast production				X	X		X				X	X	5
2,2	B	Yeast and bacteria transit responses			X	X	X	X	X			X	X	X	8
2,3	A	Bacterial molecular physiology			X	X	X	X	X				X	X	7
		No of Participations	2	2	4	4	3	2	7	1	1	3	3	7	

Each of the centre's two themes has one project described as 'basic research' while the others are 'applied'. The more fundamental work has roots in a wider range of projects funded at the university by the Science Foundation and the Ministry of Education and Science. However, the centre has yet to raise the level of interest in the consortium up to the thematic level. Partners are present largely in order to be engaged in their own projects, rather than to learn more widely. Raising the level at which the centre and industry interact should be an important longer-term objective for the centre. This requires increased absorptive capacity among the firms – one reason the centre's high production of human capital is important – but is a distinguishing mark of a competence centre as opposed to a contract research house.

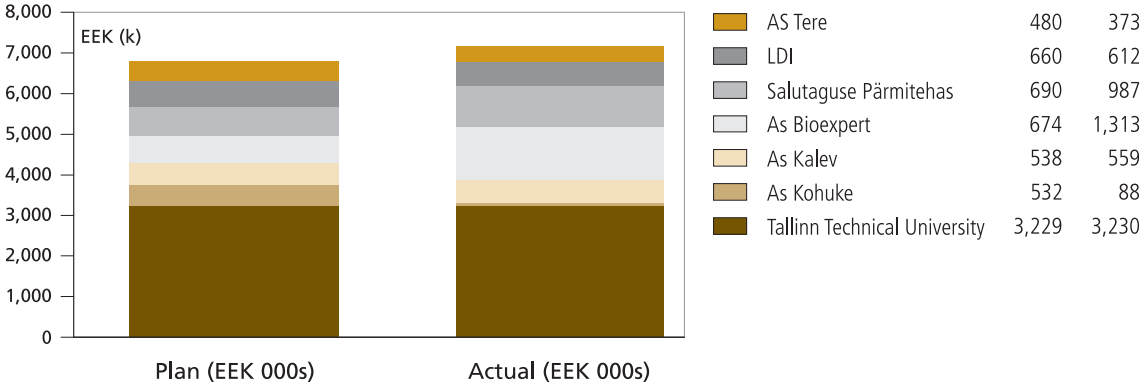

Figure 5: Food and Fermentation Partner Contributions
Source: EAS

Figure 5 shows a good overall fulfilment of the intended volume of industrial contribution but also some significant deviations from plan – both upwards and downwards – at the level of some of the partners. shows that the centre is starting to obtain income also outside the core partnership, which is an important sign that it has become established. Overall, it is clear that this centre has established itself and has a strong basis for operating as a competence centre over the longer term.

The two founding professors, whose intellectual input is key, dominate the organisation of the centre. However, it lacks commercial management and therefore continuity in marketing. This could be tackled via an overall centre manager or through separate theme managers. Generally, competence centres work well when both the scientific and the commercial aspects are championed within their internal organisation. The professors are both in their sixties while most of the staff are at the start of their career. A priority for the centre must therefore be to grow an experienced middle management and to secure the succession of the leadership. The governance of the centre appears to work quite well, but over time the numerical dominance of industry could be slightly reduced to promote more of a thematic and less of a project focus.

The centre is well embedded in the university, to which it provides a significant boost in terms of laboratories and education. Some of the more technology-focused partners have established effective, long-term relationships with the centre. At the minimum, Lallemande, Bioexpert; and LDI seem to be in it for the long haul and their personnel are present in the centre doing work on projects. Industrial relationships appear less solid on the food industry side, owing to lower industrial absorptive capacity – a situation the centre will hopefully change over time by involving industry people more actively in projects within the centre.

The self-evaluation contains a long list of changes triggered by the centre among its industrial participants. These focus on product and process improvements, with the technology specialists being more likely to adopt changes in methods and instrumentation. Over time, the centre should also trigger increases in absorptive capacity – especially by trying to 'plant' its graduates within partner organisations.

It has also had significant effects at TUT, widening the research agenda and tuning it better towards industrial needs and creating a critical mass of people working in the food and fermentation areas. The problem focus of the competence centre has triggered greater interdisciplinary cooperation in the university, raising its wider ability to tackle social and industrial needs. We see the increase in education and post-graduate training as a crucial contribution, building the conditions in which the centre and the industry can improve their performance.

We regard this centre as sustainable, though its 70% self-financing expectation – and especially the idea that it will live partly on a significant income from IPR – is unrealistic. Given the state of development of industry, it will take significantly longer before a high degree of self-sufficiency can be developed and the degree to which industry financing eventually dominates should be tempered by increased work in the centre at the thematic level so that it covers the broader needs of industry rather than only 'doing projects' – though doing projects must always be a major part of its work.

While it still faces important challenges, this is in many ways a model centre within the CC programme. It has bootstrapped itself from modest university origins to being a credible centre with good facilities and a recognisable presence. It has some strong partnerships in place and is growing new ones. It provides significant benefits to both its industrial and its academic constituencies and is itself contributing at large scale to the development of the human capital needed in both places. Its weaknesses are in the age and experience structure of the centre, so it must address not only succession in the longer term but building area and middle management in the short run. The publication rate must rise not only in order to advertise the centre's skills but also in order to ensure scientific quality is properly benchmarked and therefore raised to the international level. At present, quality may be 'fit for purpose' but the centre will not make much of an impression unless it is playing on the world stage and that means operating at world quality standards. Like all the centres, it would benefit from an international science board to act as a sparring-partner.

4.3 Nanotechnology

The Nano centre aimed after three years to have highly developed research capabilities in nanotechnology and to have developed nanotools, test nanostructures and measurements at the nanoscale. After seven years, it should be the leading nanotechnology research centre in the Baltics and be an essential link between fundamental research and commercialisation in nanotechnology.

The centre has two themes around which it organises. One is the development of novel nanotechnology materials for sensor applications. The other involves developing technologies for making novel SPM microscope tips, carbon nanotubes and specialised nanotools.

Both the core experts and the peer reviewers rated the Nano centre proposal highly, based largely on the science proposed, which was especially strong around scanning probe microscopy. Both identified the risks of having a narrow scientific base, with a single partner, however, and the need to expand the consortium, for example in the area of biosensors, if the centre is to succeed. The mid-term peer review essentially repeats the messages of the initial assessment, pointing out that while much of the scientific promise of the centre has been realised, it has not been able to build the needed industrial partnership. A large number of recommendations were made at the outset, few of which have been implemented by the centre. These were to

- Search for additional partners
- Involve a technology user in far-east Asia
- Provide management and teamwork skills to employees
- Clarify usage of the infrastructure of the University of Tartu
- IPR should be with the CC
- Revise ownership structure and distribution of shares
- Appoint the Managing Director and recruit an Office Manager.

It appears doubtful that the centre can realise its objectives under the conditions and the financing scheme of the CC Programme within the time horizon suggested. Nanotechnology is a rather new field and is not yet much developed in Estonian industry. It will take several years to achieve any significant economic impact. Therefore, industrial interest will grow only slowly and the prospects of attracting the larger number of stronger industrial partners needed are poor.

Due to the unclear financial situation the centre has acquired little permanent infrastructure and employs a very small permanent staff. Most of the competencies and all the necessary equipment are with the scientific partner, the University of Tartu. For the same reason the CC's research activities were reduced during the last year and no new projects and partners acquired.

With 27 publications, nine proceedings, 17 conference abstracts, three PhD theses and three patents within three years the centre has produced a substantial number of scientific outputs, although some of these results can be attributed to the associated university institute. The projects were performed as planned in the proposal and there were only minor deviations between budgeted and actual cost.

The centre has not become firmly established as a CC. It has managed to mobilise a large number of human resources, overall 88 persons (55 residents and 33 non-residents), mostly with part-time or temporary contracts. Also three PhD and nine MSc theses originated from the CC's projects, however with some of the PhD work already accomplished before the centre started. Table 11 shows the human resource picture as it was reported to EAS early in 2007. It underlines the minimal number of people engaged permanently in the centre and the intensive use of contract research workers. Apparently, the centre has adopted wholesale a system of paying contract workers to produce specific outputs, which may be an efficient way to operate but does have the disadvantage of making the involvement of researchers with the centre less than transparent. The large number of people involved implies that in most cases involvement with the centre can only have been for a short period. The centre supplied a list of 67 e-mail addresses for current and past research co-workers, of whom 20 appear on the list of publications and patents, confirming this impression that centre contact has been minimal in many cases.

Table 11: Nanotechnology Centre Personnel

Source: Report to EAS, 27.03.07

	Permanent		Other	
Nano	*People*	*FTEs*	*People*	*Total*
Research personnel	**2**	**3.0**	**25**	**27**
Main activity and subproject managers	0	0.0	7	7
Senior researchers, researchers	2	3.0	18	20
Other	0	0.0	0	0
incl. Bachelor students	0	0.0	0	0
incl. Master and PhD students	0	0.0	3	3
Administration	**0**	**0.0**	**3**	**3**
Project managers	0	0.0	2	2
Other administration	0	0.0	1	1
Engineers/technicians/laboratory technicians	**2**	**0.0**	**7**	**9**
Total	**4**	**3.0**	**35**	**39**

Table 12 shows the original shape of the Centre's partnership, with those companies still making contributions in the latest reporting year highlighted in yellow. This minimal size of partnership is too small to justify a CC and the small size of the partners makes the probability of valorising results at a significant scale rather small.

Table 12: Nanotechnology Original Partnership

Source: Proposal, EAS

Project	*Type*		*Mikro-Masch Eesti*	*Maico Metrics*	*Nex-Tech Supply*	*KTEK (USA)*	*Evikon MCI*	*U Tartu*	*U N Carolina*	*No of Participants*
No of Employees			*15*	*3*	*2*	*14*	*9*	*Science*		
1,1	B	Nanostructured materials					X	X		2
1,2	A	DSP/metrology of gas sensors					X	X		2
1,3	A	Microplate nano gas sensor	X				X	X		3
1,4	B	Cantilever-based bio-sensors	X					X	X	3
2,1	A	FIB and EBD technologies	X	X				X		3
2,2	A	Carbon nanotubes for SPM	X	X				X		3
2,3	A	Conductive microscopy probes	X	X				X		3
		No of Participations	5	3	0	0	3	7	1	

According to centre management, the plan was always to build up the research competence to demonstrate capability and then to recruit industrial partners in larger numbers. Only two industrial partners have been actively involved in funding and cooperating with the centre in the recent period (Figure 6). It therefore appears that while the industrial consortium has been small the centre and university have largely been getting on with research business as usual. As a result, the centre is lop-sided: scientifically quite strong, but the scientific resources are bound to the university, not the centre, which is largely missing the needed industrial dimension. A significant proportion of the projects was outsourced to the University of Tartu. In the long run, to operate as a CC the centre should build a core group at least consisting of full-time managers at the levels of the Board, strategic orientations and projects as well as specialists for financial, administrative, engineering and patenting activities.

Although members of the centre have attended international conferences frequently and scientists of the Institute of Physics of the University of Tartu have a good record in international cooperation, the centre was not successful seven times in applying for projects in the EU Framework Programmes. Given the absence of local industrial partners for whom the current research focus is relevant in the short-to medium-term, the only solution for the centre would be to concentrate on attracting new industrial partners from abroad (in which case the rational for funding under the EAS CC programme would be reduced); or to change radically its focus on technologies to better fit with local industrial capabilities and needs. In either case, it would be essential to review the scientific and industrial strategy and adapt it to the needs of a more representative sample of industrial partners.

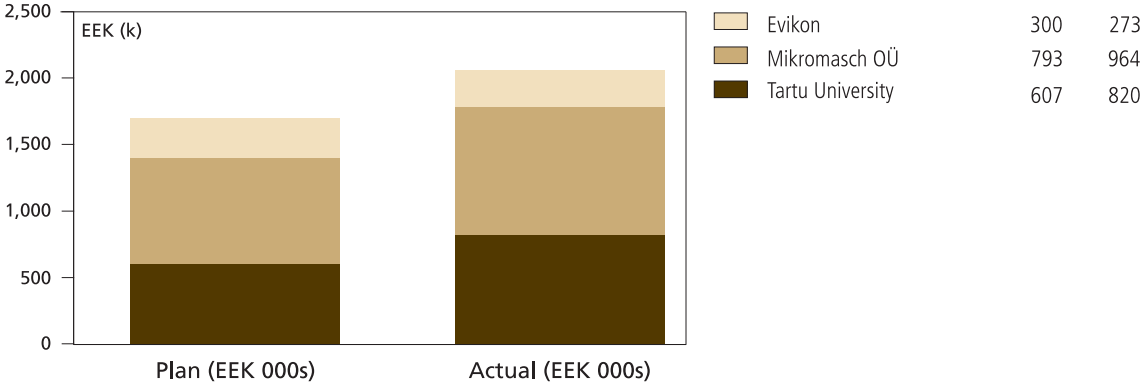

Figure 6: Nanotechnology Partner Contributions
Source: EAS

No problems were reported in the management and governance of the centre, though the limited industrial participation means that these have not been tested to a significant degree and that in practice the job of centre management has largely been to manage university research. Indeed, the centre appears well supported by the university – and vice versa. It makes heavy use of University facilities and contributes substantially to the University research agenda without being especially visible in its own right.

The centre has produced quite a number of potentially usable ideas for its industrial partners in nanotechnology sensor materials, measurement and potential manufacturing techniques relevant to SPM probes. Industry representatives indicated that the former would probably be commercialised within 3-5 years while the fate of the latter was less certain. The two active industrial partners are both very small and heavily reliant on outsourcing, so the potential economic impact of the centre depends upon a small and fragile base. If the centre's strategy were to be to focus on micro-firm beneficiaries, a much larger portfolio of clients would be needed to increase the chances of reaching the market.

The weakness of industrial demand and participation in the centre has been evident since the original proposal. It has not proved possible to rectify this in the meantime and without significantly increased industrial participation the centre really has no meaningful link to the economy. There is no evidence that industrial capabilities and interest in this area are likely to pick up dramatically within Estonia during the next four years or so. Continuing to fund this centre in the CC programme would therefore represent a triumph of hope over experience. The wider innovation systems question is whether Estonia would in the long-term benefit from continuing to build capacity towards having an essentially scientific research centre in one of the trendiest and most competitive areas of materials science. The answer to this question might well be 'yes', but needs to be addressed outside the CC programme. Given the priority that programme places on industrial participation and impact, the Nano centre cannot be regarded as a competence centre and it should seek substantial project or centre of excellence funding elsewhere in the funding system.

4.4 Dairy Centre

The Healthy Dairy centre's vision for its first three years was to establish itself as an internationally recognised research centre in its field, membership of which would confer status on its company members and where research and postgraduate studies were of high quality and competitive. There was no distinct vision for the seven-year horizon. The centre intends now to reformulate the vision for the next period in a more explicit way.

Its technical focus is on milk as a foodstuff and high-value raw material. One thematic focus is on improving the qualities of milk as an input to dairy product production and the eventual creation of a transgenic cow. The second is to develop probiotic milk-based products.

The core experts reviewing the proposal identified that IPR policy and financial arrangements needed to be more explicit and that the legal status of the centre needed clarification. The scientific experts judged the proposal to be "good/average" with most of the work being applied. Better international linkage would be helpful.

The scientific output of the centre is strong, based on the established capabilities of the universities involved, with 44 papers and four patents in the first three years. It has placed significant emphasis on developing post-graduate students and established a high rate of production with both MSc and PhD candidates frequently working in partnership with industry.

This CC has clearly managed to establish itself as a centre. It has built up considerable human resources (Table 13) and now has a coherent scientific and commercial strategy.

Table 13: Dairy Centre Personnel

Source: Report to EAS, 27.03.08

	Permanent		Other	
Dairy	*People*	*FTEs*	*People*	*Total*
Research personnel	**5**	**4.0**	**4**	**9**
Main activity and subproject managers	0	0.0	0	0
Senior researchers, researchers	5	2.3	4	9
Other	0	0.0	0	0
incl. Bachelor students	0	0.0	0	0
incl. Master and PhD studends	2	1.8	2	4
Administration	**1**	**1.0**	**1**	**2**
Project managers	1	1.0	0	1
Other administration	0	0.0	1	1
Engineers/technicians/laboratory technicians	**6**	**4.5**	**9**	**15**
Total	**12**	**9.5**	**14**	**26**

Table 14 shows that there is a comparatively high number of university partners. The industry side has by and large remained committed to the centre and has delivered on its planned commitments (Figure 7). The centre has attained critical mass.

Projects tend to involve multiple companies, providing benefits across the whole partnership. The dairy and the breeding association involved are of modest size by international standards. Almost all the work is applied in nature, the exception being the work on the transgenic cow. Despite the concerns of the experts who reviewed the centre's proposal at the outset, cooperation across two locations and multiple university institutes works well. One concern, however, is the apparent unwillingness of the existing industrial partners to extend the partnership – something that is needed in order better to valorise the centre's work. In the next phase, the centre could usefully extend the partnership.

Table 14: Dairy Centre Original Partnership

Source: Proposal, EAS

Project Type			*Visgenyx*	*Dairy Ass'n E-Pim*	*Animal Breeders' Ass'n*	*Starter Ltd*	*Valio Eesti Ltd*	*U Tartu Bio-chemistry*	*U Tartu Micro-biology*	*Agri U Reproductive Biology*	*Agri U Food Science*	*Agri U Animal Science*	*Tallina Piimatöstus*	*No of Participants*
No of Employees			*10*	*160*	*74*	*4*	*134*	*Science*	*Science*	*Science*	*Science*	*Science*	*193*	
1,1	A	Altering milk protein composition		X	X	X	X		X	X	X	X		8
1,2	A	Milk fatty acid composition design		X	X	X	X	X			X	X		7
1,3	A	Biotechnological animal feeding		X	X	X		X	X			X		6
1,4	A,B	Bovine transgenics application	X	X	X							X		4
2,1	A	Cheese probiotics		X		X		X	X		X			5
2,2	A	Modulating milk proteins	X	X				X	X			X	X	6
		No of Participations	2	6	4	4	2	4	4	1	3	5	1	

The centre has strong centre management as well as scientific leadership and it benefits from having a scientific board. IPR policy has been clarified and the governing board meets regularly. It may be that some more commercial input to the centre management would be helpful. The crucial governance constraint is the desire of the existing partners to 'close the door behind them' and not admit others. This is a constraint on centre development and obtaining returns on society's investment in the centre.

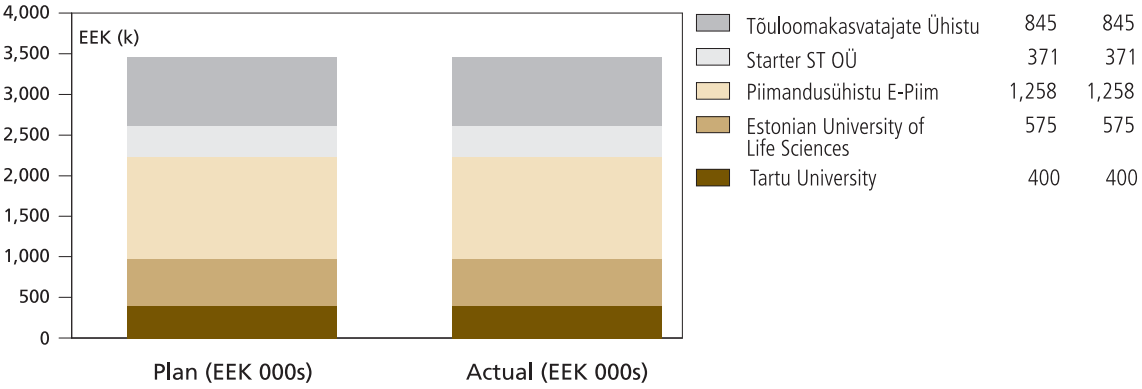

Figure 7: Dairy Centre Partner Contributions

Source: EAS

Some of the work of the centre – especially in relation to improving the characteristics of milk as a raw material – has involved collecting baseline data and databases of experimental results that the industrial partners can already put into practice. There is very concrete progress on the use of silage, while some of the other approaches to changing the characteristics of the milk will take longer to mature. On the probiotics side, various organisms have been tested and the centre is preparing health claims for the industry. The work of the centre is key to the universities' research and education missions and is well integrated with other university activities while company partners are integrated into the projects and the governance of the centre.

The companies involved are strongly committed to the centre and have both the strength and the interest needed to remain involved for the long haul. They obtain and expect to continue to obtain tangible benefits from involvement and have learnt the value that can be derived from research.

The universities are committed to the centre and their activities have been strengthened considerably through membership. The centre forms a part of their strategic development planning and tackles key areas of intellectual importance within their areas of specialisation. The centre will be further anchored in the universities by the introduction of a Micro Dairy, improving the experimental infrastructure. Inter-departmental cooperation has increased as has closeness to and understanding of industrial needs.

The Dairy centre is sustainable as a CC. It is beginning to take work outside the main CC programme, for example in functional fruit jams. The centre now needs to make its planning for the coming period more explicit. This kind of activity will always require a degree of subsidy – here as in the other centres. It is not reasonable to expect this activity to be fully self-financing, especially in the areas where it will take a long time to reap industrial benefits.

This is a strong and very applied centre that builds on existing university and industry strength in a field where Estonia is recognised as a strong producer. It has established a very good basis for continuation. In order to move forward, it should open the partnership to a greater extent and seek greater international contacts on both the research and the industry sides.

4.5 Cancer Centre

Our evaluation of this centre was hampered by its minimalist approach to self-assessment and the provision of concrete information. Our site visit was more informative.

The Cancer centre is the newest of the five CCs in Estonia. It started operation in February 2005. The centre's nature is in important respects different from that of the successful CCs in that it focuses on building small start-up companies and IPR in a highly competitive field rather than building on established industrial strengths. Potential returns are very high but the odds of obtaining them are probably less than in the successful centres.

The centre focuses on early detection of certain cancers and the development of 'new generation' cancer drugs with fewer side effects than established therapies. While many of its projects are described as basic research, it extends its work a long way into development via pre-clinical studies and early clinical trials.

The science experts rated the proposal good, yet improvable. They commended the competences of the scientific partners and the commitment of the industrial partners, and noted several innovative projects/ideas. On the other hand, they argued that the projects are not interconnected and that the management experience of the leading scientists is limited. In the mid-term peer review, the experts again stressed the fragmentation of the projects in the centre and pointed out that the centre's positioning 'upstream' in the innovation process meant it needed partners with the financial and industrial strength to tackle the later, more expensive stages of the pharmaceutical and diagnostics innovation process. The centre should develop a more sophisticated patenting strategy.

The core experts also valued the proposal as good and recommended refinements concerning IPR, management structure, Council membership, cost calculation and funding. They stated that a major industrial partner is lacking and recommended the integration of a larger pharmaceutical company. This appears to go against the exploitation strategy of the centre, which focuses on IPR and building up some of the small companies involved as partners and in which members of the centre hold shares.

The centre's vision include

- Being an internationally acknowledged centre
- Common technological platforms in cancer diagnostics and treatment
- Clinical trials implemented in Estonia
- Developed technologies implemented by industries
- Substantial revenues stemming from international co-operation.

The vision statement does not differentiate between the 3- and 7-year horizons as is the case in the other CCs. Therefore, most of the projections cannot yet be verified.

The scientific output reported to EAS in year 2 of the centre is four publications in international refereed journals and two Estonian patent applications, which is extremely modest compared with the other centres. However, it must be remembered that this centre is younger than the others and that the time lags involved in generating such output mean it is hard to produce many outputs very early in the life of a centre. By May 2007 there were 14 refereed papers published (Table 5). By year 3, it was expected the centre would have contributed to 14 PhD degrees, which is an impressive performance. The results of selected projects as presented to the panel appear very appropriate and were well appreciated by the representatives of the industrial partners. The CC has mobilised the necessary human resources (presently 42 employees and 12 commercial contracts) and also enabled already four of its employees to continue their career in university or industry. Table 15 shows the human resource numbers reported to EAS, indicating that the centre makes heavy use of existing permanent staff at the university.

Table 15: Cancer Centre Personnel

Source: Report to EAS, 09.05.07

	Permanent		*Other*	
Cancer	*People*	*FTEs*	*People*	*Total*
Research personnel	**27**	**18.6**	**12**	**39**
Main activity and subproject managers	5	3.8	4	9
Senior researchers, researchers	22	6.1	8	30
Other	0	0.0	0	0
incl. Bachelor students	0	0.0	0	0
incl. Master and PhD students	11	8.8	0	11
Administration	**5**	**3.6**	**0**	**5**
Project managers	1	1.0	0	1
Other administration	4	2.6	0	4
Engineers/technicians/laboratory technicians	**8**	**5.7**	**0**	**8**
Total	**40**	**27.9**	**12**	**52**

Table 16 shows the original partnership, comprising micro- and very small firms on the industrial side, a regional hospital and the university. A number of existing relationships with foreign partners were reported but do not appear to involve financing in either direction. Projects individually involve few industrial partners and appear to have limited interconnection.

Table 16: Cancer Centre Original Partnership

Source: Proposal, EAS

Project Type			Pro-Syntest	Kevelt	Celecure	Inbio	CeMines	TSF Trial Form Support	N Estonia Regional Hospital	TTU	NICB	Estonian Biocentre	U Helsinki I Biotech	KI (Sweden)	Angitia AB (Sweden)	UT	No of Particip-ants
No of Employees			24	10	10	4	5	48	2555	Science	Science	Science	Science				
1,1	B	FRET-based inhibition of p53-Mdm2	X							X	X	X					4
1,2	B	Identify CD443MUT endothelial target			X					X	X			X	X		5
1,3	B	Anti-cancer saccharide analogues								X	X					X	3
1,4	A	Protein expression in GP facility		X	X					X	X						4
1,5	A	Precilinal testng of CD443MUT			X					X	X			X	X		5
1,6	C	Clinical testing of CC0101		X	X				X							X	4
1,7	A	Immunotherapy			X	X			X	X		X				X	6
2,1	B	Cancer markers			X	X			X							X	4
2,2	A	In vitro drug response assay			X				X	X						X	4
2,3	A	Breast cancer markers					X		X	X							3
		No of Participations	1	2	7	2	1	0	5	8	5	2	0	2	2	5	

Industrial contributions to the budget are at or above plan (Figure 8). This is especially impressive given the small size of the companies and the fact that the centre does not receive in-kind contributions (as EAS has no protocol for checking such contributions), which would be the more normal type of input from micro firms.

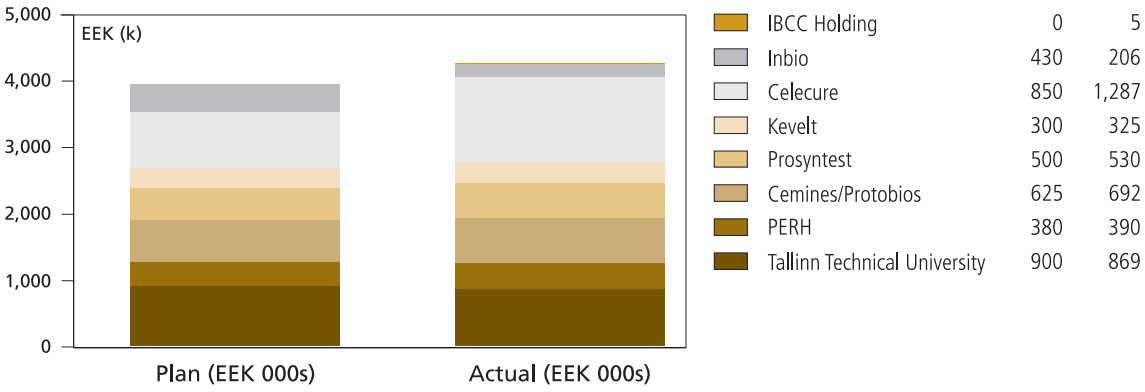

Figure 8: Cancer Centre Partner Contributions

Source: EAS

The centre exists within well-established university infrastructures. It obtains complementary funding from the science foundation that enables more fundamental work to be done. However, it systematically excludes the role of complementary applied work from its reporting so it is not possible to assess the degree to which it is building a wider base of activity that could make it sustainable in the longer term. As of now, the centre does not plan to expand the ownership unless additional know-how would be necessary. Additional partners (not shareholders) are welcome.

The CC has sites in Tallinn (6 subprojects) and Tartu (2 subprojects) and is very effectively managed. The board only consists of its chairwoman who appears very competent and energetic. The heads of the two strategic orientations and the two scientific consultants, an overall projects coordinator and the financial manager report to her. On the next level there are the project managers, who form their teams with the scientists and engineers. The shareholders each have one seat on the Council plus a professor of the University of Helsinki. The Council members are closely related to the research activities and meet very often, also ad hoc. Thus, the Council acts more like the committee of scientific and industrial partners where information is exchanged, activities are coordinated and decisions in scientific and administrative questions taken than as a supervisory power.

According to the self-evaluation report there were no problems, therefore no change of the organisational structure is necessary. Actually, the governance of the centre is very much tailored to the strong personality of the Chairwoman who enhances the team spirit by direct communication and acts as the controlling authority. The ultimate supervisory role, however, belongs to the General Assembly of the CC, in which all partners have the same voting rights according to the even distribution of the shares.

The IPR principles of the centre are simple. Licensing income originating from fundamental research which is funded at 100 % by Enterprise Estonia goes to the CC. Licensing income from applied research which is co-funded by the partners is split between the CC (5 %) and the partners involved (pro rata their financial contribution).

The centre appears to be well embedded in the university and companies involved. The statements of the representatives of the scientific and industrial partners present at the site visit reflected the strong interest of all to cooperate. Specifically, TUT provides rooms, equipment, scientific advice and the availability of graduate students on the basis of a long-term contract. The companies also have long-term commitments and fulfil their financial obligations. Since all research activities are performed at the centre, there is no company staff involved except in the project supervision and the medical trials which take place at the hospital. The growing interest in the centre's services outside the CC Programme also reflects the relevance of its work.

Financing is split between TUT (6%) and the 7 industrial partners (24%). The remaining 70% are contributed by Enterprise Estonia or ERDF funds within the CC Programme.

As regards the impact of the centre on the industrial stakeholders, the self-evaluation report is not specific but the presentations at the site visit gave a good impression of the value of the results to the industrial partners. However, since it takes years to achieve the industrial implementation of the developed technologies, it is too early to judge.

The representative of the TUT stated at the site visit the reasons for the University to be a member of the CC. These are

- Increase of the critical mass of brains
- Improved collaboration with industry, access to novel applied research projects
- Joint infrastructure
- New workplaces and practice base for students graduating from the university
- Improvement of the quality of graduate studies, incl. new projects and supervisors
- More interdisciplinary research (biology, medicine, chemistry, etc.)
- Attraction of new research groups to TUT, incl. repatriation of outstanding scientists.

The CC has solved the problems inherent in the original proposal. It has also been successful in creating know-how, personnel, efficient management structures and sound relationships to its partners in science and industry. Its financial performance is according to plan and its strategic concept ambitious. Continued funding in the CC Programme will result in further strengthening the centre according to its vision and mission.

Changes should be considered in the financial concept that seems to be optimistic. Given the high competence in the life sciences and the urgent need for the research results, the centre in due time should attract more partners to expand its activities.

The impressions of the centre gained at the site visit are good. The importance of the field of cancer research and the respectable record of the involved researchers combined with the dynamic centre management seem to be good reasons to continue funding in the CC Programme. Details of the research programme should be negotiated after the scientific mid-term evaluation. The centre's strategy is high-risk and while the potential rewards are also high, it was not possible to identify reasons why this centre should succeed better than others in such a highly competitive and (especially in the USA) massively funded field. The industrial basis for valorisation of success appears weak. If the centre is to continue, this should be strengthened.

4.6 The Mid-term Peer Reviews

During the first part of 2008, the centres have been scientifically peer reviewed, largely by those who did the scientific assessment of their original proposals. As Table 17 indicates, the reviewers worked in pairs, with each team comprising a technical specialist from VDI/VDE plus a Nordic scientist working in the relevant field. The use of one VDI/VDE expert with a research specialisation in bacteria in three cases suggests he may have been overstretched.

Table 17: CC Peer reviewers, 2008

Source: Peer review reports

Centre	*Reviewer*	*Organisation*	*Reviewer*	*Organisation*
ELIKO	Karl-Erik Årzén	Lund U	Peter Gabriel	VDI/VDE
FF	Niklas von Weymarn	VTT	Cord Schlötelburg	VDI/VDE
Nano	Christian Bohm	Stockholm U	Lars Heinze	VDI/VDE
Dairy	Asko Mäki-Tanila	MTT, Finland	Cord Schlötelburg	VDI/VDE
Cancer	Anders Virtanen	Uppsala U	Cord Schlötelburg	VDI/VDE

The peers reviewed the CCs' individual projects and produced a short synthetic report on each centre. They were not required to use numeric scores and their comments are not referenced to any set of norms, so, for example, where they judge that research is generally 'good', it is not clear whether this means 'good in the context of a very small country' or 'good compared with international quality standards'. They were required simultaneously to treat different aspects of the research in single questions, so it is difficult to interpret or to compare their evaluations across centres. A set of criteria that is both more differentiated and that uses a mix of words and numbers would in future provide a clearer picture of peers' views.

The peers' general opinion about the research was that

- ELIKO was "good to very good"
- Food and Fermentation had yet to produce much scientific output, which therefore needs to be prioritised now the centre is up and running
- Nano had achieved many good scientific results and had built research capacity to the point where it could act upon the international stage
- Dairy had high scientific value
- The Cancer centre's overall scientific value "can be considered good' taking into account the mix of basic and applied work being done.

The peers looked at the synergy among projects as a way to consider the coherence of the research programmes pursued by the centres

- ELIKO was fragmented to the point where there was duplication across two projects
- Food and Fermentation was generally good
- Nano and Dairy were both good
- Synergies within the Cancer centre were limited by the fragmentation of project research topics.

They considered the potential for industrial application of the centres' work

- The result at ELIKO was mixed, with some work being immediately applicable in Estonia and other work being usable only by large companies abroad, who were not currently involved with the centre
- Food and Fermentation results were in some cases very applicable but a number of them need international partners to bring them into practice
- The good take-up of results in the Nano and Dairy centres demonstrated that these could produce useful results
- The Cancer centre was in a different category, aiming to produce results that would have high potential for application but where the probability of reaching the results was low.

Finally, the peers commented on the centres strengths and weaknesses, which we can summarise as follows

- ELIKO's breadth is a key strength, but despite this strength it also has important gaps in its portfolio of topics. The lack of one or more large company partners was a crucial weakness
- Food and Fermentation had build research capacity and infrastructure but had yet to develop a distinct pattern of specialisation that would allow it to position itself internationally

- The Nano centre had built up a research network but lacked industrial partners
- The dairy centre was doing good, relevant and professional research but was poorly connected to the international context. Some of its research topics were in 'fashionable' areas that might lead nowhere
- The Cancer centre had established a good research team, infrastructure and partnership but was working very far from the market in high-risk areas. The partnership crucially lacked the ability to move ideas forward very far towards commercialisation because it could not afford to do much clinical work on its own account. It therefore needed a large pharmaceutical company partner.

4.7 Cross-centre issues and conclusions

The visions and missions defined by the centres at the outset were all ambitious, which is a positive sign of their enthusiasm and commitment. The experience of the first three years shows, however, that the lack of absorptive capacity in industry is a significant brake on their development and makes it unlikely that the centres can expect to become financially independent of subsidy even in the medium term, as some of them suggest. Some of the centres see revenues from intellectual property as providing a significant income stream after seven years – something that goes against all experience of similar centres elsewhere as well as being something the centres cannot yet explain in concrete terms (how much income from whom and from which pieces of intellectual property). Future plans need to be more sober and therefore also to tackle more explicitly how centres propose to survive (or leave a useful legacy) beyond the seven-year funding period.

All five centres have established themselves as credible suppliers of research. The weaknesses on the demand side that were obvious at the start of the programme remain obvious today, especially in ELIKO, the Nano and Cancer centres, and have not successfully been addressed by the centres in the meantime.

The centres' outputs in terms of numbers of publications, patents, PhDs and so on are generally quite good, given that they are at an early stage of development. The rate of production should increase as centres mature and as they overcome the normal time lags in the production, publication and take-up of research and of higher degrees.

Most of the CCs have to a degree established themselves as research centres, though ELIKO's almost virtual nature makes it hard to see it as a centre. Most if not all need to build up a stronger core of staff employed by the centre who can manage projects and project portfolios over more extended periods and provide continuity of research and applications skills. Creating a strong and more or less permanent core has been hard in the light of the short-term (annual) nature of the funding provided but the lack of staff employed continually by the centres undermines their effectiveness. Relationships between the centres and their industrial partners tend to be bilateral and none of the centres has yet established itself as a strong player on the international research stage.

While centres reported no difficulties with governance or management, the general pattern is that their governing bodies focus on the execution of the existing project portfolio and that they add limited value beyond that, for example through devising longer-term commercial and scientific strategies. The composition of the consortia drives the balance between more fundamental and more applied research. In the case of the Nano centre, where the industrial side is weak, the centre has focused on a research-driven, capacity building agenda. In other centres that are more industrially driven the various industrial interests have tended to fragment the agenda. A better balance is needed in order to both meet industrial needs and ensure that the centres have intellectual bases that are sustainable but such a balance can really only be built up once there is confidence that the CC funding and the CC consortia will be long lived. Without that assurance, consortium participants have incentives only to follow their own short-term interests and not the collective long-term interest.

The universities have taken the centres to their hearts and see them as providing significant additional value in terms of income, research focus and industrial contact. Their initial fears that the centres would prove to be competitors have been removed. Since the CC programme is about industrial research, it is easy to overlook its importance for higher education at all levels. Provided the centres remain closely linked to the universities, they provide important signals about areas where education needs to be expanded in order to meet social and scientific needs.

Given the limited size and R&D capacity of most of the industrial partners, it is perhaps surprising how well the founding partnerships have survived and it is positive that some centres are attracting new ones. This and industry's continuing willingness to pay is evidence of a good industrial engagement, though we must also note that the level of subsidy is high and that company partners therefore get an extraordinarily good bargain. In one case (ELIKO), they were collectively paid for sub-contracting work twice as much money as they put in via project contributions.

On the evidence reported by the centres, the industrial partners get a lot of relevant output from their CC relationships in the form of new product and process ideas and improved R&D capacity. Over time this needs to be reflected more in increased R&D employment in the companies, partly through mobility form the CCs. In many cases, company staff is actively engaged in the R&D projects with the CCs. At this stage, however, these benefits tend to flow only between the centres and individual companies. At a later stage we would want to see more multilateral project relationships being formed, for example working at several stages in supply chains.

There is evidence that the centres are starting to create the interdisciplinary research foci within the universities that were intended, but these initial achievements are crucially dependent upon longer term funding that will give the universities the confidence to permit more restructuring. At this stage there seems to be little effect on the overall strategies of the universities. A wider set of policy measures going well beyond the CC programme is probably needed to help the universities set clearer strategic directions. Nonetheless, the CC programme has had a positive effect on universities' receptivity to working with industrial issues and partners.

As our remarks about visions and missions suggested, the centres have yet to develop adequate strategies to cover the longer term, especially beyond the expected seven-year funding horizon. This is an urgent need if the centres are to produce a sustainable legacy in the R&D system. Both the centres and Estonian policymakers need to consider what to do in the light of the probability that none of the centres will be financially self-sustaining even after seven years of investment and that the only real prospect for self-sufficiency would involve abandoning their 'public good' roles and their nature as competence centres.

The choice to impose that the centres be established as independent legal entities (either in a for-profit or not-for-profit form) was useful as a way to prevent the universities from effectively monopolising them, in the context of the limited funding streams available in 2002 for university research, but has led to a substantial misunderstanding about the role of the centres. The CCs receive a public subsidy in order to generate both private and public goods. The private goods have a social purpose in promoting innovation and development that in turn should have beneficial social impacts. The public goods include knowledge and human capital that can be more widely shared within Estonia. It is not a purpose of the programme to provide shareholders of the CCs with a subsidised investment vehicle. However, in at least two cases, the founding partners are trying to use their position as shareholders to block the entry of new partners. Unthinkingly, they are trying to appropriate public goods for their own private purposes, and EAS needs to discourage this behaviour that will otherwise limit both the effectiveness and the social impacts of the CCs. Similarly, in at least two centres, the centre and university staff and management are also shareholders in beneficiary companies. In effect, therefore, they are unthinkingly channelling public subsidy through the centres to themselves. It is always difficult to draw the line between the public and the private where knowledge is generated in the public research system and privately exploited, for example through spin-off firms, and there are advantages in not defining the boundary between public and private rights too clearly lest this get in the way of the innovation process and its wider social benefits. However, such conflicts of interest need at the very least to be stated via a register of interests. Where the extent of ownership is high or where private owners can themselves exercise a great deal of influence over the use of public resources, such conflict of interest should be forbidden. As one of the partners put it to us at the interview, "*In some terms, legal form (limited company) is "ideologically" in contradiction with the objective of CC support measure (R&D oriented support) – public money should support activities and results available publicly, not restricted to a private collaboration organised in business form."*

Different centres reported differently the degree to which EAS has added value to the programme over and above funding. Some appreciated EAS' 'round tables' for centre managers and its work to support the centres' longer-term planning. Others saw little value in EAS' work. Broadly, we conclude that EAS has been as supportive of centre development as is possible under the circumstances. There is scope now to feed forward the cumulated experience of the first five centres into the new programme through a new set of teaching, training and experience sharing activities.

EAS has, however, had little influence over the implementation of the centres' proposed strategies. In particular, there has been no effective mechanism that takes account of the recommendations of the peer and core panel reviewers and ensures that they are seriously considered by the centres. As a result little of the advice offered by the reviewers has benefited the centres. It does not follow that such reviewers' advice should always be taken – but there should be a mechanism for thinking about it.

In our view, and without being able to say anything about their 'quality and effectiveness compared to other proposals that may be made this year, three of the existing centres have a good basis for continued funding provided they address the criticisms made by us and the peer reviewers. The Nano centre is problematic because of the apparent lack of demand. Unless it can demonstrate that such demand exists it has little place in a competence centres scheme – though it might fit perfectly with a university centre of excellence programme.

The Cancer centre is quite a different class of activity. It is essentially a way to bet public funds on an enterprise that has a low chance of success, but which – if it were to be successful – would have a major impact, both economically and on disease. Given that one of the functions of the state in relation to innovation is to reduce risks, this could be seen as a perfectly acceptable high-risk component in a funding portfolio where it is balanced by much safer bets. Finally, whether it is seen as a viable investment depends upon the risk-willingness of the Estonian Government.

Some common themes emerge from our own panel review of the CCs and from the views of the mid-term peer reviewers. One is the difficulty of operating a competence centre in a very small country. The small size of the market pulls the centre towards covering a wide range of issues while at the same time it actually needs to specialise in order to establish a competitive position in research and in serving the industrial community.

The second and related theme is fragmentation of the research portfolio, which is typical of a stage where relationships with companies are largely bilateral and where research is so close to market that companies find it hard to share. Given the high level of subsidy, there is scope to increase the proportion of more fundamental, common-good work done in the centres. Without this, their long-term survival as research centres is threatened.

The third is the limited degree to which the centres have internationalised. This applies both at the level of obtaining international scientific advice and in terms of recruiting multinational and foreign partners. The international scientific advice question is important – research centres need to be fully integrated into their respective international scientific communities and at this stage the Estonian CCs are not well integrated. We infer that each of them would benefit from a small but demanding international scientific committee or visiting committee. This is especially true for the two foods-based centres, whose natural orientation is towards domestic industry. At this early stage, it is very demanding to ask that the centres should so impress international companies that they should join in the partnerships, but this is the direction of travel needed for the future – in the first instance probably focusing on nearby countries with stronger innovation systems such as Sweden, Finland and Germany.

5 Stakeholder Perspectives

Despite initial worries that the centres might prove to be competitors, all the universities involved now strongly support the CCs, which strengthen university focus in certain areas and increase industrial contacts but have yet to exert a more profound influence on university strategy. Longer-term funding commitment and a wider portfolio of R&D funding instruments, including technology programmes and better post-graduate funding, were needed if the CCs were fully to play their potential role.

Company partners are almost all small firms, though their mean size has grown a little in the last few years. Two thirds of them are exporters. They have made strategic decisions to partner with the CCs but their aims are mainly to get rather short-term help with product and process development In practice, the CCs tend to function somewhat as 'industry platforms' where members network and get business and well as technological benefits and – as in most collaborative R&D – the results participants actually take away are more likely to be 'intermediate knowledge outputs' than results they can put directly into development. (At the same time, there is also evidence that a lot of near-to market technology transfer is happening and there is also variation among the centres.)

Companies tend 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. The majority saw the benefits of participation as outweighing the costs and most said their activities were additional: without the CC they would not be able to as much as they could with its help. Human resources produced via the centres were important to the companies. Among the 'soft' effects was that the centres were often a source of internal 'inspiration' to the companies – training their and their employees' technical ambitions.

Most of the researchers who responded to our survey were only involved with the CCs part-time, reinforcing the impression that a stronger core of more full-time people is needed. Their goals in participating were very mixed and reinforced the impression that the funding was a major influence – and that correspondingly few other research-funding opportunities were available. This is similar to the situation of the early Irish CCs (the Programmes in Advanced Technology), which were enthusiastically received by the universities because they represented a unique source of new research money. Researchers tended to work close to their core technologies but did not see the CC research as risky. On the other had, it was comparatively long-term and far from the market – which is consistent with industry's view that it was getting intermediate knowledge products a fair proportion of the time and not so often the close-to-market outputs it wanted.

5.1 Universities

As part of the evaluation process, we interviewed vice rectors for research and heads of departments involved with the CCs. The role and importance of academic institutions as research performers is relatively stronger than in many other EU27 countries and during the period since the CCs has been launched, public research funding in higher education sector has continued to grow strongly[10]. The three major public research universities involved in the CC programme were all generally positive about the contribution that the programme had brought to their relations with industry, mostly reporting increased revenue over the period from industrial sources (although both in relation to overall research budget and absolute terms the available information suggests that business funding of higher education R&D remains low[11]).

[10] *The share of the higher education sector in research and development expenditure (GERD) was approximately 40% in 2006, down from 56% in 1998, but in absolute terms HERD has increased significantly from 252 million EEK in 1998 to 959 million EEK in 2006 (in terms of HERD/GDP an increase from .32% to .39% in the same period, recalling that GDP has grown considerably).*

[11] *For instance, Tartu University reports that in the last full year, revenue generated by contracts with business was only in the range of 100-130m EEK, of which only about 10-30m EEK was really on high tech industrial development.*

Initial concerns that CCs might turn out to be competitors to the universities have proved unfounded and all the universities involved today value the CCs. Tartu University considers the CCs as complementary to their own internal efforts to develop and restructure mainstream academic research, and argued that if the university is to be encouraged to work more with industrial partners then there is a need for one or more strategic research partners with a long-term vision and able to contribute to a stable financial partnership. Tallinn University of Technology embraced the CC concept from the start as it fitted well with the University's technology focus and over the lifetime of the project this positive view has been enhanced at all levels in the university hierarchy. While the Life Science University feels it may be hampered by its small size and competition for funds with the other universities, it is keen to participate further in the CC programme, which allows it to focus its efforts on areas in which they can obtain some critical mass of research. This focus was being translated into increased student numbers at all levels.

At this stage, the CCs do not play a central role in university strategies or in affecting universities' internal structures but their problem-orientated focus was bringing some departments together and causing more interdisciplinary work to be done.

The universities see the CCs as generating positive financial returns, tending to involve increased investment in equipment, reinforcing the wider infrastructure programme, and improved links with industry. The centres also address rather high cost applied sciences and therefore tend to counteract the tendency for the universities to expand most easily in 'low cost' subjects in the social sciences, business studies and humanities that are not so equipment intensive.

The CCs appear to play an important role in building human resources within Estonian universities. Most interviewees touched on the low level of academic wages in the universities. The CCs were able to pay 150% to 200% of normal academic salaries, making it more attractive for people to stay in the universities and counter-acting the brain drain among the more successful academics, who appear to have good links abroad as well as opportunities to move to foreign universities if they so choose. Germany, Sweden and Finland are among the potential destinations. Part time work in the centres provides an attractive supplement to academic wages even where (as in the cancer centre) it is said that time contracted by academics to the CC is subtracted from their normal university contract. It emerged that the Nano centre was created in order to 'do something new' in an institute that historically had very strong laser capabilities and that had spun off three firms, including LDI, which is a key partner of the Food and Fermentation centre. Much of the Nano centre's funding to date has been used to supplement the meagre grants of the PhD students; and this is a common element of the CCs use of funds.

The universities felt that cooperation with industry tended to induce a short-term focus, given that most of the companies involved were small and had limited technological capabilities. Many companies were looking for a level of 'proof of concept' that went well beyond the academic definition (which tends to be lab-scale) and came close to product development. Until the CC programme commitments become longer and it is possible to generate strategic relationships with larger, more technologically capable (and possibly international) partners, the universities see only limited and temporary effects on their strategic directions.

The universities complained that the long-expected (Finnish style) technology programmes were still not appearing. This meant that the CCs were forced not only to try to play their intended role of building strategic research relationships with industry but also to tackle shorter-term needs. The absence of a longer-term commitment from EAS to the individual centres reinforced this overly short-term focus in the CCs. It was important to get over the 'funding gap' at the end of the first three years of the programme and to proceed into the main phase so that the character of the relationship with industry could change and that companies capable of operating in longer-term university relationships could be attracted.

Awareness of how to capture and manage intellectual property in the universities was mixed. This was not only a matter of needing to strengthen their central ability to patent and exploit IPR but of educating faculty to think in terms of IPR, identifying attractive opportunities and documenting discoveries and laboratory findings appropriately.

The academic reward system in Estonia has recently been shifted to focus even more on academic publication than was the case before. This causes a certain tension with the CCs – especially to the extent that they help meet shorter-term industrial needs.

More generally, the universities shared the frustration of the centre managements at the need for repeated bureaucratic justifications of the centres, with annual proposals being made in the context of continuing uncertainties about longer term funding. The degree of micro-management involved, with the centres needed to submit project- and not just centre-level proposals reduced their flexibility in defining and understanding needs and was unreasonable, especially in the early stages of the programme where work plans and partnerships would be volatile.

5.2 The Company View

We aimed to interview 30 companies: three founders and three subsequent partners of each CC. In 26 out of 30 cases, our interview partner was the CEO or the member or chairperson of the Board of the company. We rejected two of the interviews as having insufficient quality of response prior to our analysis, leaving us with an effective sample of 28 partners. Of these, two thirds were small R&D/engineering companies, which suggests that the Estonian CCs' clientele is very different from that of competence centres abroad, which work primarily with larger, established and fairly high capability firms.

Figure 9 shows the size distribution of the 25 partner companies, which gave us employment data, indicating that half that population had 10 or fewer employees in 2003. Over time, the firms have tended to grow a little, with average firm size rising from 64 to 79 employees.

Despite the generally small size of partner firms, they are not particularly young. Some 18 (64%) were established over ten years ago. Five (23%) were established between 5 and 10 years ago and a further three in the last 5 years while two did not record founding dates. Only one claimed to be involved in more than one CC.

A majority of partners were exporters (16 out of 28 or 64%). Eight (29%) were not exporting, while we lack responses on this subject from 4 of the companies.

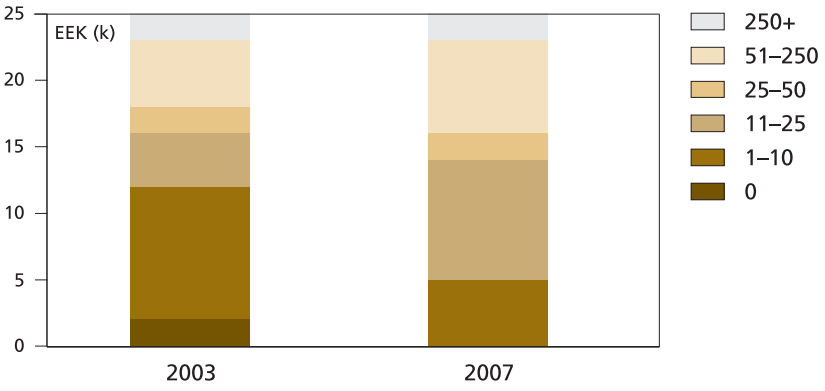

Figure 9: Number of Employees in Responding Firms, 2003 and 2007
n = 25

Figure 10 shows the overall priority the industrial partners gave to a list of alternative project goals, which we asked them to rate using a 1-5 scale. It is striking that most companies rated very few things as unimportant (2 or less) – there is little discrimination within a long list of potential goals. However, the overall priority given to improving existing products and processes (top priority) is striking. Most collaborative research and competence centre scheme participants prioritise the production of 'intermediate knowledge outputs' that can in their turn be input to future R&D processes and the enhancement of commercial and technical networks, rather than seeking immediately applicable results. Improving in-house ability to perform R&D (8th) and recruiting trained R&D personnel (20th) are goals we would expect to associate with competence centres, so their rankings are surprisingly low. Companies seem to see the CCs much more as an external source of technical help than as a research partner, playing roles that might elsewhere be filled by applied research institutes or even in some cases technical consultants, but with a high level of subsidy.

Figure 10: Partner Firms' Objectives in CC Participation

N = 25

Table 18 compares the rankings of goals by participants in the five centres with the overall rankings. ELIKO participants see the centre as an extension of their own R&D capacities, reducing risks and costs associated with R&D but also providing new knowledge and opportunities to extend their capacities through recruitment. Companies involved with the other centres did not really see their CC as a potential source of recruits. Food and Fermentation partners are focused on incrementally improving their existing core business by accessing external R&D resources. The Nano centre's partners, in contrast, want university relationships in order to make more radical product and process changes in future. They face an uncertain future in which only radical changes will do. The Dairy centre partners' ambitions are similar to those of the Food and Fermentation centre but they are nationally rather than internationally focused. The Cancer centre has quite a different profile. The key objectives are to reduce the risks and spread the financial load of R&D, improving treatments by leveraging university skills. This confirms the panel's view of the centre as involving a series of technology bets, each of which has only a modest probability of success, with much of the cost and the risk of the bets transferred to the taxpayer through the EAS funding and the participation of the universities.

Table 18: Centre Partners' Ranked Goals

Objective	Overall	ELIKO	FF	Nano	Dairy	Cancer
To improve existing products, processes or services	1	7	1	9	1	3
To improve your competitive position internationally	2	4	3	3	17	8
To gain access to skills and knowledge of academic partner	3	8	4	4	3	4
To enhance your organisation's reputation and image	4	13	2	13	7	5
To reduce the risks of research and development	5	1	14	18	16	1
To establish links with new partners in university or research institutes	6	9	20	1	8	7
To reduce the costs of research and development	7	2	17	15	9	10
To improve your in-house ability to perform R&D	8	10	7	7	4	17
To sustain existing relationships with universities or research institutes	9	11	16	6	13	11
To gain access to facilities and equipment of academic partner	10	17	9	10	14	12
To improve your knowledge of R&D options and opportunities	11	18	13	8	6	6
To establish links with new partners in industry	12	5	18	12	15	13
To develop or acquire entirely new products, processes or services	13	21	6	2	2	14
To develop new or improved methods, tools or techniques	14	14	10	5	12	15
To diversify the initial financing sources of in-house R&D activities	15	6	19	21	19	2
To access a deeper scientific understanding of technical problems than is available in-house	16	15	5	14	18	19
To improve financial performance of your company (growth of sales, profitability etc)	17	12	8	16	10	21
To improve your competitive position on local market	18	19	11	17	5	9
To obtain technical services	19	16	12	11	20	16
To recruit research-trained personnel, eg new PhD graduates	20	3	15	19	21	20
To sustain existing relationships with partners in industry	21	20	21	20	11	18

Figure 11 shows how the 25 companies said they had done in relation to their goals. The spread between the highest and lowest mean scores is even smaller than for the objectives touched in Figure 10, so we need to interpret differences within such a small range with some caution. However, the numbers do tell an interesting story.

Figure 11: Companies' Goal Achievements in the CCs

By and large, the top goals have only modestly been realised. The first-ranked goal of improving existing products and processes and the second-ranked goal of improved international competitiveness both rank low among the achievements. These are goals not normally addressed by collaborative research. In contrast, the third and fourth goals of accessing academic skills and improving the company's image – which are more typical collaborative goals – are well achieved (Table 19). However, risks of R&D do not appear to have been reduced. On the other hand, closer links with university research and companies' in-house ability to do R&D have been realised to a better degree than expected. Broadly, the companies have tended to think that they would get short-term technological transfer and help but they are in fact realising more of the traditional benefits of research collaboration.

These kinds of comparisons almost always show that achievements are more limited than expectations. Nano centre participants were pleasantly surprised how well they had been able to build university links and to get significant R&D support through the centre. In general, companies involved with the Cancer centre said that their achievements exceeded their expectations. This may be because, with all the companies involved, being part owned by researchers, in the centre, there is a good understanding of what is possible and strong convergence between the centre's and its industrial partners' goals.

ELIKO partners were disappointed at the low degree to which new network relationships had been established and at their continuing difficulties in recruiting research-trained staff. Crucially, they saw significant underperformance in product and process improvements and in increased company profitability. Food and Fermentation partners were more negative than those of the other centres, probably reflecting the amount of time it has taken to get the new laboratories working and the youth of the centre staff. Nano centre partners were disappointed at the extent to which they had been able to access the centre's staff and facilities or to develop new products and processes and to exploit them commercially. Dairy partners, too, had yet to see any new products and processes, and this was reflected in their lack of improved competitive positions.

Table 19: Ranked Company Goals and Goal Achievements

N=20

Importance of Goal	*Objectives*	*Achievements*
To improve existing products, processes or services	1	12=
To improve your competitive position internationally	2	16=
To gain access to skills and knowledge of academic partner	3	4=
To enhance your organisation's reputation and image	4	1=
To reduce the risks of research and development	5	14
To establish links with new partners in university or research institutes	6=	4=
To reduce the costs of research and development	6=	9
To improve your in-house ability to perform R&D	6=	6
To gain access to facilities and equipment of academic partner	9=	7=
To sustain existing relationships with universities or research institutes	9=	1=
To establish links with new partners in industry	11=	16=
To improve your knowledge of R&D options and opportunities	11=	3
To develop or acquire entirely new products, processes or services	11=	15
To develop new or improved methods, tools or techniques	11=	11
To access a deeper scientific understanding of technical problems than is available in-house	15=	7=
To diversify the initial financing sources of in-house R&D activities	15=	10
To improve financial performance of your company (growth of sales, profitability etc)	17	21
To improve your competitive position on local market	18	19
To recruit research-trained personnel, eg new PhD graduates	19=	20
To obtain technical services	19=	12=
To sustain existing relationships with partners in industry	21	16=

In interpreting these views, we must recall quite how new the CCs actually are. It is not reasonable at this stage to expect to see huge technological or commercial contributions from what are supposed to be long-term partnerships. Interestingly, some of the partners' implied claims about lack of results transfer are contradicted by the detailed descriptions of results of which companies have made use presented in the centres' self-evaluations.

We asked the companies about the importance of different possible measures of results from their participation in the CCs and how well they had done against these measures. Figure 12 shows their responses, in the order of importance. As one would expect, their answers focus on market-related innovations, market relationships and economic results for the company. Technical results that may help them innovate in future, such as patents or standards, have less priority and least important of all are the traditional measures of research outputs and the building of human capital. As we would expect given their size and capabilities, they take a very short-term view of what they see as important outputs from centre participation.

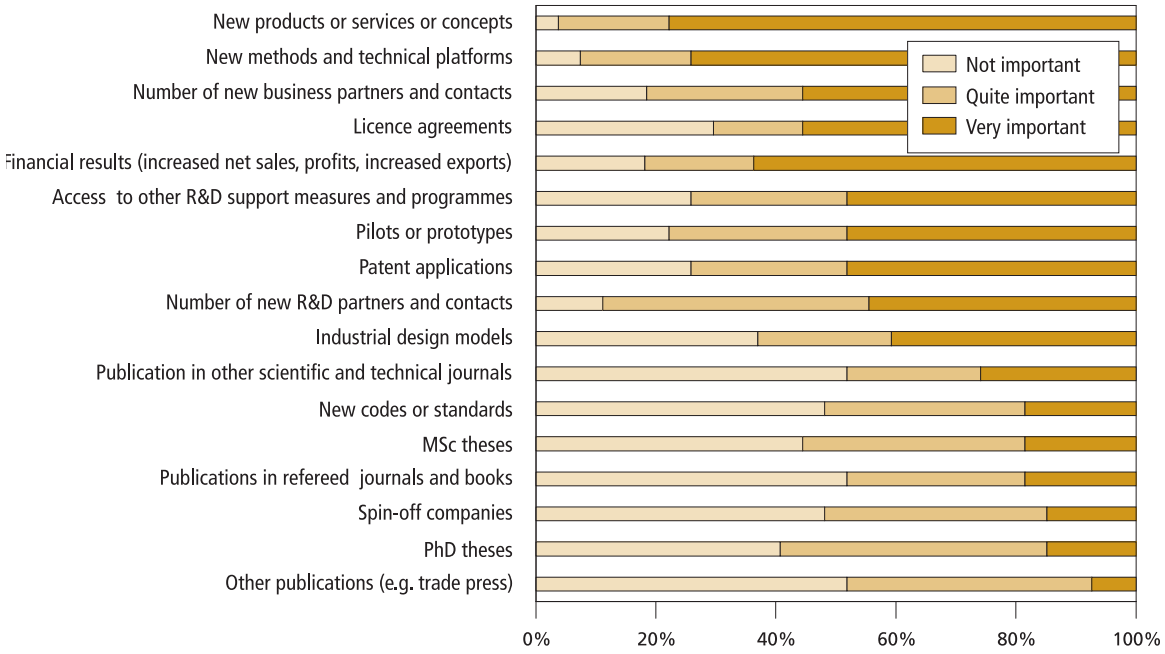

Figure 12: Companies' View of the Relative Importance of Results
N=27

Table 20 shows how the views of companies in different CCs about results vary. In order to get a simple overview, we have summarised their responses by allocating a weight of zero to results that companies say are 'Not Important'; 1 to 'Quite Important"; and 2 to "Very Important". Companies from the individual centres broadly respond in ways similar to the whole set of 27 companies. The interesting differences are highlighted in yellow in Table 20.

Table 20: Variations in Company Perceptions of Importance of Results

N=27

	Eliko	*FF*	*Nano*	*Dairy*	*Cancer*
New products or services or concepts	1.8	1.8	1.8	1.7	1.6
New methods and technical platforms	1.8	1.5	1.6	1.8	1.6
Number of new business partners and contacts	1.4	**0.8**	1.6	1.5	1.6
Licence agreements	**0.8**	1.0	1.4	1.5	1.6
Financial results (increased net sales. profits. increased exports)	1.3	1.3	2.0	1.0	1.8
Access to other R&D support measures and programmes	1.4	1.0	1.8	1.2	**0.8**
Pilots or prototypes	1.6	1.3	1.6	1.0	**0.8**
Patent applications	**0.6**	1.3	1.2	1.3	1.6
Number of new R&D partners and contacts	1.4	1.0	**2.0**	1.0	1.4
Industrial design models	0.4	0.5	1.6	1.3	1.4
Publication in other scientific and technical journals	0.8	0.3	1.2	1.0	**0.4**
New codes or standards	0.6	0.7	1.0	0.7	0.6
MSc theses	1.0	0.8	0.4	1.0	0.4
Publications in refereed journals and books	0.4	0.3	**1.2**	0.7	0.8
Spin-off companies	0.6	0.3	**1.0**	0.7	0.8
PhD theses	0.6	0.8	0.6	1.0	0.6
Other publications (e.g. trade press)	0.4	0.5	0.4	0.7	0.8

Eliko partners put less stress on licence agreements and patents, which is typical of the embedded software and systems world. Food and Fermentation companies appear more inwardly directed than others, giving low priority to new business partners and contacts. Companies in the Nano centre were more interested in new R&D partners, publications and spin-off companies than others, underlining the comparatively advanced nature of the research and their dependence upon the Institute of Physics. As befits its work, companies in the Cancer centre were less interested in access to other R&D programmes, making pilots or prototypes and publishing in technical but non-scientific journals.

We asked the companies to tell us how many results they in practice had obtained in each category (Table 21). Naturally, since this involves counting different categories there is no way we can use these numbers as proxies for goal achievement. It is interesting to see how important the traditional collaborative research results of partnerships and methods actually are – but the number of new products, services or concepts is also rather high, suggesting the centres do to a fair degree respond to the shorter- as well as some of the longer-term needs of their industrial partners.

Table 21: Number of Results Obtained by Category

Based on 27 responses

Number of new R&D partners and contacts	23
New products or services or concepts	19
New methods and technical platforms	18
Other publications (e.g. trade press)	17
Number of new business partners and contacts	15
MSc theses	12
Pilots or prototypes	11
Publication in other scientific and technical journals	10
Patent applications	10
Publications in refereed journals and books	8
Spin-off companies	7
Access to other R&D support measures and programmes	6
PhD theses	4
Licence agreements	3
New codes or standards	2
Industrial design models	1
Financial results (increased net sales, profits, increased exports)	0

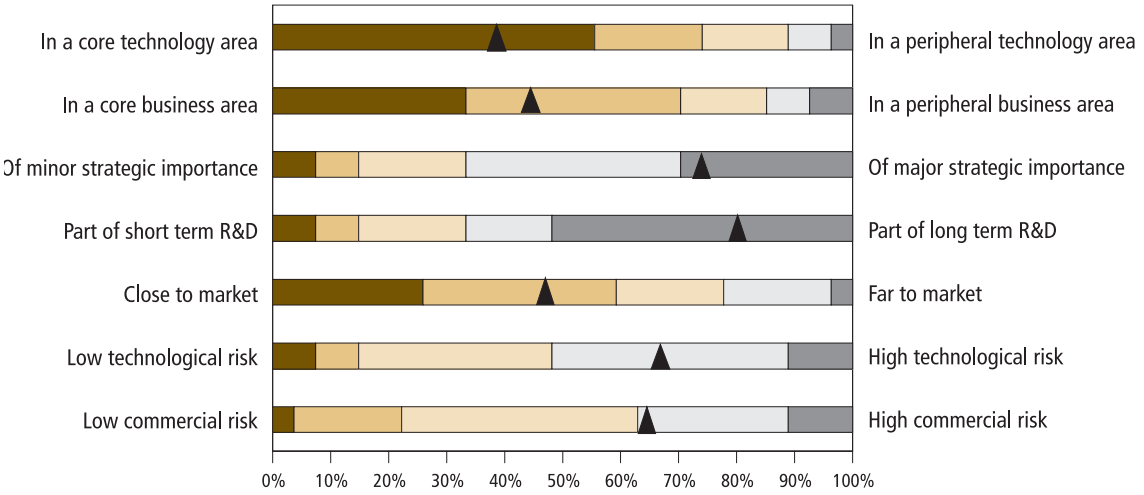

Figure 13: Strategic Significance of CC Participation

N=27

Figure 13 shows the strategic significance of the collaboration with the CC for the partners. We asked them to place the importance of their participation on a series of spectra using a 5-point scale, represented in the Figure by 1 (brown) at the left, then 2 (beige) and so on. The triangles represent the average score awarded by all 27 respondents (marks out of 5, expressed as a percentage).

The Figure shows that the partners tend to focus on technology and business issues related to their core business. This is hardly surprising, since most of the companies are very small and will therefore tend only to be engaged in one industry. The collaborations correspondingly have a great deal of strategic importance to the industrial partners and – as one would expect with CCs – the companies regard the activity as a contribution to their long-term R&D. This perception has to be interpreted in the light of their small size: earlier, we showed that the focus is actually on getting product and process changes, which is by the standards of CCs and research collaborations internationally not a long-term concern. The next row in Figure 13, which suggests that the relationships tend to focus on rather close-to-market issues, confirms this impression. The last two rows indicate that the companies see technical and commercial risks as fairly high.

Companies entered partnerships with the CCs largely on the basis of an explicit judgment that this would generate value, rather than as a routine way to deploy existing budgets.

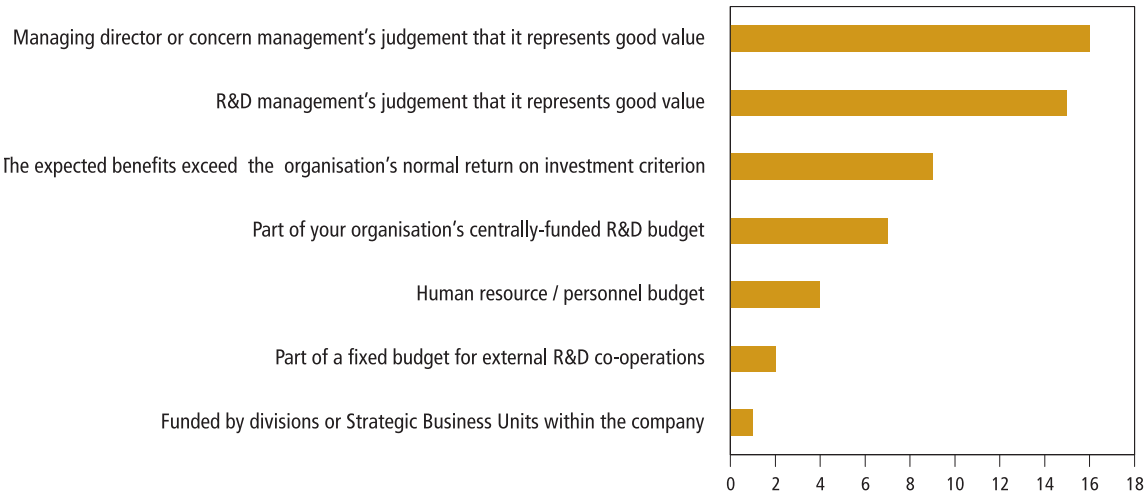

Figure 14: Companies' Reasons for Joining CC Partnership

N=27. Multiple responses possible

We asked the partners to indicate on a scale from -3 to +3 the extent to which they saw the negative costs of CC participation as larger or smaller than the positive benefits. Figure 15 shows that almost two-thirds of the partners saw the benefits of participating in the CC as exceeding the costs while a little under a third had the opposite perspective. We use this question in many surveys of R&D programmes and this type of response is normal from industry. It is perhaps more telling that only one of 27 companies responding to a question abut their expectations of future commercialisation of CC results said that it did not expect this to occur.

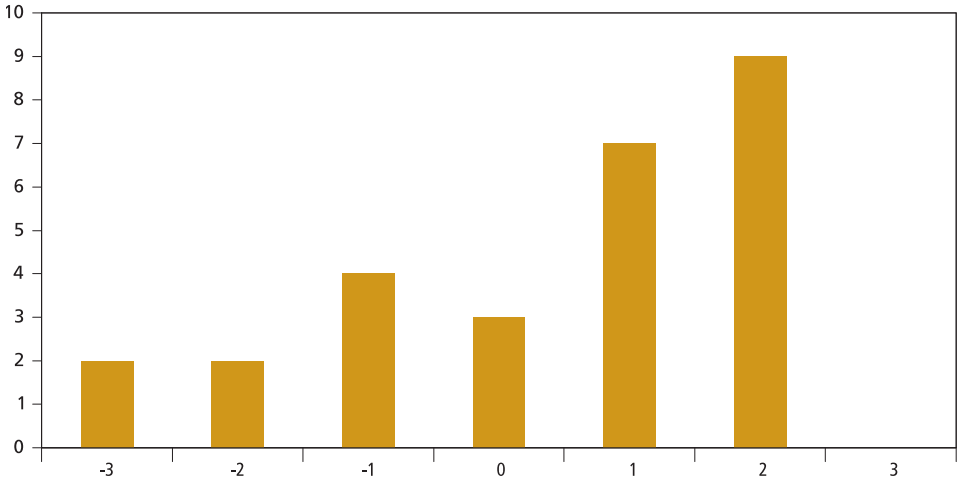

Figure 15: Costs vs Benefits of Participation: Companies' Perspective
N=26

We asked partners what would happen if the funding for their CC stopped either in 2009 (after the end of the current period) or after 2015 (the end of the programme if it is extended for a further 7 years). Figure 16 indicates that there are three firms that are 'free riding': they would carry on doing the same thing even without the subsidy. It also suggests that about one third would give up their research in the area. For these firms the CC's contribution is wholly 'additional': without the subsidy the company would simply not be involved in the research. Conventional ideas about subsidy suggest that this is the key target group. However, in our view we should be cautious about the state using subsidies to persuade companies to do things that lie outside their reach or ambition. It is more positive that in two thirds of the cases there is a close enough match between company strategy and the work that the company will look for some other way to support its ambitions.

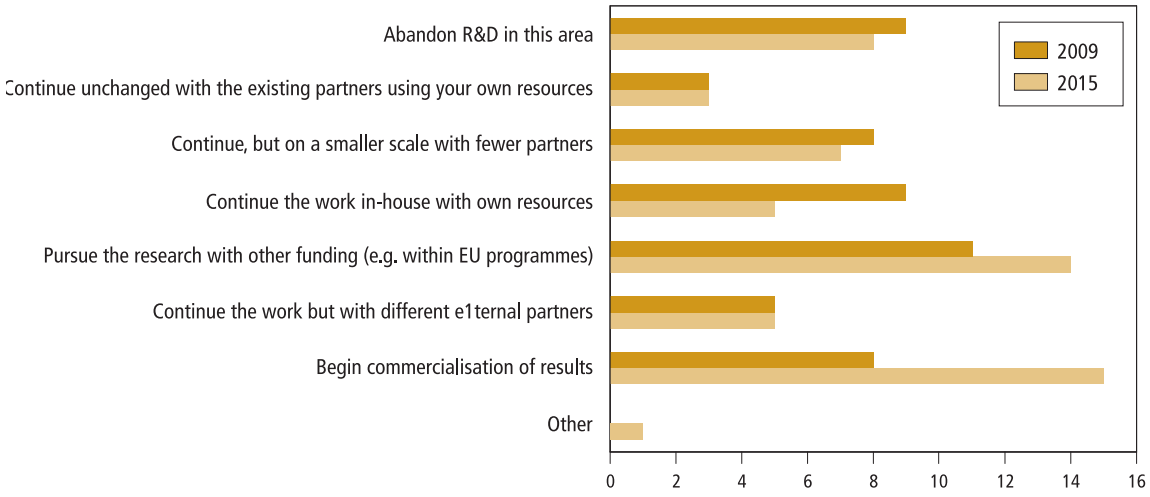

Figure 16: What Happens if the Subsidy Stops?
N=27

Figure 17 shows the participants' views of the factors that influence their ability to exploit the results of work in the CCs. We asked them to say whether each factor was negative, neutral or positive in this respect. The figures at the right of the chart are the mean score across the 26 companies responding to this question. Just as the research literature suggests, the key factor is their R&D capability. The commitment of their own organisation and their partners are also important factors and they say in effect that that the relationship with the CCs needs to continue with the help of follow-on funding if they are to reach their goal of exploiting results. Other factors were less important. Interestingly, the presence or absence of competitors was seen as rather neutral. Normally, companies will collaborate actively with competitors only on long-term or 'competition-neutral' research, such as safety, quality and standardisation. Some of the CC work is indeed fairly long term, but much of it is shorter term and bilateral, so that the CC-partner networks are star-shaped and involve limited inter-firm cooperation. This probably explains why in many cases partners are not worried about competitors' presence.

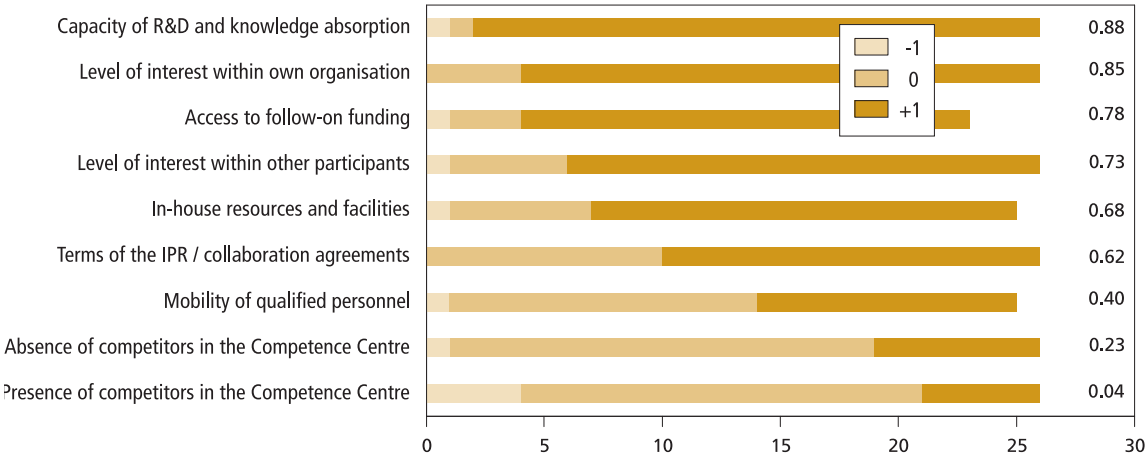

Figure 17: Factors Affecting Companies' Ability to Exploit Results

N=26. Decimal numbers indicate mean scores for each factor

Table 22 shows the personnel movements the companies reported since the start of their respective CC contracts. The majority of the movements are temporary, cementing networking and collaboration among partners. However, there is a substantial minority of permanent transfers, the majority from one company to the Nano Centre and two to the Cancer Centre. The large numbers for the Cancer Centre underline the tight relationship between the Centre (and the university) and a couple of spin-offs, whose personnel remain intensively integrated into the partnership with the CC.

Table 22: Human Capital Movements

N=27

Personnel movements		*ELIKO*	*FF*	*Nano*	*Dairy*	*Cancer*	*Total*
From the company to the CC	Permanent	0	2	6	3	3	14
	Temporary	2	8	11	1	13	35
From the university to the company	Permanent	0	2	3	1	13	19
	Temporary	0	2	15	1	3	21
From the Company to the University	Permanent	0	0	0	1	2	3
	Temporary	0	0	0	0	0	0
Totals	**Permanent**	**0**	**4**	**9**	**5**	**18**	**36**
	Temporary	**2**	**10**	**26**	**2**	**16**	**56**
	Overall	**2**	**14**	**35**	**7**	**34**	**92**

Our discussions with the companies also had an unstructured component. Some of the more frequent and generally applicable comments were that

- The CCs tended to become 'platforms' for their respective communities, where participants could more easily network together, tackling business as well as technology questions and strengthening the community
- Some of the CCs also served the kind of 'common good' needs tackled in the past by Research Associations, especially by holding a pool of instrumentation and equipment that companies could not themselves afford to buy
- Some of the CCs also created a mechanism through which companies could access skills, for example in chemistry and electronics, that are in scarce supply from people who would not necessarily find employment in a small Estonian company to be all that attractive
- The companies all relied to a greater or lesser degree on 'outsourced' R&D, indicating their lack of the needed level of absorptive capacity
- The CCs were generally actual or potential sources of relevant human capital for the companies
- Participation in many cases 'inspired' companies' internal innovation-related personnel to tackle more difficult projects and in some cases to resume their higher education, so it had a distinct effect on firms' absorptive capacity
- Uncertainties about funding undermined companies' ability to plan and commit for the longer term and undermined the universities' abilities to hire good researchers
- Many companies complained about the complexity of programme administration, with multiple proposals being required in a short period, and about delays in payments from EAS. This picture of delay appeared partly to be caused by what the companies saw as genuinely late payments but also by the fact that EAS pays subsidies in arrears and not in advance, which was seen by some as an unnecessary burden on their cash flow
- Almost everyone was satisfied with the legal form used by their centre (despite minor variations in the actual form). However, several pointed out what they saw as a contradiction in using a private, for-profit legal form to implement an organisation whose mission was ultimately to produce public goods
- Service delivery by the CCs was often not timely.

Company representatives also made a number of centre-specific points

- Short product cycles and the high rate of change in the electronics industry meant that ELIKO work could not be put on the critical path of product and process development. Rather, ELIKO projects informed the broader development trajectory, adding important knowledge and showing how to reduce innovation risks
- Market volatility meant the ELIKO's partners had especial difficulty in committing to the centre over the longer term
- The Dairy partners were driven towards a more scientific approach through their centre because they were reaching natural limits to the quantity and quality of milk they could get from current livestock varieties
- The Cancer centre was lacking in the skills and financial power needed to scale up from the laboratory to clinical trials and eventual commercialisation. It therefore needed stronger partners, especially from the pharmaceuticals industry
- The CC had been decisive in attracting inward investment that would otherwise have gone to Latvia.

5.3 Researchers' Experience

This section is based on a survey of past and present academic and centre researchers involved with the CCs. The survey is flawed by the fact that a majority of the centre managers refused to supply us with a complete list of researchers, so we were only able to mail our questionnaire to a sub-set of the researchers – in effect those whose opinions the centre managers wanted to see included in the survey. It is clear that this is a biased sample, but as to the nature of that bias we can only speculate. It is equally clear that neither the Ministry nor EAS should tolerate this kind of interference in the process of evaluation in future.

Table 23 shows the total number of researchers per centre (where we believe we know this, on the basis of centres' own claims), the number of researcher contacts the managers supplied to us and therefore the number of questionnaires we were able to e-mail and the number of responses. The returns from the Nano centre questionnaires were unfortunately not usable.

Table 23: Researcher Questionnaires and Responses

Centre	*Universe*	*Mailed*	*Returned*
ELIKO	?	31	7
Food and Fermentation	11	11	5
Nano	88	67	15*
Dairy	?	9	4
Cancer	60	11	9
TOTAL	?	129	25 usable*

Figure 18 shows the current job titles of the respondents, supporting the information we have from elsewhere that some people have migrated from the CCs into industry. The largest groups of respondents are university or centre employees. The survey obtained little input from the large number of post-graduate and other researchers who have also been involved.

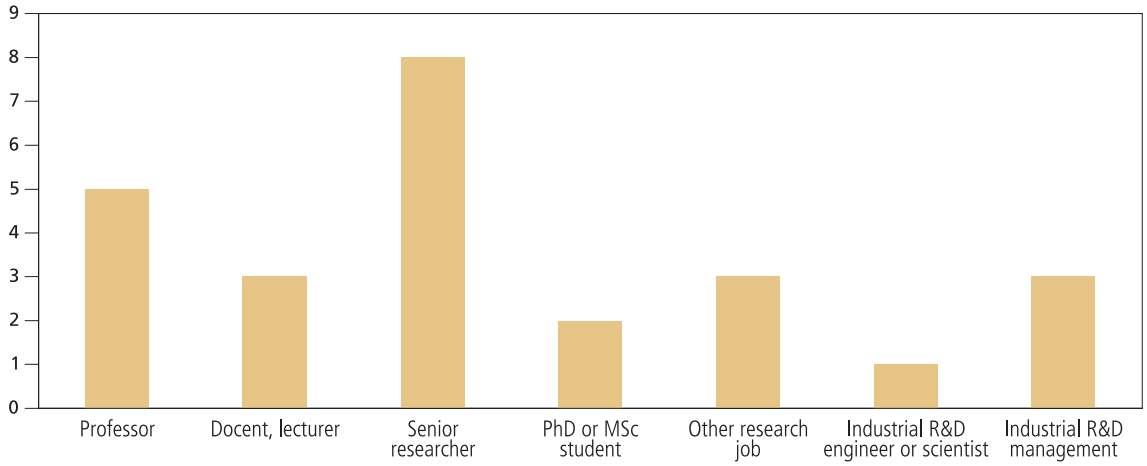

Figure 18: CC Researchers' Job Titles
N=25

Nonetheless, the majority (17) of the 25 respondents worked half time or less in the centre (Figure 19).

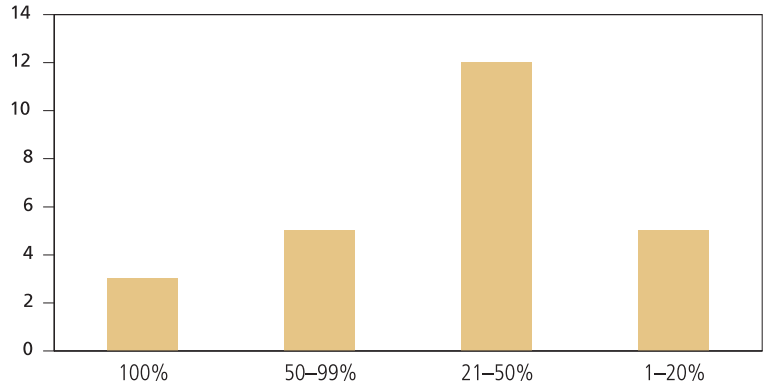

Figure 19: Proportion of their Time Researchers Worked in the CC
N=25

The researchers did not discriminate a great deal among the importance of alternative goals for their work (Figure 20). Average scores for most dimensions are high and the claimed achievement is at about the same level as the ambition. The most important goals are to do research with colleagues, get research funding and improve their own research capacity. Industrially orientated motives are also rather important but building institutional linkages are less significant. It appears that these are researchers who need money to do research, and that any money will do.

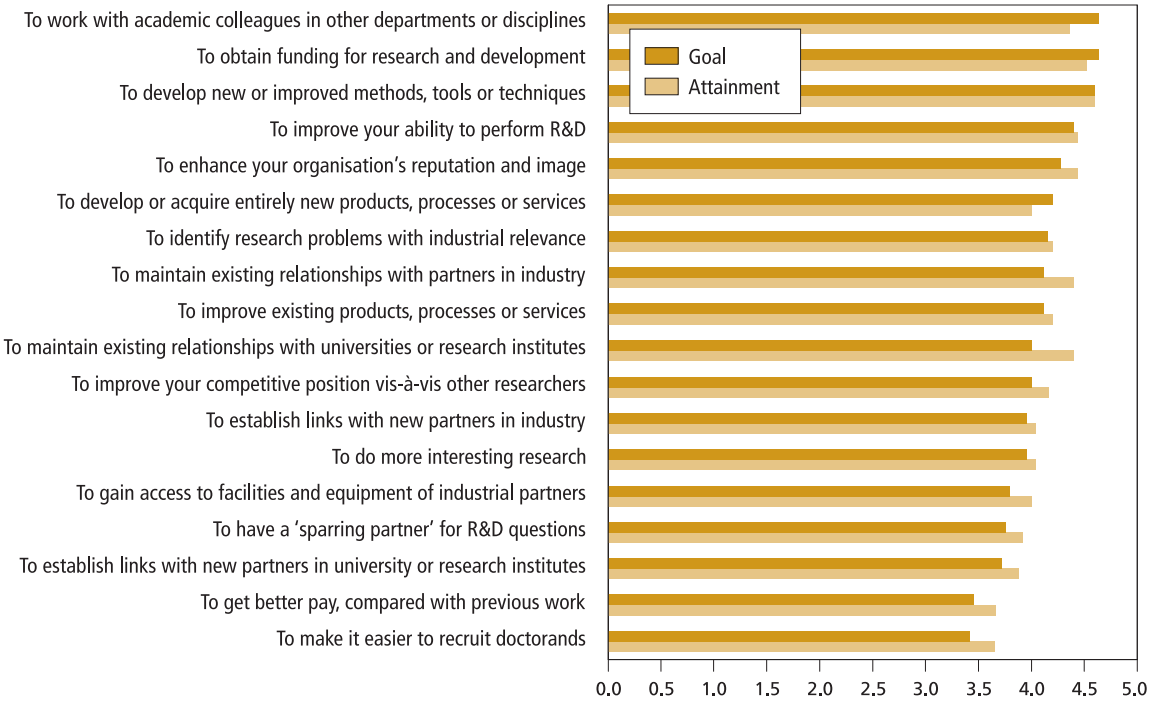

Figure 20: Researchers Goals and Goal Attainment
N=25

Figure 21 shows the strategic significance of the work in the CC for the researchers, who were asked to rank the importance of their participation on a series of spectra using a 5-point scale. The triangles represent the average score awarded by all 25 respondents (marks out of 5, expressed as a percentage). The researchers characterise their work in the CCs as fairly low-risk in technological terms but being long term in nature and a long way from the market. Its strategic importance for the researchers is only moderate and it tends to be outside, but not necessarily very far from their core areas of technology. This reinforces the impression that the CC is attractive to researchers as a source of money in an otherwise under-funded system, not because there is always a close link between their goals and those of the CCs.

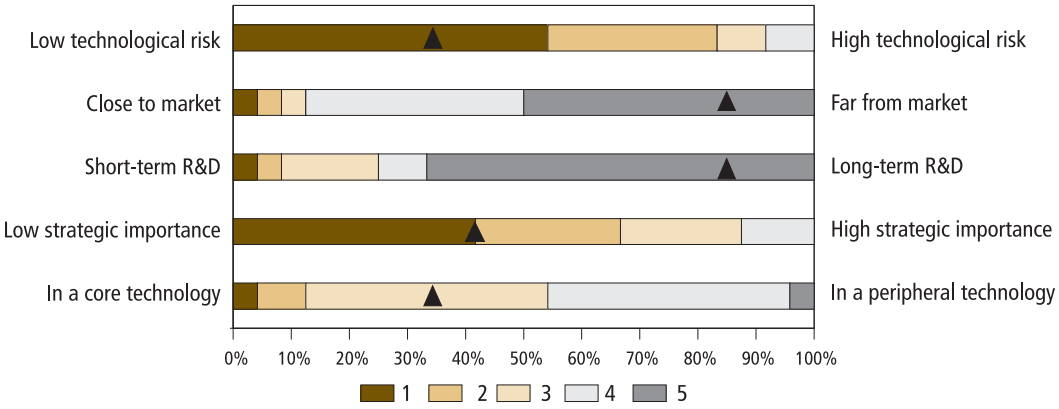

Figure 21: Character of Work Done by Researchers in CCs
N=25

As is normally the case in academic-industrial R&D collaborations, the researchers are more positive about the cost-benefit ratio than industry (Figure 22).

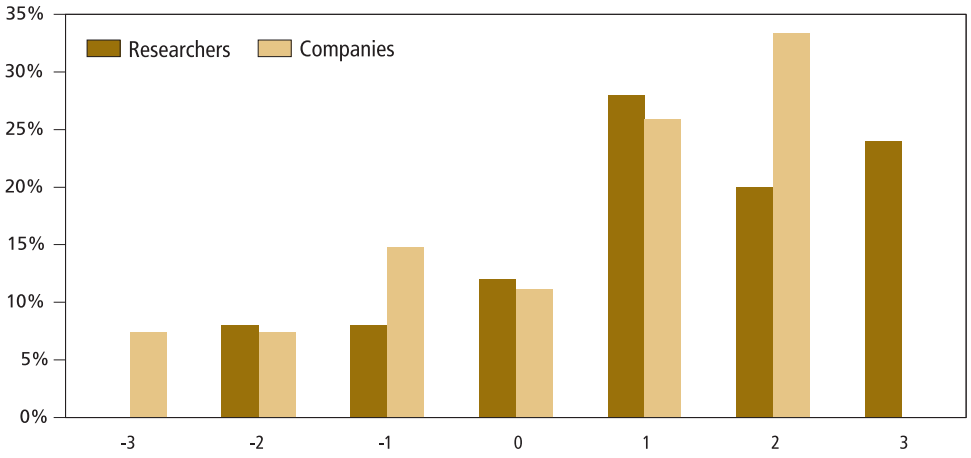

Figure 22: Researchers' and Companies' Assessments of Cost/Benefit

Companies n=27. Researchers n = 25

There is a substantial minority of researchers who are sceptical about the value they themselves derive from participation as well as many who feel that participation is on the whole positive. We suspect this is due to the lack of alternative funding opportunities rather than any innate problem with the programme itself.

6 Lessons from Abroad

Competence centres have been evolving internationally over the past 20 years or so. While they share common characteristics of long-term commitment by industry and academic to common R&D programmes, interdisciplinary problem focus, engagement with postgraduate education and doing more fundamental types of R&D than is usual for the partners involved, they are implemented in a range of ways that should be context dependent. Generally, they should be one component in a more comprehensive policy mix that tackles both researcher-driven research and the needs of lower-capability clusters in industry that would benefit less from the relatively advanced work done in competence centres.

Since CCs tackle a significant market failure, it is not realistic to expect them ever to become fully self-financing. They can be refocused on issues closer to the market but then their impacts become not only shorter term but probably also smaller. The extent of absorptive capacity among industrial partners is a crucial determinant of CC design. Design must also take account of the extent to which university behaviour needs changing and their institutional preparedness for working with industry and tackling issues such as IPR.

6.1 What are Competence Centres

Competence centres have become an international phenomenon. While they tend to have a basis in the design of the US NSF's Engineering Research Centres programme, their designs have been evolving as they diffuse through different countries and are adapted to the needs of the local innovation systems. Even within the context of a national competence centre programme, competence centres position themselves quite differently across various dimensions. Typical Competence Centre programmes include[12]

- Kplus, Kind and Knet in Austria
- Engineering Research Centres in the USA
- Cooperative Research Centres in Australia
- KKK and Péter Pázmány centres in Hungary
- Networks of Centres of Excellence in Canada
- Kompetenscentren in Sweden[13]
- Top Technological Institutes in the Netherlands.

It is not clear that competence centres were theorised as something conceptually distinct in the early stages. However, competence centres now have some recognisably special features relating to their role, in particular

- They are normally funded by three partners: industry, university and a state agency. They are intended to have an effect on university resource allocation and strategy, in addition to reinforcing university-industry links. To this end, they involve an unusually high degree of subsidy, often 60% or so
- They involve long-term contractual arrangements, requiring a much stronger commitment than traditional project by project funding of collaborative R&D
- They create new on-campus or other institutional 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 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 to join in research, they also extend academics' networks into the industrial research community.

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12 *See for a comparative review of competence centres: Erik Arnold, Jasper Deuten, Jan-Frens van Giessel, An International Review of Competence Centre Programmes, report to the Research Council of Norway, Brighton: Technopolis, 2004*

13 *Erik Arnold, John Clark and Sophie Bussillet, Impacts of the Swedish Competence Centres, Stockholm: VINNOVA, 2004*

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.

We can distinguish

- Those strongly based in academia but with industry actively involved in the research
  - Examples are the Swedish Competence Centres, Austrian K+ centres: a key objective was to achieve critical mass and change the behaviour of universities; very much campus based
- Virtual centres combining competences in existing organisations
  - E.g some Dutch Leading Technological Institutes: develop multi-disciplinary approaches in areas of importance for industry
- Newly set-up dedicated 'physical' centres
  - E.g. IMEC, partly NL Telematics Institute

The Estonian CC are clearly a mix of these models, several (Nano and Cancer) are closer to academia and undertaking research further from the market, while being independent legally; others are operating more as virtual centres (Eliko) or as new physical centres undertaking work that is often driven more by shorter-term product development or process engineering needs of the industrial partners. This appears coherent with the current level of capabilities in both the academic sector and SMEs in Estonia. In the medium-term, it should be expected that the involvement of the partners in the competence centre programme would improve the in-house capabilities and generate learning that would allow a shift towards more sophisticated and longer-term R&D cooperation.

These all aim to tackle both ends of the academic-industry link. They encourage firms to undertake more radical kinds of innovation than normal, based on more fundamental understanding of the technologies with which they work. They aim to re-focus some of the activities in the knowledge infrastructure (universities plus research institutes, though more often the first than the second) towards inter-disciplinary problem areas of importance to industry. They work primarily with established firms that have some absorptive capability. Often, they play a role in making the knowledge infrastructure attractive and supportive for multinational companies with R&D facilities in the country. Sometimes companies located outside the country may participate. In many cases, they also contain a proportion of new technology-based firms, which may include spin-offs. They do not tend to work with low-capability SMEs that lack absorptive capacity and evaluations suggest that to do so would be ineffective.

Competitors are not often present within the same centre. Where this happens, they tend to tackle different topics within the centre, or to handle long-term questions of common interest, such as how to tackle environmental requirements. Centres normally include a significant proportion of PhD education, producing PhDs who are more used to and interested in working with industrial problems than many, and who are more quickly and easily absorbed into industrial companies.

Most countries operate one or more separate, academically orientated centres of excellence programmes, but there is little contact with those, which tend to be seen as 'complementary' rather than competing. A range of different public-private partnership instruments is needed, in order to tackle different segments of need. For example, industrial clusters with low absorptive capacity need different mechanisms for cooperating with university research centres than clusters with high absorptive capacity.

The positioning of individual centres within the so-called Pasteur's Quadrant which is illustrated in Figure 23 below involves a spectrum from those who are more close to Bohr's Quadrant with a strong influence of academia to those who can almost be seen as applied research centres in the Edison Quadrant. While the latter type of CCs can have a higher immediate impact -– by solving short-term problems or developing close to market technologies – their long-term impact is likely to be smaller. This was one of the findings of the Dutch Leading Technology Top-Institutes evaluation[14]. A policy question is also whether these more applied Competence Centres should receive the high levels of public support, which CCs usually obtain, since the degree of market failure is smaller.

[14] *G. van der Veen, Patries Boekholt, Erik Arnold, Evaluation of the leading Technological Institutes, 2005*

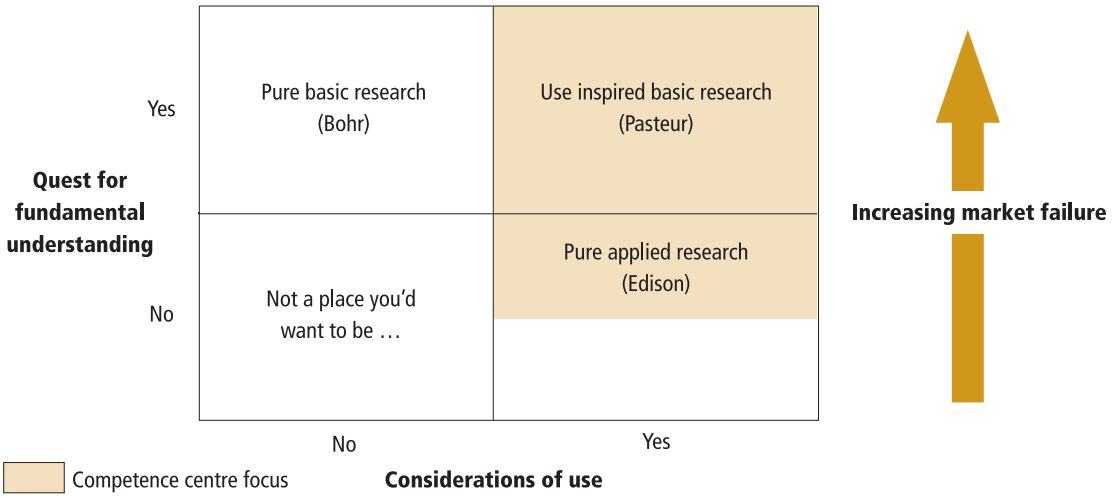

Figure 23: Competence Centre Positioning

Many programmes have been set up in the belief that industry will take over the funding role of the state at the end of the subsidy period. While thirteen of the original NSF Engineering Research Centres were able to carry on without core funding after their NSF grants ran out, there is little evidence to suggest that industry is becoming more generally able to ignore Nelson-Arrow market failure and step into the role of funding fundamental but industry-oriented R&D. This is creating an interesting puzzle in some funding systems: whose job is it to fund Pasteur's Quadrant (after Stokes, 1997[15])? Should an Innovation Agency or Research Council do this?

Thus the context in which Competence Centres operate helps determine their impacts. Some questions and issues that have to be looked at to understand the potential input relate to the academic, the business and policy context in which a centre operates. For instance a centre, established in a domain which has hardly any R&D efforts on the side of the business sector – so no industrial counterparts – will have a much more academically oriented research programming and most likely position itself more towards the Bohr Quadrant. The result is that the impacts are more likely on the academic front rather than on the business performance of the industrial partners.

6.2 Some Design Considerations

Competence Centres are bridging or linking types of instruments. They are intended to span the gap between public sector (academic) and private sector (industry based) researchers. If changing behaviour of universities is part of the key mission important questions in the design of specific Competence Centres are

- What types of universities are we dealing with? Are these universities that have a long history of collaboration with industry (e.g. technical universities) or is this quite new to them? In the latter case more efforts should most likely be made to adjust practices to taking part in Competence Centres
- Are the universities to be involved capable of running a CC activity? Are their administrations, their IP procedures, their staffing policies equipped for running a more 'business-like' unit within existing frameworks? If not setting up new legal entities might be necessary
- Do the universities or institutes have real commitment or do they regard the programme as just another pot of money?
- How do researchers divide their loyalty and priorities between their regular university job and their affiliation with the CC? A full employment contract with the Competence Centre has the advantage of clarity but the disadvantage that the Competence Centre cannot always choose the best teams for the job
- In what industrial context does the Competence Centre work?

[15] *Donald Stokes, Pasteur's Quadrant: Basic Science and Technological Innovation, Washington DC: The Brookings Institution, 1997*

The maturity of sector and time to market pressures influence the set-up of a CC. In sectors with short technology life cycles and severe competition (as in ELIKO) industry partners are likely to be pressurised to define research topics that are geared to short- or medium-term problem solving, rather than having a longer-term vision to develop new technology trajectories. This could push a Competence Centre down to the 'Edison quadrant'.

Some absorptive capacity is a prerequisite: if the industry partners do not have qualified research staff and internal R&D capacities it will be very difficult for them to have a meaningful input in defining the research agenda or to applying the results of the Competence Centre. Does a domain provide opportunities to develop a 'generic technology platform' on which industrial partners can continue doing applied research individually? If this is not the case it will be very difficult to develop a collaborative research programme and the activities will be split up in many smaller bilateral projects.

Is there an obvious need for the knowledge produced by Competence Centres? There is a great difference between technologies, which are 'nice-to-have' or those that are necessary for business strategy to succeed. The latter improves the chances of the results actually being applied by the companies involved.

Another issue that has an effect is in what National Innovation System context does the Competence Centre operate?

- Does Research Policy have continuity and 'stamina' to support the Centres for a longer period?
- Is the balance between changing university research (and education) or supporting industrial competitiveness clearly spelled out? The objectives of different CC schemes are not identical and while in some countries they tend to emphasise the 'changing behaviour of public sector research' aspect in others they are more geared to providing specific industrial sectors with strategic knowledge and thus a competitive edge
- Are other research centres / universities also working in the same domain?

Thus the context in which a Competence Centre operates not only affects the time when impacts can be expected but also the depths of these impacts in the socio-economic fabric. There is a certain generic level of impacts that one should expect (e.g. a change in the behaviour of participating researchers and organisations, the development of strategic knowledge, the training of a new generation of researchers) from all publicly funded initiatives. On top of this specific targets and impacts should be identified case-by-case.

A further factor in Competence Centre programme design is the maturity of the innovation system and institutions into which it is laced. In particular, if universities are unused to hosting this type of organisation and there are few people with experience of managing public-private research partnerships, there will be a need to support the centres with a programme of training for the centre managers and leaders and potentially a long-running programme of partly formative evaluation. Experience sharing and networking among the centres are key learning instruments and have successfully been used in, for example, Sweden and Austria to overcome the novelty of the Competence Centre concept.

A number of governance issues contribute to the success of a centre

- Leadership is key. If a Centre is run by someone who understands both academic and industrial cultures the bridging function works better
- The Centre needs a clear focus and medium to long term vision of what type of research topics and results are needed
- A clear set of rules of the game, particularly on IPR, is necessary from the very beginning. How far is exclusivity of IP an option, which partners can acquire IP and does the Centre acquire sufficient background knowledge to build a portfolio of competences?
- Given that the operation of Centres depends on their context, policymakers should give CCs sufficient flexibility to adapt their research programmes if the context changes. Thus milestones should not be set at the beginning of the Centre's operation in terms of specific projects. Rather, the centres should be bound to produce certain outputs and outcomes
- Given the central importance of how the research programme is formulated, industrial participation in Advisory Boards is not necessarily sufficient. Their role in negotiating the Research Agenda is also key
- Centres easily lose touch with international research developments, especially if they are in smaller countries or more peripheral regions. In our experience, all can benefit form an international scientific committee or an equivalent function that keeps them engaged in the global research community.

An important element of effectiveness of CCs is how the research programme is defined.

- Is it aimed at the short or long term?
- Are activities divided up in many smaller research projects, with a small number of partners or in fewer large projects or sub-programmes where more stakeholders work together? Smaller projects with fewer partners tend to have fewer spill-over effects unless the project is very strategic and the participants are in a position to create scientific leadership or a strong market position with its results. Long term and strategic projects tend to be larger in size and involve various industrial partners who would take up the results for their own further developments
- If the industrial partners in a CC are not capable of articulating their R&D needs well or if there are too few common interests in generic research themes the academic partners may take over the research agenda. If these have experience working on industry relevant topics this is not necessarily a problem. However if the programme aims to change behaviour and introduce a culture of more industry oriented research then industrial guidance is needed.

Thus the research programming process is influenced by the absorptive capacity of industry, including firms' ability to express their knowledge needs, and by the extent to which firms across the sector share interests and strategic viewpoints with each other and with the universities (Figure 24).

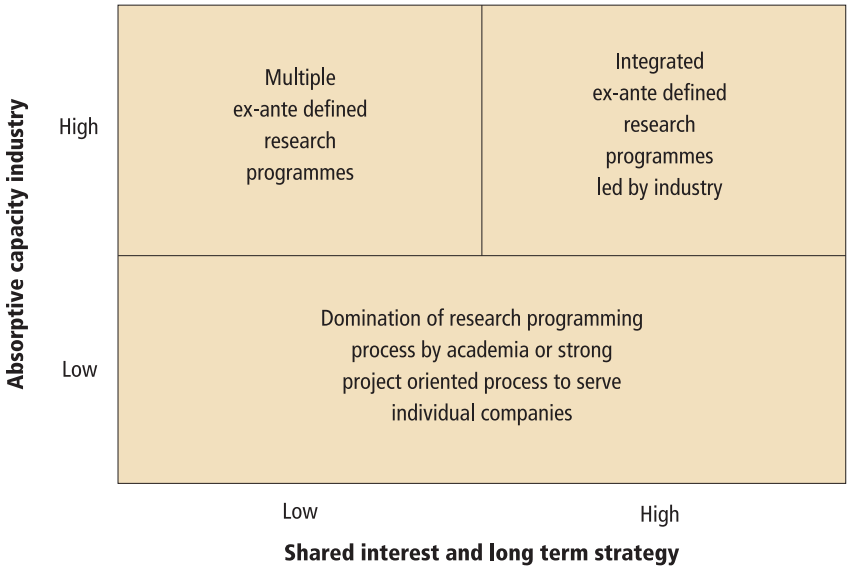

Figure 24: Determinants of the CC Research Programming Process

6.3 Some Policy Lessons

A strong centre staff and a good balance of power between academic and industrial representatives are needed in order to develop effective centres. Policymakers must have the stamina to deliver long-term funding. Strong leadership, a clear contract and international connectedness are all important elements for success.

As discussed in the previous sections the technological and industrial settings in which CCs operate have a signuficant impact on the governance model of a CC. It influences the 'time-to-market' pressures of the companies involved (e.g. the pharmaceutical industry compared to the ICT industry), the presence of R&D capable companies in a country, the role companies can and want to take in the medium to long term research programming, and therefore also the positioning within the Pasteur's Quadrant. National programmes supporting CCs therefore should – within certain policy boundaries – remain flexible in prescribing organisation models, and structures as the composition of stakeholders will have a large influence on what works and does not work in a particular area. There needs to be sufficient 'absorptive capacity' on the side of industry to capture the benefits of CC research. It would be advisable to do an ex-ante study whether commitment and absorptive capacity is really present in the private sector.

Too much policy emphasis on direct economic impacts – particularly in the case of short-lived programmes – drives CCs towards the 'Edison quadrant'. Policy makers should also have a long-term vision as to when the socio-economic impacts of these centres will take shape.

In order to secure that the centre indeed produces research excellence regular checks through peer reviews or bibliometric analysis could be envisaged to keep the academic researchers on their toes and to keep the awareness of this goal alive with all stakeholders. Some centres choose to have scientific peer review to select individual research projects or programmes to safeguard scientific excellence. Again the possibilities to use tools such as bibliometrics depend on the traditions in the technological domains, where in the more engineering and IT fields for instance publications in scientific journals is less common than in other domains.

As discussed in Chapter 4 the choice of virtual versus physical centres is dependent on the context, life cycle of the domain, the existing institutional richness in the country (avoiding duplication) and each have its advantages and disadvantages.

Last but not least: policy makers need to realise that building up of CCs takes time (at least 5-7 years) so they should not expect an immediate pay-off. Continuity in the Competence Centres policy is necessary unless of course the failure to achieve of a given Centre is obvious. For most countries with limited public R&D resources this also requires a selectivity to support those CCs with best prospects for added value, academic and industrial commitment and socio-economic impacts.

7 Findings, Conclusions and Recommendations

The competence centre instrument is appropriate in the Estonian context because it is used to extend the quantity, quality and time horizon of the innovative activities of a nationally important consortium, while focusing research and education activity on areas of national need. The instrument works best where university management is sophisticated. It depends upon the state acting as a reliable long-term funding partner and benefits from being part of a well-developed range of policy instruments.

Adopting competence centres requires a great deal of institutional and personal learning and while EAS helped with this, even more activity would have been helpful. At the same time there is a need to ensure transparency and accountability in an un-bureaucratic way. The decision to adopt a model where centres had to be established as independent legal entities (with four out of five centres adopting a for-profit structure) had unexpected and negative consequences for the programme, encouraging behaviour likely to maximise private rather than public benefits.

All the centres have progressed towards their goals – some further than others. Three of the centres appear quite robust for the longer term; the other two, less so. The CC programme has encouraged universities to begin concentrating research and educational resources in areas of national need and improve links with industry. Companies increased their R&D capabilities and were better able to tackle high-risk innovation. The research community also benefited from increased funding and produced significant numbers of research outputs – some directly useful to industry; others longer term in nature.

The evaluation was able to confirm that the rationale for the programme was and is valid and that it fits with wider policy objectives – though additional research and innovation support instrument are needed to complete the policy mix. There is initial positive impact on both the industrial and research communities and experience with running centres is being built up. A key success factor is to find a workable balance between industrial and academic interests in steering the direction of the centres. Programme management has largely worked well but the repeated need to refund the programme imposed a needlessly high bureaucratic load on both the administration and programme participants, diverting effort away from research and the learning activities that could have improved common performance more quickly.

We recommend that the CC programme continue but with greater continuity of funding and a guarantee of seven years of funding for the next round of centres. Pressure on the centres to perform and to maintain quality standards should be applied through performance contracts, a mid-term evaluation and ultimately a final impact-analysis. More flexible consortium membership arrangements should be permitted, in order to allow entry and exit in the rapidly changing circumstances of the Estonian economy. There need be no presumption that future CCs are 'high tech', though by their nature they should be knowledge intensive. Greater internationalisation should be fostered through international scientific committees and making part of the CC funding contingent upon internationalisation of the consortium. A shift to a not-for profit arrangement (allowed by the legal basis of the programme and applied already by one of the centres) to reduce the incentives for opportunism would be the optimal road to take based on international experience. If the 'for-profit' model persists, due for instance to recovery of VAT rules for not-for-profit structure, then a minimum requirement is stricter over-sight and supervisory roles via for instance 'non-executive' directors appointed to the board of each CC by the Government. There should also be a register of interests held by EAS in which policymakers and policy implementers must reveal actual and potential conflicts of interest. The Ministry should amend all research and innovation support contracts to make cooperation in official monitoring and evaluation a condition of funding. In parallel, Estonia needs to launch a range of complementary funding instruments aimed at increasing institutional, technological and human capabilities in innovation and research.

7.1 Findings

7.1.1 The Competence Centre Instrument

Adopting the competence centres instrument in the circumstances of Estonia in the early 2000s meant adapting it to its context. Elsewhere, it has been used in relatively sophisticated innovation systems and countries with fairly high levels of R&D and GDP per capita. Even though the centres were intended to increase the quantity and quality of innovation through linking with longer-term or more fundamental research concerns than companies usually confront, in other countries the programmes could rely on there being industry with at least a fair degree of absorptive capacity and on some of the companies involved being large enough that they could reliably be expected to enter into and deliver against long-term commitments. It is probably not too important that industrial absorptive capacity in countries like Austria and Sweden is absolutely higher than in Estonia. Within these countries (especially in Austria) the competence centre concept works as well in the wood product industry as in telecommunications or virtual reality. However, there does need to be a sufficiently large and stable industrial core in a competence centre consortium that the university actually has an industrial counterweight. As we have seen, this condition is satisfied in most but not all the Estonian centres.

It is also a precondition that the university system is sufficiently developed that it can house, foster and benefit from the centres' presence without trying to appropriate their resources. Basic practices such as IPR management, proper accounting and overhead rules that do not provide perverse incentives must be in place, and the universities need to be able to construct agreements with others about arrangements such as CCs that are not exposed to having their resources pillaged by academic vote. University employment rules must permit a range of contractual possibilities, including temporary leave of absence, part-time working and where (as in Estonia) academic salaries are relatively low, they must not be able to prevent CCs paying something closer to market rates in order to secure the needed personnel. We will go on to show that the use of an adapted form of the 'Austrian model' in Estonia has had perverse effects on the development of the CCs, but equally we have to recognise that there is little evidence that the universities have reached the stage of development needed to switch to the university driven Swedish model.

The State also has to be a responsible partner, able to enter into and honour long-term commitments. While it turns out that the state has been able to deliver bit by bit the first part of the original deal with the centres and to fund them for three years, the process has been painfully bureaucratic and the centres have never had the needed *financial and planning perspective* to justify behaving as if even three years funding were secure. Some of the centres were brave or foolish enough to assume the money would keep coming; others were more cautious. It is clearly the case that imposing repeated calls for proposals and a succession of short-term awards on the centres is not the same as giving them a long-term prospect. One symptom of this is that the centres have not themselves employed enough people to become sustainable. Neither the centres nor high-quality researchers could contemplate such a short-term basis for employment. This basis clearly needs to change if the CC programme is to continue and to succeed over the longer term. Then it will also become possible to create stronger ties between PhD students and the centres, which normally brings benefits in terms of the relevance and usefulness of the PhDs and those who acquire them.

Not only the economic and institutional context but also the policy context has an important influence on how well instruments work. The availability of research funding for the universities has improved since the early 2000s, but it is clear that the universities felt themselves to be so under-funded at the start of the CC programme that they would grab anything they were offered, more or less regardless of the conditions attached or its larger purposes. A sufficient and diverse source of research funding is also important for the sustainability of the centres, which will need to carry on finding research funding for the more fundamental parts of their activities after their CC grants end. A successful CC programme depends on a sufficient flow of science and engineering graduates and on the post-graduate education system (including stipends) functioning reasonably well. Other research and innovation measures also need to be in place to focus research and industrial attention on themes and fields of national importance. The long-discussed technology programmes to be modified from the Finnish model need to be implemented. On the industry side, more measures are needed that stimulate the employment of technologically capable people. An R&D tax incentive would be difficult to apply since that would conflict with Estonia's flat tax approach. However, Estonia also lacks the direct measures to inject qualified human resources into companies that are seen elsewhere, although such a programme will be launched by EAS in the autumn of 2008. The first graduate engineer and the first PhD entering companies can in different ways have massive effects on company behaviour. Typically, once one qualified person is on the inside they promote the recruitment of others like themselves, raising the technological level of the firm and enabling it to interact with external research infrastructures. There is evidence in this report that the CCs are already acting to 'inject' more qualified people into partner companies but this needs to be complemented by other measures in order to raise

companies to a level where a virtuous cycle of recruitment begins and in order to obtain the benefits of such recruitment in other parts of the economy than those touched by the CCs.

7.1.2 Implementation

In a transitional system such as Estonia's where systems-wide change and learning are in progress it is necessary to be very explicit about the 'rules of the game' – partly to support the learning process; partly in order to minimise the extent of opportunism among beneficiaries and potential free riders. One consequence of this was that the CC programme made very specific demands on proposers to specify what they intended to do in detail in all their projects for the three years to come. It also aimed to lock industrial partners into stable consortia, while – unlike in other countries that operate CC schemes – there was rather little experience of industrial-academic collaboration on R&D. With the benefit of hindsight, we can see that the Estonian consortia were likely to be far less stable than those elsewhere – indeed, the degree to which they **have** remained stable is almost surprising. A less tightly structured approach with a greater degree of supervision and negotiation might have eased this initial learning period. However, EAS did consciously take a very learning-orientated approach to the programme. Inviting applicants to visit Swedish and Austrian centres was an unusual and brave approach intended to maximise learning. A 'walk round' the centres by a very experienced CC programme manager from abroad might have brought a useful external perspective on learning needs – for EAS itself was having to learn at the same time as the centres.

It is generally agreed that the funding uncertainties of the first three years of the programme have led to a huge cost in repeated proposal-writing, assessment and administration. Effort wasted here could have been used to conduct the normal business of the centres as well as to promote learning and thereby improve programme performance. Despite the considerable reporting requirements, EAS appears not to have an overview of employment in the centres – either in terms of who is being paid or for what they are being paid. Taxpayers' money should not be spent in such a non-transparent way. Proper records should be held at some point in the system, not only to enable evaluation but more importantly for reasons of accountability. Both the centres and EAS itself would do well to hold cumulative data on centre performance that can be used for routine monitoring and for reporting on or publicising the programme.

The adoption of the independent legal entity option for the creation of the competence centres has had a number of effects:

- It has encouraged some centre managers and staff to take shares in partner companies or encourage companies in which they hold shares to join consortia. This places them in a dangerous conflict of interest, giving them incentives to redirect public funds or the fruits of work done with public funds towards companies they themselves own and, within the centres, to try to redistribute benefits away from some companies and towards others
- It empowers the members of the consortium (founders of the CC) to exclude others who could benefit from participation, effectively privatising public goods
- It allows consortium members to exclude potential partners whose presence would make the CC more likely to succeed in technological or commercial terms and likely to increase the scale of economic impacts
- It creates private windfalls from public funds and opportunities to hold the state and other consortium members to ransom
- More positively, it sets pro forma limits (due the business law and good business practice) to reveal or access to the in-house corporative business and other information needed for monitoring and evaluation purposes; particularly where the required performance indicators are not agreed in advance with the funding agency.

The risks inherent in the management of public funds by independent, mainly for-profit entities, can be reduced by the adoption of appropriate 'corporate governance' and supervision by programme managers or independent members of the supervisory council. However, although EAS did sit on the councils of the competence centres in an observer function, the agency lacked an instrument to intervene and impose changes to governance and management structures. It is not clear to what extent EAS has evaluated and analysed the annual business reports of the CCs (official reports to the State Business Register) which are publicly available.

7.1.3 Progress of the Centres

All five centres have come through the stage of establishing themselves as functioning research entities. All would need to increase their centre staff if they are to continue in the longer term. All would benefit from more international contact.

ELIKO tackles a shifting group of partners and does a mixture of research and advanced engineering in quickly changing fields. It suffers from fragmentation and the lack of a large, stable partner but is nonetheless doing a useful job. The Food and Fermentation centre has taken a long time to build up its infrastructure and now needs to pay especial attention to building middle-level personnel, producing research outputs and reinforcing the useful work it has started to do with industry. The Nano centre has done a lot of university research but the researcher population involved is very fragmented and the industrial consortium is unsustainably weak. The Dairy centre has a particularly strong consortium with which it needs to work for the long term. The Cancer centre is doing high-risk work that could potentially generate high rewards but largely lacks a mechanism to commercialise any promising results it does develop.

Table 24 summarises centre-by-centre performance in terms of the intervention logic set out in the programming document and summarised in Figure 1 and Table 1. It makes it clear that the centres have largely achieved critical mass and have established themselves as platforms for their industrial and academic stakeholders. Those operating in the more traditional branches appear already to have induced industry to think in a new way about the role of research and all by their very nature extend the length of the planning horizon in the universities. A common understanding between the universities and industry about mid-term priorities is emerging, if a little unevenly. All the centres are producing trained people, numbers of whom are going to industry while it has proved much more difficult to engage international companies.

Table 24: Centre Performance Summary

Centre performance	*ELIKO*	*FF*	*Nano*	*Dairy*	*Cancer*
Critical mass of R&D	()	✓	✓	✓	✓
Shared facilities, platform building	()	✓	✓	()	()
Extended industrial planning horizon	X	✓	X	✓	X
Extended academic planning horizon	✓	✓	✓	✓	✓
Shared understanding of mid-term priorities	()	✓	()	✓	✓
Human resource production and mobility	✓	✓	✓	✓	✓
Engaging international companies	X	()	X	X	()
Outcomes in academia/centres					
Change from project to programmatic planning	✓	✓	✓	✓	✓
Efficiency of corporate management	()	()	X	()	()
More awareness of industrial research needs	✓	✓	()	✓	✓
Increased attractiveness of their R&D fields	✓	✓	✓	✓	✓
Industrial outcomes					
Companies realise strategic objectives via cooperation	X	X	X	X	X
Business to business cooperations	()	()	X	✓	()
Academic work reorientated to industrial needs	()	()	()	()	()
Human resources trained and meet industrial needs	✓	✓	()	✓	✓
More international R&D cooperation	X	()	X	X	✓
Likely centre sustainability					
With continued high subsidy level	✓	✓	✓	✓	✓
With medium subsidy level	✓	✓	X	✓	X
With low subsidy level	X	X	X	X	X

Key: ✓ = Yes; X = No; () = partly

In academia (including the centres), planning has become more programmatic and the centres have mostly made progress towards a more industrial style of management. Everyone is more aware of industrial needs and all appear to have increased the attractiveness of their fields.

On the industrial side, there is not yet a case where cooperation has allowed strategic objectives to be realised – though particularly in the case of the Dairy centre it is clear that this is industry's intention. There is a little business-to-business R&D cooperation emerging but scope for this to go is lot further. People are being trained and some are moving to industry but there is little progress on international R&D cooperation.

Based on the preceding and the contents of the present report more generally, we describe our expectations about the sustainability of the centres in the last few rows of Table 24 as a way to summarise their performance and progress. This indicates that three of the five centres appear reasonably robust while two are built on less firm foundations.

7.1.4 Outputs, Outcomes and Impacts of the Centres

The centres are beginning to produce graduates at various levels, publications and patents. The rate of production is lower than it should be but that is natural at this early stage when there are production and publishing time lags to overcome. In most cases, they have established 'platforms' in which the consortium can meet, discussing both technology and other aspects of business. This is an important precondition for further networking within the consortia. Over time, this should develop from today's 'star' networks where companies essentially engage in bilateral cooperation with the centre to more complex 'mesh' networks where multiple co-operators cluster together within the overall consortium.

The CCs have had a positive effect on the universities, allowing them to identify where it would be industrially useful to concentrate resources, providing resources and establishing a more solid base of experience with this type of cooperation. We would expect the centres to have a more profound effect on university strategies only when CC funding becomes clearly longer-term. While competence centres are a research funding instrument, it is important to recognise that some of their most important effects come through their influence over university education at all levels, tuning it in socially desirable directions.

Companies wanted rather short-term benefits via product and process improvements and to a degree they got them but they also obtained longer-term results such as intermediate knowledge, access to human resources and in some cases a degree of inspiration about their technological opportunities and possibilities. Working with a CC represented a strategic decision and was therefore an important part of the process of raising the firms' ambition levels. They tended to be strengthened in their core technology and business areas. The 'platform' aspect of the CCs means the companies are becoming members of wider knowledge communities and building the trust needed for broader cooperation and networking. From the company perspective, the CCs were helping them tackle high-risk areas of technology and business and to take a longer time perspective than was normal for them in R&D or innovation.

The research community appeared less engaged with the CCs than industry, generally only working with them on a part time basis. Unlike industry, the researchers did not see the research involved as risky but they did see it as longer term and fairly far from the market. The researchers' motives for involvement were rather diffuse and it appeared that for a number the main thing was that they were able to do research – the wider aspects were not so important. Even then, they were often working in areas outside their research core. We attribute this to a lack of sufficiently differentiated research funding instruments in the universities. Nonetheless, the CCs were producing significant amounts of research outputs and trained people.

> As mentioned before, the peer reviews have been focused mainly on scientific and partly human resource progress of CCs. However, the scientific results have not been evaluated from a business viewpoint, i.e. no real assessment of commercial, "real" value of IPR produced. For instance, a high number of patent applications certainly indicate novelty of research but until its commercialisation (licensing, etc). It is a source of business costs only.

As the CC measure aims to raise the competitiveness of Estonian enterprises through increased in-house R&D capacities and strengthened business-academy co-operation in industrial research it is clear that future programme evaluations and monitoring should cover also the longer-term and broader economic impacts of the CCs.

7.2 Evaluative Conclusions

Our evaluation brief specifically required us to tackle the following issues

- Rationale, appropriateness and objectives of the programme
- Role and fit of the programme in the wider policy mix and against national innovation policy objectives
- Impact of the centres on the national innovation system
- Experience at the centre level – especially about the centres' compatibility with stakeholders' objectives and their influence upon stakeholders' strategies, behaviour and structure
- Management of the programme and the value added by the programmatic approach.

As regards the **rationale**, we are satisfied that the industrial need for more knowledge-based design and production and the need to create foci in academia on areas of national importance together justify the use of the competence centres instrument. This would not be the case if CCs could only work in areas of 'high technology'. However, the more unambiguously successful Estonian centres are actually in more traditional areas, these demonstrate that the instrument works where strong and balanced consortia can be built and where the research dimension takes the industrial consortium members 'one step beyond' the type of R&D or innovation activities they would otherwise have undertaken. They key is perhaps not that they always work in Pasteur's Quadrant but that they move consortia **towards** Pasteur's Quadrant. The objectives of the programme are therefore appropriate because they build academic and industrial strengths that underpin successful innovation and wealth creation.

Attaining these eventual impacts is a long-term process that is hard to measure and attribute to a single programme. We have suggested in several places that CCs depend upon complementary aspects of the research and innovation **policy mix** that include dimensions of university reform, increased university management capabilities (including in IPR), the existence of a wider mix of research funding mechanisms (these would include technology programmes, commercialisation programmes and academic centres of excellence as well as traditional bottom-up research funding) and human resource development and mobility programmes. These will of course not only support the CCs but also have significant and positive effects on the economy in their own right.

It is very early to be able to say much about the eventual **impact** of the centres on the national innovation system. Some of the centres clearly have more impact – and better prospects of future impact – than others. However, it is already clear that the centres are building knowledge-base communities whose networking is increasing the level of interest and activity in innovation, extending planning horizons and making innovation more knowledge based. Based on the experience of competence centre programmes elsewhere and on the wider research literature on innovation, these are the right kind of impacts to lead to economic benefits. The main area of weakness is internationalisation and integration with the international community.

Centre-level experience is that the centres fit well with the academic stakeholders' objectives. Industry's aims at the beginning were shorter term, as they always are, but industry is now learning the benefits of a medium-term approach. It is in the nature of competence centres that there should be a balance of power between science and industry and that there should always therefore be some mismatch between objectives and what actually happens. If either side gets things too much their own way, the centre does not hold: the researchers would drag it into fundamental but not necessarily useful research; the industry would pull it into short-term projects that generate no new knowledge and eventually consume the centre's intellectual capital. The degree to which stakeholders in the centres remain engaged is evidence that they see the value of the compromise and that time horizons have shifted towards the longer term.

Programme management has been complicated by the underlying funding shifts. As a result, too much of everyone's time has been consumed in administration rather than research and learning. EAS has made efforts to support learning across the centres network but it is perhaps easy to underestimate quite how radical the required learning is and EAS could have made more use of foreign expertise and experience to support the learning process. Administration and reporting have been insufficiently transparent for adequate accountability, adequately to support this evaluation or EAS' own need to boast about its successes with the programme. Moving to a longer term funding basis should free up the resources EAS needs internally to support a new generation of centres.

7.3 Recommendations

We have grouped our recommendations under three main policy messages comprised of more detailed and operational proposals, plus a final general recommendation concerning the overall policy-mix in which the CC operate.

1 The Ministry and EAS should combine the 'carrot' of longer term secured funding and the 'stick' of stricter 'performance contracts'

1.1 Our first and most important recommendation is, based on the experience so far and the continued justification of the rationale for the programme, to continue funding the CC programme for at least one full seven-year period. Continuity of funding is essential. Once granted, there should be a strong presumption that centres' funding will continue for the full seven years.

1.2 Of course, long-term funding also means that the centres need to be kept under pressure to perform not only in terms of research activities and outputs, but also, due to the public funding, in commercialisation and wider dissemination of their knowledge and skills in the Estonian economy. Equally the centres need to meet minimum levels of management performance in order to guarantee financial stability. Therefore, it is highly recommended to negotiate and implement a performance contract between EAS and the CC for the new round of funding starting in 2008. A performance contract would allow the introduction of scientific, economic and management-oriented performance indicators to measure progress, outcome and impacts of CCs in a comparable and reliable way. Appendix B contains a set of information on performance contracts in other countries as illustrative examples. EAS would need to reinforce and develop its own capacities and eventually seek external assistance in preparing to negotiate such contracts.

1.3 Centres should be evaluated after three years by a mixed team of competence centre and policy specialists and domain-specific peer reviewers. The presumption should be that funding will continue but the centres must satisfy the evaluators not only that their past and anticipated performance is adequate but also that they have a credible plan to tackle the ending of the funds after seven years. If the centres leave no legacy, there is little point in supporting them.

1.4 There should also be a final evaluation, more focused on impacts. These should take place in a time horizon that allows for quantification ex-post of economic and scientific returns (see for instance, the recent VINNOVA guide on impact analysis) for the Estonian tax-payers initial investment.

1.5 The Ministry and EAS should ensure that participating in official monitoring evaluations is a condition of contract in innovation policy interventions.

2 A governance model tailored to Estonia law while meeting the highest international standards of management of public funds.

2.1 The future CC programme should continue to take account of the specific nature of the Estonian context. This means that it should have more flexible consortium arrangements than the initial CC programme allowing organisations to enter and leave if they wish and the other partners agree. The option proposed in the new call for a core consortium ('shareholders') plus 'partners' (such as Estonian branches of multinationals) who can join temporarily purely on a project basis is a sensible step. However, EAS still should ensure, e.g. via specific performance indicators, that the consortium shareholding structure remains open to new permanent partners bringing new knowledge and financial resources.

2.2 The for-profit model most widely adopted to date by the centres has clearly a number of practical advantages (e.g. full deduction of VAT, a business driven approach dictated by the need to report as a company, etc.) but also a number of risks related to the management of public funds, intended to promote wider economic and social returns, by private individuals. The not-for-profit model is equally possible under law and has been proven to work for one of the more successful centres to date. The issue here is not per se the legal form adopted, although international practice and experience would plead in favour of the not-for-profit form, but rather the application of appropriate, consistently applied and adequately supervised 'corporate governance' procedures. It is therefore recommended that each CC should be a) obliged to employ, as a condition for receiving public funds, a professional managing director ('tegevjuht' in Estonian) independent of the partners and with no financial or other interest in any of the undertakings forming the consortia; b) the appoint to the 'Council' ('nõukogu', the equivalent in Estonian business law of a supervisory board) of the legal entity of at least one individual, with significant business expertise entirely independent of the consortia partners. This member would be proposed by EAS and the Ministry to the CC partners as one of the pre-conditions for signing the financial agreement.

2.3 We note, also that in at least one case, the board ('juhatus' in Estonian law, the structure that represents the company founders on a day-to-day basis) has only one member, while this is legally possible, it increases the risk of a non-transparent use of public-funds. Ideally, the boards of CC should be formed by at least representatives of three main 'share-holders', this is a recommendation we can only suggest the CC shareholders adopt.

2.4 EAS should establish a register of interests in which policymakers, programme management and the council members, board members, and the managing director and staff of the centre are required to disclose actual and potential sources of conflict of interest. This should apply not only to the CCs but more widely.

3 Maintaining a focus on research relevant to Estonian industrial capabilities while progressively attracting international recognition and partners.

3.1 There should be no presumption that CCs must be 'high tech' or undertaking 'frontier' research – though they must be knowledge-based and aim to take a community of stakeholders beyond its existing level of knowledge and R&D ambition. The CC programme in the Estonian context rightly aims, first and foremost, to increase the international competitiveness of Estonian enterprises through collaboration with research organisations.

3.2 However, the isolation of the centres from the international community should be tackled in two ways. First, all centres should establish international advisory committees as a condition of receiving funding. Such instruments are necessary but can easily degenerate into luncheon clubs. EAS should therefore itself vet the membership and attend the annual meetings of these committees at the centres.

3.3 Second, international industrial participation is crucial for such a small economy as that of Estonia. A proportion of the centre funding – say, 10% – should be made conditional on satisfying EAS that the CC consortium is working with one or more international partners of stature by the end of the first year, if not from the outset. However, the development of international partnerships must be driven by the strategic value brought by a foreign partner in terms of improving the effectiveness of the industrial R&D projects of the centre or the internationalisation of the Estonian SMEs involved in the industrial consortium of the CC. EAS needs to check that international partners brought in are not done solely for meeting contractual obligations or 'window-dressing'.

4 In parallel to these specific recommendations, we note that **Estonia needs a wider mix of research and innovation policies** that partly create the conditions in which competence centres can flourish but that, more importantly, have significant positive direct effects on the innovation system. These include

- University reforms, as outlined earlier in this report, are required to further modernise their structures and procedures for managing relations with industry
- Upgrading of university management skills, including but not only in IPR and commercialisation
- Technology programmes
- Human capital and mobility schemes for industry
- Other incentives for conducting industrial R&D.

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