Centres of Excellence as a Tool for Capacity Building

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Executive summary

The OECD has carried out a study on Centres of Excellence (CoE) as a part of the OECD project on Higher Education and Research for Development (IHERD), which is financed by the Swedish International Development Cooperation Agency.

This synthesis report of the CoE study presents an overview of the CoE concept for research funding and capacity building in research for developing countries. It provides a framework for the description and analysis of CoE schemes to support the selection of such schemes. This report also provides an overview and detailed empirical accounts of 12 CoE schemes, following this analytical framework, and analyses these schemes in terms of capacity building in developing countries.

In this study, CoEs are taken to be organisational environments that strive for and succeed in developing high standards of conduct in a field of research, innovation or learning. Most CoE schemes combine a number of academic and socio-economic goals, however a common distinction has been made between schemes that are largely intended to generate scientific excellence, those whose purpose is to stimulate technological innovation in some sector, and those with more general social objectives, including policy support or regional development. In addition some CoEs are geared towards educational or learning goals. These are normally dealt with separately, but are increasingly part of the CoE framework.

The analytical framework developed and applied in this study categorises CoE schemes according to their strategic orientation: a) basic and strategic research; b) innovation and advanced technological development; and c) social and economic development. It integrates these strategic aims with the way they are made operational via a number of institutional operational conditions such as funding and evaluation mechanisms and governance and organisational solutions. Finally, it considers their impact and capacity building outcomes.

Following this framework the study provides an empirical account of the following 12 CoE schemes:

- **Basic and strategic research**: Linnaeus Environments (The Swedish Research Council, Sweden), University Grants Commission Inter University Centres (India), Networks of Centres of Excellence (Canada), and the Australian Research Council’s Centres of Excellence (Australia).
- **Innovation and advanced technological development**: Strategic Research Centers for Industry and Society (SSF, Sweden), Indian Science Agencies Centres of Excellence (India), Centres of Excellence for Commercialization and Research (Canada), and VINNOVA Excellence Center (VINNOVA, Sweden).
- **Social and economic development**: The DST/NRF Centres of Excellence programme (South Africa), Centres of Research Excellence (New Zealand), Business-Led Networks of Centres of Excellence (Canada), and the Cooperative Research Centres Programme (Australia).

The case studies suggest that there is a mutual dependence between the strategic orientation and the impacts in terms of capacity building, while the institutional operational conditions are more neutral, and tend to vary very little between type of CoE scheme. There is no doubt that the ways in which
these institutional and governance mechanisms (such as funding, evaluation and organisational arrangements) are combined influence the results of the scheme. However at this point the strongest conclusion that can be made is that CoEs, due to their common characteristics, require a fairly homogenous set of institutional framework conditions. Implementing such institutional conditions is a source of capacity building for research funders as well as research organisations, and is expected to contribute to developing the research system in general.

The results from this study suggest that the CoE instrument may be a fruitful path towards realising capacity for human resource development, organisational capacity and the creation of an institutional and legal framework in the research and higher education field, including positive effects on innovation and socio-economic development. In addition the results suggest that the consolidation of resources involved in CoE schemes does not necessarily imply a choice between a purely scientific or socio-economic agenda, but could instead act to bridge these two types of goals. Moreover, there is a clear indication that these schemes require research organisation (including funders) to become more professional, something that will ultimately stimulate the research system as a whole away from piecemeal non-directed funding and towards a capacity for priority setting and more systematic evaluations of the research effort. All these are key research development capacities.
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AICTE</td>
<td>All India Council for Technical Education</td>
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<tr>
<td>ARC</td>
<td>Australian Research Council</td>
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<td>BL-NCE</td>
<td>Business-Led Networks of Centres of Excellence</td>
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<td>CECR</td>
<td>Centres of Excellence for Commercialization and Research (Canada)</td>
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<td>CI</td>
<td>Chief Investigator</td>
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<td>CIHR</td>
<td>Canadian Institutes of Health Research</td>
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<td>CoE</td>
<td>Centre of Excellence</td>
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<td>CoRE</td>
<td>Centres of Research Excellence (New Zealand)</td>
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<td>DST</td>
<td>Department of Science and Technology (South Africa &amp; India)</td>
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<tr>
<td>EOI</td>
<td>Expression of interest</td>
</tr>
<tr>
<td>HEI</td>
<td>Higher education institution</td>
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<td>HQP</td>
<td>Highly qualified personnel</td>
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<td>ICT</td>
<td>Information communications technology</td>
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<td>IIEP</td>
<td>International Institute for Educational Planning</td>
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<td>IIT</td>
<td>Indian Institutes of Technology</td>
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<td>IPR</td>
<td>Intellectual property rights</td>
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<td>LOI</td>
<td>Letter of intent</td>
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<td>NCE</td>
<td>Networks of Centres of Excellence</td>
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<td>NGO</td>
<td>Non-governmental organisation</td>
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<td>NRDS</td>
<td>National Research and Development Strategy (South Africa)</td>
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<td>NRF</td>
<td>National Research Foundation (South Africa)</td>
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<td>NSERC</td>
<td>Natural Sciences and Engineering Research Council (Canada)</td>
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<td>PPP</td>
<td>Public-private partnership</td>
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<td>PSAB</td>
<td>Private Sector Advisory Board</td>
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<tr>
<td>R&amp;D</td>
<td>Research and development</td>
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<td>ROI</td>
<td>Return on investment</td>
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<td>S&amp;T</td>
<td>Science and Technology</td>
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<tr>
<td>SAC</td>
<td>Selection Advisory Committee</td>
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<td>SME</td>
<td>Small and medium-sized enterprises</td>
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<tr>
<td>SSF</td>
<td>Swedish Foundation for Strategic Research</td>
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<tr>
<td>SSHRC</td>
<td>Social Sciences and Humanities Research Council (Canada)</td>
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<tr>
<td>ToR</td>
<td>Terms of reference</td>
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<tr>
<td>UGC</td>
<td>University Grants Commission (India)</td>
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<td>UPE</td>
<td>Universities with Potential for Excellence</td>
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<td>Swedish Agency for Innovation Systems</td>
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<td>VR</td>
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1. Introduction

This is a synthesis report bringing together the results from the project on Centres of Excellence as a tool for capacity building. It presents:

- an overview of the Centre of Excellence (CoE) concept for research funding and the concept of capacity building in research for developing countries
- a framework for the description and analysis of CoE schemes in support of the selection of such schemes
- an empirical account of 12 CoE schemes following the framework
- an analysis of these schemes in terms of capacity building in developing countries following the framework.

The framework is built on a literature review and a previous study of CoE initiatives reported to the OECD in 2012. This framework was further elaborated and validated using case study data of CoEs from 6 countries, including 12 CoE schemes. The framework was developed both from a methodological point of view – in order to assist the country studies – and as an analytical tool providing guidance for drawing conclusions about the institutional conditions for CoEs and the typical capacities/impacts that may be generated by this mechanism.

This report is structured as follows. Section 2 provides an analysis and delimitation of the objectives of the whole project. Section 3 outlines a brief research overview of some issues pertinent to the CoE mechanism and the issues of capacity building from research. Section 4 presents a methodological framework delineating the analytical model used and the principles for conducting the research. Section 5 presents the CoE types in an analytical summary, followed by conclusions about their respective strengths and weaknesses as capacity building tools. The 12 country cases are then presented in an appendix using the analytical model elaborated in Section 4.
2. Objectives of the project

The terms of reference specifies that this report should address the requirements at the policy and institutional level for initiating and managing different types of CoEs for the purpose of fulfilling policy needs. In addition the report will address the following points:

(a) The construction of the CoE funding instrument and its possible implications on the policy/institutional level.
(b) The identification of factors that would enable CoEs to generate excellent research and to build capacity in prioritised areas in developing countries.
(c) The extent to which, and under what conditions, the CoE mechanism is relevant to the needs of developing countries.
3. Centres of Excellence and capacity building

3.1 The CoE concept and the objectives of CoEs

CoEs may be described as organisational environments that strive for and succeed in developing high standards of conduct in a field of research, innovation or learning. They are often highly attractive to research and development (R&D) investments and talent in their field. Therefore they possess the ability to absorb and generate new knowledge. Ideally they would distribute and utilise this new knowledge in the form of new capacity in their field, be it research results, innovations or talent. CoEs are typically geographically concentrated and focused on high potential/growth areas in science and industry, but they may also be virtual/distributed and consist of a network of co-operative partners with a co-ordinating centre. In terms of size, according to the operational definitions employed by some funders, CoEs can be anywhere from the local R&D group up to regional-level semi-cohesive triple-helix networks consisting of hundreds of researchers (Hellström, 2010).

Most CoE schemes converge on a number of academic and socio-economic goals, a common division being that between schemes that are largely intended to generate scientific excellence, those whose purpose it is to stimulate technological innovation in some sector, and those with more general social objectives including policy support or regional development (Aksnes et al., 2012). In addition some CoEs are geared towards educational or learning goals. These are normally dealt with separately, but are increasingly part of the CoE framework, and should in any event be considered relevant to the developing country context. Regardless of strategic orientation, all CoEs have in common the notion of excellence, and the particular requirements that come with that label. Some of these dimensions – referred to as objectives in this context since they are also often used to evaluate centre progress – are high research quality and productivity, resource attraction and concentration, international visibility and attractiveness (including staff recruitment), and organisational robustness (good governance) (Orr et al., 2011; Aksnes et al, 2012). These are higher-order criteria, which are expected to further the strategic goals, be they in innovation or other social impacts.

3.2 What is excellence?

What are the defining markers of excellence in CoEs? Balderston (1995) discusses dimension of excellence from a management perspective. He claims that the extent to which the institution satisfies some conditions for long-term viability is of central importance, where the most important components are a sound governance structure ensuring autonomy and self-direction, and a broadly accepted commitment to academic values. By emphasising the role of autonomy and academic values in excellence Balderston accepts, with some qualification, the idea that peer judgment is established in “the province of knowledgeable peers in [a] field” (p. 352). In other words excellence is ultimately what your peers value as excellent. Key organisational correlates to this view are the ability to attract academic “stars”, high levels of recruitment selectivity and broad but essentially collegial consultation over resource allocation.

However Balderston also mentions that while excellence tends towards “the selective, the critical, the fundamental, the cosmopolitan, the long-range” (p.359), there are also trade-offs which may put some of these values into question. One is the risk of over-investing in narrow, basic projects with long
gestation periods, the uncertainty of which may threaten the ability of an institution to survive. Another is whether these are compatible with other values of the inquiry, for example those that relate to more "democratic" and equitable goals such as local engagement and social improvements. Consequently Balderston mentions three key institutional criteria for guiding the selection of excellence programmes:

(a) compatibility of aims between the programme and its institutional context
(b) effectiveness and mutual reinforcement of programmes at that location or in the broad institutional context of the centre
(c) acceptability to the centre’s most important constituencies.

These values combine an organisational and a collegial rationale for excellence.

Balderston's points are mainly relevant at a strategic level, however several authors also point towards fairly concrete organisational and group aspects of excellence. For example Hemlin et al. (2004), in a review of a number of studies on research climate, suggest that leadership (e.g. clear coordinated objectives, excellent visionary leadership, group participation in leadership, well-managed staff selection), are key to excellent research environments. As with Balderston, they emphasise that the right culture and climate – a primary focus on research and a genuine research culture – stimulate high-quality outputs from research. In addition, internal and external communications have been shown to strongly correlate with high-level performance, while diversity in age and background have also been important.

In their classic cross-discipline study on research laboratories in the United States, Pelz and Andrews (1966) also pointed to the importance of interaction between scientific colleagues for productivity, and the role played by joint goal setting for CoEs. Intra-organisational communication was found to be important for research productivity, and while such communication did not necessarily have to lead to organisational consensus, a key factor for success was shared enthusiasm for the same type of problems.

In a similar but more contemporary study on creative research groups in nanotechnology and genetics, Heinze et al. (2009) found that extra-mural collaborations play an even greater role in research excellence than was assumed in these previous reports. Successful groups draw on larger collaborative networks, provide a link between disjointed peers and work under conditions that reflect multidisciplinary contacts. Heinze et al. (2009) also point out that a scientific actor who operates at the intersection of a diversity of research groups may generate more original research by having a greater variety of perspectives and knowledge available (e.g. Burt, 2004). However, such a position may not be the optimal one for diffusing new ideas. Cohesive collaborative groups and high-trust networks may function best for such purposes (e.g. Fleming et al., 2007). This naturally poses a dilemma for evaluation: ideally both diversity and cohesion should be present in a research group to some extent – however the exact trade-offs may vary.

Excellence is also closely connected with funding outcomes. Laudel (2006) attempts to capture some of the more important conditions for fund acquisitions, which is a key proxy for excellence. In a qualitative interview study with German and Australian physicists, Laudel identified a number of conditions promoting funding which were specific to aspects of the centre or programme. These concerned the topic of research (e.g. whether it had a diverse funding landscape, large epistemic room
Laudel also points out that not all such promoting conditions are quality related. For example while mainstream/low-risk research and know-how about fundraising are also important for fund acquisition, they hardly point directly to scientific excellence. In fact Hornbostel's (2001) work on third-party funding at German universities proposes that external fund acquisition is only an appropriate indicator of excellence when: a) such funding is common in the field; b) there is a qualified peer-review system operating; c) there is a mix of resources in the system; and d) the essential infrastructure for research is available.

External funding has this character of cause-effect ambiguity, where it is not always clear if such funding is a good indicator of excellence because it actually promotes scientific quality, or whether that external income is in fact generated by scientific quality. Both assumptions can of course be questioned, and none implies by itself that external funding is good for long-term excellence. For instance external competitive funding may undermine rather than promote quality by encouraging mainstreaming and short-termism in research (Whitley & Gläser 2007). Likewise the claim that external income is proof of scientific quality is questionable given the observed "resource-mediated Matthew effects", that is where money itself begets more money (Gillett, 1991).

### 3.3 Capacity building, research and developing countries

There is no single definition of capacity building. Over the years however a general understanding has developed where, to quote for example UNESCO “capacity is [the] ability of individuals, organizations and systems to perform appropriate functions efficiently, effectively and sustainably” (UNESCO, 2005). In the development context this has come to mean the way individuals, groups, institutions and societies strengthen their abilities to, on the one hand, perform core functions, solve problems and formulate and achieve objectives, and, on the other, to understand and deal with their development needs in a broad context and in a sustainable manner (UNESCO, 2005; UNDP, 1997). For the purposes of this study we may take a leaf from the pages of the International Institute for Educational Planning (IIEP), who divides the issues of capacity building for development into:

(a) Human resource development: providing the skills, information, knowledge and training to enable actors to perform effectively.

(b) Organisational development: the elaboration of management processes, structures and procedures within organisations as well as with regard to their relationships to other stakeholders (such as the business community and government).

(c) Institutional and legal framework development: creating and maintaining legal and institutional arrangements that enable organisations, institutions and agencies to enhance their capacities (IIEP, 2006).

Capacity building in the research and higher education sector of a society is crucial to all other sectors in that society. This is important in the context of developing countries since public investment in research is often torn between (at least) two main goals: scientific and social. Scientific goals are usually expressed as a desire to achieve international recognition and academic standing in branches
of science while social goals are expressed as the aspiration to strengthen industrial capacity, educate the national workforce including its leaders and decision makers, and address national challenges (Meek et al., 2009). This simple duality however is confounded by the argument that scientific capacity is a social goal in its own right, and a key component of sustainable development and general social and institutional capacity building in developing countries. For example Kearney (2009) outlines seven values that stem from research investments that may lead to social and economic capacity benefits:

- contacts with international research
- provision of local analysis and advice
- identification of relevant research agendas
- critical thinking in higher education
- evidence-based criticism and debate for policy making
- capacity to train future generations of researchers
- stimulation of national innovation systems.

Typically in developing countries, research capacity is centralised at the larger higher education institutions (HEIs) which then assume responsibility for fostering the national commitment to research, promoting a culture of inquiry, developing the capacity to utilise international research results and assuring the acquisition of research skills. Such a system, which is both centralised but has only weak capacity at the outset, is precarious and faces three main challenges (Kearney, 2009). These are a) the dilution and redirection of possible resources for research; b) challenges posed by the rapid expansion of higher education to meet increasing demand; and c) fragmentation of research-oriented action. In all three of these areas it seems that one possible strategy would consist of creating critical mass in research in a smaller number of carefully selected areas, or alternatively using a CoE approach to consolidate research capacity in areas where a country is relatively strong.

Drawing on the above reasoning we can summarise the relevance of CoEs for capacity building in developing countries in the following way. CoEs may be an instrument for capacity building in so far as they have the potential to realise human resource development, improve organisational capacity and create an institutional and legal framework in the research and higher education field, including its effects on innovation and socio-economic development. The consolidation of resources does not necessarily imply a choice between a scientific and a social agenda, but could instead act to bridge these two. We will return to this argument in the final section of the report. In what follows we will take a closer look at how this study was organised to capture the logic behind CoE initiatives and the way these attempt to realise various capacity goals.
4. Methodology and framework

4.1 The research framework

The terms of reference for this study identify a problem, a problem context and key relationships relevant to this context, providing a guide for the development of the analytical framework and the cases. These components and relationships are described in Section 2. Together they allow us to identify five empirical objectives for the country case studies in support of developing the analytical framework and the synthesis:

(a) A characterisation of the strategic aims of the CoE funding instrument.

(b) A characterisation of the CoE funding instrument itself, including its operational/institutional conditions such as those relating to funding, evaluation and governance.

(c) A characterisation and assessment of the relationship between the strategic aims and the CoE schemes.

(d) A characterisation of the actual and potential effects of the CoE on capacity building.

(e) An assessment of whether these effects are relevant to and adequate for capacity building.

The analytical framework is a guide for case-study development but is also intended to provide a tool to address the question of the policies and operational requirements needed to initiate and manage different types of CoEs for the purpose of capacity building.

This requires a qualitative understanding of the assumptions made when setting up a CoE scheme with specific goals and which is circumscribed by specific institutional and organisational framework conditions. We need to describe in this context not only what CoEs are available (their various purposes and modes of organisation), but also whether they intend or are likely to realise capacity goals or have other desirable impacts.

The following analytical framework represents these relationships and also guided case development for this study (Figure 1). At the left is the strategic orientation (goals) of a CoE scheme. These are then made operational by means of a number of institutional operational conditions such as funding and evaluation mechanisms and governance and organisational solutions. These together are expected to generate certain impacts and capacities such as research capacity and training. This project aims to fill this model with empirical content to assess the effectiveness of a given CoE scheme at translating its strategic aims into such outputs. The bi-directional arrow between strategic orientation and institutional supporting/operational conditions suggests the mutual dependence of these two components, and the dotted line encircling the impacts and capacity building denotes that impacts are always uncertain.
The analytical categories employed in the first two boxes are derived from previous studies by the OECD and others (e.g. Orr et al., 2011; Aksnes et al., 2012; Hellström, 2011). The analytical categories representing impacts and capacity building are flexible and could involve any of the following categories and more:

- research capacities
- technology/innovation, technical co-operation
- socio-economic/development (capacity)
- infrastructure
- training and skills
- quality assurance
- internationalisation (foreign direct investment, joint ventures, network participation, research partnerships)

For a more comprehensive account of dimensions of impacts and capacity to be employed in this project see OECD (2009).

The overall hypothesis is that there are a number of ways of conjoining the strategic and institutional supporting elements with specific types of CoE schemes and, most importantly, that certain types of such combinations can be expected to generate specific outcomes in term of impacts and capacity. Optimally, such combinations may be derived from studying actual schemes and their impacts. In most of the present cases, actual impacts have not yet been identified with much certainty, and the reported impacts are often of an impressionistic and imprecise in nature. This is typical for young policy initiatives, and in research policy impacts require many years to realise. The impacts and capacity building effects reported in the present cases should therefore be assumed to be part of a tentative program theory for the respective CoE schemes that is yet to be fully tested, i.e. they are sometimes actual, but most often policy makers have deemed them likely or desirable for a given scheme, and they are included in the Terms of Reference for evaluating schemes.¹

¹ This report will focus on the CoE schemes and specifically the connection between the scheme itself and the assumed and actual capacity/impacts generated by the scheme. The policy/institutional context will be elaborated in
4.2 Data collection and analysis

General rationale
In order to assess the viability of CoE schemes for capacity building, it was important that data were collected and presented on relevant issues and with an adequate level of detail. The framework above points to many, but not all possible relevant dimensions of a CoE scheme. Therefore in some instances the empirical case studies had to go beyond the analytical framework while some areas had to be omitted due to a lack of available information. In addition, the sometimes the connection between the three areas in Figure 1 was publicly available information, and sometimes had to be inferred or hypothesised from available data.

Collection
Data were generally collected following the analytical framework for CoE in capacity building described above where possible. In many instances the number of schemes was too large to be accommodated within the study, and representative schemes had to be selected. Table 1 lists the schemes included in the study. The criteria for selection in such instances was the extent to which the selected schemes were representative of the variety present in the case-study country. Case information was typically collected through public documentation or interviews with relevant actors. Sometimes it was only possible to gather relevant information about some of the points by such means as accessing evaluation reports on individual CoEs, or application documentation. This type of data also proved useful in terms of providing examples of how a given CoE scheme has implemented its objectives. In order to facilitate analysis, the CoE schemes were selected on the basis of their coverage of the three main types of CoE schemes. Category A schemes are oriented towards basic and strategic research, Category B towards innovation and technological development, and Category C towards social development (cf. Orr et al., 2011; Aksnes et al., 2012). A further aim was to achieve a fairly good country representation within each category, and at least one developing country initiative within each category. As Aksnes et al. (2012) have shown it is not always possible to locate a CoE scheme squarely in one of these categories. Such hybridisation and overlap is indicated by more than one letter after each scheme.
Table 1. CoE schemes included in the study

<table>
<thead>
<tr>
<th>Main orientation</th>
<th>CoE Scheme</th>
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| A. Basic research | • Linneus Environments (The Swedish Research Council, Sweden) (A)  
• University Grants Commission Inter University Centres (India) (A)  
• Networks of Centres of Excellence (Canada) (A-B)  
• Australian Research Council Centres of Excellence (Australia) (A-C) |
| B. Innovation and advanced technological development | • Strategic Research Centers for Industry and Society, Swedish Foundation for Strategic Research (SSF) (Sweden) (B-A)  
• Indian Science Agencies Centres of Excellence (India) (B)  
• Centres of Excellence for Commercialization and Research (Canada) (B-C)  
• VINN Excellence Center (VINNOVA, Sweden) (B-C) |
| C. Social and economic development | • The DST/NRF Centres of Excellence programme (Department of Science and Technology and National Research Foundation, South Africa) (C-A)  
• Centres of Research Excellence (New Zealand) (C-A)  
• Business-Led Networks of Centres of Excellence Program (Canada) (C-B-A)  
• The Cooperative Research Centres Programme (Australia) (C) |

Analysis and presentation

The structure of the case studies (presented in Appendix A) follows the analytical framework as presented in the model above, in the order listed in Table 1. On the basis of these cases a synthetic summary account is presented in the next section.

For each category, the most salient key aspects are synthesised according to the model. Each of the CoE types are then summarised, starting from their characterising features, how they integrate according to the model and their implications for development capacity building.

Finally a summary discussion provides suggestions and recommendations about comparative advantages and disadvantages of these three categories of CoEs for development capacity.
5. Synthesis summary of the CoE types

5.1 CoEs for basic and strategic research

Strategic orientation
There are four main strategic aims that recur with this type of CoE. All are connected to basic and to some extent advanced strategic research, but in different ways.

1. To create support for basic and advanced strategic research. This can be defined as support for “frontier fields of science” and “internationally competitive (world class) research” capabilities and is the main aim for this category of CoE.

2. To connect researchers across fields and geographical locations, including support for multidisciplinary or interdisciplinary research.

3. To connect the science system to international research networks. This includes developing partnerships with scientifically strong environments in other countries and thereby creating the conditions for improvement of international standing in selected fields of knowledge.

4. To support scientific prioritisation in the science system. This can be done either top down, by funding CoEs in areas of national priority, or bottom up, by inviting applications in order to identify where in fact national research capacity resides. One explicit aim common to many of the CoEs in this study was also to provide HEIs with an incentive to prioritise within their organisations, by means of co-funding and other types of commitments.

Institutional supporting and operational mechanisms

Application and funding
Typical features include:
- Competitive funding where typically HEIs submit proposals after a local pre-selection. Funds are then granted to the HEI or the CoE.
- Two-phase application processes involving letters of intent (LOIs) or expressions of interest (EOIs) followed by a final proposal.
- Five to 10 year funding, extending up to 15 years in some cases.
- Matching funding of up to 50% by host HEIs and partner organisations.
- Selection by disciplinary or multidisciplinary committee, by international peer committee or a combination of these.

Evaluation
Typical features include:
- The selection criteria rank applicants using: research and programme quality, investigator quality, potential for scientific renewal, host commitment or similar, networking and
partnerships, national academic visibility, and contribution to national goals.

- Once funded, evaluations are conducted through annual financial and operational reviews, mid-term evaluations focusing on academic results and operations, and final evaluations focusing on results and impacts. Results may be used to inform future funding decision.
- CoEs may be subject to a reduction or increase in funds during the funding term depending on performance.

**Governance and organisation**

Typical features include:

- Oversight by funder (research council), group of councils or ministry/government committee.
- Many CoEs are free to organise as they see fit, but there is an emphasis on transparent decision-making structures, diversity and formal communication structures, an operative advisory and governing board, and a formal connection between the CoE leadership and HEI/host leadership.

**Impacts and capacity building**

**Research capacities**

- Critical mass in terms of scientific excellence in promising research areas of national importance (enhancing national research capacity).
- Strategic capacity for developing and acting on new research opportunities.
- International visibility through research excellence and attracting front-line international research talent.
- International benchmarking to evaluate the research work at these centres enables universities to attain the benchmarks of excellence in academic institutions.
- Creation of funding mechanisms to improve the quality of research and teaching, and modernising infrastructure.
- Research infrastructure development in some niche areas, and national or international co-operation using that infrastructure.

**Networks/partnerships**

- Increased international collaborations, partnerships and visibility, including research, training and knowledge-transfer programmes.
- Support of researcher-to-researcher collaboration, through organised programme strategies and tasks as well as stronger leadership and decision-making processes at the structural level of the networks.
- Improved national research networks and co-operation.
- Cross-sector partnerships including triple-helix type partnerships (i.e. partnerships between researchers, the public sector and private sector), such as collaboration with strategic agencies and end users.

**Training and skills**

- Professionalisation of research (including journal publishing, peer review, high-quality postgraduate and postdoctoral training, mentoring, conference attendance)
- Improvement of the quality of teaching at undergraduate and postgraduate levels.
- Development of scientific leadership in the organisation of research.
**Socio-economic development**

- Transfer of research and development capacity across sectors through cross-sector partnerships.
- Research utilisation and commercialisation through patents and licensing or spin-off firms
- Outreach through interaction with the local community.

**5.2. CoEs for innovation and advanced technological development**

**Strategic orientation**

There are three basic strategic aims for this category of CoE:

1. The overarching goal is to support strategic and applications-oriented research and expertise with potential industrial applications. This means supporting internationally competitive research and development in strategic and applied science (including medicine) with the aim of generating innovation. Sometimes this is done with a focus on government-defined priority areas, but not always.

2. Bringing together the complementary resources needed for technical development and industrial application. This includes concentrating multidisciplinary competence in particular areas of research in order to further the development of products, processes and services, typically by focusing on problems that demand larger efforts than can be provided by smaller projects.

3. Bridging the gap between researchers and users, and stimulating and strengthening triple-helix relationships. This is in order to increase the likelihood of scientific research being used by industry, and in order to make the university generally more responsive to industry needs. Expertise development and PhD training in areas of industry interest is one of the aims in this regard.

**Institutional supporting and operational mechanisms**

**Application and funding**

Typical features include:

- Two- or three-stage selection processes including pre-proposals. An international panel makes the final selection; occasionally there is a review by a private-sector advisory board.
- Five to 10 year funding timelines, where the funder provides 40% - 100% (typically 50%) of total funding and the remainder is matched by the host HEI and external stakeholders.
- A gradual decrease in base funding to the benefit of external partners where funding exists.
- In-kind contributions from external and cross-sectoral partners, such as infrastructure and expertise.
- In some cases there are no requirements to attract matching funding although industry cooperation may be a funding condition.

**Evaluation**

Typical features include:

- Pre-proposals are evaluated on the basis of their strategic fit with the programme.
• Further evaluation is on the basis of scientific worth, structural potential and organisational viability, and the impact on and fit with the host HEI. Other criteria involve innovation capacities (capacities for research commercialisation), national competitiveness and sustainable growth, modernisation of skills and diffusion of best practices to industry. Occasionally there is a business plan evaluation.
• There will be mid-term and final evaluations as well as annual reviews focusing on financial and operational aspects.

**Governance and organisation**
Typical features include:
• CoEs must usually be formally located in an HEI.
• Governance involves steering committees, an international advisory board and/or combination of ministerial oversight, steering committees and local leadership groups. There may be mixed governance boards including business partners, sometimes with a requirement that the board has a majority of external partners or reflects the stakeholders involved.
• Demands for specific organisational forms are generally weak, however requirements may include coherent milieus (“under one roof”), unitary leadership, multidisciplinary teams and integration with the host HEI.
• The structure must be able to manage complex research and commercialisation activities. Often the structure may be flexible, consisting of several smaller research groups.
• Centres sometimes have to plan for and use part of their budget for co-operation

**Impacts and capacity building**

**Research capacities**
• Attraction of international research talent.
• Mobilising complementary expertise from traditionally separate fields to solve specific problems.
• Research and innovation capacity in areas at the intersection of science, engineering and industry. Developing leadership in some niche areas of science and technology where there is an industry need.
• Strengthening the HEI/host in terms of research capacity, and enrichment of research training and basic education. University-based scientific infrastructure can also be strengthened by the development of the centres.

**Networks/partnerships**
• Creation and strengthening of international research networks, including joint centres with foreign research institutes.
• Engagement of senior private-sector talent on the governing boards, and recruitment of adjunct industry professors to forge industry-academic links.
• Increased domestic co-operation, for example with national research institutes and other firms, organisations, sectors and regions of the country.
• Triple-helix type partnerships and creation of sector-specific interfaces with research users in areas of strategic importance.
• Strengthened international position of national companies through participation in worldwide S&T activities in their respective domains.
• Infrastructure creation used by academics and industry partners alike, facilitating access for university academics and students to important research infrastructure in industry.

Training and skills
• Development of national PhD training in emerging technical front-line subjects.
• Training PhDs for industrial and university recruitment. Training, imparting skills and creating a specialised human resource base involving interdisciplinary perspectives.
• Disseminating expertise and skills to various actors, for example through public-private partnerships involving the business enterprise sector and training professionals, or through CoE graduates taking employment in partner industries.
• Opportunities for research training to be conducted within the actual process of commercialisation.

Socio-economic development
• Technology development for industry utilisation, for example new products, processes and services; and the development of prototype components (such as nanomaterials) and components for use in industrial product development.
• Demonstration projects validating how new components or processes can be integrated into products or production processes.
• Creating sufficient user capacity for an ongoing two-way exchange of knowledge and pursuit of market opportunities. This includes actual transfer of new ideas between sectors, could lead to new products and services.
• Creation of new research-based firms and support for small and medium-sized enterprises (SMEs), including incubator space, technological validation and venture capital.
• Growing and retaining domestic companies by accelerating and otherwise stimulating technology transfer.
• Attracting investment, including foreign direct and venture capital investments.

5.3. CoEs for social and economic development

Strategic orientation

The strategic aims of these CoEs can be summarised as follows:

1. To achieve distinction in research and world-class research capacity, but with an aim to addressing social and economic issues of national importance and generating qualified human resource capacity. Rather than exclusively focusing on supporting basic science capability and industrial innovation, this mainly includes improving the skills of researchers across the community and training young researchers in areas of national priority.

2. To stimulate specialisation and competence in the higher education system. Specifically, by developing research-led teaching in the higher education system, developing training programmes and increasing collaboration within the system. Developing new relationships between HEIs and communities (including triple-helix type relationships) are also included here.
3. To stimulate academic-industry collaboration including user-driven research collaboration addressing national and global challenges. By stimulating research and networks supporting social problem solving as well as product development and business development, CoEs can promote local knowledge transfer. In contrast to opposed to the previous category, the emphasis here is on engagement with SMEs rather than working with more established industry partners.

Institutional supporting and operational mechanisms

**Application and funding**

Typical features include:

- Open and competitive calls based on themes of national importance.
- Two-stage application processes including LOIs and full application.
- Funding of up to 5-10 years duration, sometimes extended to 15 years.
- Up to 50% co-funding from industry and government partners, although sometimes host HEIs are exempt from co-funding. Funding sources may include returns on patents, research contracts and other external or government sources.

**Evaluation**

Typical features include:

- Selection of schemes by discipline specific committees and international experts focusing on aspects such as strength of application; strength of business plan; how multidisciplinary it is and the complementary resources available; adequacy of management structure; human capital development; relevance to end users, wealth creation (impact of R&D on commercialisation) and national objectives; sustainability; and participant contributions.
- Evaluation includes annual monitoring focusing on research direction and financial control, as well as mid-term panel evaluations half way and two-thirds of the way through and a final evaluation, focusing on outputs, outcomes and impacts.

**Governance and organisation**

Typical features include:

- CoEs may be hosted by a HEI that provides support through institutional integration, meeting its staffing and infrastructure needs, and supporting knowledge transfer and network activities.
- CoEs can also be incorporated as a separate legal entity or as an unincorporated joint venture between partners (e.g. industrial firms, industry associations, universities and government agencies).
- Private or public-sector members form the majority on governing boards and project selection committees.
- An advisory committee overseeing CoE operations including appointments and evaluations.

**Impacts and capacity building**

**Research capacities**

- Critical mass and economies of scale in promising research areas, allowing for planned, strategic, long-term research, and the sharing of personnel, equipment, databases etc.
• International competitiveness and visibility e.g. by an increase in global share of research outputs.
• Grants and programmes offer support from pre-doctoral to postdoctoral levels, including doctoral support and mentoring.
• Increased incidence of collaborative and interdisciplinary research.
• Strategic capacity for developing and acting on new research opportunities.
• Increase in private-sector investment in R&D and advanced technologies.
• Better understanding in academic circles of the various conditions needed for industry innovation.

Networks/partnerships
• Increased international scientific collaboration, including global research and academic engagement in co-investment arrangements.
• Increased domestic collaboration between scientists, technologists and institutions to ensure that benefits spill over to a wide array of firms, sectors and regions of the country.
• Joint priority setting between academia and businesses, so that organisations can be launched more rapidly and relevant research initiated much earlier.
• Long-term public-private sector collaboration, including links between researchers and firms, to address significant research challenges that meet business needs.

Training and skills
• An internationally competitive research training environment, providing training in critical thinking, entrepreneurship skills and innovative research.
• Postdoctoral support, with internship programmes, support for students to study abroad, joint ventures in student training, and with particular attention paid to racial and gender disparities.
• Critical mass of research supervisory capacity and mentorship.
• Qualifications which are relevant to the needs of business and industry, e.g. through industry-oriented projects with clear timelines, milestones and the potential of “no/go” decisions.
• Fostering of graduate careers in non-academic settings, e.g. by providing opportunities for research students to work with industry experts and to undertake R&D activities in industrial settings.
• Improve industry R&D capacity, including among SMEs, and increasing receptivity to the results of R&D. For example, improving SME staff skills may thereby reduce the costs and risks associated with R&D activities.

Socio-economic development
• Promote better diffusion and exploitation of the knowledge produced by HEIs, e.g. through non-traditional dissemination of outputs such as using the internet or specialist training workshops, maximising the accessibility of research to target groups.
• Providing reliable advice to government, business and civil society through expertise, and by providing models and knowledge resources for policy agencies. This may also involve identifying significant shortcomings in social services and making recommendations to relevant agencies to overcome them.
• Outreach activities in order to involve, and disseminate knowledge to, students, under-represented groups and communities.
• Early application of research in the development of next generation products. Providing commercialisation benefits that position national firms in high-value segments of the production chain. This also includes licensing of technology and spin-off firms (particularly for SMEs).
6. Analysis and conclusions

In what follows we will conclude how CoE schemes can aid capacity building, and identify specific strengths and weaknesses of each type of scheme, depending on policy aims. It is clear from the material so far that while it is possible to categorise schemes as has been done here, it may be more worthwhile to consider CoEs as having some core features in common with some additional optional parts or functions that can be added depending on policy needs. In this sense we recognise that the proposed divisions, at least in some cases, are artificially imposed rather than reflecting “natural kinds”. CoEs should really be conceived as located on a spectrum from basic science to socio-economic development, where boundary instances exist. Sometimes, opposite ends of this spectrum collapse, as for instance when basic science CoEs are focused on national socio-economic problems. In these cases categorising a CoE scheme as being of one type is less important than understanding where each of the components of the CoE belongs, so as to avoid goal conflicts and contradictions and to facilitate the construction of a coherent scheme.

With these provisos we will now consider each of the parts of the CoEs as presented in the models above: a) strategic orientation; b) institutional supporting and operational mechanisms; and c) impacts and capacity building. This will facilitate comparison of the ambitions, strengths and weaknesses of the CoE types. This discussion will help identify the main characteristics of each type and their potential contribution to capacity building for development.

6.1. Strategic orientation

The main thrust of the basic and strategic research type of CoE is the development of scientific capacity for new knowledge creation – in terms of scientific production as well as institutional conditions for such production. In this regard a recurrent aim of these schemes was to strengthen “frontier fields of science” and “internationally competitive (world class) research” capabilities. Any other aims are in support of this overarching ambition and these include connecting researchers across fields and geographical locations, connecting the national science system to international research networks and supporting scientific prioritisation in the science system.

These strategic aims can build development capacity through scientific renewal and/or building up new fields of basic research that are relevant to the national science and higher education system. It also includes the mobilisation of dispersed research talent in selected fields in order to create critical mass, i.e. creating synergies in the science system. The stimulation of international networks, whether for training, quality control or possible recruitment, may aid institutional capacity building, stimulate academic social capital, as well as develop research talent. Another important by-product may be the building of institutional capacity to formulate and carry out research policy.

The innovation and advanced technological development CoEs differ in some important strategic respects. Their main purpose is of course to stimulate innovation and technological/industrial development rather than science as such. Their subsidiary aims are supporting strategic and applications-oriented research and expertise, bringing together complementary resources for technical/industrial application and bridging the gap between researchers and users. These suggest that apart from knowledge transfer from researchers to industry in the form of things like inventions,
it is transfer of knowledge and competence that is key. As with the basic and strategic science CoEs, creating a critical mass is a central strategic aim, but here it is for the purpose of focusing problem solving efforts on issues relevant to industry. Bringing academe, policy and industry closer together is an important strategic aim. Unlike in the basic science context, development of innovation capacity cannot take place in isolation within academia.

The capacity building aspect of this type of CoE is primarily to provide an established or emerging industry with the knowledge and expertise it needs for renewal and innovation and ultimately national growth by adapting the science base. As with the basic science CoEs, the benefits come from achieving critical mass and in making research accessible to industry, which in turn may simplify technology transfer. By creating the *conditions* for the use of public research and a science system which is more responsive to industry problems, it has adapted its skill set and competence to meet industry needs.

The *social and economic development* type of CoE naturally aims beyond just innovation and technological development, although those aspects may be included. The main emphasis is generating the competence and skills to address national challenges, to focus and specialise competence in the higher education system and to stimulate triple-helix and user-driven collaborations to meet socio-economic challenges. In contrast to the other CoE categories, it is intangible outputs that matter. The ultimate outcomes are expected to be various kinds of social and economic improvements, such as development and development capacity.

In this category the capacity development aspect is most clearly visible through the connection of research to national goals (problem solving for policy and development) and by using CoEs to improve the skill base in selected areas. Improved capacity for higher education in general (research-based education) and in certain specific areas of training is central here. The CoE may be used to focus skills development by providing opportunity for critical mass in parts of the higher education system and hence focused responsiveness to local needs. While this is still in many ways an academic endeavour, this is not the sort of strategic aim that the basic science and innovation-oriented CoEs will necessarily hold. It is perfectly compatible with aims such as social capital development, or the stimulation of network ties in triple-helix constellations. Triple-helix constellations usually work through the improvement of competence and skills in social problem solving, rather than through academic research output.

### 6.2. Institutional supporting and operational mechanisms

It is striking that while the strategic aims and impacts of the CoE schemes differ enough to make it useful to categorise them, the same is not true for their institutional supporting and operational mechanisms. These appear almost the same across schemes, with small variations, for example in the way they are evaluated. We will therefore summarise them together while pointing out some smaller but apparent differences.

Typically, CoEs are realised through an application/funding approach involving competitive calls, two- or three-stage selection processes (with pre-proposals) and funding timelines of 5-10 years, sometimes as much as 15 years. Generally, up to 50% matching funding is provided by the host HEI and/or partner organisations. In the case of socio-economic development CoEs, HEIs may sometimes be exempt from co-funding. Selection is conducted by academic committees (usually international) in the case of basic and strategic research CoEs and mixed practitioner-academic committees in the case
of innovation and development-oriented CoEs. Selection criteria involve programme quality, investigator quality, potential for scientific or socio-economic renewal, networking and partnerships, national academic visibility, contribution to national goals, and similar value dimensions. Evaluations are conducted by annual financial and operational reviews, mid-term evaluations focusing on outputs (whether academic results or socio-economic activities) and operations, and final evaluations focusing on results and impacts. CoEs may be subject to a reduction or increase in funds depending on their performance in these evaluations.

It is interesting to note that in most cases CoEs seem to be free to organise as they see fit, albeit with the expectation that they will have transparent decision-making structures, diversity and formal communication structures, as well as an advisory and governing board and some sort of formal connection between CoE leadership and HEI/host leadership. There is usually (but not always) also a requirement for unitary organisation, i.e. “under one roof”. These institutional conditions differ in most respects from typical project funding, and there is no doubt they will have a positive impact on institutional capacity building, as it offers scholars the opportunity to engage in academic management and leadership rather than simple self-management. For research councils the CoE institutional format provides an opportunity to carry out funding activities with a deeper involvement than is typical and to develop and test new funding mechanisms.

6.3. Impacts and capacity building

Impacts are of course crucially related to capacity building, and several of the impacts quoted can be interpreted as the creation of capacity. We will focus on these here. In the case of basic and strategic research CoEs, the primary impact will be enhancing national research capacity through achieving critical mass in particular areas of science. Others will be related to improved capacity to develop and act on new research opportunities, and research infrastructure development. Improving co-operation between researchers and public sector/industry, locally as well as internationally is a recurring theme. When it comes to training and skills, professionalising of the craft of research, and improving the ability to lead research are both central to capacity building in science. The second of these especially should be a key valued outcome when funding larger research organisations as opposed to individual project researchers. In terms of socio-economic development, the transfer of research and development capacity across sectors is another central impact that may stimulate the whole national science system in unexpected ways.

Innovation and technological development CoEs also put an emphasis on knowledge creation, but here the main thrust is towards making the most of human resources, networking – particularly creating fruitful encounters between academe and businesses, and the creation and attraction of expertise. Finding complementary expertise with the potential to solve specific problems relevant to innovation and commercialisation seems central. This involves attracting international talent and enabling international research networks, but also enabling industry talent to enter into academe and vice versa, for example through joint infrastructure utilisation, end-user involvement in research and sectorally mixed governing boards. Skills transfer through education and training of industrial actors as well as research training in situ in industry is an important outcome. The most salient direct socio-economic development capacity building are the creation of new research-based firms, retaining domestic companies and attracting investments, but there is also the more general capacity of making users available for technology verification when needed.
In a sense, the socio-economic development CoEs are a return to building research capacities in the traditional sense of building critical mass in promising areas, however the impacts here are more about improving research training, increasing interdisciplinary work, increasing research investments by the private sector and giving researchers a more practical mentality. Other impacts include increased international collaboration, but with a slant towards global co-operation in education, and investments towards this end. Long-term domestic collaboration between sectors, including joint priority setting, increases the speed of social and economic problem solving and stimulates long-term relationships between sectors. The capacity to development and renew of human capital is central to this type of CoE. It takes the form of internship programs for young academics in business, development of mentorship capacity, and skills transfer to industry. This might include the adaptation of academic programs to industry needs, for example to stimulate their capacity to undertake their own R&D. In this type of CoE it is also indicative that the outputs that count are knowledge transfer (rather than technology transfer), and training workshops, policy advice and improvement, rather than new products. Outreach activities that transfer knowledge and skill to underrepresented groups should take priority.

This analysis is summarised in Table 2 below.

6.4 Conclusions

In Section 3 of this report we hypothesised that CoEs may be an instrument for capacity building in so far as they have the potential to realise capacity for human resource development, enhance organisational capacity and the create institutional and legal frameworks in the research and higher education field, as well as their effects on innovation and socio-economic development. We also reasoned that the consolidation of resources does not necessarily imply a choice between a scientific and a social agenda, but could instead act to bridge these two.

The results from this study suggest that Centres of Excellence may indeed be a fruitful way to realise these capacities. There are clear indications that, across the schemes and scheme types, the emphasis is on human resource development for the science and HEI system, as opposed to the traditional publication-oriented emphasis of project funding. There is also a clear indication that these schemes require a professionalisation of research organisations, including funders, that may ultimately stimulate the research system as a whole away from piecemeal non-directed funding and towards a capacity for priority setting and more systematic evaluations of the research effort. All these are key research development capacities.

In addition, Kearney’s (2009) emphasis on international research contacts, provision of expertise and research training capacity, are all echoed across the CoE types, whereas they are seldom viewed as goals of project funding. Finally, and perhaps most importantly where national systems lacks critical mass in any one field of inquiry, the CoE approach, with its emphasis on resource concentration and interdisciplinary approaches, addresses the three main challenges elaborated by Kearney (2009): dilution and redirection of possible resources for research, challenges posed by the rapid expansion of higher education to meet increasing demand, and fragmentation of research oriented action. The schemes reviewed here indeed suggest, both in terms of their strategic ambitions and impacts, that creating critical mass in research in a smaller number of carefully selected areas, can be done through the CoE approach.
<table>
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<th>Strategic orientation</th>
<th>Institutional conditions</th>
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<tr>
<td>Basic and strategic research</td>
<td>- Application/funding approach involving competitive calls</td>
<td>Basic and strategic research</td>
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<td></td>
<td>- Two or three stage selection processes (with pre-proposals)</td>
<td>- Critical mass in areas of science</td>
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<td></td>
<td>- 5 to 10 year funding, sometimes extending to 15</td>
<td>- Cooperation between researchers and public sector/industry</td>
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<td>- Up to 50% matching funds provided by host HEI and/or partner organisations.</td>
<td>- Professionalization of the researcher and research organization</td>
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<td></td>
<td>- Selection is conducted by academic committees (usually international) in the case of basic strategic research CoEs and mixed practitioner-academic committees in the case of innovation and development oriented CoEs.</td>
<td>- Transfer of research and development capacity across sectors</td>
</tr>
<tr>
<td>Innovation and technology</td>
<td>- Criteria involve programme quality, investigator quality, potential for scientific or socio-economic renewal, networking and partnerships, national academic visibility, contribution to national goals, and similar value dimensions.</td>
<td>Innovation and technology</td>
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<td></td>
<td>- Evaluations by annual reviews (financial/operational), mid-term evaluations focusing on outputs (e.g. academic results or socio-economic activities) and operations, and final evaluations focusing on results and impacts.</td>
<td>- Networking across academe and business sectors</td>
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<td>- CoEs expected to have: Display diversity</td>
<td>- Expertise creation and attraction</td>
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<td></td>
<td>Formal communication structures</td>
<td>- Complementary expertise with the potential to solve industry challenges</td>
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<td>Operative advisory and governing board and formal connection between CoE leadership and HEI/host</td>
<td>- Attracting international talent and enabling international research networks</td>
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<td>- Industry talent to enter into academe and vice versa</td>
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<td>- Creation of new research based firms</td>
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<td>- Retaining domestic companies</td>
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<td>- Attracting investments</td>
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<td>- Making users available for technology verification when needed</td>
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- Support of "frontier fields of science"
- Internationally competitive (world class) research capabilities
- Connect researchers across fields and geographical locations
- Connect the science system to international research networks
- Support scientific prioritisation in the science system

- Critical mass in areas of science
- Cooperation between researchers and public sector/industry
- Professionalization of the researcher and research organization
- Transfer of research and development capacity across sectors
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<th>Social and economic development</th>
<th>Leadership. Unitary organisation, i.e. &quot;under one roof&quot;</th>
<th>Social and economic development</th>
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</table>
| - Social and economic improvements, e.g. development and development capacity.  
- Academic knowledge utilisation for societal benefits  
- Generating qualified competence and skills to address national challenges  
- Focus and specialise competence in the higher education system  
- Stimulate triple-helix and user-driven collaborations to meet socio-economic challenges | - Improved research training  
- Increased interdisciplinary work, increased research investments by the private  
- Practical mentality among researchers  
- Global cooperation in education  
- Long term inter-sectoral collaboration  
- Joint priority setting  
- Increase the speed of social and economic problem solving  
- Long-term relationships between sectors  
- Capacity to development and renew of human capital  
- Internship programs for young academics in business  
- Mentorship capacity, and skills transfer to industry  
- Adaptation of academic programs to industry needs  
- Policy advice and improvement  
- Transfer knowledge and skill to underrepresented groups |
7. References


OECD (Organisation for Economic Co-operation and Development) (2009), *Enhancing Public


Appendix A. Country cases

This annex is derived from the various case studies conducted as part of the study on Centre of Excellence as a tool for capacity-building, including case studies on Australia (Fabiana Barros, Glenda Joseph-Davies and Althea Spence), Canada (Janet E. Halliwell, Glenda Joseph-Davies and Althea Spence) India (Venni Venkata Krishna) New Zealand (Glenda Joseph-Davies and Althea Spence) South Africa (Krish Bharuth-Ram) and Sweden (Tomas Hellström).

CoEs for basic and strategic research

The Linnaeus Environments (Sweden)
The Swedish Research Council (VR), in a consortium with Formas (The Swedish Research Council for Environment, Agriculture and Planning) and in co-ordination with other government research funders, supported a total of 40 research environments in 2006 and 2008. They provided funding for proposed centres in fields stretching from the natural sciences, engineering and medical science to social science, economics and educational sciences.

Strategic orientation
The scheme is focused on creating support for basic, internationally competitive research of the highest international quality. It also aims at generating synergies in the science system thereby creating the potential for scientific renewal and increasing Sweden's competitive advantage by building environments for competitive basic research. An additional purpose is to encourage universities to prioritise fields of research and to allocate resources to these fields.

Institutional supporting and operational conditions
Applications for funds are submitted by universities and university colleges, so centres are therefore subject to a pre-selection process at the university level. Each centre is granted EUR 5 000 to EUR 10 000 a year over a ten year period. This is to complement the state’s base funding for research. The funding is matched by the host university, which provides 50% of the total grant. The initial selection is made by four academic committees overseen by a central committee. The evaluation criteria are: achieved academic quality, potential for scientific renewal and host institution commitment. A mid-term evaluation is carried out after 1.5 to 2 years by an international academic panel, and focuses on organisation, collaboration and leadership. A second evaluation at five years focuses on academic results and academic value added. The final ten-year evaluation focuses on impacts and is used to inform research funding and university development more broadly. The results of the first two evaluations can lead to a reduction or increase in funding of up to 20%.

Linnaeus environments are free to organise themselves as they see fit, but the terms of reference (ToR) of the evaluations suggest certain key desirable organisational characteristics. These include a formal connection between the centre and the university leadership, transparent decision-making structures within the centres, an operative international advisory board, gender diversity, and co-operation within the leadership team over academic, administrative and
strategic issues.

**Capacity building and impact**
The following outcomes were identified as central according to terms of reference documents, reports and evaluations.

**Resource creation**
- Developing research infrastructure and national/international co-operation using that infrastructure.
- Access to international research talent.

**Research collaboration**
- Co-operation outside of the CoE environment, including research projects, PhD students and post-docs.
- Joint publications and sustainable, transformative partnerships with other research environments.
- Increased visibility for the university.

**Research capacities**
- Strategic capacity for developing and acting on new research opportunities.
- Developing critical mass in promising research areas.

**Socio-economic and development**
- Cross-sector partnerships and transfer of research and development capacity across sectors.
- *Training and skills*
- Mentoring, research training and development of new master’s programmes.

**University Grants Commission Inter University Centres (India)**
India’s public research system consists mainly of the science agencies under the Ministry of Science and Technology and other ministries, the universities under the University Grants Commission (UGC), and HEIs under the All India Council for Technical Education (AICTE). As a result, Indian CoE schemes fall under these two domains, the ministries and the UGC. This scheme is an example of the latter.

**Strategic orientation**
This scheme is titled “Promotion of University Research and Excellence” and covers three fields of basic and applied science: nuclear sciences, astronomy and humanities-social sciences. Under this scheme, the UGC institutionalised the concept of excellence in specialised areas and frontier fields of research in the form of three Inter University Centres. These centres provide common facilities for research and various specialised services and programmes to universities. All three centres have been selected to promote basic research and advance knowledge in specialised areas.

**Institutional supporting and operational conditions**
The three Inter University Centres are jointly funded by grants from UGC, the Ministry of Human Resource and Development, the Department of Science and Technology (DST) and some
marginal funding from the state governments where the centres are located.

The selection and evaluation process begins with the UGC issuing calls for applications from the Indian universities. A committee then shortlists the proposals. Expert Evaluation Committees visit the universities and submit their reports to UGC. The committees use a scoring scale developed by the Universities with Potential for Excellence (UPE) working group for their evaluation reports. The vice chancellors of the shortlisted universities are called to present the proposal before the standing committee on UPE for the final selection of universities.

The initiative for an Inter University Centre originates with elite scientists or faculty who have achieved international recognition. However, the decision to establish is taken by the UGC governing body in consultation with the Education Ministry and the Ministry of Science and Technology. The Inter University Centres are operated as autonomous national laboratories governed by a top-level council and a governing body. While there is a scientific advisory body to advise on the structure and goals of the centre's academic and research programmes, the executive authority is vested in the director.

**Impacts and capacity building**
The scheme has had the following impact:

**Research capacities**
- Enhanced national research capacities in niche areas of national importance.
- Advancing research and enriched teaching.
- International visibility through research excellence and advancing knowledge at the frontiers.
- International benchmarking to evaluate the research work at these centres.
- Creation of funding mechanisms to improve the quality of research and teaching and to modernise their infrastructure to enable universities to attain the benchmarks of excellence in academic institutions.
- Enriched quality of teaching at undergraduate and postgraduate levels.
- Building research capacities through professionalisation.
- Scientific leadership in both organisation of research and recruitment of new researchers.

**Resource creation**
- Improve infrastructure and teaching standards in selected colleges at the national level.
- State-of-the-art scientific equipment in some niche areas.

**Training and skills**
- Professionalisation of research staff (publishing research in high-quality journals, peer reviews, research contacts with leading-edge science centres in the relevant field etc.) and improved quality of both research and training.
- Science Master's and PhD programmes, including summer training programmes.
Networks of Centres of Excellence (NCE) (Canada)
NCEs are large-scale, academically led virtual research networks that bring together partners from academia, industry, government and not-for-profit organisations for governance and research activities.

Strategic orientation
The strategic aim of the NCEs is to mobilise Canada's research talent in the academic, private and public sectors and to apply research talent to the task of developing the economy and improving the quality of life of Canadians. This implies excellence in research along the full spectrum from blue sky to proof of concept. To counteract Canada's geography and bridge its long distances, the scheme intends to connect groups of researchers and research trainees across the country to collaborate on common research problems relevant to the social and economic fabric of Canada. The suite of programmes initiated are intended to complement each other in support of excellence in various dimensions. Some of the strategic aims include stimulating internationally competitive, multidisciplinary research in areas critical to Canada's economic and social development; develop and retain world-class research capabilities in areas essential to Canada's productivity and economic growth; create nationwide and international partnerships between key individuals and organisations to create solutions to complex Canadian challenges; increase Canada's international visibility and reputation as a leader by attracting world-class collaborations, and develop partnerships with counterparts in international organisations when applicable.

Institutional supporting and operational conditions
NCEs are selected through a competitive process. Applicants are considered by a) a merit review process using expert panels involving international experts; and b) a multidisciplinary selection committee. Decisions are made by the NCE Steering Committee comprising the head of a tripartite council ('Tri-Council') and the Deputy Minister of Industry Canada. A two-phase application process is followed: first a letter of intent (LOI) after which the best submissions are shortlisted, followed by a full application. Five criteria are used to assess an NCE application at both the LOI and the full proposal stage: a) the excellence of the research program; b) the development of highly qualified personnel (HQP); c) networking and partnerships; d) knowledge/technology exchange and exploitation; and e) governance/management of the network.

Monitoring and evaluation activities involve the review of annual statistical and financial tables and annual corporate reports. This is carried out by staff and a subset of the multidisciplinary peer review committee constituted as a monitoring "standing committee". This is a new approach, which was introduced following the recent reduction in term from seven to five years for each phase of NCE funding, eliminating the need for a formal mid-term review. This annual review provides an opportunity for earlier course correction if deemed appropriate.

NCEs are funded for a five-year period (previously seven years), with the possibility of renewing for up to two further cycles of five years each. Existing NCEs may apply for two additional funding cycles and a third (and final) funding cycle which requires that it has developed and
built on its partnerships to progressively transform itself into a network driven by the needs of its partners. Evaluations of the overall NCE programme are conducted every five years to determine if any changes are needed, and to assess programme performance.

The NCE programme is administered jointly by the three granting councils, the Canadian Institutes of Health Research (CIHR), the Natural Sciences and Engineering Research Council (NSERC) and the Social Sciences and Humanities Research Council (SSHRC), in partnership with Industry Canada. The governance of the NCE programme is currently shared between two bodies. All funded NCEs are required to implement a governing board that has overall responsibility for the governance and management of the network and that reflects the interests and concerns of the various stakeholders involved. A formal Network Agreement is signed prior to release of funding, setting out the operating rules of the network, and defining the rights and obligations of investigators and participating institutions.

**Capacity building and impact**
The following outcomes were identified as central according to terms of reference documents, reports and evaluations.

**Research capacities**
- NCEs have achieved critical mass in terms of research excellence in key scientific fields by drawing together some of the strongest Canadian researchers, attracting others from abroad and enabling the resulting groups to be more competitive on international scales.
- Researchers in the NCE have produced an average of over 4,000 publications in refereed journals annually.
- Large numbers of research trainees have been involved in NCEs, offering richer opportunities to students for mentoring, conference attendance, publications, ethical debates and exposure to real-life practices.

**Research collaboration**
- Support of researcher-to-researcher collaboration, through organised programme strategies and tasks as well as stronger leadership and decision-making processes at the structural level.
- Pan-Canadian collaborations.
- International collaborations and partnerships. On average around 400 international organisations are involved each year in the NCEs, representing approximately 18% of all organisational participants.
- Partnerships between researchers, the public sector and non-governmental organisations (NGOs). Currently 18 NCEs engage over 2,500 partners who play diverse roles in the networks. They may contribute to the articulation of the research issue and methodologies, the conduct of the research itself, and the translation and transfer of research outcomes into actionable results.
Socio-economic and development

- Annually between 100 and 130 patents have been applied for and/or issued from within the NCEs, with 30-50 licenses either granted or under negotiation.
- Between 2003 and 2011, 50 spin-off companies are reported to have been formed, leading to new jobs and new market opportunities.
- User capacity in some areas has been greatly enhanced.

Australian Research Council Centres of Excellence (Australia)

The Australian Research Council (ARC) Centres of Excellence scheme aims to enhance and develop Australia's research excellence through highly innovative and collaborative research, as well as to build Australia's human capacity in a range of research areas. The disciplines supported include: biological sciences and biotechnology; engineering, mathematics and informatics; humanities and creative arts; physics, chemistry and earth sciences; and social, behavioural and economic sciences. In addition, the ARC brokers partnerships between researchers and industry, government, community organisations and the international community.

Strategic orientation

The aim of the ARC CoEs is to conduct highly innovative and potentially transformational research that aims to achieve international standing in the fields of research envisaged and to lead to a significant advancement of capabilities and knowledge. The scheme supports all types of research including pure basic research which is experimental and theoretical, strategic basic research expected to lead to useful discoveries, and applied research which is original work undertaken primarily to acquire new knowledge with a specific application in view. However it clearly tends towards basic and strategic research and capacity development.

Institutional supporting and operational conditions

Funding under the ARC CoE scheme is provided to Administering Organizations, not to researchers. An ARC CoE receives a minimum of AUD 1 million and maximum of AUD 4 million per year (Approximately EUR 0.7 million to 2.9 million). To maximise the impact of ARC funding, participants must obtain commitments for additional financial contributions from a variety of sources including the host higher education institution, collaborating organisation(s) and partner organisation(s). Financial contributions from these sources can take the form of cash contributions and/or in-kind contributions. An ARC CoE may be funded for up to seven years.

ARC CoEs are selected through a competitive two-stage process. All expressions of interest (EOIs) are reviewed by an ARC Selection Advisory Committee (SAC) comprising international experts across the discipline areas, and successful ones are invited to submit a proposal. Proposals are assessed and shortlisted by SAC members and specialist assessors against the selection criteria. The selection criteria for EOIs place 50% of the weight on the proposed research programme and 50% on the investigators; for proposals the weightings are 25% on the research programme, 25% on the investigators, 25% on governance, leadership and mentoring and 25% on outcomes and linkages. The criteria does not include gender.
The first-named researcher on an EOI or a proposal will be considered the centre director and is expected to work predominantly on the activities of the proposed centre. The centre director must meet the eligibility criteria for a Chief Investigator (CI) and should be employed by the administering organisation. The CI may be nominated on a maximum of two EOIs or proposals.

**Capacity building and impact**
The following outcomes were identified as central according to terms of reference documents, reports and evaluations.

**Research capacities**
- Achieving critical mass in promising research areas.
- Creating opportunities for Australian researchers to work on large-scale problems over longer periods of time.
- Building Australia’s human capacity with international researchers and the most promising research students.

**Resource creation**
- Development of a strategy for the national research workforce (the Research Workforce Strategy).
- Support for other Research Excellence programmes.
- Research infrastructure development, mentoring and access to international research talent.

**Research collaboration**
- International networks for mobility, e.g. in terms of research, training and knowledge transfer programmes.
- Links between Australian researchers in universities, other research organisations, strategic agencies and end users.
- Other overseas research collaboration.

**Socio-economic and development**
- Centres established in the wider community as cross-sectoral points of interaction.
- Ownership and exploitation of intellectual property and/or utilisation or commercialisation of research.

**Training and skills**
- High-quality postgraduate and postdoctoral training environments for the next generation of researchers.

**CoEs for innovation and advanced technological development**

**Strategic Research Centres for Industry and Society (Sweden)**
The purpose of the Swedish Foundation for Strategic Research (SSF) is to support natural
sciences, engineering and medical scientific research, thereby developing research milieus of high international standard to improve Swedish national competitiveness. The Strategic Research Centres programme was initiated in 2004, with a budget of EUR 80 million, and resulted in 17 funded centres in 2005 with an emphasis is on biotechnology, informatics and nanomaterial science.

**Strategic orientation**
The aim of the initiative is to fund centres for internationally competitive research in single or overlapping fields of natural science, engineering and medicine. In these centres, novelty is promoted, and the focus is on problems that demand larger, more concentrated and co-ordinated research effort than can be achieved within smaller projects. By bringing together complementary subjects this research is intended to contribute to technical development, Swedish industry and social utility, for instance through PhD training and the development of expertise. Centres typically focus on basic, application-oriented research with potential industry applications.

**Institutional supporting and operational conditions**
The foundation invests EUR 750 000-1.5 million per year in each centre over a period of five to six years. It withholds 20% of the programme budget to enable it to top up centre budgets based on the results of the mid-term evaluation, providing a performance element to the funding model. There is no requirement to attract matching funding from the host university or from industry, however industry co-operation is expected. In addition centres must develop a plan for the utilisation of research results and also set aside a portion of the budget for supporting utilisation processes.

The centres to be funded are subject to a mixed criteria, three-stage selection approach, a mid-term evaluation and a final evaluation. At the selection stage pre-proposals are evaluated on the basis of their strategic fit with the programme. Those successful submit complete proposals to three panels of evaluators focusing on scientific worth, structural potential and industrial/social value respectively. Finally an international mixed panel makes the final selection. The overall success rate is about 7%.

Key criteria in the evaluation of the centres are: to what extent the centre format would offer substantial added value compared with a conventional project, how much new content it offers compared with other initiatives (novelty), and what is the strategic relevance of the centre to both Swedish competitiveness and to the strengthening of the host university. In addition centres are evaluated on their technology transfer activities and the methods they use, including management of intellectual property rights (IPR). As with other CoE initiatives, a strong focus is put on structural conditions, such as leadership competence, organisational solutions and co-operative milieu.

The governance and organisational requirements are fairly open ended and left to the centres to decide. There are some desirable features as well as *de facto* practices that have evolved in the
centres. The funder expects coherent milieus “under one roof”, co-ordinated via a clear line of command (one leader). They should be multidisciplinary and well-integrated into the university structure in order to be able to attract international talent and funding. In addition centres should be large enough to achieve critical mass, and preferably consist of several research groups working within in the same physical location. The average sub-group size is between five to eight people with a considerable mix of competence profiles and ages. Even though the funder’s emphasis is on a tight co-ordination regime, centres show a flexible and decentralised structure, which is also best practice for CoEs. Most of them have developed fairly elaborate governance structures encompassing scientific and industrial advisory boards, steering committees, director, management team, administrative core, researchers and research schools.

**Capacity building and impact**
The following outcomes were identified as central according to terms of reference documents, reports and evaluations.

**Research capacities**
- Attracting international research talent (focus on competitive mid-career recruiting).
- Setting up joint centres with foreign research institutes.
- Mobilising complementary expertise from traditionally different fields to solve a problem.

**Resource creation**
- Development of measurement technology and simulation tools for sharing with industry.
- University-based development/research projects connected to industry problem solving.

**Research collaboration**
- Setting up and sustaining national and international research networks.
- Forging industry-academe links through adjunct industry professors.
- Co-operating with national research institutes.

**Socio-economic and development**
- Improving the level of scientific research for a field of technical development which has relevance across industries (for example, the application of photonics for biomedicine and telecommunications).
- Developing prototype components (e.g. nanomaterials) and component families for use in industrial product development.
- Creating know-how regarding how new components or processes (such as signal processing or nanostructuring) can be integrated into products or production processes.

**Training and skills**
- Development of national PhD schools in emerging fields.
Focus on training PhDs in technical front-line subjects for industrial and university recruitment.

**Indian Science Agencies Centres of Excellence (India)**

As previously stated, the Indian public research system consists of mainly the science agencies under the Ministry of Science and Technology and other ministries, the universities under the University Grants Commission (UGC), and the HEIs under the All India Council for Technical Education (AICTE). As a result, Indian COE schemes fall under two domains, the science agencies under various ministries; and the UGC. This scheme is an example of the former.

**Strategic orientation**

Though most of these CoEs are established in specialised academic institutions such as the Indian Institutes of Technology (IIT) and other national laboratories, their objective is mainly to promote research and innovation. This is in contrast to CoEs in universities, which have the objective of advancing scientific research. Given that the areas of interest are mainly in new technologies such as biotechnology, information communications technology (ICT) and telecommunications, the main aim of these centres is to establish technological competencies and research capacities for creating innovation potential. The other important aim is to convert research into technological products and processes through relationships between universities and industry. The fields of ICT and telecommunications require a variety of engineering and networking skills to aid modernisation of the industry and their implementation. An important agenda of the Science Agencies CoE schemes is therefore learning sophisticated skills, technological networking and servicing the industry to upgrade their skills.

**Institutional supporting mechanisms**

The CoEs have been established and funded with a view to attaining research excellence in the long term. Whilst in some cases (e.g. biotechnology) the ministry funds the bulk of the costs directly, the telecommunications CoEs operate through public-private partnerships (PPPs), where the government invests 10%, and the collaborating business puts in the remaining 90%. The participating institutes, such as the IITs, provide infrastructure, human resources and space for R&D. These institutions in turn obtain project-based funding for the CoE from regular government schemes.

The CoEs are evaluated from a number of different perspectives. As well as their scientific and research excellence, these include their development of innovation capacities for the commercialisation of research, and/or their contribution to the modernisation of skills and diffusion of best practices in the industry. All centres are also evaluated on the basis of their contribution to improving efficiency measures in communication.

Governing structures vary depending on which ministry science agency is sponsoring them. For example, the telecommunication CoEs have a governing council led by a senior bureaucrat from the Ministry for Strategic Planning. Each institution and the partnering business enterprise is represented in the governing council. There is an autonomous core group at each centre to address national and local issues. Each centre is managed by a core group of seven members.
under the co-chairmanship of the head of the host institute and the sponsor or business enterprise. Then there is a co-ordinating centre which co-ordinates activities amongst all the CoE situated in different institutions in the country. Industry representatives are given membership in the co-ordinating centre.

**Capacity building and impact**

The following outcomes were identified as central in terms of reference documents, reports and evaluations.

**Research capacities**

- Capacity building of research and innovation in the areas selected at the intersection of science, engineering and industry.
- Developing leadership in some niche areas of science and technology.

**Research collaboration**

- Two-way and three-way partnerships and collaborations in sectors such as telecommunications, urban development and defence. Some of these were triple-helix type partnerships between government, research institutes and business enterprises.
- Joint publications and research output.

**Socio-economic and development**

- Contribution to broader social and economic goals of serving society at large.

**Training and skills**

- Training, imparting skills and creating a specialised human resource base involving interdisciplinary perspectives.
- Involvement of the business sector and training professionals as part of PPP based partnerships.
- Disseminating expertise and skills to various actors.

**Centres of Excellence for Commercialization and Research (Canada)**

The Centres of Excellence for Commercialization and Research (CECR) initiative is designed to create world-class centres to advance research and facilitate commercialisation of technologies, products and services in priority areas of the S&T Strategy. Unlike the Networks of Centres of Excellence, the scheme is dominated by centrally located rather than distributed centres.

**Strategic orientation**

The CECR program aims to bring Canadian research advances to market by operating in proximity to a cluster of related research and user expertise, thereby bridging the worlds of researchers and research users. The nature of the personnel varies among CECRs, but are normally individuals with highly specialised skills and experience, aligned with the target community. CECR initiatives must fall within the four priority areas defined by the federal government: environmental science and technologies, natural resources and energy, health and
related life sciences and technologies, and information and communications technologies. In this regard they complement the activities of the classic NCE, and can be used to extend the reach of an NCE into the realm of commercialisation.

**Institutional supporting and operational conditions**
As a condition of eligibility, organisations applying for CECR funds must have an established board of directors responsible for the approval of their annual financial reports and audits. Private sector users should be strongly represented on the board of directors. A competitive two-phase process is used for the initial selection of CECRs. The first phase involves review of a letter of intent (LOI) by the Private Sector Advisory Board (PSAB) – a group of industry advisors – based on alignment with the overall programme objectives. Full applications are then invited and must include a business plan addressing the CECR selection criteria, a budget, CVs for the centre leaders, letters of support and a summary of the contributions from the supporting organisations. Selection criteria include benefits to Canada, track record and potential of the applicants, and strength of the business plan. The full application is considered first by a merit review process using expert panels involving international experts. It is then reviewed by the PSAB and approved by the Steering Committee. In addition to annual monitoring and evaluation activities along the same lines as for the NCEs, the PSAB monitors progress of the CECRs and contributions to the overall programme goals. Additional opportunities for ongoing monitoring and course correction if needed come from the annual meetings of CECRs involving CECR secretariat personnel and reviews of reports by PSAB members. Requests for extension of the funding period are adjudicated on the basis of how the extension of the funding period will enable the centre to maximise the CECR investment and ensure a lasting legacy. Considerations include contributions from partners and stakeholders and the quality and capabilities of the centre management and personnel.

The governance of CECRs is closely prescribed. Centres are required to establish an administrative structure capable of managing a complex research and/or commercialisation programme. Each centre’s board of directors has overall responsibility for its management, direction and financial accountability, including the approval of its annual financial report and audit. The boards are accountable to the NCE Steering Committee for the CECR funds they manage. The membership of the board must reflect the interests and concerns of the various stakeholders involved in the centre. The centre director is accountable to the board of directors.

**Capacity building and impact**
The following outcomes were identified as central in terms of reference documents, reports and evaluations.

*Resource creation*
- Creating sufficient user capacity for an ongoing two-way knowledge exchange and pursuit of market opportunities.
- Offering a wide variety of SME support, including incubator space, technological validation, and venture capital.
Research collaboration
- Strengthening domestic collaboration and ensuring that benefits spill over to a wide array of firms, organisations, sectors and regions of the country.
- Creation of sector-specific interfaces with research users in areas of strategic importance to Canada – an aspect not common in other funding actions.
- Engagement of senior private-sector talent on the governing boards offering a new dimension to the academic research environment.

Socio-economic development
- Creating bridges between academic research and market application
- Building on prior success in commercialisation – especially through individuals experienced in the art of commercialisation.
  Creating, growing and retaining companies in Canada that are able to capture new markets with breakthrough innovations.
- Accelerating the commercialisation of leading-edge technologies, goods and services in priority areas where Canada can significantly advance its competitive advantage.
- Attracting investment (including foreign direct and venture capital investments).

Training and skills
- Opportunities for research trainees to interact with the actual process of commercialisation.

VINN Excellence Centres (Sweden)
The Swedish Agency for Innovation Systems (VINNOVA) has funded a number of centres in areas of high technology research of relevance to industry, for example biotechnology, informatics and ICTs, product development and new materials, transport, and labour studies. The scheme aims to achieve co-operation between industry, policy and academe in support of basic and applied research as well as to generate new technology and economic growth.

Strategic orientation
The scheme aims to create internationally competitive concentrations of multidisciplinary research competence in certain areas of basic and applied research, in order to develop new knowledge leading to new products, processes and services. This also includes achieving co-operative partnerships between academe, industry and the public sector and to strengthen the universities’ role as providers of research to industry and the public sector.

Institutional supporting and operational conditions
The typical centre has a turnover of about EUR 21 million over a ten-year period, of which VINNOVA typically funds 30-40%. The remaining share is split half and half between the host university and the industry/public sector partners. Government funding recedes gradually over the course of the centres’ development and is replaced by increased funding by the external partners. The centres are subject to a selection process carried out by an international, cross-
sector panel that takes into consideration the proposed centre's ability to contribute to economically sustainable growth, the concentration of competence, the commitment of the host and centre partners, the connection between university strategy and the centre’s, and the centre’s ability to grow and achieve excellence. Evaluations are conducted by annual review as well as at the two-year mark, mid-term and at the ten-year mark. The focus of the mid-term evaluation is on scientific quality and productivity, utilisation and commercialisation, and organisational viability, for instance in terms of leadership and administration. These evaluations are carried out by international teams who represent both field experts and generalists with experience of university-industry partnerships.

The initiative for creating a centre can be taken by an industry or public sector actor, but a centre must always be formally located at a university or university college. The evaluations put emphasis on the role of the university leadership in the development of each centre. Research programs are formulated and conducted jointly by the partners regardless of which sector they belong to. For this reason cross-sector involvement on the governing board of each centre is emphasised; actors external to the centre should hold a majority of the seats on the board. There is no requirement for an international scientific advisory board, and in other respects centres are free to organise themselves as they see fit.

**Capacity building and impact**
The following outcomes were identified as central in terms of reference documents, reports and evaluations.

**Research capacities**
- The location of the centres at universities is expected to lead to a strengthening of the hosts in terms of research capacity, as well as an enrichment of research training and basic education.
- International excellence in research is expected and the traditional outputs such as publications and citations apply.

**Technology and innovation**
- Creation of new long-term co-operative relationships between universities and industry/public sector that benefit all parties.
- Transfer of new ideas between sectors, which have the capacity to lead to new products and services.
- Creation of new research-based firms.

**Socio-economic and development**
- New products, processes and services. Initial results have been modest but several centres have shown an ability to make such contributions.
- Centre graduates take up employment in partner industries.

**Resource creation**
- The university-based scientific infrastructure has been strengthened by the development
of the centres.

- Several of the centres have developed experimental and social infrastructure which is used by academics and industry partners alike.
- The centres have facilitated access for university academics and students to important research infrastructure in industry.

**Training and skills**

- Permanent recruitment and development of new and relevant competencies.

**Internationalisation**

- Strengthening of international networks through academic co-operation.
- Strengthening of the international position of Swedish companies through participation in worldwide S&T activities in their respective domains.

**CoEs for social and economic development**

**The DST/NRF Centres of Excellence programme (South Africa)**

The strategic framework of the CoE programme in South Africa derives from the National Research and Development Strategy. As the then President, Thabo Mbeki, notes in its preface: “Critical in this regard (wealth creation in the context of globalisation) is the matter of human resource development. We have to exert maximum effort to train the necessary numbers of our people in all the fields required for the development, running and management of modern economies. ...” The NRDS identifies the creation of “centres and networks of excellence” in science and technology as a key component of the highly skilled human capital and transformation imperatives of the government’s policy.

**Strategic orientation**

The centres are envisaged as having two key roles: stimulating sustained distinction in research while simultaneously generating highly qualified people who can make a meaningful impact both nationally and globally in key areas of knowledge. The CoE programme is designed to raise the research ceiling of already existing top-level scientists at the HEIs and to further enhance capacity development and the regeneration of the broader science community. The scheme’s strategic aims include stimulating cutting-edge research and offering a training ground for the next generation of researchers while addressing transformation imperatives, building South Africa’s research standing, and researching key questions for South Africa. The final point is central as all of the CoEs are researching key questions of strategic importance to South Africa, mainly related to social and economic issues pertaining to South Africa’s industrial, medical and resource/environmental challenges.

**Institutional supporting and operational conditions**

The National Research Foundation (NRF) initiates an open and competitive call for the establishment of CoEs based on themes it has identified as being of national importance, and invites pre-proposals for initial assessment. If a proposal meets the selection criteria, invitations
are extended to the research leader/host institution to submit full proposals. These detail the research and capacity development plans of the proposed CoE for the duration of the CoE, which was 10 years, but has now been extended to 15 years. The criteria for funding are: the level of maturity of the proposal, the nature of the centre, how multidisciplinary it is, additional resources available, the needs of the applicants and other relevant factors. A discipline-specific selection panel evaluates the full proposals according to these evaluation criteria. The review of full proposals includes postal/electronic reviews by international experts and on-site reviews by local experts. The selection committee’s recommendation for the establishment of a CoE is then placed before a DST-NRF committee which makes the funding decision.

There are three phases of monitoring and evaluation of the performance of the CoEs. Annual monitoring is conducted by a suitably appointed Advisory Board, which is generally chaired by the Deputy Vice Chancellor of Research of the host institution, with representatives of the NRF as members. Of particular interest are strategic research direction and financial control. An international panel evaluation of the CoE is conducted after five, seven and ten years, considering outputs, outcomes and the impact of NRF support. Finally, an end-phase evaluation is undertaken in the penultimate year, or on completion of a funding cycle, to determine the exit strategy.

In terms of governance and organisation the host institution of a CoE commits itself to formally endorse the CoE from inception to its full operation. It should also be involved in the oversight and effective integration of the CoE into its broader institutional context, award the head/director of the CoE the position of university chair, ensure that effective management and appropriate staffing of the CoE (as described below) are in place, and meet all the basic infrastructure and some administrative needs of the CoE.

**Capacities and impacts**
The following outcomes were identified as central in terms of reference documents, reports and evaluations.

**Research capacities**
- Allow for planned, strategic, long-term research.
- Develop economies of scale in research through the optimisation of resources and effort by sharing personnel, equipment, data and ideas.
- Enhance the international competitiveness and visibility of South African science, e.g. by an increase in global share of research outputs.
- Retain, attract, sustain and improve scientific excellence.
- Promote collaborative and interdisciplinary research.
- Provide access to a highly developed pool of knowledge, maintain data bases, and promote knowledge sharing and knowledge transfer.

**Research collaboration**
- Collaborate with reputable scientists, technologists and institutions, and help to realise
national, regional, continental and international partnerships.

**Socio-economic development**
- Promote knowledge and human capital development in areas of national strategic importance. Promote better diffusion and exploitation of the knowledge produced by HEIs.
- Rendering services through analysis, policy, and other services, including informed and reliable advice to government, business, and civil society.

**Training and skills**
- Generate a critical mass of research supervisory capacity and mentorship.
- Create and developing an internationally competitive research training environment
- Human resource development through masters' and doctoral programmes, post-doctoral support, internship programmes, support for students to study abroad, joint ventures in student training, with particular attention to racial and gender disparities.

**Centres of Research Excellence (New Zealand)**
New Zealand's Centres of Research Excellence (CoRE) have developed a strong identity in the country's research environment since their establishment in 2002. These collaborative organisations enable scientists from universities, Crown Research Institutes and other organisations to work together on research projects, to produce truly innovative and excellent science as well as train a new generation of scientists. CoREs are inter-institutional research networks, with researchers working together on commonly agreed work programmes. They focus on the development of human capital, so they undertake outreach activities (for example, within the wider education system). The centres are expected to make a contribution to national development and focus on the impact of their research.

**Strategic orientation**
The scheme stresses the building of world-class research capacity and capability, and the importance to New Zealand of achieving this with Maori and Pacific Island peoples. It aims to create greater specialisation in tertiary research, increased collaboration across the system, support for research-led teaching, and greater investment in research infrastructure. The government's vision for the CoRE fund is that it should establish and promote excellent, collaborative, strategically focused research; create significant knowledge transfer; provide opportunities for the creation and diffusion of knowledge that are not available through existing funds; and encourage tertiary education institutions to develop relationships and linkages with other research organisations, enterprises and the communities that they serve. Research should be of excellent quality and should focus on New Zealand's future development and should lead to significant knowledge transfer activities including the training of new researchers. Core areas include molecular ecology and evolution, bio-protection technologies, materials and nanotechnology, molecular bio-discovery, growth and development, and Maori development and advancement.
Institutional supporting and operational conditions
Applications to the CoRE fund must be led by a New Zealand tertiary institution. Proposals are peer reviewed by international experts and evaluated by assessment panels against excellence and access or human capital development objectives. Providing they meet a minimum excellence standard, the top-ranked proposals from this assessment proceed to final evaluation by the specially formed CoRE Fund Committee against the criteria of “relevance of the research to New Zealand’s future development” and the adequacy of their proposed governance and management structures. The committee further shortlists 10-12 applicants and, after making a series of site visits, selects the Centres of Research Excellence. The weighted criteria are: 40% for excellence (the programme, team and collaboration), 20% for access or human capital development (future workforce, graduates education, expertise in wealth creation), 20% for relevance (New Zealand’s future development, innovation, transfer of knowledge), and 20% for governance and management (management structure, business plan, organisational synergies and facilities).

All of the selected CoREs must be hosted by a university, but many have other tertiary education institutes and research providers as partners. They also have broad inter-institutional research networks. CoREs take responsibility for the management and co-ordination of the research plan and general support for knowledge transfer and network activities, and are expected to maintain high quality, innovative research and research training environments. The centres will be encouraged to become self-sustaining eventually where realistic. Potential funding sources include industry investment, sponsorship by enterprise, returns on patents, research contracts or other government research funds.

Capacity building and impact
The following outcomes were identified as central in terms of reference documents, reports and evaluations.

Research capacities
- Strategic capacity for developing and acting on new research opportunities.
- Developing critical mass in promising research areas.

Resource creation
- Doctoral support and mentoring.
- Doctoral conferences and symposia.
- Specialist training workshops.
- Grants and fellowships programmes to support students from pre-doctoral to post-doctoral levels.
- Wānanga (Maori culture oriented tertiary education institution) mentoring and support.

Knowledge sharing
- Maximising the accessibility of research to target groups.
- Exceeding conventional academic criteria in publication.
- Non-traditional dissemination of outputs such as through the internet.
**Research collaboration**
- Scientists from universities, Crown Research Institutes and other organisations to work together on research projects to produce knowledge, disseminate it, and to train new researchers in partnership with the wider research and business community.
- Umbrella association of CoREs to further promote and connect research and educational excellence.

**Socio-economic and development**
- Using results of research to develop ways of minimising risk to Māori communities.
- Research projects identifying significant shortcomings in social services and making recommendations to relevant agencies.
- Providing models and resources for policy agencies.
- Outreach activities for students, under-represented groups and communities.

**Training and skills**
- Providing qualifications that respond to the changing needs of business and industry.
- Providing research training, advanced critical thinking, and entrepreneurship skills within research degrees.
- Focus on training a new generation of scientists.

**Business-Led Networks of Centres of Excellence (Canada)**
Business-Led Networks of Centres of Excellence (BL-NCEs) are intended to create large-scale, collaborative research networks led and managed by not-for-profit private-sector consortia. While these are not CoEs in the classic sense, they do create clusters of researchers and users around particular research themes of importance to Canada. It is anticipated that the development of trust and meaningful partnerships will have a long-term impact on the innovation system.

**Strategic orientation**
The BL-NCE program aims towards a partnership model involving the Canadian NCEs, where the private sector drives the research agenda, with academic and private-sector partners equally engaged and funding allocated to those best positioned to deliver on the research challenge. The scheme aims to fill a gap in the innovation spectrum between proof-of-concept and product development by identifying industry-specific or business-specific needs from the private sector and also through the involvement of the private sector in the design and conduct of the research. Teams of researchers may be university-based, private-sector based, based in a not-for-profit organisation, or any combination of the three.

**Institutional supporting and operational conditions**
As with other Canadian NCE initiatives, there is a two-phase application process: a letter of intent and a full application. The full application has three selection criteria: benefit to Canada, track record and potential of the applicants, and strength of the business plan. The same criteria are used for assessing bids for renewal funding, but additional critical success factors are the excellence of the proposal, the impact on the major R&D and commercialisation challenges of
their sector vision from the first funding cycle, expected impacts over the next five years, and the overall benefit to Canada. The BL-NCE is governed by the NCE Steering Committee advised by the PSAB, with management through the Tri-Council NCE Secretariat.

The governance structure for the BL-NCEs is seen as playing a pivotal strategic role. Private sector members are in the majority on the boards and project selection committees. Experience with the boards of the mainstream NCE networks and university-industry partnerships is an asset. The board also constitutes a forum for discussion of pre-competitive projects in support of common interests.

**Capacity building and impact**
BL-NCEs occupy a specific niche in the innovation system that has been identified as a weakness in Canada. They are also intended to be an interface between existing NCEs, other centres of research excellence and the research community more generally to help bring the research outputs and outcomes to market. Therefore the emphasis on scientific impact is downplayed in favour of social and economic impact.

**Research capacities**
- Increase in private-sector investment in R&D and advanced technologies.
- Better understanding in academic circles of the various conditions for industry innovation.

**Research collaborations**
- Academic-business consensus around the priority needs of a sector, so that research organisations can be launched more rapidly and the research initiated much earlier.
- Long-term public-private sector collaboration, including links between researchers and firms, to address significant research challenges that meet business needs.
- Domestic collaboration to ensure that benefits spill over to a wide array of firms, sectors and regions of the country.

**Socio-economic and development**
- Early application of research in the development of next-generation products.
- Increase in business receptivity to the results of R&D across large, medium and small enterprises.
- Commercialisation benefits that position Canadian firms in high value segments of production chains.
- Create, grow and retain companies in Canada that are able to capture new markets with new innovations.
- Accelerate the commercialisation of leading-edge technologies, goods and services in priority areas where Canada can significantly advance its competitive advantage.

**Training and skills**
- The exposure of postgraduate and postdoctoral researchers to industrially oriented
projects with clear timelines, milestones and the potential of “no/ go” decisions.

- High-quality postgraduate and postdoctoral training in innovative research.
- Industry R&D capacity, including among small and medium-sized enterprises (SMEs), and receptivity to the results of R&D.

The Cooperative Research Centres Programme (Australia)
The Cooperative Research Centres (CRC) programme is one of the few which have actually supported long-term collaborative programs between the university sector and industry with a focus on research application. It is estimated that 85% of Australia's universities participate in CRCs. CRCs were conceived to have a twofold aim: first, to improve the economic and social impact of publicly-funded research and second, to increase the level of R&D performed by the private sector. A further objective was to increase research co-ordination and boost synergies on priority areas.

Strategic orientation
The CRC program supports end-user driven research collaborations to address clearly articulated challenges facing Australia, some of which are considered to be global challenges. The close interaction between researchers and end users is a marked feature of the programme. The proposed solutions are expected to display an innovative character, high impact and be effectively deployed by end users. The planned activities of CRCs must include research, education and training programmes; an engagement plan with small and medium enterprises; and utilisation strategies. The scheme is open to all disciplines including humanities, arts and social sciences, and medical S&T-related research.

Institutional supporting and operational conditions
The Minister for Tertiary Education, Skills, Science and Research has overall responsibility for the CRC programme. The Minister appoints an advisory committee, the Cooperative Research Centres Committee, to advise on the selection and evaluation of centres and on the conditions to apply to the provision of funds under the programme. There are two legal arrangements CRCs can adopt: they can be incorporated, meaning that the CRC is established as a separate legal entity generally limited by guarantee and tax exempt; or they can be an unincorporated joint venture with one of the partner institutions (generally a university) providing the legal infrastructure and acting as the employer for CRC staff. The CRC board must include a chairperson who is independent from the participants and a majority of board members who are independent of the CRC research participants.

The CRC Association defines a CRC as: “A company formed through a collaboration of businesses and researchers. This includes private sector organisations (both large and small enterprises), industry associations, universities and government research agencies such as the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and other end users. This team of collaborators undertakes research and development leading to utilitarian outcomes for the public good that have positive social and economic impacts” (www.crca.asn.au). Funding for a CRC is provided for varying periods of up to ten years. Applications must score highly in three main dimensions: a) milestones, outputs, excellence and innovativeness; b) utilisation strategy, intellectual property (IP) arrangements, triple bottom line impact, relevance to end-
users and return on investment (ROI); and c) quality of leadership team, governance and management structures, and participant contributions.

Co-funding requirements require partners to the CRC to provide contributions that, added together, at least match the requested funding. Commitments by participants may be for part of or the entire funding period. All CRC participants must contribute cash or in-kind resources to the centre operation, which can be tied or untied contributions. Universities and other publicly funded research agencies are not required to contribute cash resources.

**Capacity building and impact**

The following outcomes were identified as central in terms of reference documents, reports and evaluations.

**Networking and partnerships**
- Medium to long-term end-user driven collaborative research.
- Global research and education engagement in co-investment arrangements.
- Reinforcing international scientific collaboration.

**Training and skills**
- End-user focused training and education programmes including PhD education.
- Fostering of graduate careers into non-academic settings.
- Opportunities for research students to work with industry experts and to undertake R&D activities in industrial settings.
- Vocational education and training.
- Improving SME staff capabilities and skills and reducing costs and risks associated with R&D activities.

**Technology and innovation**
- Licensing of technology and spin-off firms (particularly for the agricultural sector and in SMEs).

**Socio-economic and development**
- Strategies that empower SME innovation and R&D capacity and utilisation strategies that promote the deployment of research outcomes by end-users.