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Excellence and growth dynamics: A comparative study of the Matthew effect

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In the past two decades, centres of excellence (CoE) and other 'research excellence initiatives' likely to increase the cumulative advantages and stratification of science, have been implemented in many countries. Based on empirical studies of CoE in four Nordic countries, this paper examines how the resources provided by CoE schemes (generous long-term funding, prestige and visibility) add to the success and growth dynamics of the CoE. The data indicate a modified Matthew effect with ceilings and limits avoiding excessive accumulation of resources. Important impacts of the CoE are found, in particular in terms of enabling more interdisciplinary collaboration and risk-taking and enhancing international recruitment to the research areas involved. But, in contrast to what might be expected, the CoE grant seem to add less to the relative citation rate of those already performing at the highest level, than for those performing at a somewhat lower level prior to the CoE grant.

Keywords: centres of excellence; impact of funding instruments; cumulative advantages; Nordic countries.

1. Introduction

Academic research is highly stratified and scientific performance highly skewed (Cole and Cole 1973). Some researchers and some research units become known as the best, and as producing groundbreaking and important results. It is held that:

> . . . superior scientific performance is a disproportionately rare phenomenon. A small number of scientists historically have been responsible for a large share of important contributions to knowledge. Moreover, the production of useful if not major scientific innovations is also skewed, though to a lesser degree. (Zuckerman 1987: 7)

The skewness is often illustrated by the fact that a small proportion of the scientists accounts for a large part of all citations (Seglen 1992; Aksnes and Sivertsen 2004; Albarran et al. 2011). Moreover, cumulative effects are also presumed to contribute to the stratification of science on an institutional level. The best units (and the scholars that inhabit them) are benefitting from self-enforced processes confirming and strengthening their status, often referred to as the Matthew effect—discoveries by already renowned scientists receive disproportionately more attention than the discoveries of less renowned scientists (Merton 1968: 62). In a parallel vein, institutional

rewards are skewed as impact and visibility is unevenly spread. A small number of institutions dominate and shape research fields (as evidenced for instance in the Leiden ranking exercises).

In the past two decades, policy measures which possibly augment the inherent level of competiveness and stratification of science have emerged, in terms of national schemes for centres of excellence (CoE) and other types of 'research excellence initiatives' developed and implemented in a large number of countries (OECD 2014; Orr et al. 2011; European Commission 2009; Malkamäki et al. 2001). The CoE funding has elements of both institutional core funding and project funding. In providing general long-term funds which may be used for research and research infrastructures, as well as the recruitment of researchers and researcher training, the funding resembles institutional core funding. Still, the funding is time-limited and selection is based on application and open competition, much like project funding (OECD 2014). The major objectives of the CoE schemes are to promote high scientific quality, groundbreaking research and international competitiveness, and the means are concentration of resources and long-term funding for the best research environments—hence, the very idea is that these CoE should experience cumulative advantage over the course of their existence.

To fulfil such aims the CoE schemes are competitive: centres are selected on the basis of open calls for proposals and international peer review. Funding schemes based on peer review may accelerate cumulative advantages, and centre of excellence schemes allocating both prestige and generous long-term funding even more so. Hence, the total funding impact of the CoE schemes may be much higher than the allocations from the schemes. Indeed, the CoE status may be seen as a token of their success and prestigious additions, reflecting earlier successes and rewards.

The CoE schemes have become a core feature in research funding in the Nordic countries, albeit with significant differences. In the four Nordic countries we have data for (Denmark, Finland, Norway and Sweden) the allocations from the national CoE schemes accounted for 2.5–6.1% of the total public expenditures on R&D in 2009 (Aksnes et al. 2012). In addition, there is the co-funding for the CoE which the host institutions are obliged to provide, and the centres also attract considerable additional funding from a variety of third-party sources. As illustration, a study of the Norwegian CoE (SFF) scheme found that on average the allocation from the CoE schemes accounted for only 20% of the total income of the CoE (Langfeldt et al. 2010).

Moreover, evaluations of the CoE schemes in the four countries report extensive added value for CoE. An evaluation of the Finnish CoE scheme found added value to the ability to attract additional funding, senior researchers, postdoctoral fellows, PhD students and international partners, and more generally an increased international visibility (Hjelt et al. 2009: 36–40). An evaluation of the Norwegian CoE scheme concluded that the CoE funding and excellence status enables the building of strong research communities, securing additional funds and attracting highly qualified scholars and partners, and in general increases the international visibility (Langfeldt et al. 2010: 11). Similarly, an evaluation of the Swedish CoE scheme concluded that the CoE have attracted additional grants and high-level researchers from around the world (Swedish Research Council 2012: 16). Evaluations of the Danish CoE scheme conclude that national and international visibility is improved (Banda et al. 2003: 14), and that CoE have attracted talent and top researchers from abroad, as well as prizes and awards, and moreover created foci of excellence with a catalytic effect on Danish universities and research institutions in general (Krull et al. 2013).

In this paper we analyse the added value and accumulative advantages of CoE schemes based on data on CoE in these four Nordic countries. We ask: To what extent, and how, do CoE schemes add to the skewness of science?

2. The Matthew effect in science and assumptions about the dynamics of CoE

At the individual level, the Matthew effect entails a number of self-confirming processes which strengthen the ego of high-ranking scientists, as well as their reputation and their ability to attract funding for their research. Advantages are accumulated by the outcome of various types of peer review, adding research resources, opportunities, prestige and visibility—generated by credibility circles (Latour and Woolgar 1986; Rip 1988) and increasing the resource gap between the most renowned and the less renowned researchers (Merton 1968; Price 1976; DiPrete and Eirich 2006; Bothner et al. 2010). Described with categories borrowed from economics, the presumed underlying drive is that researchers need to accumulate credibility and are caught up in a logic of success which structures and coordinates research activities:

> If they want to survive among their colleagues, they have to accumulate credit or credibility, which constitute their capital. Without capital they cannot obtain support for new programs. On the other hand, the more capital they have, the more they are able to carry out research, the result of which would increase their initial endowment. One of the features of the economic metaphor is that the psychological motivations of the scientists are not important. Competition coordinates individual behaviour. (Callon 1995: 38)

Similar processes can be seen at the institutional and group level: the most prominent institutions are more attractive to eminent scholars and talented students as they expect affiliations with renowned groups and institutions will be beneficial for their research as well as their careers. The most prestigious institutions are therefore more able to employ eminent scholars and attract talented students. In consequence, they continue to attract eminent scholars and

attract talented students and more funding than less renowned institutions. According to Merton:

> These social processes of social selection that deepen the concentration of top scientific talent create extreme difficulties for any efforts to counteract the institutional consequences of the Matthew principle in order to produce new centers of scientific excellence. (Merton 1968: 62)

On the other hand, it is argued that there are limits to cumulative advantages. Scientific skills are limited and there are reasons to expect that some 'preeminent departments will decline and other rise' (Merton 1988: 618; DiPrete and Eirich 2006). Moreover, various social mechanisms inhibit highly unequal distributions of funding and other benefits (Hicks and Katz 2011; Hermanowicz 2011).

The literature discussed so far primarily deals with CoE that emerge more or less *ad hoc* on the basis of the clustering of individuals in certain institutions and academic environments. Science policy steering instruments only intervene indirectly in this process (although credit is, as Callon (1995) pointed out, also translated into economic resources). Our study deals primarily with the impact of programmes to develop coherent, clearly delineated and delimited environments organised and funded as CoE for a defined period. While in the case of CoE initiated locally or emerging in a more spontaneous fashion (without responding to specific calls for CoE), we would expect a fairly straightforward cumulative advantage, the case of centres formed by science policy programmes is more complex. The former emerges on the basis of self-organisation and the clustering of reputed scholars; the latter from competition for the support of specific configurations of scholars where plans, division of labour and other measures are specified and defined beforehand.

In sum, a variety of advantageous resources provided by CoE schemes, including generous long-term funding, prestige and visibility, are likely to help the success and growth dynamics of the CoE, and hence accelerate cumulative advantages. In addition, there may be more indirect cumulative effects of the CoE schemes. Quantitative indicators used in research policy are often aggregated results of prior peer assessments (e.g. publication scores and amount of external grants). The indicators are used by funding authorities in order to increase accountability, provide productivity incentives and enhance quality in research, for instance as indicators for performance-based funding (Langfeldt and Kyvik 2011). By introducing competitive funding schemes selecting (based on peer review) centres to be generously funded and given a formal status as 'excellent', the importance of, attention to, access to and transparency of review decisions are increased. Hence, both the colleagues in the research community and the policy-makers obtain a better overview of some groups that stand out as being particularly high performers. Moreover, funding agencies are inclined to promote their excellence schemes and announce the success of the selected centres—as do the CoE host institutions. However, being selected and designated as 'excellent' does not necessarily translate into being acknowledged as such in the competition for other funding sources. We may even hypothesize that there may be a negative effect where CoE grants are deducted from other grants (disadvantage). Again, we may hypothesize that this is valid primarily in funding systems marked by limited floor funding and sharp competition for resources.

Summarising the conditions for growth dynamics, based on previous studies and the literature, we assume that cumulative advantages and subsequent growth dynamics of CoE are most likely to appear when:

(1) CoE are awarded to already high-ranking/distinguished groups.
(2) The CoE scheme enjoys high status and awards generous funding.
(3) The recipients of CoE funding have a broad potential set of funding sources (i.e. a setting where they may compete for research funds from multiple sources in addition to CoE support).

The first assumption follows from the Mathew effect itself. Success breeds success. When CoE status is awarded to already high performing and distinguished groups, they have a head start. The status and funding of the CoE scheme add to their ability to attract eminent scholars, talented students and other vital resources for their research activities and success. They may more easily receive attention and standing in their role as CoE, because they were already widely known and acknowledged. In this study, we measure the initial ranking and prestige of the CoE in terms of the performance scores of the principal investigator (PI) prior to the award of CoE status.

The second assumption is that the characteristics of the CoE scheme may contribute to growth dynamics. In short, this assumption implies that CoE schemes work as intended: the status and the size/length of the grant are important. We assume that the more funding provided, and the more flexible, long-term and high-status funding from the scheme, the better basis for cumulative advantages. A scheme simply allocating 'status', but not much more funding or more long-term funding than regular research grants, is assumed to generate less growth dynamics than a scheme with generous, long-term funding enabling the researchers involved to initiate more (potentially path-breaking) research—which may feed back into an even more elevated position in terms of both status and competition for resources. Moreover, grants for fundamental, independent and researcher-initiated research normally enjoy higher prestige in the academic community, than thematic calls and more applied research. Hence, we presume that what we here name 'classic' CoE schemes (schemes open to researcher-initiated, fundamental research in all fields) will have the highest prestige, whereas CoE schemes for research-based

innovations and strategic research areas will carry somewhat lower prestige and will have less impact on the status of PIs. Such support normally entails negotiations over relevance, co-funding and partnerships with industry, which may enhance the groups' capacity for financial recruitment but not necessarily their credibility and status. In sum, we presume that the ability of the CoE schemes to contribute to growth dynamics differs, and we distinguish the CoE schemes according to the funding and prestige awarded.

The third assumption is that the availability of additional, external funding is a precondition for growth dynamics, in terms of funding for additional projects and positions impacting the size of the CoE. The key idea of credibility cycles is the possibility of converting resources (e.g. converting visibility into prestige into funding and research results etc.) (Latour and Woolgar 1986: 200; Rip 1988: 65). Moreover, a plurality of funding sources and a broader funding base is expected to provide autonomy and good conditions for research groups (Clark 1995). Furthermore, the CoE schemes themselves are not sufficiently large that they can carry the costs of all activities in the centres. For them to be 'successful', they 'must' generate spill-over effects in the form of ensuing funds from other sources. Hence, when there is a set of alternative funding sources and programmes relevant for the CoE so that they can compete for additional funding (and use the status as a CoE as a leverage), the likelihood of growth dynamics and cumulative advantages is higher. In this study, we have categorised the availability of additional external funding according to informants' accounts and general knowledge of the priorities of funding bodies.

As a result of assumptions (2) and (3), we may see different effects of CoE in different policy settings, depending upon the characteristics of the CoE schemes as well as their broader funding environment. The largest likelihood of successful outcome (in terms of impact on scientific visibility) may be expected in systems where CoE operate in tandem with high levels of floor funding, whereas the combination of low floor funding and CoE schemes lead to fragmentations of resources and an opportunistic search for funding opportunities (Öquist and Benner 2012).

In sum, the overall assumption to be studied is: If CoE contribute to the skewness of science, high score on the 'input factors' listed above (PIs' initial status, the status and funding of the CoE scheme, and options for additional funding) should be followed by high scores on the PIs' scientific success and growth of the CoE ('output' factors). In Section 3 we describe the data and methods used to analyse and elaborate these assumptions.

3 Data and methods

The research questions are explorative and demand a design for close case studies/thick descriptions to examine how research groups respond to and benefit from excellence policy instruments. CoE vary with regard to a large number of factors, and previous research gives little guidance concerning the crucial variables for analysis. Hence, designing a comparative study with the adequate similar/different cases to control for a number of key variables was not feasible. In this situation we chose a design combining a most-similar and a most-different systems design (Frendreis 1983: 268), including 2–3 cases for each major dimension (country, type of excellence scheme and research area). This mixed strategy allows us to explore common experiences and results across the various CoE, but only to a limited extent to draw conclusions about the differences between the countries. Three centres in each country were studied, two from 'classic' CoE schemes (mainly scientific objectives) and one from a scheme with economic/innovation or broader social/strategic objectives. The 12 cases studied are presented in Table 1.

The Appendix provides an overview of the aims, terms and funding level of the eight funding schemes involved. The schemes provide centre funding for 5–10 years, 10 years being the most common for the 'classic' CoE schemes, whereas most of the schemes with an innovation/economic rationale award funding for less than 10 years. There is large variation in the amount awarded per centre (€0.5 million to €16.5 million per year), as well as the number of centres per scheme (in the range 6–48). In all schemes, centres are selected on the basis of open calls for applications and thorough international peer review. Aksnes et al. (2012) provide detailed information on the policy origin and objectives of the schemes.

To allow us to study the impacts as well as ensuring access to informants, we selected centres which had been active for at least five years and were still active during data collection (in 2012). To reduce differences between the cases from each country, similar research areas were studied in all four countries. Hence, the dominating research areas in the four countries' CoE schemes (biomedicine and engineering) are covered in all countries. In addition, fields with a particular national emphasis were selected (e.g. geosciences in Norway, information and communications technologies (ICT) in Finland and Sweden). Moreover, groups sponsored by multiple sources/CoE grants were included to enable the study of cumulative advantages. Hence, cases were selected to maximise good conditions for cumulative advantages, including research areas given high national priority as well as groups with multiple CoE grants.

Data sources included in-depth interviews with centre staff, partners and representatives of the host institution, as well as available documentation on the activities of the centre in terms of: research portfolio, annual reports, budgets, mid-term evaluations and other information available on the CoE's websites. It should be emphasised that in order to identify Matthew effects we study the impact on the, in most cases, already highly ranked PIs/

Table 1. Overview of cases (see Appendix for an overview of aims, terms and funding level of schemes)

Case	Name of centre	Scheme*	Period for centre	Field	Host/location
D1	Centre for Epigenetics	DG CoE	2007–17	Biotechnology	University of Copenhagen
D2	Center for Quantum Optics	DG CoE	2001–12	Quantum optics, physics, ICT	University of Copenhagen
D3	Strategic Electrochemistry Research Center	DSF Centres	2007–12	Energy	Technical University of Denmark
F1	CoE in Molecular and Integrative Neuroscience Research	AKA5, AKA2	2008–13, 2000–5	Neuroscience	University of Helsinki
F2	SMARAD - CoE in Smart Radios and Wireless Research	AKA5, AKA3	2008–13, 2002–7	Radio science, wireless telecommunications	Aalto University
F3	Finnish Bioeconomy Cluster	SHOK	2007 onwards	Forestry, bioeconomy	(Consortium, no host)
N1	Centre for Cancer Biomedicine	SFF	2007–16	Cell biology, cancer research, biostatistics	University of Oslo
N2	Bjerknes Centre for Climate Research	SFF	2003–12	Geosciences	University of Bergen
N3	Concrete Innovation Centre	SFI	2007–14	Materials, engineering	SINTEF
S1	Organizing Molecular Matter	SRC Linnaeus	2006–15	Physical chemistry	Lund University
S2	Chalmers Antenna Systems Excellence Center	Vinn Exc	2006–15	ICT	Chalmers University of Technology
S3	Neuronano Research Center	SRC Linnaeus	2006–15	Neuroscience, nanotechnology	Lund University

*Full names of funding schemes:
DG CoE: CoE funded by Danish National Research Foundation
DSF Centres: Strategic research centres funded by Danish Council for Strategic Research
AKA (2nd, 3rd and 5th generation): CoE funded by Academy of Finland
SHOK: Strategic Centres of Science, Technology and Innovation funded by Tekes and Academy of Finland
SFF: CoE/(Sentre for fremragende forskning) funded by Research Council of Norway
SFI: Centres for Research-based Innovation funded by Research Council of Norway
SRC Linnaeus: Linnaeus Environments funded by Swedish Research Council
Vinn Exc: VINN Excellence Centres funded by VINNOVA

key personnel. Hence, we collected data on the research grants, and publication and citation profiles of the key personnel, before and during the CoE period. Impacts on the young researchers recruited and more general impacts, were addressed in interviews, but not studied quantitatively.

The interviews comprised 2–12 informants per centre of excellence[1] (in total 52 persons), and dealt with a broad set of questions: how the centre is established, funded, organised and integrated, key personnel's previous research groups and funding, the role of the centre leader and the role of the host institution, how the CoE grant is allocated and controlled within the centre, recruitment strategy, competitive advantages from the CoE scheme and the role of the CoE grant compared to other funding, as well as the future plans and challenges of the centre, and more general topics related to the research activities (such as multidisciplinary and international collaboration).

3.1 Bibiometrics

The bibliometric analysis is based on a dataset of articles indexed in Thomson Reuters' Web of Science (WoS) and cited until September 2012. With some exceptions for publications in engineering research, the WoS represents the scientific production of the 12 CoE quite well. Only regular journal articles and review articles by key personnel at each centre of excellence are included. Other affiliated personnel are included if they appear as co-authors. We validated the bibliographical data retrieved from WoS by using comparable information from CVs, annual reports, current research information systems and other available information sources.

The publication and citation performance in five-year periods before and after the establishment of the CoE are compared by using four indicators. Two of them are the number of publications and the percentage international publications (with co-authors in other countries). The other two are the relative citation rate (RCR) and the journal profile:

- Citation rates have been field normalised as RCR by comparing them to the average citation rate of articles published in the same year and subfield (the disciplinary journal category used in WoS). The RCR is 1.00 when equal to the world average and 1.30 when it is 30% above.
- The journal profile of a CoE is measured by dividing the average citation rate of the journals in which the centre's articles were published by the average citation rates of the subfields covered by these journals. If this

indicator exceeds 1.00, the centre publishes in journals with higher impact than the average of journals in the same fields.

3.2 Funding data

For the study of the ability of CoE to attract international funding, we identified EU-funded projects (signed contracts) in the EU's Framework Programme (FP) FP5, FP6 and FP7 until 2012, with connections to key personnel at the centres. Information available at their websites and their annual reports were used to identify relevant FP-projects, and the project lists which were generated were subsequently sent to the CoE for verification. In addition, we had access to the Ecorda databases for FP5 (26 April 2004), FP6 (7 May 2007) and FP7 (13 February 2012), and the Cordis website was used. The Ecorda databases give information about size of the projects, funding, starting point, duration and partners in addition to more administrative information. Using this information, we analysed the EU funding to the PIs during the relevant periods (before and during the CoE grant period) and changes in their collaboration patterns.

Moreover, data on the success of the key personnel in obtaining grants from their major national funding agencies was collected. In most cases, these data contain the number of grants, not the amount of funding, but still give an indication of national success in the CoE period compared to the funding of the key personnel prior to the CoE funding. The funding agencies covered are listed in the footnotes to Table 4. The data from the funding agencies was supplemented by information from the annual reports and interview data from the CoE.

3.3 Categorisations of input and output indicators

In Section 2, we sketched three major input factors laying the base for cumulative advantages. We expect different effects from the CoE schemes depending on whether or not the status as CoE is awarded to already high-ranking/distinguished groups. The CoE scheme enjoys high status and awards generous funding and depending on whether the centres have a broad potential set of additional funding sources. In studying these input factors, we apply the following data and categories (see Section 4.1):

(1) PIs' performance scores prior to inclusion in the CoE scheme, is studied based on the RCR of the core group/key researchers at the centre (see above).
(2) Centre scheme prestige and size of grants are studied based on general characteristics of the schemes. Concerning prestige, the schemes are classified as having high or very high prestige in the academic community. All schemes aiming at fundamental research, with mainly scientific objectives and open to all fields of research ('classic CoE schemes') are considered to have very high prestige. Other centre schemes are considered to have high prestige. It should be noted that it is academic prestige which is classified (prestige linked to fundamental research) that is, the type of prestige most likely to impact academic output indicators and Matthew effects in an academic setting.[2] Concerning the amount of funding, the schemes are classified according to the average allocation per CoE per year: €0.5–1 million is considered an 'average' size; €1–2 million is considered 'high; €2–5 million is considered 'very high'; and above €5 million is considered to be 'exceptionally high'.
(3) The availability of additional funding sources is studied on the basis of general knowledge of the priorities of the funding agencies and the accounts of the informants at the CoE. For each research field studied, the availability of relevant external funding is classified as low, average, high or very high. Moreover, the CoE host institution's level of floor funding is taken into account.

Centre success and growth dynamics ('output') are studied based on the following criteria (see Section 4.2):

- Increase in citation scores: measured in key researchers' increase in the RCR compared to pre-CoE period.
- Attract more prestigious/competitive international grants: measured by an increase in key researchers' number of grants/funding compared to pre-CoE period.
- Attract more grants from the main national agency funding academic/fundamental research: measured by increase in key researchers' number of grants/funding compared to pre-CoE period.
- Growth dynamics of centres: centre size, measured in terms of number of involved researchers active in the centre.

The growth dynamics is elaborated on the basis of the interview data, including informants' accounts about how the CoE status enables them to attract and recruit high-level foreign researchers, possible advantages in the competitions for additional research grants, and more generally how CoE success is obtained (see Section 4.3).

As mentioned, the methodological design implies limitations when generalising results. The comparative design permits us to explore common experiences across the various CoE, but is not adequate for studying general country differences or differences between research areas. Hence, in the analyses below we look for similar patterns across all the cases, and use informants' experiences and accounts to elaborate findings.

4 Results

This section presents the findings from the case studies. First, the scores of the 12 cases on the various 'input' factors are described (see Section 4.1), then the scores on the success factors (see Section 4.2), and subsequently

Table 2. Overview input indicators for selected centres

Case	PIs' performance scores prior to CoE*	Prestige and type of centre scheme		Available relevant external funding sources for CoE, 'hot' fields of research given in brackets	Core funding (%)****	Sum (No. of H)
		Prestige/type of scheme**	Size of funding***			
D1	HHH	HH	H	H (epigenetics/biotechnology)	69%	7
D2	HH	HH	H	H (quantum optics)	69%	6
D3	HHH	H	A	H (electrochemistry/energy)	30%	5
F1	HHH	HH	A	H (neuroscience)	45%	6
F2	HH	HH	A	H (wireless communications)	42%	5
F3		H	HHH*****	A (forestry/bioeconomy)	(No host)	
N1	HHH	HH	H	H (cancer biomedicine)	57%	7
N2	HHH	HH	H	HH (climate research/geosciences)	64%	8
N3	H	H	H	L (concrete/material science)	7%	3
S1	A	HH	A	H (molecular matters/physical chemistry)	47%	3
S2	H	H	A	H (antenna systems/ICT)	32%	3
S3	A	HH	A	H (neuronano research)	47%	3

HHH = extremely high, HH = very high, H = high, A = average, L = low

*Based on RCR (Relative Citation Rate) prior to CoE award, as presented in Table 5. Derived from 1 = world average, A = 0.9–1.1, H = 1.2–1.5, HH = 1.6–2.5, HHH ≥ 2.6

**Prestige: All classic CoE schemes (basic research/mainly scientific objectives) are considered to have very high prestige (HH), other centre schemes to have high prestige (H)

***Size of funding: Average allocation from CoE scheme per CoE per year: €0.5–1 million = A; €1–2 million = H; €2–5 million = HH; €5 million and above = HHH

****Proportion of host institution's R&D expenditure which is covered by institutional funds/general university funds. Norwegian, Swedish and Finnish figures are from 2011, Danish figures from 2009. Source: national R&D statistics

*****Operational mode of SHOKs makes it difficult to estimate amount of funding allocated from SHOK scheme per research unit participating in SHOK activities. Budget of F3 for period 2008–11 was €75 million (of which €35 million was public funding). This funding has been distributed to several research programmes carried out by SHOK shareholders (companies, universities and research institutes). Each programme has been divided into several work packages and projects. Budgets of individual projects may vary from hundreds of thousands to several million euros. Extensive information on SHOK model and its limitations is provided by Lähteenmäki-Smith et al. (2013)

informants' accounts about the cumulative advantages, growth dynamics and the role of the CoE grant are presented (see Section 4.3).

4.1 Allocation of CoEs

There is considerable variation between the cases regarding performance scores prior to the CoE grant (see Table 2). Whereas the PIs of most of Danish, Finnish and Norwegian centres score very high or even exceptionally high on the RCR prior to the CoE period, the Swedish CoE are awarded to PIs with somewhat lower performance scores. We cannot say whether the Swedish cases are representative of Swedish CoE in general: the Swedish selection criteria and processes do not substantially deviate from those in the three other countries, and the lower Swedish citation scores may be due to special characteristics of the selected cases. Still, it might be that the Swedish CoE schemes are somewhat less attractive to researchers, and that some of the most eminent Swedish research groups have not applied for CoE grants, for instance, because of higher Swedish demands for institutional co-funding or the lower relative status of the Swedish CoE schemes. On the other hand, a previous study of the citation scores of CoE host institutions (in the relevant field of research), did not indicate that the allocation of Swedish CoE was less elitist than the allocation in the three other countries (Aksnes et al. 2012).

Moreover, there is a difference between the 'classic' CoE schemes and those aimed at research-based innovation and strategic areas.[3] Of the 12 cases, eight were awarded by CoE schemes with mainly academic aims, here named 'classic' CoE schemes and classified at very high (HH) prestige in Table 2. The four remaining CoE (one in each country) are awarded by centre schemes with additional strategic/economic aims and selection criteria (classified at high (H) prestige in Table 2). Contrary to what could be expected, the two Swedish CoE from the classic scheme (Linnaeus Environments) score somewhat lower on past performance than the Swedish case from the scheme for research-based innovation (VINN Excellence).

As explained in Section 3, we have also classified the availability of external research funding in the respective research areas. Most of the centres are assessed to be in research areas given a reasonably high priority in national and European funding programmes and ranked H in Table 2. The exceptions are climate research, which is assessed to be somewhat higher on the agenda and generates more funding options (ranked HH); forestry/bioeconomy which has no particular priority (ranked A); and concrete research which is assessed to have lower priority and less funding options (ranked L). Moreover, there is a difference in the host institutions' general level

Table 3. Centre size: number of key researchers, and total number of researchers affiliated with CoE

Case	No. of PIs	Total No. of researchers involved	Comments	Size
D1	7	74	5 research groups	Large
D2	5	44	4 research groups	Medium
D3	2	14	Estimated 12 PhDs/postdocs in parallel, plus the 2 PIs	Small
F1	7	72	7 PIs	Large*
F2	5	90	5 PIs, and 2 professors	Large*
F3			Operates as a research programme (€75 million for a 4-year period). 4 persons in head office. Hundreds of researchers are involved in projects	Large
N1	6	145	Includes 25 scientists, 65 PhDs, 25 postdocs	Large
N2	7	140	Includes 72 scientists, 33 PhDs, 14 postdocs	Large
N3	9	21	9 PIs and 13 PhDs	Small
S1	7	81	22 scientists and 59 PhDs	Large**
S2	5	> 40	Includes 9 senor scientists and 17 PhDs and postdocs	Medium**
S3	8	> 40	Includes 17 scientists and 17 PhDs and postdocs	Medium**

Data sources: CoEs websites and annual reports
*CoE with two subsequent CoE grants
** Groups sponsored by multiple CoE grants in parallel

Table 4. Key researchers'/groups leaders' funding from EU FPs and major national funding agencies

Case	Funding from EU FPs					National competitive research grants**		
	Before CoE period		During CoE period		Significant increase in EU FP funding?	No. of grants or amount/years		Increase?
	No. of projects/ years	EU funding (€ million)/ years	No. of projects/ years	EU funding (€ million)/ years		Before CoE period	During CoE period	
D1	0.8 (3/4)	0.5 (1.9/4)	1 (5/5)	0.8 (3.9/5)	**Yes**	0 (0/3)	0.8 (5/6)	Yes
D2	*	*	0.2 (2/11)	0.02 (0.2/11)	Missing data*	No data	0.1 (1/9)	
D3	0.7 (0 2/3)	0.33 (1.0/3)			No	0 (0/3)	0.2 (1/6)	(Yes)
F1	*	*	0.3 (3/9)	0.1 (0.9/9)	Missing data*	€1.0 million (€4.1 million/4)	€0.9 million (€11.1 million/13)	No
F2	*	*	0.8 (8/10)	0.28 (2.8/10)	Missing data*	€0.5 million (€2.7 million/6)	€0.4 million (€4.8 million/11)	No
F3					No EU funding	No data	No data	
N1	1.0 (1/1)	0.2 (0.2/1)	0.2 (1/5)	0.5 (2.3/5)	**Yes**	1.2 (21/17)	1.3 (8/6)	(Yes)
N2	3.3 (13/4)	0.9 (3.4/4)	1.9 (17/9)	1.4 (12.5/9)	**Yes**	1.8 (18/10)	1.2 (13/11)	No
N3					No EU funding	0.27 (3/11)	0.33 (2/6)	(Yes)
S1	2.0 (4/2)	0.6 (1.2/2)	0.6 (4/7)	0.2 (1.1/7)	No	2.4 (12/5)	2.1 (15/7)	No
S2	1.0 (4/4)	0.2 (0.8/4)	0.2 (1/6)	0 (0.0/6)	No	1.0 (5/5)	0.9 (6/7)	No
S3			0.2 (1/6)	0.1 (0.4/6)	Little EU funding	1.6 (8/5)	1.4 (10/7)	No

Sources: Ecorda database and national funding agencies websites, see Section 3
*Missing data before CoE period: D2 started in 2001, F1 started in 2000 and F2 in 2002. Hence, FP5 data with first project staring in 1999 are not sufficient for comparing before and during/after CoE period
** Includes grants from major national funding agency for academic research in each country. Grants from the following agencies included: Denmark: Covers grants from councils under Danish Agency for Science, Technology and Innovation (data available for 2004 onwards); Finland: Academy of Finland (data available for 1995 onwards, amount does not include CoE grant); Norway: Research Council of Norway (data available for 1990 onwards); Sweden: Swedish Research Council (data available for 2001 onwards). Note that in several cases information is only available for a limited number of years before CoE period
ERC grants: D2 (Advanced Grant 2012); F1 (Advanced Grant 2012); N1 (Advanced Grant 2008); S2 (Advanced Grant 2012)
(Yes) indicates marginal increase, that is 0.1 grant per year
Available national grants: some general national competitive grant programmes in Denmark and Finland are closed to CoEs (they are not entitled to apply). There are no such restrictions in Sweden and Norway

Table 5. Overview of bibliometric indicators for selected centres, before and during CoE period

Case	Period	Exp. succ.****	No. of publications selected PIs	Total No. of citations	Relative Citation Index (RCR)*	Increase in RCR (%)	Journal profile**	International publications (%)***
D1	Pre 2002–5		70	7637	4.03	−3%	1.89	71%
	CoE 2006–10	7	149	8012	3.89		1.84	63%
D2	Pre 2001–5		53	2598	2.12	142%	1.60	42%
	CoE 2006–10	6	96	3159	5.14		1.94	67%
D3	Pre 2002–5		27	1347	3.07	−12%	1.68	37%
	CoE 2006–10	5	73	1229	2.69		0.96	27%
F1	Pre 1995–9		119	9422	3.71	−44%	2.14	53%
	CoE 2000–5		168	9898	2.08		1.52	52%
	(pause) 2006–7		49	1690	2.26	37%	1.72	43%
	CoE 2008–10	6	64	1284	3.10		1.65	48%
F2	Pre 1997–2001		135	2208	1.60	46%	0.78	31%
	CoE 2002–10	5	328	4739	2.34		0.97	32%
N1	Pre 2002–6		156	11469	3.04	22%	1.78	58%
	CoE 2007–10	7	124	4129	3.70		1.87	46%
N2	Pre 1998–2002		26	1284	2.90	12%	2.89	85%
	CoE 2003–10	8	74	1810	3.25		2.23	70%
N3	Pre 2002–6		16	187	1.25	11%	1.01	63%
	CoE 2007–10	3	21	119	1.39		1.06	67%
S1	Pre 2001–5		220	5324	1.18	21%	1.26	54%
	CoE 2006–10	3	215	3256	1.43		1.17	68%
S2	Pre 2001–5		56	798	1.51	65%	0.79	36%
	CoE 2006–10	3	43	341	2.49		0.94	56%
S3	Pre 2001–5		119	2883	1.08	17%	0.99	32%
	CoE 2006–10	3	90	1070	1.26		1.24	35%

See Section 3 for data and methods. Data includes publications of PI/group leader of each centre before and during CoE period
* World field average = 1.00.
** Average journal profile = 1.00.
*** Publications with international collaboration as share of total for selected centres before and during CoE-period.
**** Expected success, as in last column of Table 2

of core funding. The CoE with additional aims are located at host institutions provided with little core funding (7–32%), or as in the Finnish case, have no host institution. Two of the Danish and one of the Norwegian classic CoE are at host institutions with above 60% core funding, whereas the remainder are located at institutions provided with 42–57% core funding.

Table 2 provides an overview of the pre-CoE conditions of the 12 cases, in terms of the three main input factors discussed in Section 2. The last column sums up the input factors for each case. The higher the score, the better the expected conditions for success and growth dynamics. Three CoE score rather high (7 or 8) and should, according to cumulative advantage assumptions, have clearly better chances of success than those scoring lowest (the four CoE scoring 3). The highest scoring CoE include two Norwegian and one of the Danish centres funded by classic CoE schemes, while the lowest scoring CoE include all three Swedish cases and the Norwegian centre funded by other CoE schemes. In between this we find two Danish and two Finnish centres scoring 5 or 6.

4.2 Success of CoE

Table 3 shows the size of the CoE measured in number of PIs and total number of researchers involved. Table 4 shows the grants to the PIs from the EU FPs and main national funding agencies before and during the CoE period. Table 5 shows bibliometric indicators for the CoE studied before and during the CoE period (based on PIs' publication records).

The majority of the CoE are large units, counting more than 70 researchers, and centre size seems to be in line with

the expected success. All centres with the highest expected success are large centres, and none of the centres with the lowest expected success are large centres (Table 3 compared to Table 2). Hence, our assumptions are supported when it comes to centres' ability to attract and employ researchers.

There are large variations in the funding sources of the CoE. Some of the centres have marginal/no funding from the EU FPs, while some have much (see Table 4). In most cases we find no measurable increase in the funding of PIs from the EU FP or from the major national funding agencies. The exceptions are D1 and N2—which notably are among the cases with the highest scores on expected conditions for success and growth (cf. Table 2). N2 has had an increase in funding from the EU PF, and D1 has had an increase in both FP and national funding. However, data is available for few years prior to the CoE period and no clear conclusion can be drawn. More significantly, some of the PIs involved in four other CoE have obtained European Research Council (ERC) grants (D2, F1, N1 and S2). The scores of these CoE on the expected conditions for success vary from low to high (scores are 3, 5, 6 and 7, as shown in Table 2). In conclusion, some of the groups have obtained a substantial increase in their external funding, but in most cases there is no increase in the competitive research funds obtained by the key personnel of the centre of excellence, and no evidence supporting the expectations of cumulative advantage.

Measured by RCR, all CoE that were studied score above world average, in many cases way above, and in most cases the RCR increases after the CoE grant (see Table 5). Six of the 11 centres for which we have data, score at least two times above the world average before the CoE grant, whereas eight of them score at least two times above after the CoE period. Notably, the only two cases without an increase in RCR, are CoE with extremely high RCR before the CoE grant (D1 and D3 with 3–4 times above world average pre-CoE). Moreover, comparing with the overall scores on expected success in Table 2, we find increase in RCR among all those with the lowest score (3) on expected success, and the largest increase (%) in RCR is found among CoE scoring 3, 5 or 6 on expected success, not among the centres with the top score (7–8). In conclusion, the expectations of a cumulative advantage are not supported by the bibliometric data. It should, however, be taken into account that for some of these cases, the number of publications is small, and hence data robustness is low.

Somewhat surprisingly, changes in the number of partners in EU projects,[4] seems to have limited impact on the proportion of publications by CoE which are internationally co-authored (see Table 5). For example, case N2 experienced a substantial increase in EU funding (see Table 4) and number of international partners in EU projects, but in terms of the international co-authorship, Table 5 shows a decrease. Similarly, case D1 has an increased number of partners in EU projects (and amount of EU funding), but a decrease in international co-authorship. In contrast, in two cases we find an increase in international co-authorship without an increase in EU project partners (cases N3 and S2). There are still two (Swedish) cases where an increase in the number of partners in EU projects goes along with an increase in international co-authorship (S1 and S3), and two cases where a decrease in the number of partners in EU projects go along with decrease in international co-authorship (D2 and N1, for the remaining cases data is missing). In sum, this indicates that EU projects, and the international network generated by these projects, are not a major basis for the international co-authorship of the CoE. However, our 12 cases give a limited basis for conclusions and the period studied may be too short to identify changed international collaboration patterns in scientific publications.

4.3 Advantages of CoE

Tables 2–5 paint a complex, but still incomplete, picture of the advantages of CoE. Input and output data on 12 cases is not sufficient for understanding how research groups profit from CoE grants. In this section, we elaborate on those conditions conducive to scientific impact from CoE schemes based on in-depth interviews with key informants. In general, the CoE staff and representatives of the host institution who were interviewed emphasise that CoE grants entail much added value. A recurrent theme is the importance of gaining access to long-term, flexible funding. Such funding is held to facilitate more risk-taking, to support collaboration and to foster interdisciplinarity. In particular, informants saw the interdisciplinarity of the CoE as an advantage rather than disadvantage for success in scientific journals, and pointed to their new interdisciplinary collaboration as an important basis for their scientific success and best publications. CoE grants open opportunities for intellectual combinations (theoretical, methodological and empirical) that other grants do not enable, in particular project grants of shorter duration and for smaller groups. Again, CoE support paired with stable floor funding, is said to allow for the combination of risk-taking within the CoE schemes and long-term stability within fully funded positions, whereas the circumstances in which CoE support functions as a substitute for diminishing floor funding is perceived to hamper their impact and efficacy as CoE funding then functions as a substitute for diminishing floor funding. Taking the four CoE within biomedicine as an example, we find that all of them have much additional research funding, but few alternatives to the CoE grant when it comes to long-term flexible funding. The CoE grant is said to enhance collaboration, including cross-disciplinary collaboration, which has enhanced quality of analysis, and hiring technical staff to support complex projects. Similar accounts are found in the other CoE, regardless of fields of research, country and type of

scheme. The long-term flexible funding allows for more dynamic research strategies, more risk-taking (i.e. time for developing new analytical models, recruiting from top international institutions, and in some cases co-location of groups to facilitate interdisciplinary work). The degree of importance of the CoE grant still varies. In one case with few other funding sources, the CoE grant was characterised as a vitamin injection for the research in the field as such. In cases where the CoE grant forms a small part of the total budget, some informants had difficulties accounting for distinctive impacts of the CoE grant. Consequently, the added values of the CoE grant may seem higher for those groups who were not among the most successful before the award of the grant. Higher added values for these groups may be a key mechanism counteracting cumulative advantages.

Moreover, the research activities enabled by the grant are perceived as important for obtaining subsequent grants, whereas the CoE label is not perceived to be important in the decision-making/peer-review processes of the funding agencies. As one informant commented:

> . . . ultimately it is the content and potential of the project, and the track record of the applicants—as papers in *Nature*—which counts.

Hence, interview data support the conclusion that the label of 'centre of excellence' does not automatically generate advantages for the individual members of such centres and constellations. The Matthew effect does not operate automatically, it has to be translated into selection practices within funding bodies and become a performative force, and this is not always the case. Other factors and motivations may be in operation, such as a focus on newcomers, or specific fields or modes of operation. It should be noted that informants emphasise that they do not know the impact of their CoE status: they do not have insight into the relevant review processes, and do not know why they obtain some competitive grants and are rejected for others.

On the other hand, informants claim that the CoE label has an impact on their capacity to raise non-competitive grants in a national context—in terms of convincing policy-makers and other non-peers that the CoE is important and outstanding. Hence, the reputational effect and institutional prestige of a CoE grant is considerable in a wider context, but its impact in peer-controlled circumstances has not been demonstrated to be consistently high. This casts some doubts on the long-term impact of CoE schemes on cumulative advantage, at least more consistently. Some members of CoE certainly experience cumulative advantages, but the wider impact seems to be weaker.

As illustrated in Section 4.1, compared with the classic CoE, the groups awarded by additional aims CoE schemes have somewhat lower scores on the input indicators. In most cases they have also moderate or negative increase in the RCR in the CoE period, and no or marginal increase in funding from other competitive funding schemes. This can be interpreted as supporting the cumulative advantage expectations: CoE with a lower score on scheme prestige and other input indicators tend to obtain less cumulative advantages.

On the other hand, data indicate that for the centres awarded by the additional aims CoE schemes, the CoE grant is often especially important for enabling new research activities and research that could not have been performed without that grant. These centres often have no funding other than the CoE grant, co-funding from the industry partners and the host institution. Hence, the CoE grant generates almost all the research funding and is decisive for the centre's activities. Informants at these centres emphasise the added values from the CoE grant more strongly. However, some also emphasise that the links to industry partners imply a drift towards industrial application rather than long-term overall research plans, give little room for blue sky research and in some cases impede scientific publication. The different research orientation is probably a more important explanation of these centres' lower score on academic success criteria than the presumed lower status of the CoE schemes with additional aims.

Notably, the Swedish 'additional aims' case deviates from the other cases in this category, both in terms of funding sources and academic success. This CoE for research-based innovation had a 65% increase in the RCR and obtained an ERC grant, demonstrating that additional aims of CoE may be combined with a high score on such success criteria.

5 Conclusions and implications

We started from the observation that CoE schemes have proliferated in the Nordic countries in recent decades. They have been installed to concentrate resources to fewer, more internationally visible environments, but also to have wider spill-over effects, to lead to cumulative advantages in terms of reputation and funding opportunities. The question we posed was if the CoE schemes have had this impact, if there are differences between schemes, and how we may explain general patterns and possible differences in growth dynamics.

A first observation is that there are no general cumulative effects of CoE schemes, at least there is not a strong connection between obtaining a CoE grant and being rewarded in other competitive funding schemes. While most CoE participants are already well established in their national research systems, and many of the centres funded have high or very high scientific visibility, they experience only marginal effects in the wider 'funding market'. Their status increases as does their ability to generate non-competitive funding, but the impact beyond

that is limited. This may reflect the fact that they are already established and that the CoE schemes do not propel any further enhancements in their cumulative advantage (which has already been saturated at a high level). Hence, our CoE seem in most cases to represent the 'top' of research activities in their respective countries, but the funding systems seem unable or unwilling to absorb any further skewing of resources in favour of these already favoured groups. In its turn, this may represent another sociological mechanism, namely the controlling of the Matthew effect: those who already have gain more but within limits. In other words, the data indicate a modified Matthew effect, enhancing productivity but with ceilings and limits to avoid 'over accumulation' of resources.

In some cases the CoE grant seems more important for success when awarded to groups who are not already high performing groups and groups with few other funding options, quite the opposite to what we expected based on the literature of cumulative advantages. This is most clearly stated in the Swedish case, where a large, inchoate and weakly governed research system has to some extent 'captured' the CoE instrument and utilized it for managing functions that have been undersupplied, like securing the continuation of long-term research lines or interdisciplinary experimentation, even if none of these cases represent that ideal typical CoE environment (in terms of citation impact at least).

Conversely, CoE grants seem to have limited impact for some already high performing and distinguished groups. Measured according to data in this study, the status and opportunities offered by the CoE grant add less to the situation of some of the highest performing groups, than for less recognised groups. If a group is already very highly cited, it is harder to keep up and surpass the high citation level.

Even considering these examples of limited cumulative effects, the CoE schemes have been highly successful. They have empowered research groups and environments of international standing, have intensified competition and concentration and have embedded leading scholars from the Nordic countries as well as enhanced international recruitments to the centre areas. The impact on individual and group levels is therefore significant and funding policies have made a difference: top science in the Nordic countries has been identified and supported in a more coherent and long-term manner. While we see some interesting and significant differences in how the schemes play out in the national contexts, the overarching and recurrent theme is one of focusing efforts and talents, and creating sustainable research environments with international visibility. But their wider repercussions and impact vary, and in Sweden the major CoE scheme has not yet lived up to expectations. The expectation that CoE grants would remodel the research landscape has not been fulfilled, and the drive to find ways of controlling and stratifying the research landscape has taken new routes, including a partial turn from centre support to individual grants.

The limited cumulative effects, point at a 'normalisation' of CoE grants: the grant does not in itself constitute a CoE environment. It functions as a sign of reputation and impact, but is not profoundly dissimilar from other types of competitive grants. The main difference is the long-term flexible character of the grant, enabling more interdisciplinarity collaboration and risk-taking.

For policy-makers, the findings indicate that there is less need to worry about cumulative advantages from CoE grants. CoE grants only accelerate the cumulative advantages of the already highest performing groups to a modest extent. In some respects the CoE grant seems to have a higher impact when awarded to groups who are not yet performing at the highest level, than on those who, measured by past performance, appear to be most outstanding. Moreover, the CoE grant seems to have an extensive impact when awarded to groups with few other funding options.

In sum, the assumptions on growth dynamics derived from previous studies and literature were not, or only partly, confirmed:

(1) 'CoE grants have most impact when they are awarded to already high ranking/distinguished groups'. This is not confirmed. In several cases the grant has higher impact when awarded to groups not yet performing at the highest level.
(2) 'CoE grants have most impact when the CoE scheme enjoys high status and awards generous funding'. This is not confirmed. There is no clear pattern in the collected data. In the Danish and Norwegian cases, CoE awarded by the higher status schemes seem more successful, whereas the Swedish CoE awarded by presumably a lower status scheme, is the most successful both in terms of increased RCR and ERC grant. Still, it can be argued that the assumption is partly confirmed as far as the status hierarchy of Swedish schemes diverge from the standard that scientifically aimed schemes enjoy higher status than schemes with additional aims.
(3) 'CoE grants have most impact when the CoE have a broad potential set of funding sources'. This is partly confirmed. In terms of ability to attract and employ researchers, the CoE grant has the highest impact when awarded to groups with multiple funding options. In terms of enabling new research activities and interdisciplinarity, the grant may have a wider impact when awarded to groups with few other funding options.

It should to be emphasised that the present study is explorative and its conclusions are based on a limited number of cases. Additional studies including more CoE and more countries, as well as studies of the possible long-term advantages (after the CoE period) to those scientists

awarded these grants, are needed in order to substantiate the conclusions. The present study identifies key input and output indicators for studying the impact of CoE grants, most of which are adaptable to larger, quantitative studies. Finally, it should be emphasised that this paper studies Matthew effects and addresses the impact on already highly awarded PIs, whereas it is also important to study the more general impacts on the research environment and especially impacts on the young talents recruited to the centres.

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Notes

1. In some cases only the centre leader and head of department or faculty were interviewed, in other cases a number of staff members and partners were covered by group interviews. The number of informants depends on the size and complexity of the CoE (e.g. the number of partners).
2. Prestige is subjective and in more applied institutional settings, centre schemes aimed at innovation and economic growth may carry higher or just as high prestige as academic schemes.
3. See Appendix for the aims, terms and funding level of the schemes.
4. No table here, figures are provided in Langfeldt et al. (2013: Table A3.3).

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Appendix: Aims, terms and funding level of CoE schemes studied

Scheme, funding agency and start year	Type of scheme/aims	Centre period	Number of active centres 2013	Scheme funding per centre 2010 € million*	% of total public R&D expenditure 2009 or 2010**	Co-funding (per centre)
Denmark						
CoE, Danish National Research Foundation, 1993	Classic CoE scheme/ scientific	10-year scheme	48	1.01	2.1	Co-funding expected, no fixed percentage
Strategic research centres, Danish Council for Strategic Research, 2007	Additional aims scheme/strategic/social challenges rational	5–7 year scheme	31	0.65	0.7	Co-funding expected from participating public and private-sector actors
Finland						
CoE, Academy of Finland, 1995	Classic CoE scheme/scientific	6-year scheme	33	0.52	1.4	Co-funding required, no fixed percentage
Strategic Centres of Science, Technology and Innovation (SHOKs), Tekes and Academy of Finland, 2007	Additional aims scheme/innovation, economic rational	No set period/ may vary	6	16.50	4.7	SHOKs shareholders contribute to research they take part in. Tekes funding is max. 70%
Norway						
CoE/SFF, Research Council of Norway, 2003	Classic CoE scheme/ scientific	10-year scheme	21	1.44	1.1	Co-funding required, no fixed percentage. Average contribution 24% (2009)
Centres for Research-based Innovation (CRE/SFI), Research Council of Norway, 2007	Additional aims scheme/innovation, economic rational	8-year scheme	21	0.91	0.7	Host and partners total 50%. Company partners at least 25%
Sweden						
Linnaeus Environments, Swedish Research Council and Formas, 2006	Classic CoE scheme/ scientific	10-year scheme	40	0.69	0.8	Host 50% (including infrastructure/in kind) of which SEK1 million per centre per year in cash
VINN Excellence Centres, VINNOVA, 2005	Additional aims scheme/innovation, economic rational	10-year scheme	18	0.67	0.4	SEK14 million from universities and companies (of which university $\approx$. SEK3 million)

*Annual average per CoE per year

** Danish and Swedish figures for 2009, Finnish and Norwegian figures for 2010

Sources: Table 2.1 in Aksnes et al. (2012) and Table 1.1 in Langfeldt et al. (2013). Aksnes et al. gives detailed information about background and rationales of schemes