
Centers of Excellence from the Danish National Research Foun- dation 1993-2005

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Introduction

The Danish National Research Foundation (DNRF) has asked the Danish Center for Studies in Research and Research Policy (CFA) to conduct a retrospective analysis of the DNRF Centers of Excellence (CoEs) from the initial three rounds from 1993-2005.

The purpose of the analysis is to analyze: 1) what elements of the CoE framework were effective in promoting excellence in research and why, 2) the impact of the CoE on the involved researchers, institutions, and society, and 3) potentials and challenges for the DNRF CoE as seen by involved researchers and institutions.

This document reports the results from five work packages, carried out by CFA in the spring and summer of 2023 to analyze the above-mentioned questions. These were: 1) a review of literature on the CoE framework, 2) a document analysis of reports from the DNRF CoEs, 3) a survey distributed to CoE Center Directors, 4) an interview study among researchers and university leaders, and 5) a bibliometric analysis of the citation impact of CoE publications.

The report finds that the elements of the CoE framework that are effective in promoting excellence in research are stability, volume, visibility, and flexibility. These elements improve recruitment options, collaboration possibilities, increase risk tolerance and allow for acquisition of specialized research infrastructure. This, in turn, increases interdisciplinarity, and allows testing of a greater variety of research questions. Particularly interdisciplinarity, but also the collective "spirit" of the CoEs, are found by leaders and CoE participants to have been key to success. The collaboration with DNRF is also highly praised. The study also finds some challenges or points of attention, particularly revolving around building up an organization and a management structure and around the transition to the CoE-afterlife. The main impact of the centers has been academic, i.e., by establishing and consolidating research fields or training the next generation of researchers. In relation to this, the bibliometric analysis finds that the majority of the CoEs have a portfolio of publications with an above average citation impact.

The structure of the report follows the central questions behind the study as mentioned above. Chapter one outlines the elements of the CoE framework as it has been studied in academic literature and develops a theoretical model of how the elements facilitate excellent research. Chapter two use survey and interview data to analyze what mechanisms were present in the early Danish CoEs and why certain elements of the CoE framework were seen as important. In the third chapter, the outcome and impacts of the CoEs are analyzed through both survey data, interviews, and bibliometric analyses, and in the fourth and final chapter, we discuss potentials and challenges for the DNRF CoEs based on the study findings.

1.0 Central mechanisms in the CoE framework

This chapter presents and builds on existing literature on CoEs, and outlines the central mechanisms proposed herein. We discuss how the theoretical model used in the present study builds on and expands these propositions and explain how this model is used to inform our understanding of the potential of CoEs to produce excellent research.

There is no widely agreed definition of what excellent research exactly is and a review of the literature is outside the scope of this report. Here we define excellent research as research that to a high degree is 1) credible, i.e., rigorous, consistent, coherent, and transparent, 2) contributory, i.e., original, relevant, and generalizable, 3) communicable, i.e., consumable, accessible, and searchable, and 4) confirming, i.e., ethical, sustainable, and aligned with regulations. For a thorough explanation of this definition see Mårtensson et al. (2016).

1.1/ From block funding to CoEs

Originally, research was mainly financed via institutional block funding. In this type of funding, universities and research organizations are given a long-term budget with a relatively high degree of autonomy. Around the end of World War Two, however, competitive project funding was introduced, and has since accounted for an increasing share of research funding across the world (Gläser & Laudel, 2016; Madsen, 2021). This type of funding is awarded to individual research projects (or researchers) and has a shorter time period and offers a lower degree of flexibility in how to use the money compared to block funding.

In the 1990's and 2000's a new type of funding was introduced in western countries, namely one focusing on funding CoEs. On a continuum, with block funding on one end and project funding on the other, the CoE concept lies somewhere in the middle (Aksnes et al., 2012; OECD, 2014). First, while CoE grants are time-limited, they typically have a much longer time frame than project grants. Second, while CoE grants are not comparable in size to institutional block funding, they entail a significantly larger amount of money compared to projects grants. Third, CoE-grant holders have a significant amount of autonomy and flexibility in choosing research direction within their research topic when compared to project grant-holders. Finally, CoE grants entail a significant amount of visibility and prestige in the academic community.

These four attributes of CoE grants - a long time horizon, a high amount of money, and a high degree of flexibility and visibility - are some of the attributes which characterize CoE concepts that have been introduced in the OECD and Nordic countries (Aksnes et al., 2012; OECD, 2014). As will be explained below, the four attributes also explain why CoEs have the potential to produce excellent research.

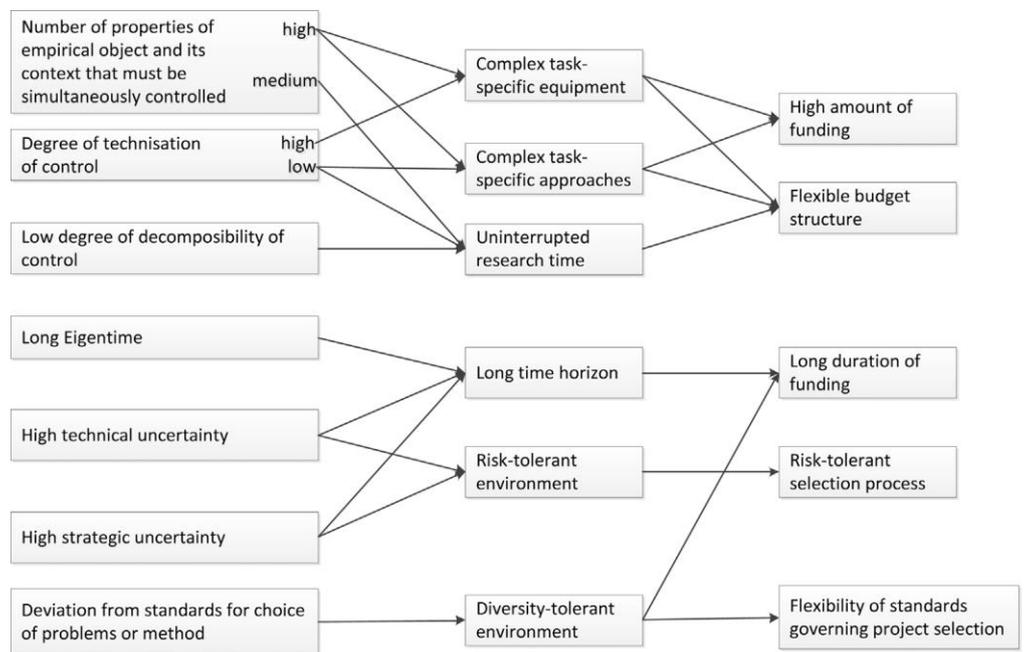
1.2/ CoEs and excellence in research

This section presents and discusses how the CoE concept has been addressed in the literature so far, and how these insights have informed our theoretical framework for understanding what elements of CoEs are effective in promoting excellence in research and why. This theoretical framework underpins the survey developed for the study. The results of the survey are presented in chapters 2 and 3, where propositions of the theoretical framework are tested and evaluated.

1.2.1/ Epistemic properties of research and their consequences for research funding

By way of interviews with ERC grant holders, Laudel and Gläser (2014) study epistemic properties of different types of research (i.e., properties that characterize the research process in different research fields), how these are connected to necessary or favorable conditions for research, and how these conditions can be provided by research funding. They summarize their findings in a figure, which is reproduced below.

Figure 1.1: Links between epistemic properties of research, necessary and favorable conditions for research and institutional conditions.



Note: Reproduced from Laudel and Gläser (2014, p. 1211)¹

Laudel and Gläser (2014) finds that when the epistemic properties in the left side of the figure are present, researchers need specific conditions in order to produce “breakthrough” research (middle part of figure). These conditions can then be fostered by research funding with specific attributes (right side of figure). As is evident, some of these attributes are the exact attributes which CoE grants have. For example, the long duration of CoE grants allows for long time horizons in research projects, which allows for testing of problems with high technical uncertainty. This means that CoE grants are particularly beneficial to research areas with high technical uncertainty.

¹ The number of properties of the empirical object and its context that must be simultaneously controlled to make the experiment work or to complete the data collection would for example be high in ultra cold physics study of Bose-Einstein condensates and lower in an engineering study of car design features effect on car safety measured via crash test. Technisation of control refers to the degree to which methods are technologized. Decomposability of control refers to extent to which research tasks can be subdivided into discrete and standardized tasks, which can be performed by different researchers Nelson, J. P. (2023). Differential “progressibility” in human know-how: A conceptual overview. *Research policy*, 52(2), 104663. (Nelson, 2023, p. 3). Eigentime refers to the period between research initiation and the time at which outcomes may be observed (ibid.). Technical uncertainty refers to the “lack of knowledge about the way in which a certain goal can be achieved”, e.g., making an experiment work, while strategic uncertainty refers to “the uncertainty about the existence of an outcome” (Laudel and Gläser, 2014, p. 1210), e.g., whether there will be an (scientifically interesting) effect when the experiment works.

Other links are, however, missing from this framework. For example, a high amount of funding can provide for a larger portfolio of research projects meaning that failure of individual projects is not as detrimental when compared to smaller research grants. Therefore, a high amount of funding can also provide risk-tolerance. Another omitted link is that a long duration of funding can also provide uninterrupted research time.

1.2.2/ Connecting organizational capacities and epistemic effects

Whereas Laudel and Gläser (2014) study how properties that characterize different kinds of research lead to requirements for different kinds of research funding, Hellström et al. (2018) start from the other end of the process. Through interviews with Swedish CoE members, they study how the attributes of CoE funding create conditions for doing research and how this affects what kind of research is conducted. They summarize their findings in a table, which is reproduced below.

Table 1.1: Progression from resources to epistemic effects in CoE.

Resources →	Slack/critical mass →	Collaboration →	Epistemic effects
Stable financial guarantees	New recruitments and scholarly development	Interaction and collaboration around data sources	Using complementary expertise on new and old problems
Matthew effects: Attracts researchers with grants who wish to co-locate	Frees up time for researchers through investment in management functions	New research constellations/groups	Testing and exploring new research programs
Improves academic credibility and thus more resources	Longer time-frames and reduction of 'reporting urgency'	Common social platform for reaching out to other academic groups and communities	Testing risky hypotheses/projects

Reproduced from Hellström et al. (2018, p. 80)

The table shows how the volume, length, and credibility leads to time/resource slack and critical mass, i.e., many researchers and resources within the same centre. This, in turn, has effects on the types of research collaborations that are carried out, which in the end have three types of epistemic effects, i.e., the collaboration types affect what research projects are initiated and how research questions are investigated.

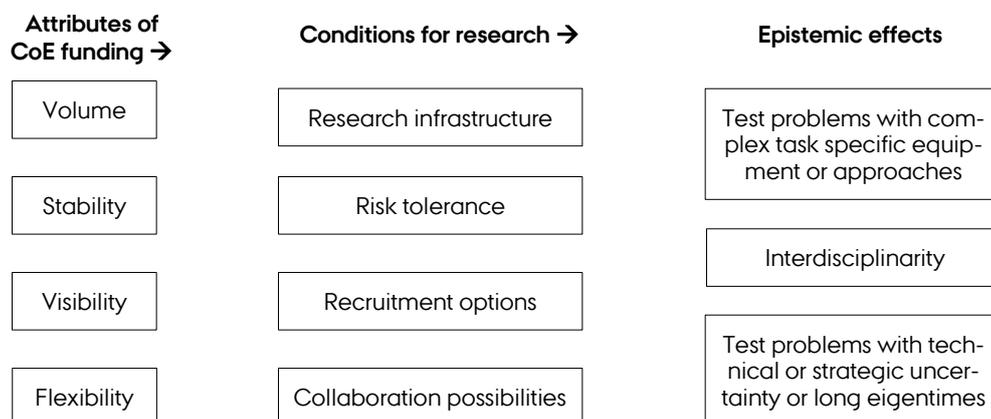
Some factors and links are, however, also missing in this model. For example, the model does not describe the effects of the flexibility that CoE grants have (cf. section 1.1). Furthermore, the effect of the concepts described in the column 'Resources' on 'Collaboration' and 'Epistemic effects' could be direct, i.e., the effect does not necessarily go through 'Slack/critical mass' or 'Collaboration'. For example, the credibility of CoE grants could expose CoE researchers to more potential partners thereby having a direct effect on collaboration possibilities.

1.2.3/ What elements of the CoE framework are effective in promoting excellence research and why

In this report, we have drawn inspiration from the existing literature and developed a model, which structures the investigation of the epistemic effects of CoE grants. The figure below

shows how the attributes of CoE funding identified in section 1.1. affect conditions for conducting research, which, in turn, have three types of epistemic effects.

Figure 1.2: Links between attributes of CoE funding, conditions for research and epistemic effects.



The figure can be used as a heuristic tool in structuring thinking about what elements of the CoE framework are effective in promoting excellence in research and why. The 'what elements' part of the question is answered by looking at the four attributes in the left part of the figure, i.e., the relevant elements of the CoE framework are length, volume, visibility, and flexibility. The 'why' part of the question, or how these elements promote excellent research, is answered by the middle and right part of the figure, i.e., length, volume, visibility, and flexibility promote excellent research because they lead to the conditions for research and epistemic elements listed in the figure. These are then expected to increase the credibility and contributory dimensions of the quality of the resulting research cf. the definition of excellent research in the beginning of this chapter.

While the figure suggests a flow of causality between the columns, it should also be noted that elements within each of the three columns can affect both themselves and other elements in the same column. For example, the volume of CoE funding is self-reinforcing: Because CoE researchers have large amounts of grant money available they will be able to produce large amounts of publications and thus be able to attract even more grant money (Langfeldt et al., 2015) - a phenomenon known as the Matthew-effect (Merton, 1968). Another example is that good recruitment options can be a prerequisite for having the in-house skills necessary to build or operate research infrastructure which, in turn, can make CoEs more attractive as collaboration partners.

Some of the propositions of the framework are tested and the results are presented in sections 2.2-2.4 in the next chapter.

2.0 DNRF CoEs 1993-2005

This chapter explores the mechanisms proposed in chapter one. Based on survey and interview data, it examines which of the mechanisms can be seen in the case of the early Danish CoEs. First, however, the chapter presents a brief history of CoEs in Denmark and a descriptive overview of the early CoEs and how they are studied in this report. This chapter thereby also builds on document material from the CoEs themselves.

2.1/ CoEs in Denmark

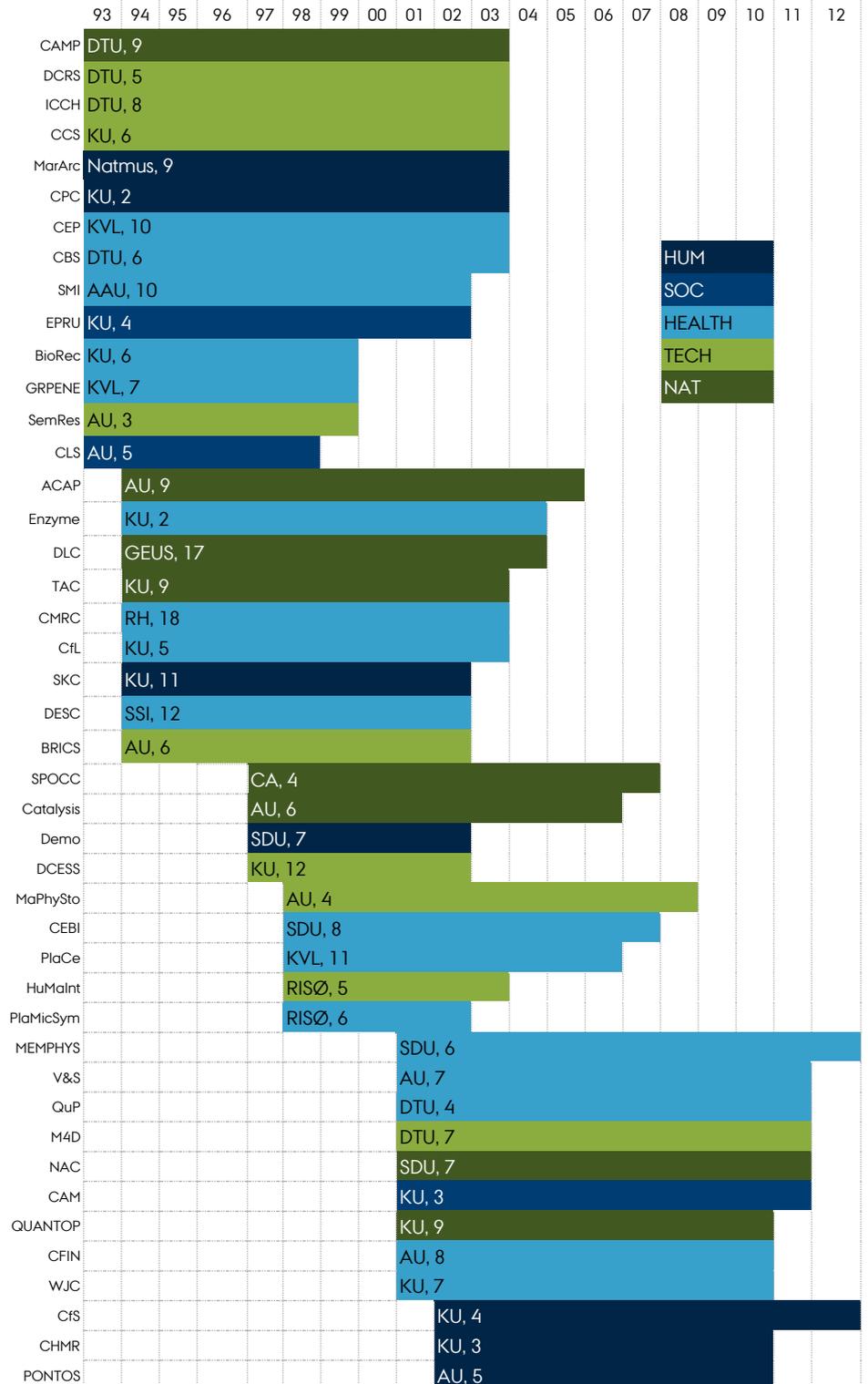
Denmark introduced CoEs into its funding policy in 1991. Compared to other western countries, this was relatively early and can be explained by the right timing of an idea. In 1990, chairman of the Danish research policy council Jens Rostrup-Nielsen argued that Danish basic research should be strengthened by establishing research institutes inspired by the German Max Planck Institutes. To Rostrup-Nielsen's favor, his idea coincided with the fact that a large amount of public funds was available after the privatization of a former public life insurance company. Negotiations to establish the DNRF were prolonged due to the 1990 Danish general election, but in 1991 a nearly unanimous parliament passed the bill to establish the DNRF and transfer 2 billion DKK to the foundation (Lov om Danmarks Grundforskningsfond (* 2), 1991), and in 1993/1994 the first 23 Danish CoEs were funded (Aksnes et al., 2012, pp. 18-19). The second round of CoE grants were given in 1997/1997 to 9 centers, and the third round of CoE grants were given in 2001/2002 to 12 centers.

Figure 2.1 visualizes the period of DNRF funding, yearly DNRF-grant, main host institution and research area for the CoEs from the first three rounds. As is evident from the number of bars in the lightest shade of blue, the Medical and Health Sciences had the largest part of CoE in the first 3 rounds. 17 out of 44 CoEs were within Medical and Health Sciences, 9 CoEs were within Engineering and Technology, while Humanities and the Arts and Natural Sciences both account for 7 CoEs. Relatively few (3) centers were within the Social Sciences. Figure 2.1 shows some variation in the length of the CoEs. All CoEs were initially granted funding for approximately five years and were required to undergo a mid-term evaluation to determine eligibility for a second five-year grant, which not all CoEs successfully obtained. Finally, figure 2.1 shows considerable variation in the DNRF grant size measured as DKK per year. The largest yearly grant of 17.5 mill. DKK was given to The Copenhagen Muscle Research Center (CMRC), while the smallest yearly grant of 1.9 mill. DKK was given to the Copenhagen Polis Center (CPC). It should be noted, however, that this is not evidence of variation in the CoEs total yearly budgets, as all CoEs also received funding from other sources than the DNRF.

Aksnes et al. (2012) distinguishes between CoEs aimed at three different types of objectives, namely, scientific excellence, economic growth and innovation, and societal challenges such as climate change mitigation. In this categorization, the DNRF CoEs were clearly targeted towards attaining scientific excellence. This could be due to the fact that the economic objective was relatively new in science policy in the 1990s (when the DNRF was established), while the societal objectives (today included in so-called mission-oriented research) were not broadly included in science policy until the 2010s (Aagaard et al., 2022). The economic objectives were instead delegated to three separate research funding organizations established in the 2000's (The Council for Technology and Innovation, The Strategic Research Council, and The Advanced Technology Foundation). These were merged into the Innovation Fund Denmark in

2013, which also included the societal objectives in its main instrument 'Grand Solutions' (ibid., pp.10-11).

Figure 2.1: DNRF CoEs rounds 1-3. Period of DNRF funding, main host institution, yearly DNRF-grant (mill. DKK current prices) and research area.



Abbreviations: See appendix. Source for budgets: Danmarks Grundforskningsfond: Årsrapport 2017. Fejring af Danmarks Grundforskningsfond. Source for period: Data received from DNRF.

In the interviews conducted for this project, the informants highlight exactly this focus on scientific excellence as one of the key characteristics of the early CoEs. Several informants contrast this with the current drive towards more mission-oriented research funding, not least by the private foundations in Denmark.

To answer the questions posed in the introduction, the study of the CoEs was designed as a mixed methods study, consisting of a document study, a questionnaire survey sent to members of the management at the DNRF CoEs from rounds 1-4, and an interview study (28 interviews in total) with leaders and researchers from nine case CoEs.² The case CoEs were selected based on the variables shown in table 2.1.

Table 2.1: The nine case CoEs.

Center	Round	Institution	Research area	DNRF-grant (mill DKK / year)	Granted second period from DNRF?
SKC	1	KU	HUM	11	Yes
CLS	1	AU	SOC	5	No
BRICS	1	AU	TECH	6	Yes
CBS	1	DTU	HEALTH	6	Yes
CMRC	1	RH	HEALTH	18	Yes
SPOCC	2	CA	NAT	4	Yes
DEMOG	2	SDU	HUM	7	No
CEBI	2	SDU	HEALTH	8	Yes
QUANTOP	3	KU	NAT	9	Yes

Abbreviations: See appendix.

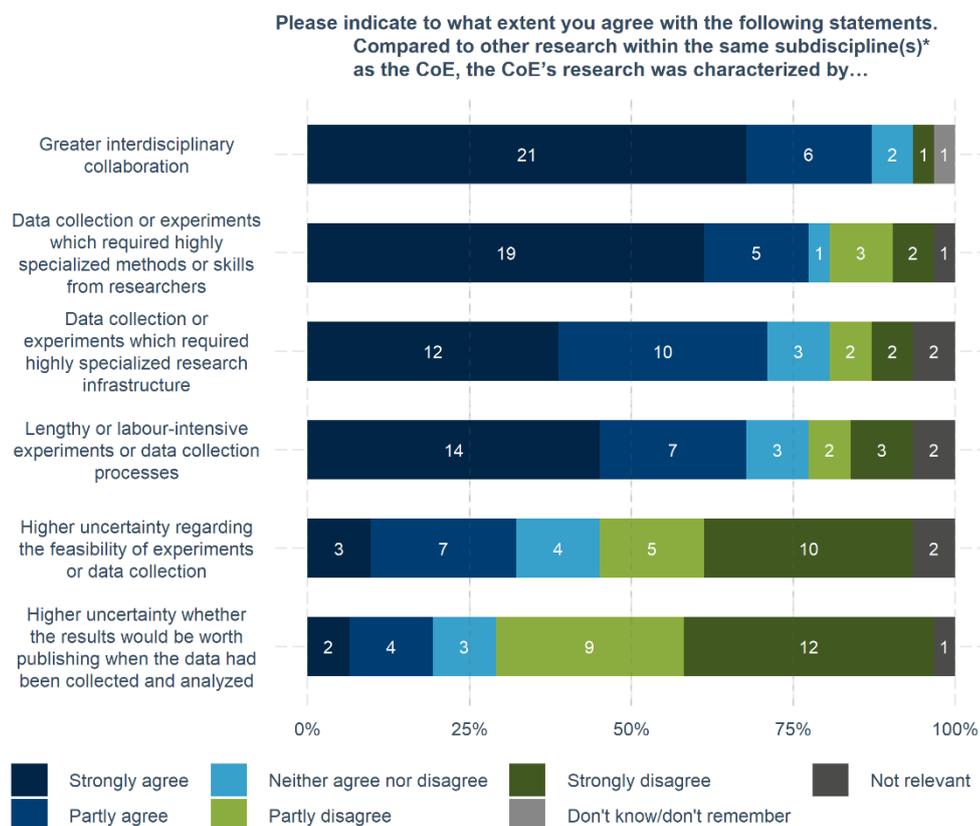
In the following sections, survey results are based on answers from respondents from the full population of CoEs from rounds 1-4, whereas interview results stem from the nine case CoEs. Throughout the report, results from the two sets of data are distinguished by referring to *respondents*, when reporting from the survey and *informants*, when reporting from the interviews. The results from the survey should be interpreted with caution as the number of respondents is low and because many of its questions concern events that happened more than 20 years ago. For more information on the methods in relation to the survey and interviews, see the appendix.

2.2/ Characteristics of research at the CoEs

The first questions in the survey concerned what kind of research was done at the CoEs. As described in section 1.2, Laudel and Gläser (2014) finds that certain types of research require the funding characteristics of CoE grants (length, size, autonomy, risk-tolerance) in order to be excellent and Hellström et al. (2018) find that CoE grants lead to certain types of research. To assess whether these theoretically expected types of research were conducted at the CoEs, the respondents were asked the questions shown in figure 2.2.

As figure 2.2 shows, the attribute which most respondents think characterized their CoE's research is 'greater interdisciplinary collaboration'. 21 respondents or 70% strongly agree with this statement. For the first four attributes in the figure, at least 70% of respondents strongly or partly agree that their research was characterized by this compared to other research within the same subdiscipline(s) as the CoE.

² Initially, 10 case CoE were selected. However, it was not possible to arrange interviews with one of the case CoE before the deadline of this report, therefore this CoE was excluded from the study. Note that round 4 center management is included in the survey, even though the study mainly focuses on the first three distribution rounds. This was done to increase the pool of respondents, which when excluding round 4 is very low.

Figure 2.2: Survey respondents' assessment of epistemic properties of research at the CoEs.

Note: At the bottom of the survey questions, the following text was presented: “We apply the following levels of categorization 1. Field (e.g., Physics), 2. Discipline (e.g., Nuclear Physics), 3. Subdiscipline (e.g., study of collision processes)”. Source: Survey among DNRF CoE management members.

This is backed by the interviews, where several informants point out that what made their CoE special or what was positive about having such a grant, was the opportunity to collaborate with researchers from other areas than their own, or to be allowed to venture into new interdisciplinary areas and shape new research fields.

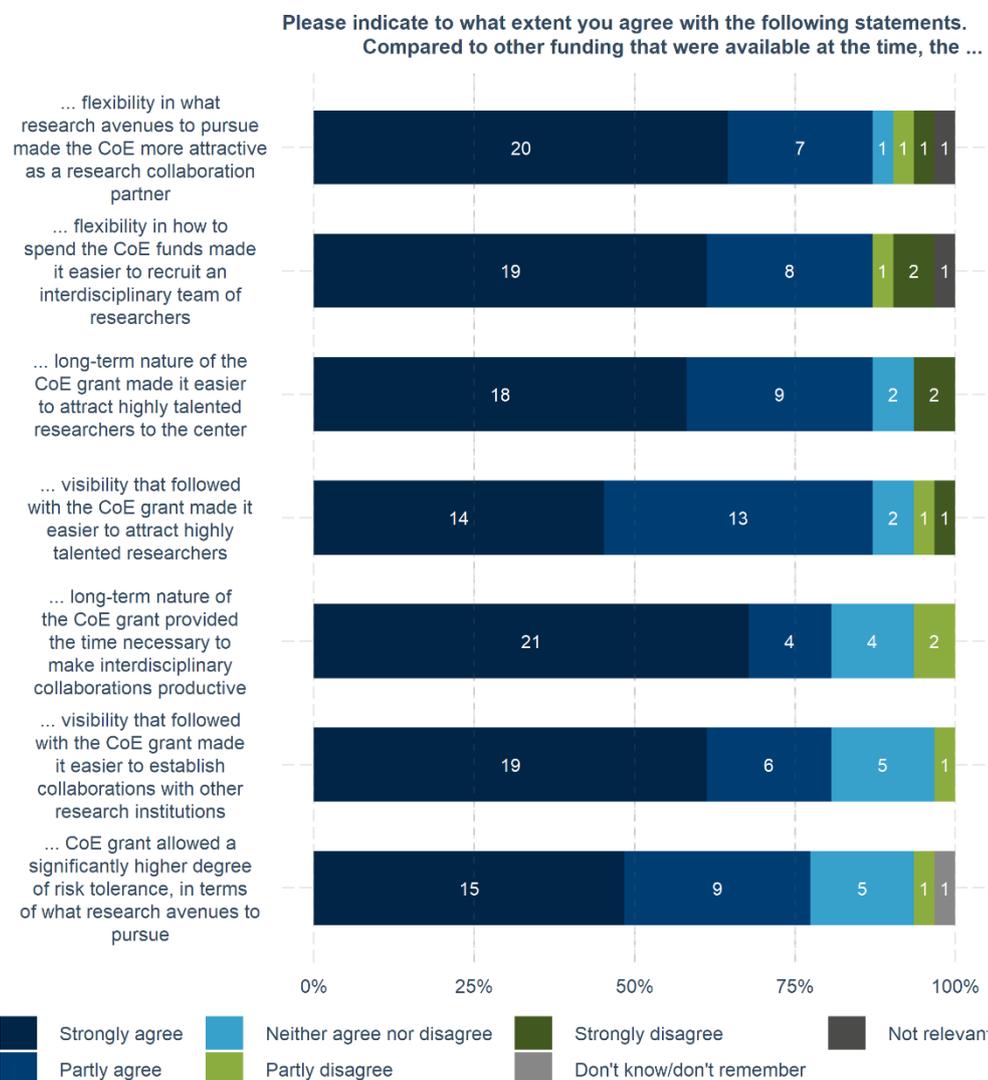
For the two bottom questions in figure 2.2, the share of respondents who partly or strongly disagree are larger than the share of strongly or partly agreeing. In theoretical terms, this indicates that the main part of the CoEs did not conduct research with high technical or strategic research uncertainty (Laudel and Gläser, 2014; see footnote 1 for an explanation). On these two parameters, the CoEs did not conduct high-risk research.

2.3/ Mechanisms of the CoE grant

As described in section 1.2, the attributes of CoE grants (i.e., size, length, autonomy, and visibility) can lead to excellent research via different mechanisms. The questions shown in figure 2.3 attempt to capture the respondent's assessment of whether the attributes of the CoE grant activated the theoretically expected mechanisms.

As figure 2.3 shows, all questions have received shares of respondents strongly or partly agreeing higher than 75%. This indicates that in the main part of the CoEs, the CoE grant attributes (flexibility, length, visibility) lead to the theoretically expected mechanisms.

Figure 2.3: Survey respondents' assessment of the effects of the CoE grant attributes relative to other funding.



Source: Survey among DNRF CoE management members.

The statement which received the relatively lowest share of agreement is whether the CoE grant allowed a significantly higher degree of risk tolerance in terms of what research avenues to pursue. However, the share that strongly or partly agrees is still high (77%),

Following the questions above, the survey respondents were asked “In your opinion, what characteristics of the CoE grant (e.g., flexibility, risk-tolerance, length, or size of grant) were the most important for the CoE’s ability to produce its research outcomes?”. Most likely primed by the examples in the question, the survey respondents list flexibility, length, size, and risk-tolerance as important characteristics.

The number of respondents listing each of these attributes indicates what attribute was the most important. Out of the 25 respondents who answered the question, 23 list length, 16 list size, 13 list flexibility, and 6 list risk-tolerance as import characteristics of the CoE grant. Table 2.2 lists some of the answers which qualitatively describe how the characteristics of the CoE grant enabled the CoE’s research outcomes. Please note that while half of the quotes in the

table list risk-tolerance as an important characteristic, this is not a representative share of all the quotes.

Table 2.2: Survey respondents' description of most important characteristics of the CoE grant

#	Quote
1	"The flexibility made it much easier to use the funding optimally and get the best candidates. The length and size made it possible to take risks that I would not have been able to take with conventional funding"
2	"The possibility to have a relatively large group of highly skilled researchers to work interdisciplinary on one research theme over a long time period without worrying too much about next employment"
3	"Flexibility, risk-tolerance, length of funding and size of grant were all equally important in securing the interdisciplinary synergy that is essential for cutting edge fundamental research"
4	"The length (and flexibility) of the grant made it possible to immerse oneself in a long-term study that spanned several years. This is (and was) rarely possible. You could concentrate" *

Note: *translated from Danish: "Bevillingens længde (og fleksibilitet) gjorde det muligt at fordybe sig i et længerevarende studie, der forløb over flere år. Dette er (og var) sjældent muligt. Man kunne koncentrere sig."

The interviews offer some nuances to these descriptions of the most important features of the CoE funding instrument. All informants highlight the size of the grant and elaborate that this enables the center participants to focus on academically interesting topics and problems. They also highlight that the size of the grant allows for the recruitment/attraction of international scholars to not only visit, but also remain at the CoE for extended periods, thereby allowing for the establishment of a sustainable environment. The length of the grant also plays a role in this and is also highlighted by almost all the informants.

Two other key features that are mentioned by a vast majority of the informants are that the grant offers *freedom* and "*peace*" or "*stability*"³. These two characteristics can be seen as outcomes of both the flexibility and the size and length of the grant.

Freedom is described as the possibility to pursue new research avenues. Importantly, this is mentioned not only by center leaders, who were formally in charge of the strategic direction of the CoE, but also by the (then) junior researchers. These informants describe how the flexibility and freedom in the funding in many cases trickled down through the CoE, making their autonomy greater. This is, by many, mentioned as something that was highly motivating and led to more collaboration and more interesting research.

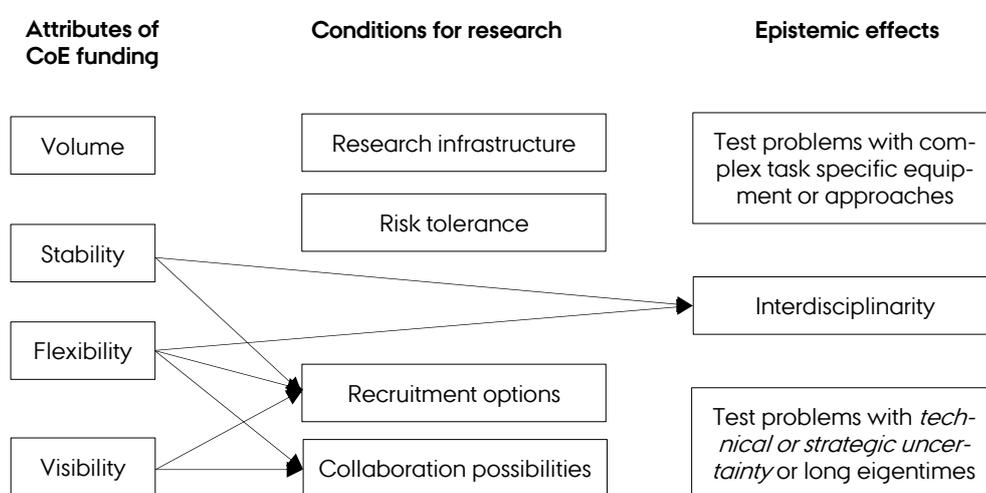
Peace or stability is also mentioned by a majority of the informants and is described as an absence of "strings attached" at the organizational/CoE level (in terms of what the grant money should be used for) and as a moderator of competitiveness at the individual level. Center leaders and department heads are most often the ones mentioning the low level of administrative and reporting requirements attached to the grant, while the peace/stability in relation to competition is most often brought forward by the younger researchers. They emphasize a collective spirit – leading to more collaboration on research and motivation to pursue more risky ideas – rather than a hyper-competitive environment, which is experienced in their career afterwards.

³ The word which was used in Danish was "ro", which has connotations to both the English terms "peace" and "stability", without being equivalent to either.

2.4/ Effective elements in the CoE framework

Figure 2.4 summarizes the findings of the chapter in relation to the theoretical model developed in chapter one. The concepts in normal font were found to be present, while the concepts in *italics* were found not to be present. In the survey, we also tested seven mechanisms, i.e., whether specific attributes of CoE funding had specific effects. We found support for all seven mechanisms, which is signified by the arrows in the figure. For example, the survey found that the stability (length) of the CoE grant facilitated interdisciplinary research.

Figure 2.4: Empirically tested links (arrows) between attributes of CoE funding, conditions for research and epistemic effects. Concepts in normal font found to be present, concepts in *italics* found not to be present.



As was the case with figure 1.2., figure 2.4. can be used to answer the question regarding what elements of the CoE framework are effective in promoting excellent research and why; the difference between the figures being that figure 2.4 increases the confidence in the identification of the relevant elements and of their mechanisms, because they now have been empirically tested.

To be clear, while the presence of an arrow strengthens the confidence in the existence of a mechanism, the absence of an arrow should not be seen as weakening the confidence in the existence of the mechanism. We tested seven mechanisms and found support for these but could not test all mechanisms due to length limitations of the survey.

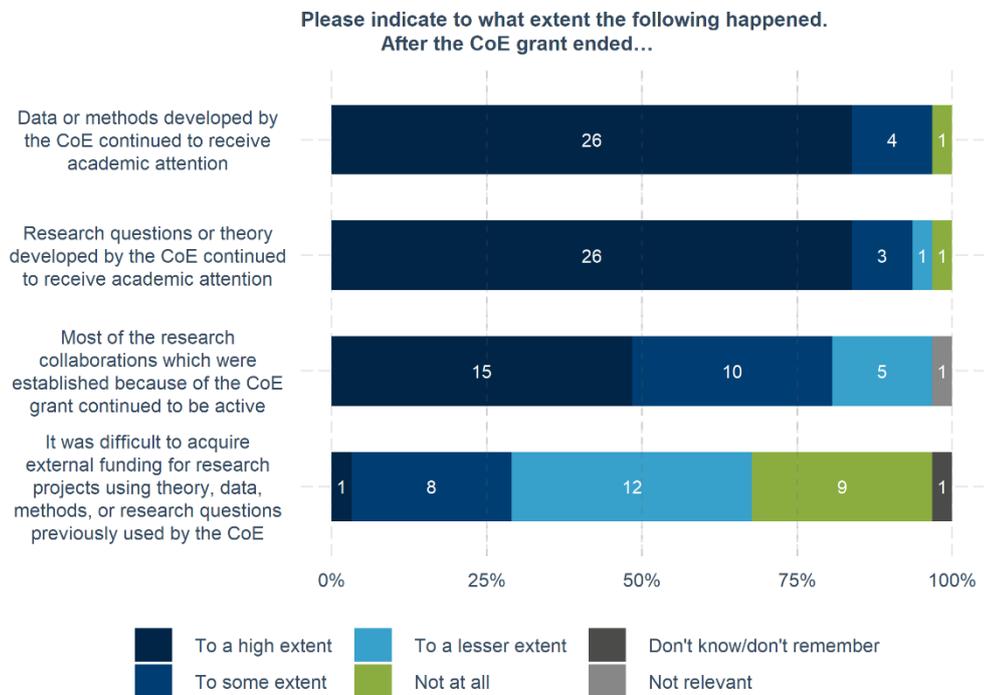
The figure omits the last part of the causal chain, namely whether the epistemic effects on the right side of the figure lead to excellent research. While we do not test the mechanisms or in any way claim that citation impact is a complete measure of excellence (Aksnes et al., 2019), we analyze the citation impact of the CoEs in the bibliometric analysis, which is reported in section 3.4. in the next chapter.

3.0 Outcomes and impact

This chapter examines the outcomes, long-term impacts, and "legacies" of the CoEs through survey data, interviews, and bibliometric analyses. First, the results from the survey on immediate and longer-term effects are presented and related to the interview results. Second, the bibliometric analysis of the citation impact of the CoEs is presented.

3.1/ Immediate effects

Figure 3.1: Survey respondents' assessment of events after CoE grant.



Source: Survey among DNRF CoE management members.

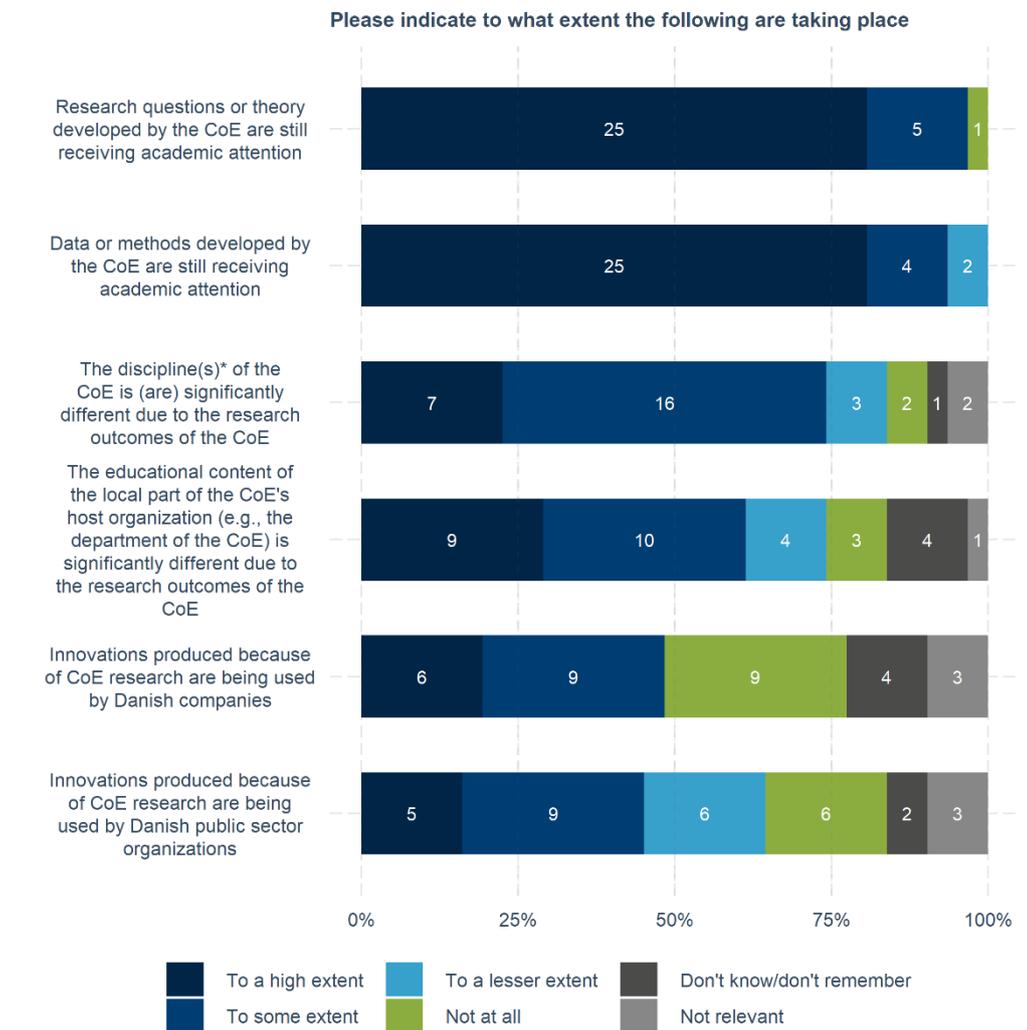
Figure 3.1. shows that nearly all respondents assess that their CoE's research to a high or some extent continued to receive academic attention after their CoE grant ended. Most respondents also assess that research collaboration established because of the CoE grant continued to be active after the end of the CoE grant. Two thirds of the respondents answer that it was not difficult at all or to a lesser extent difficult to acquire external funding to continue the CoE research, however, one out of four respondents answer that it to a high or some extent was difficult.

The survey results are echoed by the informants in the interview study. There is consensus that the case CoEs had immediate effects on their environments, e.g., through the establishment or consolidation of emergent research fields or through the development of new methods or establishment of large-scale datasets.

In relation to the question of attracting additional funding, the informants are also split in their assessment of how difficult it was to attract funding after the grant had ended. Some informants describe that they found it quite difficult to find funding after the termination of the CoE, and some describe it as a kind of reverse Matthew-effect. However, other informants describe how they got additional funding from other sources, after the CoE grant had ended, without much difficulty.

3.2/ Long term effects

Figure 3.2: Survey respondents' assessment of effects of their CoE anno 2023.



Note: At the bottom of the survey questions, the following text was presented “*We apply the following levels of categorization 1. Field (e.g., Physics), 2. Discipline (e.g., Nuclear Physics), 3. Subdiscipline (e.g., study of collision processes)”. Source: Survey among DNRF CoE management members.

Where figure 3.1. showed that nearly all respondents assess that CoE research to a high or some extent continued to receive academic attention in the immediate years following the end of the CoE grant, figure 3.2. shows that nearly all respondents assess that CoE research *continues* to receive academic attention in the year 2023. Around 3 out of 4 respondents assess that the CoE discipline(s) to a high or some extent is (are) significantly different due to the research outcomes of the CoE. In relation to this, and as will be described in section 3.3., the

bibliometric analysis shows that a majority of the CoEs have more publications from their portfolio than expected among the 10% most cited in database. Some of these CoEs perform exceptionally well.

The two questions that received the lowest share of respondents answering to a high or some extent are the questions regarding whether innovations produced because of CoE research are being used by Danish public sector organizations. As described in section 2.1, CoEs can be distinguished regarding whether they aim at scientific, economic or broader societal objectives (Aksnes et al., 2012; Aagaard et al., 2022). The interview informants emphasize the focus of the Danish CoEs on scientific excellence, which could be the explanation of the low amounts of respondents assessing that CoE innovations are being used by organizations outside academia. However, the interviews provide some nuances, as most of the informants highlight what we may call societal impact of “their” CoE, i.e., spinoff companies, impacts on local businesses, and impact on public sector organizations. In many cases informants also mention that researchers affiliated with the CoE end up using methods or knowledge produced at the CoE in non-academic organizations, e.g. large companies in Denmark. This might not fit the definition of innovation, but still provides an insight into the broader impact of the CoE.

3.3/ Bibliometric analysis of CoE publications

In connection with the evaluation of DNRF back in 2013, the then Danish Ministry of Science, Innovation and Higher Education commissioned CFA to carry out exhaustive bibliometric analyses of publications linked to eligible CoEs funded between 1993 and 2010. Whereas some main findings were outlined in the evaluation report, all bibliometric analyses and the substantive data processing work behind them were presented in Schneider and Costas (2013)⁴. Here, we briefly revisit and extend some of these findings.

In the previous analyses, 66 CoEs were included. Some CoEs were discarded due to lack of journal publication coverage in the citation database (Web of Science), mainly centers from the humanities, social and computer science. In addition, 31 CoEs were still active at the time of the analyses, meaning that their portfolios of journal publications were not completed as in the case with the earliest funded centers. Publication portfolios for the individual CoEs were established based on annual reports from the centers to DNRF. This reporting, however, especially among the early funded centers, was not consistent for all CoEs. We refer to the previous report for methodical details. Here we revisit two analyses and provide a new one.

The main conclusions in the evaluation report for the overall set of publications linked to the DNRF through CoEs for the period 1993-2011 were that the set constituted 7% of the Danish publications, accruing 9% of the normalized citations, and 10.% of the highly cited Danish publications in the period. More than 20% of the DNRF-publications were among the 10% most cited publications in the database⁵. While these findings are important, it is perhaps more informative to examine the variation of impact among the CoEs as depicted in figure 3.3 below. We have updated figure 6.2 in the previous report by extending the citation window up until now. The results are similar.

Assuming that CoEs can be seen as research groups, as a rule of thumb, van Raan (2005) suggested that at the group level, a performance level of 20% indicates a very strong group, and above 30% groups can generally be considered to be excellent and comparable to top groups at US universities⁶.

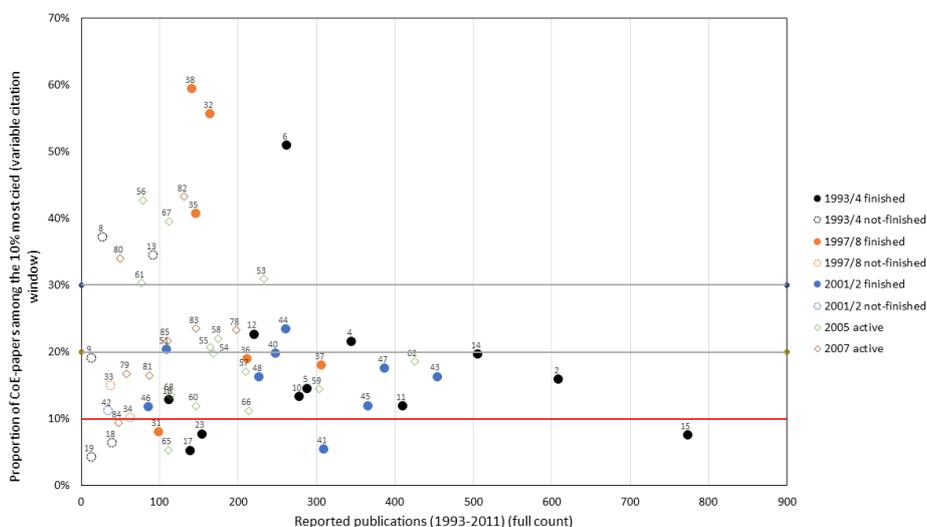
⁴ Accessible via: https://dq.dk/wp-content/uploads/2018/10/Appendiks_5_bibliometrisk_report_03122013.pdf

⁵ The report contained a number of aggregated analyses where DNRF was the unit of analysis, and a number of universities were selected as benchmark units. Such a basis for comparison is questionable because the units are fundamentally different.

⁶ Note such performance levels are not valid for larger units such as universities. With larger units, performance level tend to regress toward the mean.

Figure 3.3 documents considerable variation in output and performance among the individual CoEs. Eleven centres perform extremely well, on or above the 30% threshold. Four of those had finished, two had not finished, and five were active at the time of the evaluation, of which two had already reported more than 100 publications. Other ten or eleven centres also have very strong performance levels for their portfolio of publications between 20 and 30%. Around 24-25 centres, slightly under half of those examined, have performance levels between the expected database level at 10% and 20%, whereas nine centres had performance levels below this expected level of 10%.

Figure 3.3: Proportion of papers among the 10% most cited in the database (PPTop10%) as a function of publication output.



Note: Updated performance for 57 CoEs. Full circles are CoEs running the full period (finished); open circles are CoEs that were terminated (not finished). All circles have complete publication portfolios. Diamonds are CoEs that were still active at the time of the evaluation in 2013 and therefore did not have complete publication portfolios at the time. For this update, we have left out nine CoEs funded in 2009/10. The red line indicates the expected performance level of 10%. A unit is expected to have 10% of its publications among the 10% most cited in the database. The two grey lines indicate the group performance levels of 20% (very strong) and 30% (excellent) suggested by van Raan (2005). Individual CoEs are numbered, table 5.5 in the Appendix provides their names.

Three CoEs stand out with more than half their publications among the 10% most cited: Center for Atomic Scale Materials Physics (6), Center for Catalysis (32), and Center for Experimental Bioinformatics (38). Given their substantial publication output, such performance levels are remarkable.

This kind of citation analysis examines performance relative to the total reported output from a CoE. The previous evaluation also included a specific analysis aimed at identifying potential 'breakthrough' papers irrespective of the overall performance of the CoE. Breakthrough papers were operationalized in three different ways.

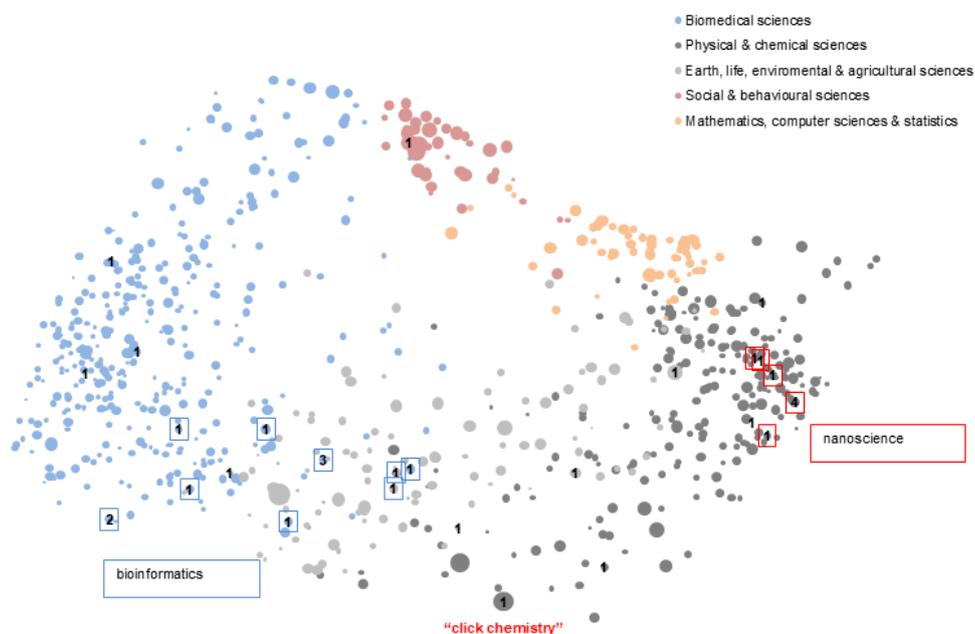
A breakthrough paper should not only be highly cited, it should also show various kinds of network influence upon later citing articles. If we just focus upon this most restrictive of these approaches (figure 3.4 below⁷), several interesting results come up. Center for Biological Sequence Analysis (12) had 23% of its publications among the 10% most cited, and also had an impressive

⁷ Based on Figure 10.4 in previous report. For a detailed description and results of the breakthrough paper analyses, see page 80 to 93 in the report.

eight potential breakthrough papers spread out on a number of meso-level research fields concerning various aspects of biosequencing and bioinformatics - these papers are pivotal for these fields as indicated by their role in the citation network.

Only 32 potential breakthrough papers were identified with this very restrictive approach distributed among 15 CoEs where only three (no. 6, 12 and 38) had more than two potential 'breakthrough' papers. Among these 15 CoEs, the Centre for Solid Phase Organic Combinatorial Chemistry and Molecular Recognition (SPOCC) (31) is a very interesting case. Although correlations are often strong, a percentile indicator such as PPtop10% is generally seen as more robust than mean normalized citation scores (MNCS), as the latter is more 'vulnerable' to the much-skewed underlying citation distributions. In the present case, the PPtop10% for SPOCC were 8% or around 8 out of 99 publications among the 10% most cited which is below the expected database performance level. However, the mean normalized citation score for SPOCC is the third largest among all CoEs examined suggesting one or more very highly cited papers. Indeed, the identified potential breakthrough paper from SPOCC went on to be one of the founding papers behind 'click chemistry', which eventually received the 2022 Nobel Prize in Chemistry. The meso-field of 'click chemistry' is identified in figure 3.4. While the overall performance of all papers from SPOCC was among the lowest in the set of examined CoEs, the center did produce an extremely influential breakthrough paper. This is a reminder that citation performance can reflect different aspects and that one measure is not necessarily better than the other.

Figure 3.4: Identification of breakthrough papers through the most restrictive approach. Map of 784 meso-fields where potential DNRf-'breakthrough' papers are indicated with numbers on top of fields.



Note: The figure shows science maps based on all publications in the WoS database as of 2013. Papers are linked to each other based on their citing patterns and subsequently hierarchically clustered into micro, meso and macro level fields. The maps shows the meso level containing 784 fields indicated with circles. Circles are color-coded according to main fields and their relative size indicate the number of publications in them. The map shows where the potential 'breakthrough' papers identified using the most restrictive ap-

proach are located in the map of science. The numbers provide the frequency of 'breakthrough' publications in the cluster. Notice, 'breakthroughs' are detected in the micro-fields and a meso-field is constituted by several micro-fields.

In this operationalization, breakthrough papers are very rare phenomena. Recently, two articles in Nature have created quite a debate about so-called 'disruptive' papers in science (Wu et al., 2019) and the claim that such papers are declining over time (Park et al., 2023). While the disruption measure as defined in these papers is problematic, it is somewhat related to the breakthrough approaches used in the evaluation report. Here we will just reflect upon disruption in relation to the set of papers from CoEs compared to the total set of Danish papers in the period 1993 to 2011. Disruptive papers are also rare phenomena, even more rare than the suggested approach for breakthrough papers. Put simply, a disruptive paper is one where future citing papers only cite this paper and not its references. The index goes from -1 to 1 and interestingly around 95-99% of all scores are between -0.05 and 0.05 where the abovementioned articles set a strict threshold of 0.75 to indicate disruption. Here we take a more cautious approach compared to the one presented in the papers requiring that a paper should have at least five citable sources and have received at least 100 citations since their publications. This results in 24 Danish publications published between 1993 and 2011 with a disruption index on or above 0.20. One paper has an index above 0.75 and among the 24 are two papers from the set of DNRF-papers used in the evaluation, one from CBS (11) and one from SPOCC (31) (i.e. the paper linked to the Nobel Prize in Chemistry In 2022); both these papers are also included in the set of breakthrough papers presented above.

Citation performance comes in various guises. Some CoEs produce many papers that eventually drive the research fronts, others produce few exceptional papers that 'disrupts' the research front and create new pathways, some do both, and some do not. It is very difficult to identify or construct suitable benchmark units for CoEs. Ideally, such units should be comparable in relation funding instrument, resources, duration etc. All else being equal, publication portfolios from instruments with more resources and longer duration, on average tend have slightly higher Impact. An evaluation of the Danish Research Council from 2014 showed that for a restricted period from 2005-10, the research council's varied portfolio of instruments, constituted 7.8% of Danish publications in the database, accrued 9.7% of the citations and 9.7% of the highly cited publications. Publications linked to DNRF constituted 8.1% of the Danish set, accrued 10.5% of the citations and 11.3% of the highly cited articles. Some 15% of publications were linked to both funding institutions. It is important to stipulate that these instruments are very different. While the differences between them are small, it is to be expected that publication sets linked to instruments such as CoEs generally will perform at a slightly higher level because in principle their conditions generally favors factors known to have positive influence on high performance. But one thing is noticeable. CoEs seem to be especially efficient when it comes to producing highly cited papers and as we have seen, such papers are very important in driving the research front.

As one should expect, performance-levels vary among the individual CoEs. But it is noteworthy that almost half of the 57 centers examined have performance levels characterized as 'very strong' or 'excellent' at the group level.

4.0 Case summaries and lessons learned

To nuance the findings from the survey and bibliometric analysis on the immediate and longer-term impact of the CoEs, this final chapter is devoted to summarizing some of the main impressions from the interviews with participants in the case CoEs. To protect anonymity, the findings are aggregated and summarized in short narratives below, which should give a sense of how the people who were involved in the centers – centrally or in shorter periods, as well as seen from the outside through institutional management lenses – remember and reflect on the CoE and its impact. To conclude the section, common themes are described and discussed.

4.1/ Case summaries

4.1.1/ Søren Kierkegaard Research Center (SKC)

Informants describe a CoE which was unique in its size and scope, and which has been very successful in terms of establishing a research area on Kierkegaard and particularly in bringing together many high-profile researchers – also from different research areas. One informant speaks of a sense of “vacuuming the competences”, meaning that all the research capacities within the field of Kierkegaard research were gathered here.

It is also a story of success, stagnation, and revitalization and one informant mentioned that “legacy requires maintenance” meaning that the long-term legacies will disappear if nothing is done to update, expand and revitalize them. As one informant says: “you will never get an environment such as this one back”, but the center still exists in some form. The center was successful in securing state funding for continuation in a period of turmoil.

Positive aspects that are mentioned include collaboration with the foundation (particularly in the first phases) and the visits from the DNRF. Informants express a perception of risk-tolerance from the DNRF in the fact that they dare to support long term “dry research”. There have, however, also been challenges – the ambition was bigger than the grant could support in some ways, and there is a perception that an even longer term was needed. Informants mention that it might be an idea to give the CoE a better “sense of the future”, as the transition to the after-CoE-life can be hard.

The main legacy mentioned by informants from the CoE is the publication of *Søren Kirkegaards Skrifter*; 28 volumes with all of Søren Kirkegaards published and unpublished books, notes and articles, and 27 volumes of commentary. In 2023, SKC is still an active research centre at KU.

4.1.2/ Center for Labour Market and Social Research (CLS)

Perceived by informants as a successful CoE, which was also to some extent tied to the establishment of register-based research in Denmark and the use and availability of register-data from Statistics Denmark. The descriptions from the informants to a high extent revolve around what one informant calls “dis-embedment” (“aflejring” in Danish), meaning that the physical location of the center, detached from existing environments, meant that it was difficult to couple to the surrounding organization and research environment. This is simultaneously described as a very stimulating micro-environment that was motivating for young academics, also because the CoE was extensively visited by inspirational guest researchers. The dis-embedment, however, was also a challenge in relation to coupling and to help in relation to building up a new “organization”.

Informants speak of being able to really “change something” and create an environment with this type of funding. Also mentioned is the freedom and the length, which are contrasted to other grants where you must be very specific. Challenges are, however, also mentioned, in addition to the challenge of embedment. It is mentioned that having a CoE can skew the focus in smaller fields and departments to the disadvantage of other researchers and areas. It is also highlighted that data is expensive and needs to be maintained, which can be difficult when the grant runs out.

The main legacy is described as being carried on by the young researchers that were brought up in the CoE (becoming highly influential researchers and e.g., members of the Economic Council) and in the “mindset” of empirical labor market studies. Also mentioned in the success is impacting the state administration's approach to evidence-based policy.

4.1.3/ Center for Basic Research in Computer Science (BRICS)

Informants describe a very successful and impactful center, which clearly helped to establish a very strong environment and a “hub” for theoretical computer science in Aarhus. They mention that it became a “brand” – something that was recognized internationally. There was a good social environment as well (including a football team, TGIF-bars etc.), which is mentioned as very important. Informants highlight that what made it special was the fact that there were many guest researchers, which was very inspiring for young researchers, and helped establish the environment, because they stayed on. In this way, the CoE grant also functioned as a “leverage” and helped attract additional funding.

Some of the key features mentioned also include the physical co-location, the freedom to pursue goals and adjust underway, and the fact that researchers could pursue common visions. The informants generally convey that the CoE was a collective.

The interaction and meetings with the DNRF were seen as a very positive feature. There is great appreciation for the focus on basic research and informants mention that CoEs create cohesion and collaboration. Very few challenges are mentioned, but it is recognized that having a CoE requires something from the host institution, and that there can be challenges involved in that.

BRICS is described as living on in the department and the environment, and also as being the basis for other CoE grants within theoretical computer science.

4.1.4/ Center for Biological Sequence Analysis (CBS)

Informants describe a very successful CoE and mention that it has made a significant impact on the field by almost establishing bioinformatics as a field. One informant mentions a “pioneering spirit” as a key characteristic of the CoE and a sense of “paving the road as we were driving”.

The center continued to run after the grant ended and to some extent ended up in the establishment of a department at DTU (DTU Health Tech). A key positive aspect of the CoE mentioned by informants is the explicit focus on basic research; allowing it to be academically interesting and relying on that something applied will come later is seen as highly valuable. Or as one informant puts it: allowing for “useless basic research”.

The follow-up from the DNRF and the “co-creation” is mentioned as positive elements, as is the size of the grant, even if the informants mentioned that this was a “cheap” center. It is also pointed out that where newer grants are one-man-shows, the CoE are focused more on team-science, which is seen as more compatible with how science actually works. The main challenge mentioned is that the grant runs out. Furthermore, one informant makes a point about

risk: Since it is often the already established researchers who get the CoE, this does not favor risky research.

The main legacy of the CoE is described by informants as the establishment of bioinformatics as a field. This has also led to other centers focusing on bioinformatics, and to some extent also to the establishment of an entire department at DTU.

4.1.5/ The Copenhagen Muscle Research Center (CMRC)

CMRC is described as a highly inspirational CoE and as key in establishing “the field” and an environment which is described as “the best in the world”. Informants describe how the CoE put “Copenhagen on the map” and that the CoE was an excellent community, where researchers from a wide range of fields worked together and had common goals. It is also described as a CoE characterized by strong personalities, which also is seen as inspirational and potentially challenging. Collaboration is a term which is often used by informants, as something which is particular for this CoE, as well as freedom to pursue the original ideas.

A key element which is mentioned is that the PI and the norms and values promoted by the senior researcher is key to the success of a CoE. Mentorship and passing on freedom and autonomy to the younger researchers is described as important, and informants also highlight that in the time of the CoE there were few grants for younger researchers, so being part of a CoE was a unique opportunity.

One informant describes CMRC as a “talent factory” and indeed it seems that the legacy of the CoE is carried on by the participating researchers. Several of these have gone on to establish their own successful groups and other CoE, which build on the work carried out in CMRC.

4.1.6/ Centre for Solid Phase Organic Combinatorial Chemistry and Molecular Recognition (SPOCC)

SPOCC was located at the Carlsberg Research Laboratory, which is described as a very inspirational environment, and as one which was highly successful at the time. The CoE is seen as a place that had space and room for differences (“højt til loftet”), and informants mention the motivation that they experienced in working with high-class researchers at the CoE. As one informant describes it: “when you talk about a research project, you describe the results, but when you talk about a CoE, you tell a story”. The CoE is thereby seen as a “whole story”.

Informants emphasize the “center-way of doing research” as a main component in the success of the CoE. A larger group and a longer time span are thereby seen as vital, as it creates continuity in the activities and room to make mistakes and change direction. The PI is described as very important, but also the fact that there was room for autonomy for younger researchers to grow and carry out independent work. The DNRF collaboration is seen as very beneficial for the CoE work. Some challenges are mentioned, particularly in relation to building the organization and constructing the administration and leadership style.

The legacy of the CoE is very much described as being the people and the mindset that characterized the work – and which was closely linked with the PI. The main legacy, however, can be seen as the Nobel Prize in Chemistry, which was awarded to the PI (along with two international collaborators) in 2022.

4.1.7/ Center for Demographic Research (Demog)

Informants describe a highly inspirational environment, which has very close ties to the Max Planck institute in Rostock via one of the PIs. The grant is described as enabling large scale data collections, which are still used today, and which would not have been possible on smaller grants. They describe how the flexibility of a CoE grant and the freedom to make decisions and change direction is a strong and valuable feature of the concept. This also trickles

down and provides flexibility and a “room to maneuver” also for younger researchers, giving them autonomy and a learning space that was unique for an early career researcher.

Informants highlight how the CoE gave unique opportunities for PhDs and Postdocs, and that this depends on whether the PI is good at mentoring and giving responsibility. Not many challenges are mentioned, but there is, however, some reflection upon the risk of “skewing” the PhD population towards a specific area, which is not always able to absorb them afterwards.

The CoE has paved the way for a number of subsequent grants and centers and is described by informants as the building block for the Interdisciplinary Centre on Population Dynamics (CPop) at SDU.

4.1.8/ Center for Experimental Bioinformatics (CEBI)

CEBI is described as a successful CoE, and one which to some extent lives on through embedded positions and through its impact on the local business life. It was well-renowned when it was active and has a special position in the host department.

It is mentioned that there are challenges when a CoE is established within a department and that it can lead to a “clash of cultures”. The growth that comes with a CoE needs to be “organic” and be within the profile of the department to not become isolated.

4.1.9/ Center for Quantum Optics (Quantop)

Informants describe a very good and harmonious CoE. There are descriptions of a good sense of community; the groups that were established were larger and there were more activities across the groups, which gave a good sense of collective spirit. As one informant describes it: “there is no grant like it”, and the CoE were highly visible and impactful in their environment and field.

Informants highlight the flexibility and the length of the grant as significant characteristics, because it brings with it the opportunity to put together good people. Challenges are mentioned primarily in relation to the shifts in the organizational structure and embedment. And informants also mention that it was difficult when the grant ran out, with no possibility of extension even when the CoE was extremely successful.

QUANTOP was the first large scale effort in Quantum Information Science and Technology in Denmark, and therefore had a significant impact on the development of the field in Denmark, and has left a significant legacy, both in terms of infrastructure, and the groups that still exist.

4.2/ Common patterns

Looking across the interviews from the CoE cases, there are a number of common themes that provide insight into the strengths and weaknesses of both the individual CoEs, but also the concept as a whole. In this section, these themes are unfolded and followed by a number attention points that emerge from the themes.

4.2.1/ Strengths and potentials

Many informants mention that the approach of the DNRF at the time with visits from the board and director was a very helpful and appreciated practice. It is mentioned several times, that these visits were more than “check-ups”, but were constructive and authentic inquiries into the progress and focus of the CoE, which kept CoE leadership and staff “on their toes” without feeling like micro-management. One particular strength of this, which was mentioned by some of the informants, was that it was not only the CoE director who was present and presenting at the meetings, but also junior staff, which led to a feeling of ownership amongst the junior staff.

Focus on interdisciplinarity is also mentioned several times as a strong feature of the CoE. The opportunity and encouragement to bring together researchers from many different fields and areas is by many informants mentioned as a key factor in the success of the CoE. The grant facilitates this, where other types of grants are seen as more “conservative” or mono-disciplinary.

Along the same lines, the collective aspect of the CoE concept is also mentioned by many – although it emerges as both a strength and a potential challenge. The strength of the collective lies in the opportunity to put together a large group – critical mass is a term used by most of the informants. The physical co-location of this creates a strong internal bond and collective sense of identity, and many describe also a close social bond which endures even today.

4.2.2/ Challenges

However, there are also challenges involved, even in the face of all the positive aspects mentioned above. First, the physical co-location and sense of collective which was mentioned above, also has drawbacks, as it is mentioned several times, that some of the CoEs became “islands”, isolated from the surrounding local, academic community, which may make it difficult to re-integrate when the CoE closes.

And exactly this, that the CoE closes, is mentioned by most informants during the interviews. Some describe it as very severe, and others more as a natural development. But nonetheless, many informants describe that it was a difficult transition from being a CoE to something else. The case CoEs obviously have very different trajectories and embeddings, ranging from still in existence in some form, to being almost instantaneously shut down and dispersed. But most still mention that the transition was a difficult process, which took time and energy.

Another challenge which is mentioned is that it takes a lot of effort to establish a CoE, both in terms of negotiating terms and embedment with the host institution, and in terms of building up an organization, both academically and administratively. This process is tied very closely to the CoE director and many of the CoE directors from these early rounds were, according to informants, relatively young and thereby did not necessarily have experience to draw on in relation to this.

4.2.3/ Effective elements in the CoE framework

With these findings in mind, it seems possible to elaborate on the theoretical model which was tested in chapter 2 of this report. The interviews shed light on potential links and dynamics, which can obviously not be confirmed based on the qualitative study, but at the very least provide interesting insight into the workings of the CoEs.

Mainly, the interviews provide support for the connection between the stability provided by the CoE grant and recruitment options, as well as collaboration opportunities. As mentioned above, stability is seen as both enabling recruitment of the best researchers within the field, because it is possible to offer them more long-term employment, but also as a facilitator of collaboration, because it moderates the hyper-competition and allows for a more collective effort.

Additionally, the interviews seem to support a connection between volume and research infrastructure. Several informants mention that the size and length of the grant enables, e.g., an establishment of large datasets, complex experimental, setups etc. which would not have been possible otherwise.

4.2.4/ Attention points

This overview of common themes leads to three attention points regarding sustainable outcomes of the CoEs.

Firstly, it seems clear that *legacy requires maintenance*. Several informants point out that many of the early CoEs became “brands”, that were known worldwide within their fields. But it is also pointed out that such brands lose their shine after a time if they are not sustained and maintained. This is of course because science and the scientific world moves forward at an accelerated speed. This is related to the common descriptions of the difficult transition into CoE-after-life. As mentioned above, several informants describe the transition from being a CoE to something else as difficult. Some, however, describe how this transition was made easier by the continual planning and reflection upon what should happen when the grant ran out. The continual application for additional funding seems to have made it easier for these CoEs to transition into a new state after the CoE grant had ended, and this “exit strategy” might be something that could be fostered and encouraged as an integrate part of the CoE grant itself.

A second point is the focus on “the next generation”. Many informants describe how the legacy of the early CoEs also lies very much in the people associated with the CoEs – the PhDs and postdocs who were a part of the centres and who are now spreading the work and knowledge gained here across the world. A few of these (then) junior researchers mention that it might have been beneficial if the DNRF had had an explicit focus on their capacity and competence building, e.g., through network activities for junior researchers across CoEs, or activities aimed at enhancing their skills e.g., in relation to application writing.

A final point, which is also described above, is the challenge involved in managing and organizing an “organization” like a CoE. Several centre leaders – and junior researchers – mention difficulties in relation to management (e.g., finding a leadership style that fits one's own personality as well as the CoE setup), administration (e.g., lack of experience with accounting, budgeting, and other types of administrative tasks), or organization (e.g., constructing and implementing an organizational structure, which fits the work and leadership style of choice). Given the importance of the PI, which is also mentioned in the sections above, it might be worth considering how best to support a well-functioning organization and management of the CoE, to ensure that the PI has time and resources to act as a mentor and academic “light-house”, which is by most informants mentioned as key to success.

5.0 Appendix

This chapter presents methodological details, abbreviations and the reference list used in the report.

5.1/ Methods

5.1.1/ Procedure for survey

An electronic survey was sent out to Center Directors at CoEs from the first four rounds. We excluded two CoEs (CAMP and DARC) because present members of the DNRF had been part of their management. In case a Center Director was not contactable, e.g., due to illness or because he/she had retired, the survey was sent to a Co-PI of the CoE instead. The survey was sent May 2nd, 2023, two reminders were sent on May 9th and May 16th, respectively, and the data collection closed May 16th. We received 32 out of a possible 60 responses yielding a response rate of 53%. Table 3.1. show descriptive statistics for the population (all CoEs contacted) and sample (CoEs that answered the survey).

Table 5.1: Statistics for survey sample and population

		Population		Sample	
		%	N	%	n
Round	1	38%	22	31%	10
	2	16%	9	19%	6
	3	21%	12	28%	9
	4	26%	15	22%	7
Research area	Humanities and the Arts	16%	9	25%	8
	Social Sciences	7%	4	6%	2
	Medical and Health Sciences	36%	21	31%	10
	Engineering and Technology	31%	6	28%	3
	Natural sciences	10%	18	9%	9
Main host institution	KU	33%	19	38%	12
	AU	21%	12	19%	6
	DTU	12%	7	6%	2
	SDU	10%	6	13%	4
	Other	24%	14	25%	8

Note: Percentages may not sum to 100 due to rounding.

Table 5.1 demonstrates that the sample adequately reflects the proportions of rounds, research areas, and main host institutions found in the population. Therefore, we conclude that the sample has an acceptable level of representativeness. Still, the results from the survey should be cautiously interpreted as the number of respondents is low and because the questions concern events which happened many years ago.

5.1.2/ Procedure for interviews

For this study, a total of 28 interviews were conducted. The informants were selected based on their affiliation with the case CoEs as this was indicated in the documents obtained from the DNRF. We attempted to recruit informants representing both center management, junior researchers (at the time of the CoE) and institutional leadership. In the latter category, most informants represent current or more recent institutional management, but in many cases with an in-depth knowledge of the CoE in question.

An interview guide was constructed, based on the research questions and early results from the survey. The guide focused on experiences related to the establishment and “life-course” of the CoE, the perceived legacy as seen by the informants, and the characteristics of the CoE framework, including strengths and potential weaknesses. The interviews were conducted (primarily) online and lasted between 30-60 minutes. They were recorded and notes were taken, but not transcribed.

5.1.3/ Procedure for bibliometric analysis

The methodological details for the bibliometric analysis are presented in greater detail in the report: Schneider, J. W., & Costas, R. (2013). Bibliometric analyses of publications from Centres of Excellence funded by the Danish National Research Foundation. Accessible via: https://dg.dk/wp-content/uploads/2018/10/Appendiks_5_bibliometrisk_report_03122013.pdf

5.2/ Abbreviations

Table 5.2: CoE abbreviations

Abbreviation	Center
ACAP	Center for Atomic Physics
BioRec	Center for Biomolecular Recognition
BRICS	Center for Basic Research in Computerscience
CAM	Centre for Applied Microeconometrics
CAMP	Center for Atomic Scale Materials Physics
Catalysis	Center for Catalysis
CBS	Center for Biological Sequence Analysis
CCS	Centre for Crystallographic Studies
CEBI	Center for Experimental Bioinformatics
CEP	Danish Center for Experimental Parasitology
CFIN	Center for Functionally Integrative Neuroscience
CfL	Center for Sound Communication
CfS	Center for Subjectivity Research
CHMR	Centre for the Study of the Cultural Heritage of Medieval Rituals
CLS	Centre for Labour Market and Social Research
CMRC	The Copenhagen Muscle Research Center
CPC	Copenhagen Polis Center
DCESS	The Danish Center for Earth System Science
DCRS	Danish Centre for Remote Sensing
Demo	Center for Demographic Research
DESC	The Danish Epidemiology Science Centre
Enzyme	Center for Enzyme Research
EPRU	Economic Policy Research Unit

GRPENE	Center for Gene Regulation and Plasticity of Neuro-Endocrine Network
HuMaInt	Center for Human-Machine interaction
ICCH	International Research Centre for Computational Hydrodynamics
Lithos	Danish Lithosphere Centre
M4D	Center for Fundamental Research: Metal Structures in Four Dimensions
MaPhySto	Network in Mathematical Physics and Stochastics
MarArc	Center for Maritime Archaeology
MEMPHYS	Center for Biomembrane Physics
NAC	Nucleic Acid Center
PlaCe	Center for Molecular Plant Physiology
PlaMicSym	Center for Plant-Microbe Symbiosis
PONTOS	Centre for Black Sea Studies
QUANTOP	Center for Quantum Optics
QuP	Quantum Protein Centre
SemRes	Center for Semiotic Research
SKC	Søren Kierkegaard Research Center
SMI	Center for Sense-Motor Interaction
SPOCC	Centre for Solid Phase Organic Combinatorial Chemistry and Molecular Recognition
TAC	Theoretical Astrophysics Center
V&S	The Water and Salt Research Centre
WJC	Wilhelm Johannsen Centre for Functional Genome Research

Table 5.3: University and research institute abbreviations

Abbreviation	Institute
CA	Carlsberg Research Laboratory
DTU	Technical University of Denmark
GEUS	Geological Survey of Denmark and Greenland
KU	University of Copenhagen
KVL	The Royal Veterinary and Agricultural University
NatMus	National Museum of Denmark
RH	Rigshospitalet
RISØ	Risø National Laboratory
SDU	University of Southern Denmark
AAU	Aalborg University
AU	Aarhus University

Table 5.4: Research areas

Abbreviation	Research area
HUM	Humanities and the Arts
SOC	Social Sciences
HEALTH	Medical and Health Sciences
TECH	Engineering and Technology
NAT	Natural Sciences

Table 5.5: CoE fully or partially included in the bibliometric analysis (Figure 3.3.)

CoE No.	CoE name
2	Center for Epidemiologisk Grundforskning

4	Teoretisk Astrofysik Center
5	Center for Atomfysik
6	Center for Materiale fysik på Atomart Niveau
8	Internationalt Center for Numerisk Hydrodynamik
9	Dansk Center for Telemåling
10	Dansk Lithosfærecenter
11	Center for Eksperimentel Parasitologi
12	Center for Biologisk Sekvensanalyse
13	Center for Biomolekylær Genkendelse
14	Center for Muskelforskning
15	Center for Sansse-Motorisk Interaktion
16	Center for Lydkommunikation
17	Center for Krystallografiske Undersøgelser
18	Center for Enzymforskning
19	Center for Genregulation og Plasticitet i det Neuro-endokrine Netværk
23	Center for Forskning i Økonomisk Politik
31	Center for Fastfase Organisk Kombinatorisk Kemi
32	Center for Katalyse
33	Center for Plantemikrobe Symbiose
34	Demografisk Forskningscenter
35	Center for Jordens Klima og Biokemiske Kredsløb
36	Center for Matematik, Fysik og Stokastik
37	Center for Molekylær Plante fysiologi
38	Center for Eksperimentel Bioinformatik
40	Center for Metal Structures in 4 Dimensions
41	Center for Nucleic Acid
42	Centre for Applied Microeconometrics
43	Center for Biomembrane Physics
44	Center for Quantum Optics
45	The Water and Salt Research Center
46	Quantum Protein Centre
47	Center of Functionally Integrative Neuroscience
48	Wilhelm Johansen Center for Functional Genome Research
51	Centre for Subjectivity Research
53	Nordic Center for Earth Evolution
54	Centre for Individual Nanoparticle Functionality
55	Centre for Inflammation and Metabolism
56	Centre for Genotoxic Stress
57	Centre for Social Evolution
58	Centre for mRNP Biogenesis and Metabolism
59	Centre for Insoluble Protein Structures
60	Center for Oxygen Microscopi and Imaging
61	Center for Viscous Fluid Dynamics
62	Dark Cosmology Centre
65	Centre for Models of Life
66	Danish Arrhythmia Centre

67	Center for Sustainable and Green Chemistry
68	Center for Molecular Movies
78	Center for Research in Econometric Analysis of Time Series
79	Center for Carbohydrate Recognition and Signaling
80	Centre for Comparative Genomics
81	Centre for DNA Nanotechnology
82	Centre for Epigenetics
83	Centre for Ice and Climate
84	Centre for Massive Data Algorithmics
85	Membrane Pumps in Cells and Disease

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