ORGANISATIONAL CAPACITY, LEADERSHIP AND MANAGEMENT OF AUSTRALIAN RESEARCH CENTRES OF EXCELLENCE

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ABSTRACT

Centres of Excellence (CoE) are increasingly adopted by governments world-wide as a mechanism for the funding of science, technology and innovation activities in the knowledge-based society. Behind the adoption of policies for the creation of CoE there are some key underlying strategic rationales, such as fostering scientific excellence, promoting relevance of research to societal problems and building scientific and technological capacities in areas deemed of national significance.

Research on CoE is usually performed at the macro science and innovation policy level, and the associated trends of increased selectivity and concentration on the allocation of public funds (Hellstrom, 2013; Hellström, 2017; Orr, Jaeger, & Wespel, 2011) or assessing individual programs across different countries (Aksnes et al., 2012; Beerkens, 2009; Cremonini, Horlings, & Hessels, 2018; Hellstrom, 2011). There is a considerable gap in the literature of studies focused at the micro, organisational level. More specifically, there is a need to understand the fundamental nature of CoE in terms of the organisational capacity required to establish such centres.

This study aims to contribute to addressing that gap. It draws upon the long-standing Australian experience in running CoE programs by investigating centres created in the framework of two major governmental programs – the Australian Research Council Centres of Excellence program, and the Cooperative Research Centres program.

To investigate CoE organisational capacity, two well-validated frameworks were used as theoretical and analytical lenses: Toma's (2010) 'Building Organisational Capacity' which supported identifying and understanding the nature of CoE key organisational elements; and Quinn et al. (2007) 'Competing Values Framework' which facilitated an in-depth exploration of key leadership and management roles.

By means of an Interpretive Inquiry, a qualitative multi-method approach served to investigate the CoE organisational setting as the unity of analysis. A sample consisting of six active and long-standing Australian CoE was identified on the basis of a pre-defined, purposive selection criteria aimed at narrowing down the number and diversity of existing centres in a meaningful way. Data was collected through three methods – document analysis, face-to-face semi-structured interviews and observations carried out during site visits.

Results allowed for identifying which elements are at the core of building organisational capacity of CoE, given their role in informing and shaping other elements. Findings suggest that symbolic elements such as 'purpose' and 'culture' play a crucial role in representing and conveying the organisational nature and profile of a CoE and are strongly perceived to influence all other aspects and capabilities of a CoE. Moreover, 'culture' has been found to be consistently harnessed as a mechanism to increase the cohesion and performance of CoE collaborative teams. Similarly, given its strong emphasis on collaboration, 'Governance' as an element is perceived to have a distinct function and significance depending on the centre orientation. The role of leadership and management (L&M) appears to be critical in building and maintaining CoE organisational capacity.

This study shows that the appropriateness of organisational capacity and L&M approaches depends on the profile of a CoE which, in turn, is determined by the nature of the problem tackled and the purpose and use of knowledge and technology produced at the centre.

DECLARATION

I hereby declare that this thesis comprises only my original work towards the Doctor of Philosophy. This thesis contains no material previously published or written by any other person except where due acknowledgement has been made in the text.

The thesis is fewer than the maximum word limit in length, exclusive of tables, maps, bibliographies and appendices, and complies with the stipulations set out for the degree of Doctor of Philosophy by the University of Melbourne.

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'Never let the future disturb you. You will meet it, if you have to, with the same weapons of reason which today arm you against the present.'

Marcus Aurelius

'In a dark place we find ourselves, and a little more knowledge lights our way.'

Star Wars Episode III: Revenge of the Sith

'A group of people can be smarter than its smarter member – but only if those members have different ways of thinking and seeing the world, and only if those things mix and match and smash together.'

Shane Snow

DEDICATION

This thesis is dedicated to my daughter Vicki, my pride and joy, who was born during the course of this work.

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ABBREVIATIONS AND GLOSSARY

ARC: Australian Research Council

BOC: Building Organisational Capacity Framework

CoE: Centre(s) of Excellence

CRC: Cooperative Research Centre(s)

CVF: Competing Values Framework

ERA: Excellence in Research for Australia

EU: European Union

Experimental development: systematic work, using existing knowledge gained from research or practical experience, that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially to those already produced or installed.

GDP: Gross domestic product

GERD: Gross domestic expenditure on R&D as a percentage of GDP

HE: Higher Education

HEI: Higher Education Institutions

HERD: Higher education sector spending on R&D as a proportion of GERD

In-kind contributions: a contribution of goods, services, materials and/or time to a ST&I program from an individual, business or organisation.

Innovation: Onadera and Kim (2008, p. 112) define innovation as "the successful exploitation of new ideas and the invention, development and commercialization of new technologies, services, business models and operational methods. Innovation is thus related to a process connecting knowledge and technology with the exploitation of market opportunities for new or improved products, services and business processes compared to those already available on the market".

Institutional-based funding: block funding allocated to institutions on an annual basis which can be used in any discretionary way. Basic research is usually supported from this type of funds.

L&M: Leadership and Management

NHMRC: Australian National Health and Medical Research Council

NIS: National Innovation Systems

OECD: Organisation for Economic Co-operation and Development

PFRA: Publicly-funded research agency

PFRO: Publicly-funded research organisation

Project-based funding: funding attributed on the basis of a competitive project application addressed to a funding body (usually research councils) by a group or individuals to undertake a R&D activity that is limited in scope, budget and time. Contract research often falls under this label since it is also project-based.

PubGERD: Public expenditure on R&D as a percentage of GDP

R&D: Research and Development

RDI or RD&I: Research, Development and Innovation

REI: Research Excellence Initiatives

Research emphasis: the definitions below were adopted from the Australian Department of Education, Employment & Workplace Relations (DEEWR).

Research (applied): original work undertaken primarily to acquire new knowledge with a specific application in view. It is undertaken either to determine possible uses for the findings of basic research or to determine new ways of achieving some specific and predetermined objectives.

Research (basic): experimental or theoretical work undertaken primarily to acquire new knowledge without any particular application or use in view.

Research (strategic): experimental and theoretical work undertaken to acquire new knowledge directed into specified broad areas that are expected to lead to useful discoveries. It provides the broad base of knowledge necessary to solve recognised practical problems.

S&T: Science and Technology

SME: Small and medium enterprises

STI or ST&I: Science, Technology and Innovation

CHAPTER 1. INTRODUCTION

1.1 Background

Why CoE constitute a relevant and timely topic for research

Centres of Excellence (CoE) have been widely adopted by national government agencies worldwide over the last two decades and used as an instrument for funding of and capacity building in research, technological development and innovation (Hellstrom, 2013; Orr et al., 2011). The growing interest by policy-makers on CoE is due to the key role attached to knowledge generation and application in our globalised knowledge society. In this paradigm, there is an assumption and expectation that investments in research, development and innovation (RD&I) will translate into socio-economic development, particularly with a national focus. For this reason, there has been a continued interest, at the policy level, to identify effective mechanisms to better promote and harness the production of basic and applied knowledge.

At the knowledge production level, research leaders need to attract funds, and engage in science that addresses societal grand challenges but still find obstacles to join and successfully participate in large-scale collaborative projects with a diversity of partners; this demands resources and specific leadership and management skills in addition to necessary scientific capacity. Therefore, the interest in new forms of collaborative and knowledge-intensive organisational settings is a critical and booming area of research (Cooke, Uranga, & Etxebarria, 1997; Foray, 2015; OECD, 2014c; Öquist & Benner, 2012; Orr et al., 2011).

CoE constitute a particular type of organisational structure which is widely used in OECD countries and increasingly in developing countries that see it as a promising tool to build national capacity. Nevertheless, studies in this field are scarce, usually focused at the national and program levels (Aksnes et al., 2012; Cremonini et al., 2018), with more research required if the potential of this type of organisation is to be realised and positively affect research and innovation performance. This doctoral study explores

this gap, thereby contributing more broadly to research and innovation performance scholarship.

Science Policy and drivers behind the adoption of CoE funding programs

Up to now, CoE programmes are rolled out to implement policy agendas within what is currently known as "science policy" drawing on the widespread theoretical perspective of National Innovation Systems (NIS) (Nelson, 1993). Since the early 1990's, countries with developmental trajectories as diverse as Canada, Finland, South Africa, Norway, China, and Australia have introduced government-funded CoE schemes. It is interesting to note that both developed and developing nations display particular reasons for adopting CoE as part of their national research and innovation strategies. As a result, the CoE concept has emerged as an instrument to address two major challenges: 1) fund large, complex, and expensive research programs in scientific areas potentially strategic for the country and 2) steer and concentrate research resources on selected topics or problems of perceived relevance to end-users of research.

The conception and adoption of CoE as organisational settings for research and innovation comes as a response to a number of underlying issues and reflect wider dynamics at play. First and foremost is the 'critical mass' argument which regards the recognition that the most pressing problems and grand challenges of our time (such as climate change and renewable energy sources) can only be tackled through collaboration, particularly through multidisciplinary or interdisciplinary research. From a scientific knowledge-production perspective, CoE have been used to pursue topics at the frontier of knowledge production and to facilitate the consolidation of the critical mass of resources needed for groups to perform at an internationally competitive level. The increasing global competition for resources, particularly high-skilled human capital, and the need for organisational arrangements that facilitate collaboration (including inter-institutional, international, or multidisciplinary collaboration) is another type of demand met by CoE.

From the perspective of national science, technology and innovation (STI) systems, CoE emerged to implement the processes of prioritisation and investment in

areas of strategic importance as well as to support the argument of efficiency and cost-effectiveness on the use of tax-payers money in fostering RDI activities. Funding agencies in the more consolidated research systems of developed countries are looking for more selective ways of administering increasingly scarce and contested research funding and at the same time bridging the gaps between research producers and users. Conversely, developing nations are primarily concerned with developing research capacity in niche or strategic fields that could contribute to socio-economic development, support the international competitiveness and leadership aspiration of national groups and offer a competitive edge to domestic industry.

From a research-user, problem-based perspective, CoE have been introduced as an instrument to bridge the gap between research-producers and research-users. Many CoE programs have a core focus on inter-sector collaboration, implementing ideas based on the "knowledge triangle" and focusing on the potential "impact" (social, economic or environmental) of research outputs.

How CoE are defined in the context of this study

The term "Centre of Excellence" has come to be used in a multitude of contexts (depending on the country, sector or disciplinary field) and has come to acquire very different connotations since its original inception.

In this study, the term 'CoE' is adopted to refer to a particular type of research centre, an organisation for the conduct of research, development and innovation activities.

CoE are framed in this study as organisational entities, and for that, defining the meaning of the term 'organisation' is necessary. In this study, 'organisations' are defined as social units of people that are structured and managed to pursue a collective goal. As Buchanan and Huczynski (1991) put it, in line with the scholarly tradition of organisational studies, "organisations are social arrangements for the controlled performance of collective goals" (p. 7).

Also, a key characteristic of CoE under the scope of this study is that these centres are typically created as a result of a competitive funding allocation process launched by governmental funding agencies to implement an underlying policy agenda. In response to such calls, consortia of academic and non-academic partners submit CoE funding proposals. Such bids are required to propose research and operational plans for a fixed-term period that ranges from seven to fifteen years. Co-funding is a major feature of these CoE schemes. Budgets are a combination of public funds matched by cash and in-kind contributions on behalf of partner organisations.

Drawing upon these considerations, it is timely to introduce the operational definition of CoE adopted for this study. In line with Hellstrom (2017, p.2) CoE are defined as "organisational environments that strive for, and succeed in, developing high standards of conduct in a field of research, innovation, or learning". In addition, for the purposes of this study, they are characterised by the following:

- Created in the framework of governmental programs for STI;
- Strongly oriented by a pre-defined strategic mission;
- Underpinned by collaboration (inter-institutional, inter-sectoral, international);
- Often multidisciplinary;
- Tackle large-scale problems and operate over longer timelines than typical projects under competitive funding, and
- There are usually high expectations placed on outcomes and impact assessment by the funding organisation.

CoE initiatives are one of the most widely-adopted policy instruments in the context of national science and innovation policy (Aksnes et al., 2012; Atkinson-Grosjean, 2006; Orr et al., 2011). Despite its popularity, relatively little research has been conducted about CoE operation, particularly at the organisational grass-roots level, with a view to understanding the dynamics in place and hopefully designing better, fit-for-purpose centres.

Both practitioners and scholars acknowledge the need for better understanding of what makes CoE effective organisations in achieving their pre-defined mission and in delivering expected impact. More importantly, research on what collaborative and excellence-driven organisations such as CoE is needed if their potential is to be fully realised in an increasing knowledge-intensive society (Dill & Van Vught, 2010c; Garret-Jones & Turpin, 2009; O'Kane, 2008).

Another major outcome from a review of the literature that underpins this study is that leadership and management (L&M) approaches are consistently seen to have a critical role in CoE effectiveness and perceived success. Given this contextual relevance, the existing gaps in the knowledge base and the highly specific nature of L&M in the context of research-intensive organisations, provide the motivation and claims of significance for this study.

1.2 Research Problem and Rationale for the Study

While there is significant and growing interest in CoE, there is relatively little scholarly work published yet on this topic. Policy-makers want to adopt or improve funding programs for the creation of CoE. Developing countries weigh if it is a viable and effective tool to channel scarce resources into building national scientific capacity. Scientists and research leaders weigh up the cost-benefits of joining CoE consortia and often lack the necessary knowledge, and skills to design, apply for and manage a CoE bid. Users of research are extremely interested in closing the gap that separates them from knowledge producers in order to be more innovative.

In addition, CoE are complex organisations to set-up and run. Very few groups have the necessary capacity to design a competitive CoE bid as little is known yet about how to match a research problem to the necessary strategic and organisational capacity involved when assembling and resourcing consortia. Once operational, CoE are characterised by large budgets, a very diverse and distributed partnership, multiple demands and often ambitious goals to be accomplished in a pre-defined time-frame. Adequate leadership and management becomes critical in these circumstances. Indeed,

CoE funders, program reviewers and participants emphasise the need for better leadership and management approaches as a pre-condition for effective performance of CoE.

To bridge these gaps, it is necessary to understand the basics of CoE. This study maps out CoE organisational elements and the different dynamics in place for leadership and management. This process draws attention to how these organisational elements interrelate and which elements have a key role in shaping a centre's profile.

CoE are complex organisations that are put in place to tackle the challenging processes of knowledge production and utilisation. A poor understanding of the organisational nature of CoE leads to considerable inefficiencies in the use of R&D resources (particularly human resources), the use of public and private research funds, and on the overall performance and impact of centres, compromising the potential of this promising instrument.

Research problem:
How can we understand the nature and character of CoE as an organisational setting for the conduct of RD&I activities?

1.3 Scope of the Study and Research Questions

This study is concerned with better understanding the organisation and operation of CoE as organisations for the conduct of ST&I activities. Its focus is to investigate the elements of CoE organisational capacity. This study adopts Toma's definition of organisational capacity: "capacity is the administrative foundation of an institution which is essential for establishing and sustaining initiatives intended to realise its vision" (Toma, 2010, p. 3).[1]

[1] A detailed description of Toma's organisational capacity framework is presented in Chapter 4.

The proliferation of CoE schemes has led to a great deal of research about the overarching policies for the establishment of CoE. However, very little attention has been dedicated to the organisational capacity including the nature of CoE's research leadership and management. This PhD thesis aims to address this gap.

To do this, the geographical focus is on Australia, one of the pioneers in the creation of state-sponsored CoE schemes to support RD&I activities. Australian CoE have been running for decades but recent program reviews and guidelines point to the need for more research to inform program improvement and evidence-based policy-making, as well as support CoE members to become more effective in their leadership and management approaches (Allen Consulting Group, 2012; ARC, 2017; Garret-Jones & Turpin, 2009; Gray, 2000; O'Kane, 2008).

Thus, this study will investigate those CoE created in the framework of governmental agencies' funding programs requiring the creation of multi-institutional consortia which are often also multi-sector and interdisciplinary. In addition, CoE to be studied are co-funded on the basis of pre-defined periods of seven to 15 years and upon the end of public funding they must transition into another legal entity.

Research excellence does not occur accidentally or easily, particularly in large collaborative research groups. At this level, involving high-performing individuals, large budgets and expensive research and development infrastructures, the importance of fit-for-purpose approaches and individuals who are equipped with appropriate leadership and management skills becomes evident. This study is set out to understand what "appropriate approaches and skills" means in the context of CoE (ARC, 2017). To explore this, the study is organised around one main research question which is segmented into two sub-questions.

1.3.1 Research questions

Key research question:

What is the organisational capacity of a CoE?

- Sub-question 1

What are the elements of CoE organisational capacity?

- Sub-question 2

What leadership and management (L&M) roles come to the fore at CoE?

The key research question addresses the research problem tackled by the study which is to understand the 'organisational capacity' (the administrative foundation) of CoE. To do that, two subsidiary research questions structure the research around two major dimensions of organisational capacity according to the literature – the key organisational elements required for the operation of a CoE and, the key L&M roles perceived as critical in these organisations.

1.4 Audiences

This study covers a range of topics relevant from both scholarly and practitioner perspectives. The findings of this research are relevant to the following audiences:

First, researchers and graduate students active in the field of higher education studies, organisational capacity, or research and innovation policy and management. To this scholarly audience, the study's conceptual significance and contributions in regard to the constructs of 'governance' and 'leadership & management' of CoE are particularly relevant. As far as governance is concerned, the study offers a sound conceptual understanding on the nature of CoE governance at the organisational level, a topic that is usually tackled at the system or policy levels. The study's empirical base allows for appreciating how governance is perceived in this organisational setting and what key aspects it encompasses, leading to a conceptual abstraction of key principles of good governance at CoE stemming from studied organisations. Similarly, the study offers a strong conceptual understanding on the nature of leadership and management in the

organisational context of CoE. The conceptual contributions are made in three main domains within leadership and management roles identified in the study. Such conceptual contributions are elaborated in the presentation of findings (Chapters 5 and 6) and within the Discussion and Conclusions (Chapter 7).

Second, scientists, research leaders and managers (such as centre managers, chief operating officers, centre directors and principal investigators) with responsibilities in leading and managing research in CoE or similar collaborative, large, interdisciplinary, and often publicly-funded, research centres and networks.

Third, policy-makers interested in an analysis of the grassroots practitioner perspective within collaborative research environments and looking for empirical evidence and conceptual understandings for designing or improving CoE policy instruments.

1.5 Research aims

This study aims to shed light on the nature of CoE as an organisational environment used for the conduct of RD&I activities. It has two primary aims:

1. To identify the nature of the CoE organisational capacity
2. To understand the role of leadership and management in building and maintaining CoE organisational capacity

With these aims the study aims to address the existing gap at the micro (organisational) level contributing to the current scholarly line of inquiry towards understanding how CoE can be used as mechanisms to support the production of knowledge, technology and innovation and their relevance to society. Another key contribution of the study is offering new insights into the nature of leadership and management required in these types of organisations.

1.6 Limitations

This study is constrained by the limitations of a PhD research project in terms of time and resources (financial and human) available. In that sense, the empirical phase is limited regarding the number of centres and individuals that can be investigated. The

geographical dimension of Australia adds an extra burden in terms of field work as CoE nodes are often scattered across the nation.

There is a wide diversity of CoE profiles in terms of the core scientific disciplines, nature of the problem tackled, and core centre purposes (from knowledge advancement to the economic exploitation of technological innovations) found in each centre, and for that reason, the study adopts an interpretive methodology research design aimed at producing a rich, thick description and analysis of selected case studies that can serve to shed light on complex and under-researched social phenomena.

Both potential limitations in terms of geographical spread and diversity of existing CoE in Australia are addressed and justified in Chapter 2 – Research Design and Methodology.

There are advantages and limitations inherent to any research paradigm and methodology. In the case of a qualitative interpretive paradigm the limitations typically revolve around the possibility of extending or generalising results to a wider population.

In this sense, the present study does not aim to make sweeping generalisations that are applicable to any possible existing or future CoE. Instead, it provides an in-depth analysis of archetypical centres and intends to make meaning from data to point out to basic elements and approaches that are relevant to centres with similar characteristics and circumnstances. As discussed in the findings and conclusions chapters, it is up to the reader to identify such similarities and applicability of research findings. The adoption of such research approach was preferred as it clearly suits the research problem and the perceived strengths are clearly outweighted by its limitations, namely the possibility of producing rich evidence about under-investigated complex social units (CoE) opening up avenues for future research as identified in the last chapter.

Finally, the researcher acknowledges that she is the primary instrument of data collection and analysis and that the process of inquiry is based upon interpretation. Therefore, I have, to the best of my ability, tried to be as transparent and objective so that the research, analysis and discussion process is made clear to the reader.

1.7 Chapters Outline

This thesis is structured as follows:

Chapter one introduces the study by offering the reader an overview of the background and rationale of the thesis. The scope of the project is defined and narrowed down to its aims and significance operationalised by its research questions. The target audiences that will potentially be interested in its outcomes are identified.

Chapter two sets out the research design adopted for the study. It describes the rationale behind the study's methodology and the connection between its components. The empirical stage is described including the methods of data collection and the approach for data analysis.

Chapter three presents the context for the study and narrows it down to its specific research focus. At the same time, it locates the study within the existing literature by reviewing relevant research.

Chapter four presents the two frameworks that together provide the conceptual and analytical under-structure for the study. This chapter presents the theoretical foundations of each framework, the reasons for their adoption and their role in the conduct of the study.

Chapter five is the first of three chapters presenting the key findings of the study. Under the theme of "Governance", this chapter encapsulates the findings associated with governance of CoE at the organisational level. Conceptualisations and practical approaches are described based on the evidence collected during the study.

Chapter six is the second chapter presenting key findings with an overarching focus on the leadership and management capacities found at studied CoE.

Chapter seven is the third findings chapter as it brings together the several threads identified in the previous two chapters. The interrelations and analyses of the findings are discussed. It also provides a summary of the study and its findings in the light of the research questions and goals.

CHAPTER 2. RESEARCH DESIGN AND METHODOLOGY

The previous chapter provided an overview of the nature, purposes, and scope of the study. This chapter describes the overall strategy used to integrate the study's components and accomplish the study's goals in a logical and cohesive way. The rationale behind the methodology for collecting, analysing, and reporting data, given the stated research problem, questions and aims, is presented.

2.1 Research problem and questions

The main research problem that this study addresses is to improve understandings about organisations known as CoE. There is still little research on CoE in general and Australian CoE centres in particular. The study aims at contributing to the existing knowledge-base by conducting an empirical investigation exploring the most fundamental features of CoE as organisations for the efficient and effective conduct of RD&I activities.

Thus, to investigate the organisational nature of CoE, the study examines the organisational capacity required for establishing a CoE; the organisational foundation necessary for the conduct of STI activities. There are neither standard models nor formal prescriptions for the structuring and operation of CoE (except for a few funding requirements to be observed when setting up a CoE). In practice, every centre is quite unique in its conception, organisation and operation.

As mentioned in Chapter 1, the research question and sub-questions for this study are:

What is the organisational capacity of a CoE?

- Sub-question 1: What are the elements of CoE organisational capacity?
- Sub-question 2: What leadership and management (L&M) roles come to the fore at CoE?

To address the research problem and question, this investigation focuses upon two key dimensions, directly derived from the research sub-questions: the first lens is primarily organisational, looking at the foundational layer to identify the general components that make up CoE organisational capacity. The second explores the nature of key leadership and management roles performed by CoE members.

To accomplish these objectives, the study is designed to carry out an empirical investigation of active Australian publicly-funded CoE by means of an interpretive methodology which enabled the enquiry to have the necessary level of depth while allowing for potential diversity of existing CoE. The broader principles behind the adoption of an interpretive research design are detailed in the following section.

The subsequent sections describe the elements of this research design and substantiate the adoption of this methodological approach.

2.2 Guiding principles and philosophical assumptions

As noted, this study adopts an interpretivist methodology. Underpinning this is a logic of justification regarding the nature of knowledge, informed by the principles of pragmatic philosophy (Newman, 2006). In this regard, these approaches have congruence. Pragmatist and interpretive philosophies overlap as both recognise and validate the value of multiple ways of seeing and interpreting the world to produce new knowledge. Their principles also underlie the methodological decisions on the most suitable methods and the conceptual framework for the study and recognise that any scientific inquiry is contextual in nature (Rorty, 1991). In this sense, pragmatist approaches are concerned with producing knowledge and its application to current problems. It locates the research and its findings at the interface between knowledge and action (Creswell, 2008).

Thus, the study combines interpretive thinking and methods with a pragmatist outlook towards generating evidence and constructive knowledge that can be useful from a conceptual/theoretical perspective but also from a practical perspective. The researcher considers that a pure and narrow interpretive approach would fall short in offering a systems'

approach in addressing the research problem at hand and the proposed research questions. In this sense, the study combined interpretive but also pragmatist principles, the latter emphasising that the purpose and nature of the research questions posed is what determined the methodological approach taken (Yin, 2009).

More specifically, grounding this study within a pragmatist philosophical approach makes room for interpretive inquiry which draws upon making meaning from the inquiry, data collection and analysis. This approach in turn generates evidence and research-based findings from the cases used in this study to inform discourse and practice regarding the suitability of CoE as a potential organisational setting for the conduct of RD&I activities; as well as supporting the development of existing centres.

This study also embraces the interpretive nature of research in noting social reality and in the favouring of lived experiences of human beings (Geertz, 1973). Of particular relevance to this study, in which concrete organisational cases are explored, is the acknowledgement that the way people experience and report their experiences is essentially "context-bound, that is, they cannot be free from time and location or the mind of the human actor" (Holloway & Galvin, 2017,p.26).

While acknowledging that an external reality exists, the interpretive inquiry methodology also assumes that it is only knowable through the human mind and through socially constructed meanings (Creswell, 2012). Interpreting and creating a picture of the way a complex organisational setting is configured and how individuals go about it (Bryman, 2004), constitutes a significant and concrete contribution in building new knowledge about CoE.

Congruent with pragmatist and interpretive philosophies, the study predominantly adopts a bottom-up inductive logic of knowledge construction (Duff, 2007; Gall, Gall, & Borg, 2003). The qualitative methodology used allows for a rich and thick description generating evidence to answer not only the "what" questions but also the "how" and "why" questions which are crucial to the findings of this study (Geertz, 1994).

This approach aligns with the researcher's perceptions about the nature of reality and beliefs that guide action while conducting the study. The researcher acknowledges her perception on the ontological nature of reality in terms of 'multiple realities' as seen through different views (Creswell, 2012). This stance implies that the multiple and diverse accounts of informants' perspectives on similar issues are all taken into consideration by the researcher.

Consequently, the role of the researcher is to report these different perspectives and abstract them as themes developed throughout the empirical process of data analysis and reporting the findings (Creswell, 2012; Hurworth, 1996).

2.3 Interpretive Inquiry methodology with cases

As stated before, this study aims to describe and make sense of the CoE organisational context. One of the first decisions regarding the research design was to identify the methodological approach (either positivist or interpretive) that would best align with the research questions and intent of this study.

The question of how the organisational nature of CoE is understood has both exploratory and descriptive components. It is exploratory in the sense that it is focused on expanding the available and rather limited scholarly knowledge of CoE's organisational nature by delineating CoE's core organisational elements and analysing potential similarities and differences across studied centres. The descriptive component relates to the study's goal to use collected data to identify how individuals go about their roles in building CoE organisational capacity.

When considering a positivist versus an interpretist approach to conduct the study, the researcher was confronted with some compelling reasons for the adoption of a qualitative approach. As apparent throughout this chapter, the study is not well aligned with a positivist philosophical approach seeking statistical significance to ground knowledge claims using quantitative analysis. Rather than seeking to make generalisations from the data to posit broad claims about the wider population, or about archetypal organisations, this study is more concerned with exploring the dynamics of a particular organisational type within the contexts and purposes shaping members' behaviour (Holliday, 2007). The focus of the study is therefore highly "context-bound" and concerned with making sense of complex phenomena paying particular attention to the nature and influence of context on each case studied (Baxter & Jack, 2008; Holliday, 2007). In this study, the research context is defined as the CoE organisational setting and the investigation is oriented to uncovering organisational behavioural aspects which could be captured through qualitative approach analysis.

Thus, an interpretive inquiry methodology was adopted as an adequate fit with the types of questions asked as well as for properly reflecting the nature of the evidence needed to address them. The study aims are only accomplished by undertaking rich, in-depth, and diverse qualitative data analysis, derived from a relatively small, manageable (but still minimally representative) number of cases allowing the analysis to render potentially interesting findings.

The exploration of CoE organisational nature as a social phenomenon required the investigation of real-world individual cases. This inquiry involved the analysis of individual centres which required an approach with some features of the case study methodology (Hamel, Dufour, & Fortin, 1993; Yin, 1994). Because the intention was not to conduct an exhaustive analysis of any individual CoE, but rather to investigate aspects transversal, common or representative to selected CoE, particular methods were chosen to contribute to these cases. More details about methods will follow, but briefly the methods chosen to be used with the interpretive inquiry case methodology were observations during site visits, documentary analysis and semi-structured interviews.

Understanding the role of people in building CoE organisational capacity was a crucial part of this study. A great part of that was accomplished by collecting data for the cases by interacting with and interviewing people about their professional and personal experiences within CoE. Interviews allowed for further exploring and refining of the ongoing data collection and early analytical stages. A qualitative approach offered the necessary tools to capture individual accounts and allowed probing of emerging themes across different organisations. In addition, it allowed capturing of CoE diversity arising from the different disciplinary and technological orientations of CoE as well as in terms of different organisational purposes and configurations.

Finally, as is well recognised in the research methodology literature (Guba & Lincoln, 1989; Patton, 2002), the interpretive inquiry case methodology offered the researcher the necessary level of control and room to further develop and refine the inquiry to fully explore the research questions as the study evolved and preliminary findings emerged. This was critical for producing findings that were more accurate, reliable, and relevant in describing the nature of CoE and in showcasing through selected cases and interviewees the significance of the problem addressed and the findings generated by this study (Agee, 2009).

2.3.1 Role of analytical frameworks in Interpretive Inquiry

As mentioned elsewhere methodology informs the processes of data collection and analysis, therefore choosing appropriate theoretical frameworks as analytic lenses is vital. To be discussed more fully in Chapter Four, two theoretical frameworks provide theoretical foundation for the two research sub-questions. Firstly, Toma's (2010) Building Organizational Capacity (BOC) framework, was used to guide the process of data collection and analysis concerning organisational elements of CoE (sub-question 1), and it also supported the process of identifying the particular ways that leadership and management roles that influenced or were influenced by the process of organisational capacity-building (sub-question 2). Secondly, Quinn et al's (2007) Competing Values Framework (CVF) was also used to analyse leadership and management roles (sub-question 2) and provide a structure to explicate underlying and complementary roles existing in most organisations.

2.3.2 The units of analysis and use of cases in this study

This study design incorporated some features of the case study approach as a research methodology. This section describes in what ways the case study approach was used to address the needs of the study.

What made the use of specific cases relevant in this study is that cases allow investigation of specific phenomena within or across social settings (Hammersley & Atkinson, 1995). More specifically, a case-based methodology offers the tools to study complex phenomena pertaining to CoE within a real-life context.

There are a number of definitions of what a case study is as a research method. Yin defines case study as:

> *an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. (Yin, 2009)*

The notion of context is of major significance for the present study. Case study is a research method that facilitates the investigation of phenomena within their context letting the researcher explore several levels of analysis, from the macro to micro layers embedded in any given system.

In this study the unit of analysis was the centre (the CoE) as it is the major entity being analysed in the study. Nevertheless, the primary goal is not an exhaustive investigation and description of the individual centres, but instead, cases are used to find commonalities and differences between the units of analysis (centres) by drawing on common units of observation (organisational elements and leadership and management roles).

Thus, a multiple-case approach based on purposive selection criteria was considered as the most appropriate approach to address the research questions, exploring differences across centres, and drawing comparisons where possible. These are seen as necessary measures to yield reliable and relevant findings for the cases at hand (Yin, 2014).

The adoption of a research design that integrates features of case studies does not define or limit the methods of data collection. In practice, it allowed the researcher to select and define the scope of the study and the levels of analysis.

The researcher is aware of issues traditionally identified in the literature as disadvantages of the case study approach, such as the potential of excessive collection of information pertaining to a single case, the limits to generalising findings to other contexts; and the issues concerning reliability and validity (Flyvbjerg, 2011; Hamel et al., 1993; Yin, 1994).

This study is designed to incorporate the use of cases to contextualise (within cases) and contrast (across cases) the evidence gathered through the adopted research method which includes the semi-structured face-to-face interviews, observation, and document analysis. Also, this research design addresses the case study shortcomings mentioned above by using well-validated theoretical and analytical frameworks that guided the process of data collection (see Chapter Four).

The tactics used to strengthen the reliability and validity of the study are described in the following section.

2.3.3 Case selection approach

This section describes the rationale behind the purposive selection criteria established for identifying centres to be included in this study.

According to the literature, sound case selection criteria are equally important to the study as the individual cases. Case selection typologies can be based on a typical, diverse, or

deviant pool of cases (Seawright & Gerring, 2008). In any case, what the chosen selection approach must ensure, is that enough data is generated to address the stated research questions.

The main principle underlying the selection of cases is that of 'representativeness' (Seawright & Gerring, 2008). By pursuing a 'representative' sample of cases, it is not intended to imply that selected cases reflect the existing population of cases. That would be extremely difficult to accomplish, if not impossible, given that centres are unique and not intended to be replicated. What the study does intend to do, is achieve a degree of variation enough for analysing the dimensions of interest from different angles and different development stages.

It is also important to emphasise that selected centres are independent from each other. As previously mentioned in section 2.3 of this chapter, the analysis is not case-oriented but rather makes use of cases as means to analyse elements of interest across cases which are different based on a number of operational criteria (discussed below). It is up to the analytical process to determine if eventually these criteria proved central or not in differentiating centres from an organisational capacity perspective. For a study of this size and nature, another type of selection criteria or even a random selection approach would seem impractical and not necessarily an unbiased sample given the limited number of cases that can be investigated anyway.

Considering the study's rationale and requirements previously described, specific criteria were developed to identify a pool of cases that would be manageable within the time and financial resources available to the researchers, and at the same time allow for a reasonable degree of diversity and coherence.

The following criteria were defined to guide the selection of centres:

Criterion 1 – Funding program

As previously described, in Australia two main governmental programs give rise to CoE that fit the scope of this study – the Australian Research Council (ARC) CoE program and the Cooperative Research Centres (CRC) program. More detailed information about both is presented in Chapter three.

In order to investigate centres from both funding programs in a proportionate way, probing for any potential major differences, the study included an equal number of centres from each program.

Criterion 2 – Disciplinary focus

The study aims to cover a balanced pool of centres reflecting a diversity of scientific disciplines. For instance, centres focused on basic natural and applied sciences and also including at least one centre with a substantial soft science component, were included.

It is important to reinforce that CoE typically rely on interdisciplinarity and for this reason a clear-cut disciplinary categorisation is not possible. In addition, a balanced approach will be maintained not only at the centre level but also in terms of the disciplinary background or affiliation of potential interviewees.

Criterion 3 – Maturity stage

With a view to learning from and analysing the accumulated experiences, the study will focus on centres that: have been running for at least five years and preference will be given to those approved for funding renewal (meaning a second seven-year period). Recently created centres and deceased centres will not be considered.

Criterion 4 – Centre emphasis

There is a wide array of purposes and visions behind the creation of CoE in Australia. To be consistent with the underlying principles and goals of this study, three major centre orientations were considered: first, CoE created for the advancement of knowledge (basic or strategic) within a scientific field as a primary purpose. Second, CoE focused on using knowledge to promote social innovation. And third, CoE oriented to fostering knowledge-based technological innovation with an emphasis on translation and adoption. The following table provides an overview of studied centres profiles according to the selection criteria.

Criteria **Id**	**1**	**2**	**3**	**4**
CoE 1	ARC	Basic Natural sciences Earth sciences and mathematical modelling	Renewed	Science Grand challenges
CoE 2	ARC	Basic and applied Natural sciences Chemistry and biotechnology	Renewed	Strategic science
CoE 3	ARC	Applied	Renewed	Technological innovation

		Formal sciences Computer and modelling		
CoE 4	CRC	Basic and strategic Biology	Renewed	Science Grand challenges
CoE 5	CRC	Applied Health sciences	Renewed	Technological innovation and social innovation
CoE 6	CRC	Soft science component Health and applied social sciences	Renewed	Social innovation

Table 1. Selection criteria and selected centres

2.3.4 Strategies for enhancing trustworthiness in the conduct of the study

One of the key principles behind the research design was that the researcher commits to construct a genuine interpretation of reality (Bryman, 2004). To enhance the credibility of the findings, the goal was to offer a believable and consistent holistic interpretation of the meanings found in the evidence (obtained through the three methods of data collection) instead of attempting to offer a supreme and authoritative account of reality. Such an approach would ignore the necessarily subjective evaluation to be performed by the reader of the analysis conducted. In this sense, the research design adopted does not aim to offer objective measurements of reality but instead provides a transparent description of methods and analysis undertook to achieve the presented findings and conclusions (Krippendorff, 2004).

As with most studies following a similar research design, provided that the study is conducted in a transparent way, the reader may be able to assess the design choices made, trustworthiness, significance, and applicability of the findings as well as the possibility of replicating the study in a similar context.

Although documents and interviews were considered as sources of rich qualitative data, the researcher was aware of the importance of maintaining a critical stance throughout the analysis. Recognising that no particular account of a phenomenon can encompass all aspects at play nor reflect different or contrasting viewpoints (Thurmond, 2001). Triangulation strategies were used to minimise these issues. Different methods and data sources allowed exposure to different meaningful aspects and perspectives on the same topic as well as

enhancing the researcher's ability to validate qualitative data by comparing data acquired through different sources and methods (Thurmond, 2001).

First, to implement the triangulation of findings, the study involved different types and sources of evidence. The use of three different methods in concert – observations, individual face-to-face interviews and document analysis – is deemed to have compensated for potential individual limitations while leveraging their respective strengths. For instance, the use of documents provided relevant background information that was used to enquire, complement, contrast and assist in explaining the beliefs and behaviours of participants (Lincoln, 1995).

Another form of triangulation was achieved by involving a wide range of participants, thus increasing the variability of data sources. Participants came from centres with different orientation in terms of core purposes, from science-driven to industry-driven. A purposive diversity of participant profiles also reflected the perspectives of different career stages, from doctoral candidates and early-career researchers up to senior principal investigators.

Finally, a diversity of participants' disciplinary backgrounds and institutional affiliations also served to strengthen triangulation. This allowed the researcher to contrast and check out bits of information across informants with potentially different underlying sets of drivers and constraints (Van Maanen, 1983, pp. 37-55).

Validity

As mentioned before in this chapter, the use of cases in the research design incorporated strategies to enhance the validity and reliability of the findings. Specific tests of validity used are listed in the table below.

Tests	Tactics	Phase of research
Construct validity	Use of multiple sources of evidence Establish chain of evidence	Data collection
Internal validity	Do pattern matching Do explanation building	Data analysis

External validity	Use replication logic in multiple case studies	Research design
Reliability	Use interview protocol Develop database De-briefing with peers and follow-up of interpretations with participants	Data collection

Table 2. Validity tests incorporated in the study. Adapted from (Yin, 1994, p. 33)

Validity refers to the "appropriateness" of tools, processes and data including the appropriateness of research questions and methodology vis-à-vis desired outcomes. In addition, various measures were used to enhance the validity of conclusions by the use and triangulation of multiple data collection methods and multiple cases. This included semi-structured face-to-face interviews which were the primary method of data collection, analysis of key documents and site observations. In terms of construct validity, the use of the pre-identified theoretical and analytical frameworks (see Chapter 4) as a foundation for data collection and analysis ensured the use of valid operational measures for the concepts being applied and investigated within the study.

In order to make sense of and explain the organisational dynamics of CoE and how the main concepts played out at different CoE, internal validity was addressed by an iterative process of pattern matching and coding (further describe in section 2.5 Data Analysis). Transparency was also pursued by means of explanation building during the processes of data analysis and reporting findings (Yin, 2009).

External validity is relevant in the sense that results may be generalizable, to a degree, beyond the individual case (Yin, 2009). Regarding similar qualitative research designs, Guba and Lincoln (2006) perceive external validity as the degree to which the results can be transferred to other contexts or settings by the reader. In addition, these authors believe in a shared responsibility with the reader to the extent that the reader is responsible for understanding the study's context and design conditions before applying the findings into another setting.

The present research study is concerned with enhancing the transferability of results by describing in detail the types of centres selected and discussing the findings in accordance with the different types of centres identified (please see Chapter 7 Discussion). This is intended as a transparent and pragmatic way to support the reader in assessing whether any given organisational entity of interest has a similar organisational nature to the centres investigated in this study. Centre profiles investigated in the study are informed to the reader through the selection criteria.

Last but not least, reliability (also known as dependability) refers to the possibility of repeating similar results by replicability of procedures. This is maintained by disclosing the complete protocol for data collection and analysis. The methods, approaches, and analytical frameworks are made transparent to the reader (Yin, 2009). Nevertheless, it is also acknowledged that the case study approach is characterised by the uniqueness of individual organisations and participants' perspectives in a snapshot of a certain context at a particular moment in time. An exact replication of all such conditions may not be viable. This, however, does not affect the validity or relevance of the study since the essence of "reliability" within qualitative research is more closely associated with retaining a certain level of consistency that will allow for "data that are ontologically similar but may differ in richness and ambience within similar dimensions" (Leung, 2015).

Ethical considerations

An analysis of ethical issues potentially pertinent to the study has been conducted. The main ethical issues are related to participant interviews. Measures were put in place to ensure the protection of participants.

Privacy and confidentiality were major concerns during all stages of the study. Participants were assured that all personal and organisational information would remain confidential and not be revealed in any output of this research project. Anonymity was ensured by the use of codes and pseudonyms to refer to any participant, specific position within the organisation or centre name. This was in line with participants and their organisations' consent requirements.

All interviewed participants' names are de-identified and kept confidential in the text. Similarly, centre names are mostly de-identified in the text except for instances where the

centre names are used for contextual background and based on publicly available information not in connection to site visits nor interviews.

Informed consent was an integral part of the ethics approach in the study and all interactions took place on the basis of prior informed consent agreement. No minors or other vulnerable participants were included in this study. Participants were informed in advance of the nature and objective of the study, the identity of the researcher, which data types were collected, how they would be used, and how the results would be published.

The researcher ensured participants were protected from any physical or mental distress, and they were not forced to disclose any personal information. Consent was a primary aspect, participants being informed at all times of the nature and aims of the study before giving consent and engaging with the researcher. No conflicts of interest were identified for the study and the researcher did not know personally or hold any type of prior-relationship with any individual participant or organisation included in the study.

To protect personal and organisational information, the researcher made use of secure data storage methods such as disk storage accessible through hardware activated passcode and files protected by password.

A formal ethics application has been submitted and approved by the formal body within the University of Melbourne. A copy of this is attached in Appendix 1.

2.4 Methods

This section describes the methods used in the study for data collection to inform the cases. Considering the proposed research questions and goals, the empirical stage of the study aimed at collecting rich qualitative data that could be later used to describe and analyse the nature of CoE organisational capacity and the roles taken up by its members, especially those exercising leadership and management roles. It is timely to reiterate that the study findings are not aimed to be exhaustive, or statistically significant, in describing the nature of every possible CoE. The goal was rather to define a selection strategy that allowed for a level of diversity coherent with the meaning making purpose of the study and, at the same time, viable within the researcher’s time and other resources constraints.

Since there is no unique or pre-defined model or template for establishing and running a CoE, diversity was an expected feature of the subject studied. Because of that, the researcher aimed to collect a reasonable amount of primary data, particularly through interviews and field notes from direct observations during the site visits.

The frameworks (introduced in section 2.3.1 and further detailed in the next chapter) facilitated the process of structuring the organisational dimensions for data collection, in defining interview questions, including which types of data to collect, which data sources to focus upon and, equally importantly, offered the initial, basic lens for analysis. The role of frameworks within data analysis is explored in the following section (2.4.4 Data Analysis).

In this study, three methods of data collection were used:

1. Semi-structured face-to-face interviews

2. Direct observation and field notes during site visits

3. Document analysis

The lead up period to the qualitative data collection stage required substantial planning and preparation. After following the selection process laid out later on in this chapter, the researcher carried out the necessary arrangements for inter-state visits and interviews, to develop the interview schedules based on the analytical frameworks that anchor the study which allowed conducting and analysing of interviews and observation data collected.

2.4.1. Semi-structured interviews

In-depth, semi-structured open-ended interviews were considered as the most adapted form of interview for the purposes of this study and they were the main method of data collection. They provided a more structured approach than an unstructured interview would since the researcher was able to initiate and conduct interviews with the necessary underlying theoretical and analytical layer provided by the adopted frameworks while, at the same time, allowing the researcher to steer the interview to unfold topics of interest that were more closely related to the particular interviewee's experiences or expertise. It also proved to be a good method for in-depth exploration of key topics during follow-up interviews.

The use of interviews allowed, by means of face-to-face exchanges between the researcher and participants, the coverage of broad themes and specific issues pre-identified by the researcher. This is based on the literature review but with a flexible structure that allowed building upon or extending such issues within the particular context of CoE. According to Edwards and Holland (2013), these are all aspects that can be typically addressed by the use of semi-structured interviews.

Interviews were conducted in two stages:

Stage 1: the first stage marked the first face-to-face interaction between the researcher and interviewees. All interviews took place during the time spent on CoE site visits which took two days on average at each centre, providing opportunities to build rapport and trust prior to interviews. Semi-structured interviews were conducted with individuals in different roles and levels of seniority according to the categories identified in the next table.

Stage 2: The second stage of interviews served to delve deeper into topics identified during the first round of interviews as significant for further investigation. The analysis and synthesis of stage one site visits and interviews fulfilled the role of mapping the organisational configuration and more importantly in building rapport with people in the centre for further interviews.

The second round of interviews took place, primarily, face-to-face as much as possible or alternatively over the phone or via Skype video-call in the case of distant locations. In addition to clarifying and further refining issues emerging from the initial interviews, follow-up interviews allowed going deeper into topics selected as key to the study and relevant to the respective participants' experience, position or skills.

2.4.1.1 Participant profiles

The following table provides an overview of interviewed participants' profiles:

	Total
Research and Development	
Senior members	20
Early career members	9
Research Leadership	
Centre or node leader	5
Stream leader or principal investigator	10
Professional management	
Centre manager	4
Managers in specialised areas	6

Table 3. Participant profiles

Participants identified above came from three main groups of interest for the study: people conducting R&D activities, people in leadership and management positions (who most of the time are also involved in the conduct of R&D activities), and people in professional administrative and management roles.

The semi-structured basic interview schedule is attached in Appendix 2.

2.4.2 Direct observation during site visits

Observation is considered as a very effective and appropriate data collection method particularly when gathering direct information and observing individuals' performance can potentially provide better information than relying on reports and key informants only (Lofland & Lofland, 1995). This was certainly the case in a study looking at organisational capacities and organisational behaviour where participants many times are more focused and aware about their end R&D activities than on reflecting about the means to perform them. In addition, the researcher was interested in witnessing the dynamics within centres and amongst members, in addition to gathering individual accounts of such dynamics (Delamont, 2004).

To accomplish that, the researcher conducted comprehensive, physical visits to each of the research sites, consisting of six Australian CoE selected based on the criteria described in this chapter.

Site visits and interviews constituted the major components of the empirical data gathering phase. They provided a privileged vantage point into the real operation of CoE through the possibility of observing the behaviour of individuals in their everyday work environment. Site visits permitted collection of information data in various forms: observational, documentary and interviews. Most of the data collected during site visits proved to be most significant for data analysis given that they were not available elsewhere such as in internal policies and memos, performance reports and working documents.

The possibility to be immersed in the daily routine of a CoE and make first-hand observations proved to be extremely valuable, adding a great deal of insight and nuances to findings, much more than interviews and document analysis alone would be able to afford. Interviews with key participants were previously scheduled ahead of site visits. Thus, the time in between and after interviews, was devoted to observation and note-taking. Many interviewees were helpful making referrals to other people in the centres, or based in other centre nodes, that either matched the target participant profiles or could offer some sort of contextual or complementary information about the centre.

Because the researcher was able to spend two full days on average at each centre, a substantial amount of time was spent in the studied CoE's premises making it possible to meet informally with CoE members and taking part as an observer in the centre's normal daily activities. The researcher was able to participate as an observer in leadership or team coordination meetings and staff training activities and engage in conversations in social shared areas.

The opportunity to have first-hand exposure at visited CoE and to engage with people in an informal way (at least more informal then the actual interview setting) offered a privileged perspective into the climate and life of the centre, going beyond what was conveyed in interviews and expressed in public documents. It allowed for a first-hand perspective on the attitudes and behaviours of people allowing a chance to "feel" and analyse not only objective information but also abstract and more subjective notions such as those pertaining to the culture of a centre.

Field notes were taken during site visits, prior to the conduct of participant interviews as a primer and captured aspects (such as centre environment and physical configuration) and perceptions that were complementary in describing and analysing interviewees' accounts, within a single centre, across distributed nodes of the same centre, and even across centres. It

is important to note that the process of gaining access to participants and sites and conducting and recording observations required a good level of interpersonal and organisation skills on behalf of the researcher but also allowed for further refining of such skills.

To ensure the dependability and confirmability of findings a few precautions were taken. Observations were initially recorded in narrative form and subsequently structured and coded based on the elements and analytical components of both frameworks described in Chapter four. Observation and interview notes were de-briefied with peers and supervisors during regular meetings. Participants were also contacted (either in-person or by telephone/e-mail) to double-check the interpretation of findings whenever necessary. Many of the aspects identified during centre observations served to narrow down the general frameworks into CoE-specific categories according to emerging centre types. For instance, leadership and coordination meetings provided excellent opportunities for observing the nature of L&M at CoE and the roles adopted by leaders and managers according to different goals.

2.4.3 Document analysis

The retrieval and analysis of key documents was an integral part of the empirical data collection process. The method of document analysis is considered as a comprehensive and stable data collection method (Bowen, 2009). In this study, document analysis not only allowed for the collection of additional information but also the verification of data collected by other means. It played a preparatory role prior to site visits and interviews and it also served, depending on the nature of the document, to provide background, contextualise and complement evidence collected via other methods. Bowen (2009) states that document analysis used in concert with other methods can also serve the purposes of triangulation, which was another role played by documents in the study.

The analysis of publicly available documents (such as annual reports, reviews and institutional websites), prior to the conduct of site visits and interviews, provided background information, and allowed for the initial identification of key issues for further in-depth investigation during centre visits and participant interviews. During site visits, the researcher had access to more exclusive and detailed internal documents in some cases. That also allowed contextualisation and complementing of interview data.

The analytic procedure involving documents is discussed in the following section “Data analysis”.

Different documents can offer different types of evidence and serve different descriptive and analytic purposes. Documents considered were both in printed and online PDF formats, including online information on institutional (centre) and governmental (funding program) websites. To provide a general understanding of the role of documents in this study, the following are the main types of documents consulted:

Centre annual reports

Centre reports contain important pieces of evidence on their organisational capacity. Centre annual reports offer an initial sense on the history, purposes, goals and objectives of a centre. They may also convey information that can lead to identifying the predominant culture of a centre. They also convey preliminary information on the roles and skills of individuals in leadership and management positions to be further explored during site visits and interviews.

Government papers

Government documents such as policy documents, program blueprints describing the nature of CoE funding programs, calls for applications, funding guidelines and requirements, and websites can provide insight into the expectations and reasons behind the creation of CoE programs.

Independent program and centre reviews

Program and centre reviews produced by independent reviewers commissioned to evaluate the performance and impact of a centre against pre-defined indicators were useful. Reports also refer to potential deficiencies and areas for improvement. Since CoE programs have been running for many years in Australia, these types of documents can provide interesting topics for the study and greater insight into the evolution of CoE and their framework conditions.

2.5 Data analysis

The process of qualitative data analysis involved describing, summarizing, interpreting, and identifying common patterns to make sense of the collected evidence. The description component served to provide an account of the phenomena being studied and the conceptualisation component involved building abstract analytical categories from the data,

identifying their properties, and searching for explanations as to if and how they relate to each other. This was an iterative process pursued, up to a point of saturation, to explain the phenomena under investigation.

The preliminary stage for data analysis was markedly preparatory in that interview data was transcribed, observation notes re-written and organised, and relevant sections within key documents selected.

Next, a process of critically interrogating the evidence, in light of adopted frameworks and relevant literatures took place. The data analysis process was based on an 'integrated approach' to analysis (Fereday & Muir-Cochrane, 2006), which partly combined both inductive and deductive approaches to data analysis. Differently from a purely inductive (grounded) approach where the code structure emerges entirely from the process of analysis, the integrated approach makes use of a preliminary organising framework that scaffolds the coding process by providing an initial coding structure. This deductive dimension was implemented through the use of the analytical frameworks (presented in Chapter four) which provided some core concepts on organisational capacity and L&M. The deductive layer consisting of broad, theory-based, code types allowed for a more efficient and structured process that led into the main stage of inductive generation of specific, CoE-based sub-codes emerging from the data.

The primary goal of data analysis was to extend the knowledge about CoE organisational nature and the role of L&M in building CoE organisational capacity. In addition, the process of data analysis also served to estimate the applicability of the selected frameworks to the particular context of CoE.

2.5.1 Thematic analysis of qualitative data

Thematic analysis was the method used to analyse qualitative data in the study. Thematic analysis is described as "a method for identifying, analysing and reporting patterns (themes) within data" (Braun & Clarke, 2006, p.79). This process involves the identification of themes through "careful reading and re-reading of the data" (Rice & Ezzy, 1999, p.258). In this study, it involved the thematic analysis of content extracted from interview transcripts, documents, and field notes with the goal of identifying commonalities and differences that supported the process of describing potential relationships between different "chunks" of data. These relationships can then lead to descriptive or explanatory conclusions clustered around themes (Braun & Clarke, 2006).

The study involved an iterative process consisting of the following stages for the thematic analysis of data:

Data collection
Organising and preparing data
Initial coding: defining and describing broad framework-based codes
Classifying, categorising, and cross-referencing data
Inductive Coding: generating emergent CoE-specific codes
Classifying, categorising, merging, cross-referencing, and identifying themes
Interpreting, creating explanatory accounts and discussing findings in the light of adopted frameworks and literature

Table 4. Process of data analysis

The stage of organising and preparing data consisted of transcribing and classifying interviews according to centre and participant profile, compiling observation notes and selecting key documents or key extracts from pre-selected documents.

The coding process involved a preliminary deductive, and a major inductive approach. This type of hybrid approach to coding which is based on notions provided by previous research and existing analytical lenses was used by other studies and perceived to facilitate the analysis of specific or context-dependent issues in the light of a broader more general framework (Fereday & Muir-Cochrane, 2006).

The deductive dimension of coding refers to the initial use of codes which were derived directly from the adopted analytical frameworks. These broad codes were used initially to systematically structure the data around the major organisational and L&M dimensions considered. After this preliminary stage, coding was conducted in an inductive way, with codes and underlying themes emerging from data in an iterative process which is further described next.

2.5.2 Coding qualitative data

The reduction of data followed an inductive approach to coding outlined in the literature (Miles & Huberman, 1994; Saldana, 2015). This involved an iterative process of interpreting, refining, differentiating, and merging categories and sub-categories of emergent topics (Bowen, 2009). This iterative process of pattern recognition within the data supported the generation of categories for analysis (Corbin & Strauss, 2008).

By being an iterative process, where data gathering and analysis are conducted concurrently, the preliminary steps of this process served to extract themes for further investigation, as the research evolved throughout the remaining empirical stages. It served to contrast and contextualise preliminary findings.

Themes were thus developed by creating, comparing, and merging data categories within and across cases (Braun & Clarke, 2006). To keep up with the evolution of codes and themes, the researcher made use of a "code book" matching codes and keywords of meaningful sentences) and their respective description. Towards the end of the code generation process, the researcher also used a matrix to enter pieces of evidence that illustrated consolidated codes and themes.

As the coding process evolved, the coding of categories and themes consisted of interpretive propositions that described or explained patterns within data. This process was conducted until theoretical saturation was achieved and is presented in narrative form (supported with quotes and extracts as evidence) within the findings and discussion chapters as the final output of the data analysis process (Lofland & Lofland, 1995).

The final goal of analysis was to reach constructs that could provide a sufficient understanding of the nature of key framework elements and dynamics seen from the perspective of studied centres. Taken in concert, these constructs can provide an overview of the nature of CoE organisational capacity and the perceived influence of leadership and management roles.

The following figure serves to illustrate the main components of the overall research design developed for the study.

2.6 Research design chart

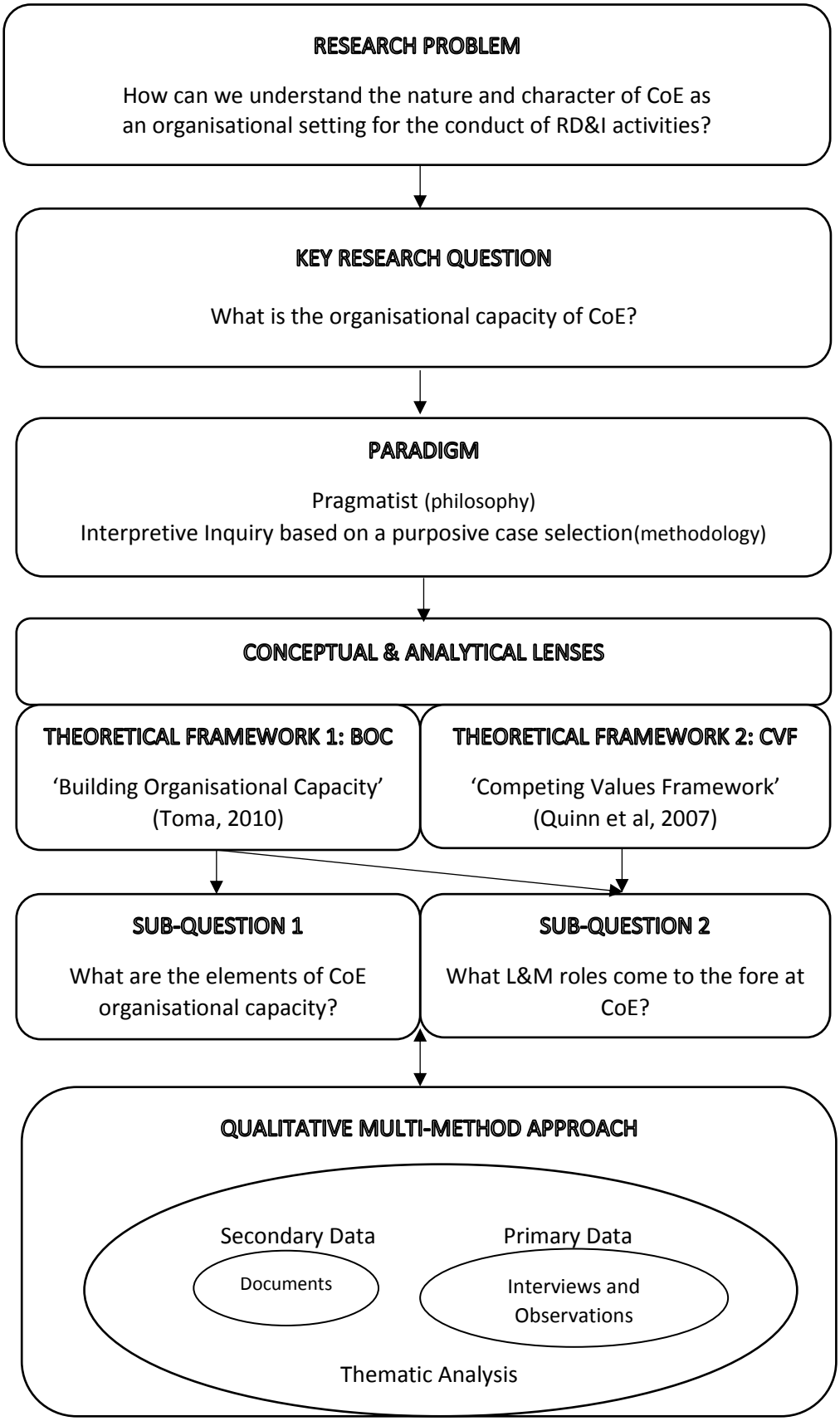

Figure 1. Research design chart

CHAPTER 3. RESEARCH CONTEXT AND LITERATURE

3.1 The Emergence of Centres of Excellence (CoE) Policies in the Transition to Knowledge-Based Economies

This chapter aims to describe the overarching context that provided the framework conditions for the rise of CoE worldwide. Programs for the creation of CoE emerged in a period when public policies putting emphasis on innovation and competitiveness started to be adopted in most developed countries. More recently, the widespread acknowledgement that Science, Technology and Innovation (STI) play a critical role in achieving sustainable development, which has put STI policies at the heart of national developmental strategies, has been a major driver behind the adoption of CoE-type of policy instruments (UNESCO, 2016).

Understanding these dynamics is central to appreciating the different forces and nature of the expectations placed on the creation of a CoE and upon its operation and the outputs they generate. To do that, the first half of the chapter presents the core trends and underlying concepts associated with the adoption of CoE policies. Next, the second part of the chapter focuses on the particular context of Australia and the main governmental programs that provide funding for the centres considered under the scope of this study.

3.2 Research, Development and Innovation Policies within the Knowledge-based Society

In twenty-first century society, research, development and innovation (RD&I) activities came to be regarded as key drivers for development and competitiveness (Powell & Snellman, 2004). Knowledge production and other activities related to the development of new technological applications, referred to as Science, Technology and Innovation (STI) activities,

are considered as the tenets of the Knowledge Economy. Powell and Snellman (Powell & Snellman, 2004, p. 201) define the Knowledge Economy as the:

> *Production and services based on knowledge-intensive activities that contribute to an accelerated pace of technological and scientific advance as well as equally rapid obsolescence. The key components of a knowledge economy include a greater reliance on intellectual capabilities than on physical inputs or natural resources, combined with efforts to integrate improvements in every stage of the production process, from the R&D lab to the factory floor to the interface with customers.*

Thus, the production and transformation of knowledge into socio-economic value have been considered as the key drivers of growth in the knowledge-based society for a considerable time now (Drucker, 2002; Earl & Gault, 2006).

During the 1990s, when the first CoE funding programs were introduced (including Australia as one of the pioneers), the National Innovation Systems (Nelson, 1993) approach was gaining traction amongst policy-makers as a systems-oriented approach for the promotion of technological innovation through national (or supra-national) policy. This led to a number of framework conditions that encouraged a greater interaction amongst the various types of users and producers of knowledge through new innovative instruments and collaborative configurations (Lundvall, 2010). The increasing focus on "national innovation policies" in contrast to the traditional focus on "Science and Technology policy" characterised the policy environment of this period in most developed nations (Dill & Van Vught, 2010b; OECD, 2005).

One of the immediate effects of the innovation systems' approaches was that governments (at all levels) became more assertive in prioritising specific fields for funding according to national needs and significance (Dill & Van Vught, 2010a). A number of mechanisms were introduced to implement this process of prioritisation such as Strategic Foresight Analysis and other priority-setting approaches (Martin, 1996). This resulted in some specific fields of research rapidly becoming commonly targeted for funding such as nanotechnologies, biotechnologies, and IT technologies (Georghiou & Harper, 2011). The value of such top-down strategies has been questioned given the potential lack of capacity of government bureaucrats to properly define mid to long-term scientific priorities coupled with the inherited negative effects that an overly applied focus can have on the evolution of the scientific capabilities of a system (Geiger, 2010).

Moreover, of critical importance during that period, was the renewed perspective on role of the public sector. There was increased recognition that the public sector plays an important role in the processes of knowledge production and innovation mainly through, but not restricted to, policy-making and the funding of education (particularly tertiary education), research training and RDI activities (Block, 2011).

The widespread notion of the "knowledge triangle" (government, universities and the private sector) (Maassen & Stensaker, 2011) as the engine of knowledge economies served as the foundation to most system-level reforms. This metaphor emphasises the core role and relationship between the three dimensions identified by activities related to Higher Education-Research-Innovation and their respective key actors. It also highlights the importance of jointly fostering the three dimensions and strengthening the links and coordination amongst the key actors, including the strategic role of universities (Markkula, 2013) (Maassen & Stensaker, 2011), and also that of research labs and the private sector. The revamped and strengthened role of government, which plays a key role in these dynamics not only through setting up the policy environment and sponsoring STI activities but also as a main user of disruptive technological innovations developed by private firms, increasingly has come to the fore (Mazzucato, 2013, 2018b).

Government's role in fostering the conditions for an enhanced interaction has been more pronounced in the OECD countries (OECD, 2017a) and particularly through the European Union institutions' initiatives such as the Lisbon Strategy, the Europe of Knowledge, the Horizon 2020 initiatives including the Framework Programs for Research and Innovation (European Commission (EC), 2010) and more recently the post-2020 agendas (European Commission (EC), 2015). European Union initiatives have invested a total of 77 billion Euro in the period of 2014 to 2020 (European Commission (EC), 2015) with the upcoming Framework Program 9, and the Horizon 2020 successor, introducing an even higher spending of up to 120 billion Euro over the next seven years (Science Business, 2018).

The Fourth Industrial Revolution

Nowadays, the importance of science and, particularly the collaboration in producing knowledge and responding to challenges, is amplified by the speed and scale of trends affecting society globally, encapsulated by the notions of the Fourth Industrial Revolution and the Circular Economy. It is argued that we stand on the brink of a technological revolution, the Fourth Industrial Revolution, which will fundamentally alter the way people live, work and

interact. The Fourth Revolution builds on the Third Digital Revolution by implementing a fusion of technologies (such as artificial intelligence, robotics, the Internet of Things, big data analytics, cloud computing, autonomous vehicles, blockchain, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing) that, combined, have the potential to disrupt most industries leading to a radical transformation of production, management and governance systems worldwide (OECD, 2017b; Schwab, 2015). These radical transformations, require, more than ever, the scientific, technological and innovation capabilities within national and regional systems, able to keep up with knowledge being produced worldwide and to take advantage of the opportunities and markets these new technologies will offer.

The understanding that the current extractive model of use of natural resources based on "take-make-dispose" cannot keep up with population growth is a strong argument behind the transition towards a Circular Economy. The Circular Economy paradigm evolves around redefining growth in a more sustainable way, where industrial systems are designed to be regenerative, highlighting the need for new knowledge, technology and innovations that will lead to socio-economic development that this model can create (World Economic Forum, 2018).

Again, the leadership role of governments is perceived as critical in fostering new technologies and making them enablers of the circular economy (OECD, 2017a). National Governments are already taking an active role in supporting the transition to a circular economy, such as the case of Denmark for instance, where the government is taking a leadership role by encapsulating principles that foster a circular economy as selection criteria within public procurement instruments (Ellen Macarthur Foundation, 2018).

Other equally influential philosophically-grounded ideas are also gaining traction, closely associating the pursuit of economic development with an increased focus on exploiting individual personal potential and capabilities as a basic human right and a critical aspect in fostering social justice and equality (Sen, 2011).

As they evolve in concert, these dynamics and new ways of understanding and fostering human and economic development have a common factor: the use of knowledge and innovation, at all levels from individuals to organisations to countries, as engines for a more sustainable and inclusive world.

It is against this backdrop that scientific policy of many countries (including Australia) changes to respond to and cope with these trends. The introduction of funding programs for the creation of CoE-type centres is one of its responses. CoE offer a space that is able to aggregate and foster a number of the underlying rationales described previously, notably:

First, by facilitating a specific organisational entity for the support and pursuit of "excellence" in research not only purely from an epistemic perspective but also from the more comprehensive and process-based perspective of scientific knowledge production (Heinze, Shapira, Rogers, & Senker, 2009; Hellstrom, 2011).

Second, by creating a formalised and independent organisational environment for collaboration (inter-institutional, inter-sector, inter-disciplinary) where the diversity of actors and interests within the knowledge triangle can co-exist. Such organisational arrangements are based on the expectation that synergies will be created and leveraged to deliver on a wide range of benefits not only those focused on the private returns of RDI activities but including those with a strong public-good nature (Atkinson-Grosjean, 2006).

Third, CoE have a strong national capacity-building dimension in that they are often adopted to strengthen national scientific capacity in a certain field or with a view to addressing a problem of national significance. CoE are used to concentrate resources in order to create a critical mass at a scale that would not be achievable through other means (Orr et al., 2011).

3.2.1 STI role in fostering smart, inclusive and sustainable growth

There is growing recognition that the centrality of knowledge and technology-based innovation goes beyond economic growth and is fundamental in addressing pressing global challenges (also known as Grand Challenges). In 2015, two landmark global events took place. First, the United Nations General Assembly endorsed the 2030 Agenda for Sustainable Development, when for the first time (at a high level) the role of science, technology and innovation was explicitly recognised as crucial for the sustainability of nations (UNESCO, 2016).

STI are explicitly acknowledged to play a critical role in the pursuit of Sustainable Development Goals. In this new agenda (Agenda 2030), 17 agreed Sustainable Development Goals replaced the Millennium Development Goals adopted in 2000 (UNESCO, 2018). In

Agenda 2030, again, STI are at the core of the development of strategic thinking in a new science policy paradigm that goes beyond the national growth perspective into valuing science as a global enterprise for a more sustainable and just world (Hackmann & Boulton, 2018).

The second event was the signature by 195 countries committing to (with only two opposing) the most far-reaching climate agreement to date, the Paris Accord (UN, 2015). The sustainability and inclusiveness of societies are increasingly associated with the capacity of states to put STI at the core of national strategies for development.

Smart innovation-led growth public policies acknowledge the notion that "mission-oriented research and innovation policy" (Mazzucato, 2018a) has a critical role to play in enhancing sustainability and equity in society. Mission-oriented policies aim to steer frontier research and innovation activity and focus actors' attention on target problem areas of great significance for society (European Commission, 2018).

The "mission-oriented" approach to research and innovation policy-making emphasises the importance of combining, simultaneously, the top-down steering capacity and the bottom-up experimentation that reveals what works in practice, a fine balance considered difficult to achieve. The challenge is the diversification of collaborative instruments that can translate societal challenges into research and innovation programs, making STI activities incorporate, in a prominent way, the social dimension. Mission-oriented policies couple major societal challenges with opportunities for conducting "big science" while creating opportunities that are attractive to private actors (companies or across industrial sectors). Examples range from the development and commercialisation of science-based solutions and technologies to the creation of entirely new markets based on addressing a significant socio-economic challenge (Mazzucato, 2017, 2018a). The notion of 'missions' provides a compelling rationale for securing support (and funding) from societies and their governments, the scientific community, and the private sector.

This is reinforced by the idea that societies are increasingly dependent on their ability to generate and harness knowledge and information. It is also increasingly a major underlying rationale for governmental policy development and steering in developing countries alike, reflecting a global convergence in the use of STI as the basis for not only economic growth, but also greater social inclusion and long-term sustainability (Meek & Suwanwela, 2006).

Collectively, such dynamics powered by scientific and technological innovations are directing individuals, businesses, and countries as a whole towards fast-paced change and radical transformation. Governments have been active in the design of science and innovation policies that are aligned with these dynamics and that can harness national capabilities. In this sense, national strategy and policy formation have been promoted by a number of international organisations, the OECD being particularly influential in the case of Australia (OECD, 2014a, 2017a, 2017c).

The above-described dynamics have been strongly influencing the ways in which RDI activities are conducted. From new and purposeful approaches to priority-setting to the diversification of RDI funding mechanisms, the trend clearly is towards increasing collaboration (particular cross-sector) and the utilisation of research results.

Before discussing how these trends are reflected in Australia and in the particular cases studied, the next section explores the principles that underlie the creation of excellence and user-driven research centres.

3.2.2 Excellence and Relevance Rationales in Research Policy

Excellence and relevance are two important concepts in this study. Although the notion of 'scientific excellence' is ubiquitous, it is considered a complex, hard to define and highly contested concept (Nature, 2018; Walloe, 2009). Despite that, the importance attached to pursuing excellence in science is not questioned. High-quality science, assessed on the relative performance of different actors and based on their S&T capacities, research activities and outputs, is desired and promoted in the development of all fields of science (Tijssen, 2003).

Research excellence for policy purposes

The meaning attributed to excellence has been based primarily on indicators using bibliometrics (such as citation impact of publications). This has generated debate as to the most appropriate indicators of excellence (Ferretti, Pereira, Vértesy, & Hardeman, 2018; Schmoch & Schubert, 2008). Because the notion of research excellence has become central to the context of STI policy and given that particular utilitarian and economic drivers can play a role behind its promotion, the process of identifying and assessing excellence has been critically discussed in the literature (Fuller, 2000; Hellström, 2012).

In the practical context of STI funding agencies and their programs, research excellence functions as a proxy for scientific quality which is used to benchmark groups and their funding bids and identify which consortia are deemed fit-for-purpose to conduct STI activities with a view to pursuing pre-defined goals and outcomes.

The focus on investing in scientific excellence is closely related to the capacity of research-intensive organisations in general, and that of research-intensive universities in particular. They have traditionally been key knowledge producers in society and key actors in international scientific networks working on state-of-the-art knowledge production (Rip, 2008).

Roger Geiger (Geiger, 2017) states that "universities are the central institution of the modern global knowledge society" and that is because they perform a multitude of key and in many cases unique roles in society. Governments and the private sector increasingly rely on research universities as the key and most legitimate institutions for equipping a workforce with advanced post-secondary education and training for the professions, for training the next generation of researchers, providing society with expert input to address social challenges and conducting cutting-edge research activities that produce authoritative knowledge and practical technologies (Powell, Fernandez, & Baker, 2017). University-based research, which in most countries is complemented by the activity of publicly funded research institutes, plays a key role in creating and disseminating knowledge through high-quality, objectively verifiable, and peer-reviewed scientific research activities.

The role of research-intensive universities

It is important to understand why, since the 1980s, governmental policies are consistently put in place to encourage interactions between universities and with other actors, particularly industry, based on the expectation of producing benefits and spill-over effects (Geiger, 2005). Universities have endured throughout centuries as an effective "locus" for scientific activity and training of the next generation of scientists (Geiger, 2017).

World-wide, the great majority of basic and strategic research is performed in universities. The main science and technology indicator used in OECD countries is the gross domestic expenditure on R&D (GERD) as a percentage of GDP (OECD, 2017b). When breaking down GERD by performing sectors, the higher education sector spending on R&D

(HERD) is the most significant component of GERD across all OECD countries, and its share continues to grow in many countries. On average, universities and government institutes perform more than three-quarters of all OECD basic research (OECD, 2014b). Australia[2] is no exception.

A recent assessment of Australia's publicly funded research system analysed the use and significance of an indicator framework that is able to reflect the characteristics of a healthy and high-performing publicly funded research system and facilitate further analysis and benchmarking of a system's research performance against that of other comparable countries (Bentley, Goedegebuure, Meek, Pettigrew, & Woelert, 2018). This analysis shows that a balanced research system (in the sense of different sectors' expenditure but also performance across multiple fields of research) underpins national long-term innovation performance and features universities as central actors. It highlights that a system's performance is highly correlated with the extent to which research-intensive universities are well supported to conduct both basic and applied research. The quality of university research is measured by peer-reviewed publication outputs and other research metrics such as citations data, the annual number of PhD completions reflecting the university as the supplier of highly skilled talent needed to drive the innovative and absorptive capacities in the workforce. They have considerable engagement with the private sector denoted by university R&D funded by businesses and income from other sources such as licences and consultancies, all of which will eventually have positive spill-over effects into private R&D investments (UNESCO, 2016).

Conversely, key knowledge producers, such as universities and public research centres, are encouraged to become global players and to compete internationally with other "world-class" research actors in their fields. These arguments are partially advanced by the relevance and perceptions of "world-class" promoted by university rankings.

However, the long-standing notion that collaboration and competition are closely interconnected (Brandenburger & Nalebuff, 1997) in the form of a "competitive cooperation" (Merton, 1973) has been exacerbated by globalisation forces (Huisman & Van der Wende, 2005). The underlying rationales of investing in supporting scientific excellence are also put in

[2] Further data about Australia higher education is provided in the last section of this chapter which presents the particularities of the Australian context relevant to the study.

response to the global race in attracting and retaining scientific talent (Jacob & Meek, 2013; Teitelbaum, 2014).

Enhancing the relevance of research activities

Globally, and particularly in Australia (Australian Government, 2015), the policy argument for the increased relevance of research activities is used in a combined and complementary way to the excellence argument and is associated with the increasing importance attached to "strategic research" and the exploitation or application potential of research outputs (Rip, 2004). Often, STI policy uses the term "relevance" to highlight a focus on emerging technologies, research areas of particular national interest or prior research capacity with further development potential, or on concrete socio-economic problems. Fields like nanoscience, biotechnology, energy research, climate research, and information technology, among others which are commonly perceived, in the context of STI policy, to have a great potential to impact on the economy, society, or even humanity as a whole (Beerkens, 2009).

Thus, scientific excellence (Altbach & Salmi, 2011; Salmi, 2013) and the socio-economic relevance of research, particularly of university-based research (Jongbloed & Goedegebuure, 2001); (Rip, 2004) became two major underlying rationales for funding programs for the creation of collaborative research centres such as CoE.

Thus, a policy environment that encourages competition in the funding of research and allocates these funds on the basis of "excellence" and "relevance" goals, gave rise to new instruments (such as CoE) that differ from more traditional funding methods such as block grants and project funding.

Promoting scientific excellence as a strategic rationale for public research funding is based on the ideas and arguments discussed in this chapter regarding collaboration, competition, tackling big and complex problems through multidisciplinary research teams and strategically concentrating resources on fewer selected actors, fostering a combination of cultures and interests that can be potentially conflicting at times (Atkinson-Grosjean, 2006). The nature and effects of such strategic funding of STI activities that are particularly relevant to CoE are discussed in the next section.

3.2.3 Selectivity and Concentration

Selectivity and concentration are characteristics of a growing emphasis on more deliberate approaches behind the set-up of STI policies. A substantial portion of science funding budgets has moved, during recent decades, towards increased selectivity in the process of allocating research funds: to fewer actors instead of spreading funds across the system, and a greater concentration of research funding in selected areas deemed of priority whether for its relevance to existing challenges of national significance or based on comparative national strengths relative to other countries (Kitagawa, 2010; Williams, 1993).

These types of policies emerged based on an argument of greater efficiency in the use and allocation of resources, and with the goal to encourage the creation of a critical mass in certain areas in order to exploit economies of scale and synergies within the national system's STI capabilities (Johnston, 1994).

However, the initial effects of a resource concentration strategy, implemented through selective funding, on the wider knowledge production system were perceived as being potentially counterproductive (Harley & Lee, 1997; Johnston, 1994) particularly in the UK where such systems were initially introduced at a system's level. Some of the potential downsides are that a selective funding strategy runs the risk of over-concentration of research funds in a few institutions or fields, inciting institutions to adapt to "play the funding game" at the expense of curbing the development of other academic fields and the organic development of the national system as a whole (Adams & Gurney, 2010; Harley, 2002).

The selectivity and concentration phenomena were initially associated with the growth and increasing diversity of both funding agencies and mechanisms for the administration of competitive funding (Van den Besselaar, 2010). Some of these mechanisms encourage research excellence in priority areas and an increased collaboration between the public and private sectors, and amongst the producers and users of knowledge. Some examples are science parks, regional or sectoral clusters, programs for the creation of centres of research excellence (CoE), collaborative centres between industry and academic partners, and more recently the concept of Smart Specialisation (Foray, 2014) (Amin & Thrift, 1994).

Within these new funding approaches, the evaluation of the quality and especially the estimated impact of research activity is of particular relevance for governments in steering the performance of public research organisations (PROs) of a system through funding. The UK

Research Excellence Framework (REF), the successor to the earlier Research Assessment Exercise (RAE), is a classic example of assessing research activity produced by PROs, one that has served as a model for other nations and influenced the development of Australia's own framework "Excellence in Research for Australia" (ERA). Informed by a range of output metrics including publication and citation data of peer-reviewed publications, REF was established with the goal to adopt a set of indicators that could be used to benchmark quality against international standards and provide the basis for distributing funding according to proxies of "research excellence" through the adoption of a stable framework for continuing support (Higher Education Funding Council for England (HEFCE), 2018b).

The actual goal to define and measure "impact" is an issue of current debate. Impact is defined within REF as a form of impact exerted outside of academia being 'an effect on, change or benefit to the economy, society, culture, public policy or services, health, the environment or quality of life, beyond academia' (Higher Education Funding Council for England (HEFCE), 2018a), something that raises objections as to potentially influencing researcher behaviour and undermining academic freedom as well as being complex to measure in a fair and impartial way (Adams & Gurney, 2010; Fernández-Armesto, 2009; Given & Winkler, 2014; Harley, 2002; Kwok, 2013).

The renewed focus on the impact of research within the framework of the public funding of research activities has been influencing the way funding instruments are designed and, in response, the way public research organisations, particularly those universities striving to survive the funding game, strategically prioritise and engage in collaborative and interdisciplinary research arrangements (Allen Consulting Group, 2012; King's College London, 2015; Technopolis, 2016).

Overall, the effect of trends associated with increased selectivity and concentration in research funding have been influential on the way quality, excellence and the impact of research are perceived and assessed. All these issues are significant factors in the way priorities are defined for the establishment of CoE programs and conversely on the criteria CoE research is funded through and its outputs assessed, as will be further discussed in the coming sections.

3.2.4 The link between strategic research policy and new funding instruments

The previous sections described the growing focus on excellence and relevance, fostered through more selective funding approaches, promoting a concentration of resources and the profiling of institutions as ways to create a critical mass in STI. This focus underpinned the strategic policy process leading to funding instruments such as CoE.

Governments have been historically involved in supporting STI activities. Public expenditure on R&D as a percentage of GDP (expressed by PubGERD as a proportion of GERD) is currently used as a key indicator of the intensity of public support of STI activities. The recent steady increase of PubGERD levels across the majority of OECD countries (OECD, 2017b) shows that governments continue to commit significant financial support to STI activities as a strategic choice despite the ever-growing range of competing demands and scarcity of public funds.

There is a widespread consensus around the argument for the need of public financing of basic research given that its public good, and long-term and risky nature tend to drastically reduce the incentives for private investment (Nelson, 1959). Traditionally, public funding for research has been provided through a dual system composed of institutional block grants (basic funding for discretionary institutional use or performance-based) (Box, 2010) and the award of funding on a competitive basis for projects. More recently, and in combination with the selectivity and concentration trends described previously, there is a growing political pressure for an increased funding diversification of public research performers (namely research institutes and universities) (EURYDICE, 2008). According to Orr et al. (2011), the agenda behind the push for funding diversification includes reducing the dependency of institutions on a single source (the state) and the incentive for an increased profile-building on behalf of institutions, based on key excellence areas, an increased relevance to funders' agenda, and more links with private stakeholders.

Thus, the drivers towards a diversification of research funding refer to a diversification of funding sources but also to increased variety of funding mechanisms administered by funding agencies. Core recurrent research funding is supplemented by other types of funding instruments (such as performance-based funding, formula-based budgets, Smart Specialisation to name a few (European Commission (EC), 2011)) for funding and greater steering of research (Salmi & Hauptman, 2006). New competitive funding instruments, such as CoE, are awarded on the basis of peer-reviewed project proposals submitted by collaborative partnerships and

evaluated against a set of pre-defined objectives and selection criteria. They have been used as mechanisms for a number of goals such as improving quality, relevance and innovation while enabling increased funder oversight over priorities and expected outcomes than other existing mechanisms.

New funding instruments are not only perceived to permit steering research priorities and funding allocations but also to facilitate the application of New Public Management (NPM) principles (Dixon & Lodge, 2012; Hood, 1991), particularly transparency and efficiency, on the use of taxpayers' money to support research activity (Olssen & Peters, 2005).

Orr et al. (2011) use the label Research Excellence Initiatives (REIs) to identify models and instruments that are set to promote excellence such as CoE. As the authors put it: "REIs focus on rewarding and fostering exceptional quality in research and research-related activities rather than providing funding with equal shares for all institutions, regardless of past merits or future prospects". The authors suggest that the recent spread of REIs is strongly connected to the push towards reinforced political steering mechanisms that can encapsulate the issues described before such as diversification and application of NPM principles by means of increased selectivity and concentration of public research funds. The influence of NPM is discussed in more detail below.

3.2.5 Research Excellence Initiatives (REI)

Research Excellence Initiatives (REI) arise as part of the trend towards the introduction of a greater diversity of mechanisms for the public funding of research discussed earlier in this chapter (Orr et al., 2011). The growing interest on this diversity of competitive-based mechanisms (including performance-based funding), specially by policy-makers, was shaped by a combination of different underlying rationales (depending on the characteristics of a given national system). Some of the main drivers behind the introduction of such mechanisms were based on increased efficiency and innovation, the increased ability to better steer the national RDI system, to raise the quality of research, and to create a critical mass in a given field, and also included additional goals such as enhancing accountability, offering more autonomy to research-performing organisations, fostering greater collaboration and knowledge transfer, and raising third-party income (Box, 2010).

This is the context in which REI emerge. In the specific case of REI, the focus of funding programs is usually placed on enhancing national research capacities and strengthening its links to innovation (Benner & Sörlin, 2007; Orr et al., 2011).

Characterisation of REI

Despite the difficulty in defining what excellence is and how to assess it (Hellstrom, 2011), REI were increasingly adopted as a funding instrument to encourage outstanding and strategic research. The key operational characteristics of REI-types of funding programs are that they provide large-scale and long-term funding. In addition, they serve to competitively allocate funds within earmarked governmental programs with the aim to promote quality and relevance of research activity.

Because CoE, the focus of this study, are organisations created within the context of REI a further characterisation is provided below in order to help understanding the multi-faceted nature of CoE and, also, to distinguish CoE from other funding instruments.

REI are based on the assumption that resourcing selected groups and institutions with significant funding and other resources, provide the most favourable conditions that will enable excellent research and outputs to flourish. Overall, the factors that are deemed fundamental for the conduct of quality research are (Salmi, 2009):

1. Concentration of talent both academic staff and students
2. Abundance of resources
3. Favourable governance approaches that enable strategic vision, flexibility, and innovation
4. Large-scale and long-term research programs
5. Potential links with end-users of research
6. Large budgets
7. Greater stability provided by fixed-term and longer funding periods

Although REI are considered as a hybrid instrument, combining elements of institutional grants and project funding, Orr et al (2011) highlight some of the key differences and similarities between the three funding approaches:

1. REI are similar to institutional funding in that they have relatively longer funding timelines, and, both can be allocated to organisations as a whole. However, the main difference lies in that institutional and block funding flows from institution to goal (where goals are defined by the institution itself), whereas in REI, funds flow from goal to institution. The scope and identification of goals is defined at the program-level and the selection process narrows down to the institutions most likely to achieve such goals;

2. REI are similar to project funding in several ways: funding is usually granted to research units (not individuals), directly administered by a funding agency on competitive grounds which are based on pre-established priorities and criteria and implemented through a formal peer-reviewed application process. The attainment of a pre-defined objective within a pre-defined time-period is also common to both. However, there are two major differences: whereas project funding is granted based on research merit solely, REI assess merit and the extent the proposed research plan responds to the strategic goals of the funding program. Another key difference is the tendency of project funding to support "low-risk applied research", whereas some types of REI are focused on supporting blue-sky, open-ended research projects to enhance the international competitiveness of national research capabilities (involving higher risk levels) and during longer time-frames.

Another set of characteristics intrinsic to REI are important to highlight. The incorporation of New Public Management (NPM) principles is a feature of most REI schemes (including CoE schemes in Australia included in this study) which are also common to other funding allocation methods such as formula-based approaches. Hicks (2012) cited in (Orr et al., 2011) provides three central aspects of REI that reflect the application of NPM principles:

1. Focus on output: REI selection processes are based on programmatic pre-defined priorities. The selection criteria outline expected results and successful initial and regular evaluations depend on the consortium research capacity and strategy to foresee and deliver expected outputs and outcomes that clearly contribute to the program's super-ordinate goals.

2. Competitive funding approach: funding agencies award a limited number of REI grants to selected consortia based on competitive selection processes. Through this approach, states act as buyers of research services having the possibility to outsource nationally and possibly internationally through the composition of international research teams.

3. Alignment of institutions with broader socio-economic goals: research, development and training activities and outcomes carried out in the context of REI are expected to contribute to improved research capacity but also to the achievement of broader socio-economic goals, such as contributing to tackling the so-called "grand challenges" (e.g. climate change, public health, biotechnology) and fostering innovation and economic performance of key sectors.

In sum, REI mechanisms for the funding of research activities have spread in most developed and increasingly developing countries as a tool for capacity building in STI (Hellstrom, 2013). As described above, they have a common set of characteristics which are mainly the incorporation of New Public Management principles, a competitive approach to funding through the selective allocation of mid to long-term, large-scale funding. REI include, but are not restricted to, the funding of fundamental, open-ended research. Selectivity and concentration are core features of REI based on excellence-related measurements combined with the future potential of outputs and their application or impact.

CoE is the general term used in this study to refer to REI types of instruments found in Australia, namely ARC CoE and CRC programs. The next sections discuss the significance and application of CoE in the particular geographical context of this study, Australia.

3.2.6 Centres of Excellence (CoE) as a tool for strategic research funding

The introduction of strategic research policy instruments, such as CoE, is based on the idea of concentrating funding, human resources, infrastructure, and management capacity on fewer and more selected groups and areas in order to create a critical mass and address thematic or national priorities and pursue pre-established goals. Some authors point out to an emerging "global model" of CoE, referring to an increasing global convergence in terms of research topics and funding approaches for this instrument (Beerkens, 2009).

Hellström (2017) defines CoE as "organisational environments that strive for, and succeed in, developing high standards of conduct in a field of research, innovation, or learning".

By creating CoE, funding agencies aim to pursue, at the same time, strategic policy goals and to satisfy the interests of researchers, by providing a significant amount of resources to be used over a long timeline while also providing a substantial amount of autonomy in the conduct of research activities (OECD, 2014c).

Such strategic policy goals can vary greatly in nature. In terms of topics, CoE as a funding mechanism is often applied to (but definitely not restricted to) emerging, knowledge-intensive, high-potential scientific and technological areas such as nanotechnology, information technology, climate science and biomedical research that require a combined disciplinary and technical expertise of highly-skilled human resources (often only assembled through the collaboration of multiple organisations) and the availability of expensive and sophisticated infrastructure (Fischer, Atkinson-Grosjean, & House, 2001; Hellström, 2017).

CoE are also adopted as platforms, hubs of expertise, used to make a system more dynamic by reducing fragmentation and isolated pockets of activities within a system, by concentrating resources, attracting domestic and overseas talent (from students and early-career academics to senior scientists) and creating a critical mass of resources (Langfeldt, Benner, & Sivertsen, 2015).

As CoE schemes spread all over the world during the recent decades, it was possible to observe a progressive diversity in terms of underlying rationales as well as new organisational arrangements which are highly associated with national circumstances (Luukkonen, Nedeva, & Barre´, 2006). CoE programs can lead to creation of organisations of different sizes and configurations. They may be geographically and physically concentrated on a single institution, a regional cluster, a national network of distributed nodes (which is the case, for instance, of ARC CoE in Australia) or even virtual networks (Fischer et al., 2001).

Before addressing the particular context of Australia, it is important to highlight some of the key underlying rationales behind the introduction of CoE schemes found in most developed countries. A common factor is a focus on re-structuring national capabilities according to pre-defined policy goals (achieve a critical mass, reduce fragmentation, address a particular problem, just to name a few).

As an international trend, CoE schemes have three main underlying strategic rationales which also apply to the Australian context (Aksnes et al., 2012; Hellström, 2017; Langfeldt et al., 2015):

1. Scientific excellence focus: science policies oriented to building research capacity and promoting world-class research in basic and strategic or applied fields. The focus is placed on pursuing excellence in research activities at an international standard of quality.
2. Economic and Innovation focus: research and innovation policies oriented to building research capacity in strategic fields with the aim of responding to socio-economic challenges (especially focused on research-based innovation and economic growth). The focus is placed on relevance and impact.
3. Grand challenges and societal focus: policies oriented to tackle societal challenges and provide input for evidence-based policy making. The focus is placed on societal challenges and policy-making.

Given the existing diversity in terms of CoE programs' strategic orientation, the operational principles and conditions that implement CoE programs and the associated or expected outcomes and impacts in terms of capacity-building achieved through CoE, Hellstrom (2017) provides an analytical framework for understanding the relationship between goals-operational conditions-effects surrounding CoE schemes.

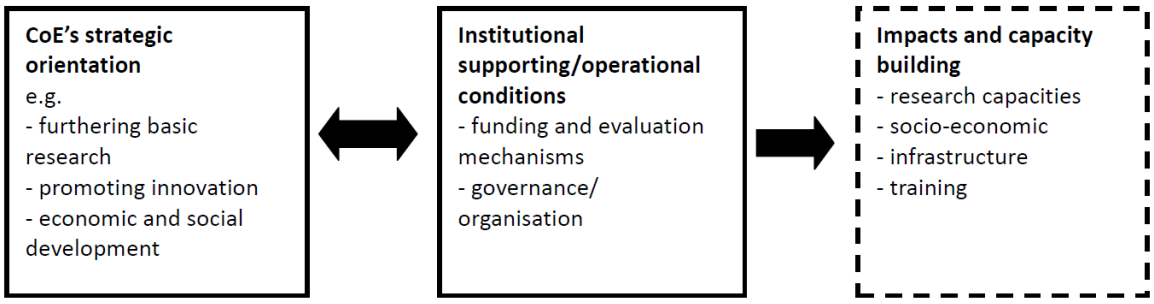

Figure 2. An analytical framework for CoE schemes in capacity building (Hellstrom,2017)

This framework provides a summarised illustration of the interconnected issues described so far. In particular the framework illustrates how national circumstances and policy goals affect the strategic orientation behind the creation of CoE schemes which are in turn

bound and shaped by operational conditions, funding requirements and impact expectations of funding programs.

In this first half of the chapter it was argued that CoE schemes have been widely used as a policy instrument with the aim of promoting a more robust and strategic research and innovation environment. During the last few decades, CoE schemes have been introduced and multiplied in most OECD and EU countries following different rationales but generally focusing on the agenda of achieving a critical mass in strategic research areas while improving cross-sectoral links between R&D performers and end-users with a view to improving the translation of research outcomes for socio-economic benefit.

The first part of this chapter also situates the topic of the thesis within the current literature, starting from the broader dynamics of knowledge production within society and narrowing down to the underlying policy rationales behind the creation of REI and more particularly CoE.

The next section focuses on the geographical context of the study, Australia. The origins and nature of CoE programs in Australia are described to provide the local background within which the case studies are situated.

3.3 Australian context and the emergence of Centre of Excellence (CoE) policies in the context of governmental STI strategy

This section discusses the background context of Australia by identifying the key features of the STI system in which studied CoE are immersed. Most importantly, the key framework conditions that led to the adoption of CoE as a mechanism for the funding of STI activities in Australia are presented.

First, the discussion begins by presenting the structure of the Australian R&D system and the significance of higher education institutions as major actors within the system. Then, the key shifts affecting the policy framework and leading to the introduction of REI are presented. Finally, the two funding programs that underpin the centres within the scope of this study are presented.

Australia is no different from other OECD countries in that a substantial portion of the country's R&D investment and capacity has traditionally been concentrated in the public sector and more specifically in the HE sector, with research-intensive universities as major R&D performers in the country (Meek, Goedegebuure, & Van der Lee, 2010).

Some key indicators regarding expenditure on R&D are quite indicative of the configuration of the Australian STI system. Australia's current gross expenditure on R&D as a proportion of GDP (GERD)[3] has recently fluctuated from 2.11 percent in 2013-14 to a current 1.88 percent of its GDP (Australian Bureau of Statistics, 2017), a figure below the OECD average which is currently 2.38 percent (Australian Government, 2017b).

Two other indicators differentiate the Australian context. Firstly, the Commonwealth government alone (not including state-level government funding) contributes 68 percent to total government expenditure on R&D (GOVERD), a figure above both OECD and EU averages (Australian Bureau of Statistics, 2012; OECD, 2013).

Secondly, Higher Education investment in R&D (HERD) accounts for 0.58 percent of GDP, also above both the OECD and the EU averages (OECD, 2014d). In addition, private sector investment in R&D has been traditionally relatively low in Australia, which has also contributed to the dominant role consistently played by the Commonwealth government in funding Australian STI activities (Meek et al., 2010).

The Australian HE sector is a major performer of R&D activities, being responsible for slightly over 30 percent of GERD and according to the latest available data on human resources[4], the HE sector is responsible for the majority of human resources devoted to R&D, accounting for 45 percent (Australian Bureau of Statistics, 2017).

Another set of structural dynamics strongly affecting the country as a whole is that Australia is currently in the middle of a major economic transition, following the end of a fifteen-year growth period enabled by the latest mining boom (Battellino, 2010). The nation is searching for a new and innovation-based growth cycle in the hope of transitioning from a resource-based economy into a service and advanced manufacturing economy (Australian Government, 2009).

[3] In 2016, Australia's latest estimate for GERD is AUD$31,179 million (Australian Bureau of Statistics, 2017)
[4] 2008-2009

Therefore, the transition from an industrial to a knowledge-based economy is even more critical and palpable in the Australian context, placing even greater demands on Australian universities and other key tertiary education institutions such as the Vocational Educational Training (VET) providers (Goedegebuure & Schoen, 2014; Goedegebuure & Schubert, 2017).

This first section showed some key characteristics of the Australian STI system: the dominant role of the Commonwealth government in overseeing and funding the system and that of HEI as key performing actors. Steering the performance of public R&D actors, especially those of the HE sector, has increasingly become an intrinsic part of the Australian public policy strategy in pursuing innovation and socio-economic development. The following discussion outlines the underlying forces and idiosyncrasies of the Australian context that led to the adoption of new funding mechanisms for STI activities, including CoE.

3.3.1 Governmental steering and control over the substance and conduct of academic research activities

Because universities are at the core of knowledge production, governments try to steer their performance so that their agendas are met. In the particular context of this study, universities are central actors with respect to CoE. Each of the two funding programs for the creation of CoE that give rise to the centres included in this study (presented in detail in the next section), identify university participation as an imperative pre-condition. The CRC Program requires, as a pre-condition, that a CoE bid must include at least one Publicly Funded Research Organisation (PFRO), which in Australia are represented, in great majority, by universities as well as public research organisations (eligible universities are listed in the funding rules) (CRC, 2015). The ARC CoE Program goes even further by identifying universities (eligible universities are listed in the funding rules) as the only eligible organisations to submit and lead a funding application, and once funding is approved, this same university acts as the administering organisation of the funds and in liaising with the funding agency (Australian Research Council (ARC), 2017).

The existence of a “pact” between the higher education sector and society is something largely explored in the scholarly literature, including how the relationship and expectations between the parties evolve and have considerably changed over the recent past (Maassen,

2014). Higher education, which has historically been perceived as a social institution, has been increasingly perceived as an "industry" (Gumport, 2000). Moreover, universities are expected to actively and more explicitly contribute to socio-economic growth and innovation in addition to their core roles of generating and applying knowledge and training highly-skilled individuals (Burton, 1998; Dill & Van Vught, 2010c). The combination of the issues faced by the HE sector in Australia, described in this section, can be associated with a more utilitarian view of HE, and the application of New Public Management (NPM) principles (Dixon & Lodge, 2012; Hood, 1991; Olssen & Peters, 2005) for greater accountability and efficiency of publicly-funded organisations have contributed to the complex transformation and greater professionalisation of Australian universities management capacity (Goedegebuure & Schoen, 2014; Marginson & Considine, 2000; Yates, Woelert, Millar, & O'Connor, 2017).

The notion of HE "industry" is particularly relevant in Australia, where HEI operate in a remarkably competitive and market-based environment. Based on the recruitment of fee-paying international students, HE is openly regarded as Australia's third largest export, a sector only behind iron ore and coal (Universities Australia, 2017).

Not only do HEI compete to attract full-fee paying international students (particularly from the growing Asian region), they also compete for research funding. This competition for research funding has been purposefully fostered by the government in the last decades.

It is important to note that, historically, the state governments had legislative control over education as a whole including HEI while financial responsibility rested with the Commonwealth government of Australia (Meek et al., 2010). However, since the Second World War, there has been substantial and growing federal intervention in higher education. A number of system-wide reforms have impacted the system increasing the Commonwealth government control over HEI as it oversees planning and funding of the sector (Meek et al., 2010). These shifts have largely influenced how universities are funded and perform STI activities.

Substantial shifts have taken place since the 1980s Dawkins Reforms (National Board of Employment Education and Training (NBEET), 1988) seen at the time as revolutionary and highly controversial, which, amongst other goals, can be used as a landmark in the organisation and funding of the HE system, but also within the governmental drive to increase its steering power over the research activities of publicly-funded HEI (particularly research-intensive universities) in the recent past (Meek & Hayden, 2005; Yates et al., 2017). Since then, some of

the main approaches adopted by the government were the introduction of performance-based mechanisms to fund academic research (a trend perceived in most OECD countries) (Glaser & Laudel, 2007), and the assessment of university research capacity through a quantitative performance assessment through the "Excellence in Research for Australia" (ERA) framework (in contrast to traditional recurrent block funding) (Woelert & Yates, 2015), and the introduction of new, competitive funding schemes for STI activities through the its main governmental agencies (Croucher & Woelert, 2016). For the context of this study, two governmental entities are central: the Australian Research Council (ARC), which oversees the ARC CoE Program, is one of the two main Australian government funding agencies together with the National Health and Medical Research Council (NHMRC); and the Department of Industry, Innovation and Science which oversees the CRC Program.

More recently, a number of policy interventions have marked the government drive in steering and are having more leverage on the activities of research actors. In 1999, the liberal coalition government released "*New Knowledge, New Opportunities: A Discussion Paper on Higher Education Research and Research Training*" targeted at the perceived deficiencies in the sector which were considered to limit the institutional capacity required to address the requirements of the emergent knowledge economy (Kemp, 1999b). The paper kickstarted a national discussion around new funding incentives that could encourage: greater diversity and increased excellence, enhance the connections between the actors of the innovation system, increase concentration by institutions on areas of relative strength, and improve research graduates' employment prospects, while a particular focus was placed on improving graduate research training (PhD and research masters') through a dedicated policy statement (Kemp, 1999a).

As a result, a number of concrete changes were initiated in the country at that time, affecting the organisation of the STI system. The core changes, all of which are of particular significance for this study on CoE, were:

- A strengthened role for the Australian Research Council (ARC)
- A revamped national competitive grants system
- Performance-based funding for research activities and research training for the university sector (Kemp, 1999a)

In 2014, a Productivity Commission report included a number of recommendations proposed to increase efficiency and reduces costs in the allocation of funds and performance

of publicly-funded R&D, strongly recommending a "strategic, whole-of-government approach to where Australia's research dollars are spent" particularly targeted at the collaboration between publicly-funded research agencies (PFRA) and universities with the private sector (National Commission of Audit, 2014).

There is some evidence that, in Australia, since the Dawkins reforms, governmental efforts to steer the academic research sector have had a significant influence on the entire system. First and foremost, it should be noted that it did facilitate a major expansion in student places increasing access and equity (Moses, 2004). In terms of research, government influence can be considered as a significant external force, that has been exerting considerable influence and shaping institutional research profiles and cultures of Australian universities.

While lower performing universities have experienced an initial boost in the process of trying to "catch up" with top performers (Beerkens, 2013), by and large, government steering through funding can contribute to stratification and concentration in the system; increasing the gap between top performers and compromising a healthy diversity of actors in the tertiary education system (Beerkens, 2013; Meek, Hayden, & O'Neill, 1996; Moses, 2004).

For all above reasons, the issue of promoting diversity and differentiation in the national knowledge production system, mainly through the higher education system, has been a significant and ongoing debate in Australia (Eckel, 2008; Meek, Goedegebuure, & Huisman, 2000; Meek et al., 1996; Moses, 2004). The next sections discuss how CoE were introduced as a governmental strategic move to leverage the scientific capacity fragmented in pockets of scientific excellence scattered around the country to build a critical mass in research and concentrate funds and resources in areas of national significance.

3.3.2 National Innovation and Science Agenda: The Australia 2030 Plan

In 2015, The Australian Government unveiled its National Innovation and Science Agenda (NISA), which identifies science and innovation as the main pillars of Australia's policy agenda (Australian Government, 2015). The NISA report states that "innovation and science are critical for Australia to deliver new sources of growth, maintain high-wage jobs and seize the next wave of economic prosperity" emphasising the need for tertiary institutions to develop a highly-skilled, entrepreneurial, digitally savvy, collaborative and innovative workforce able to cope and thrive in a world characterised by the so-called "fourth industrial

revolution" (Australian Government, 2017a; Gray, 2016; World Economic Forum, 2016). Some of the other key underlying goals of NISA are to push for better articulation and collaboration between industry and tertiary education institutions, and a better balance between basic and applied research as a way to drive innovation and socio-economic growth.

More recently, in January 2018, the Australian government introduced the Australia 2030[5] agenda, a strategic plan for the implementation of NISA (Australian Government, 2018). With a view towards the 2030 horizon, the Australia 2030 agenda is proposed as a roadmap consisting of thirty recommendations for governmental authorities at all levels to be adopted as principles to enhance Australia's innovation system by mobilizing key actors in science, research, education, culture, and technological development in addition to the industrial sector.

Australia's current policy dialogue is consistently emphasising the role of science, in particular the role of university-based research, undergraduate education, research training and engagement with other actors of the system, all of which are mentioned as fundamental.

NISA and the 2030 Agenda are particularly relevant for STI in general and CoE in particular because they reinforce principles and approaches to S&T capacity-building that have also been advanced through CoE: the centrality of collaboration between knowledge producers and users, the importance of building on Australia's scientific areas of strength and building scientific and technological skills perceived as critical for the workforce of the future. The focus on knowledge-based innovation and the increased engagement between knowledge producers (namely universities) and knowledge users (namely industry) is made explicit through the significant changes in the way institutional research block grants are determined. Institutional block grants are now allocated through a new, more streamlined funding formula that gives equal weight to applied or industry-relevant research programs further encouraging engagement with end-users. The competitive grants portion is maintained[6].

The current context is to a large extent a product of the above-mentioned reforms. These significant shifts have affected the allocation of research funds, coupling traditional funding requirements around merit and track record with an increased focus on "excellence", on outputs and on impact measures. During the same period, overall public funding to universities dropped dramatically, putting emphasis on performance measurement, efficiency, demonstrable

[5] https://www.innovation.gov.au/event/released-australia-2030-plan
[6] https://www.innovation.gov.au/page/agenda

relevance to socio-economic growth and competition for resources as key strategies for steering the sector (Meek et al., 2010). As a result, universities, feeling "over-reviewed and under-funded", have developed some coping strategies in their approach to research management by identifying priorities, concentrating resources and adopting internal performance indicators and management systems (Wood & Meek, 2002).

It was during this period of dramatic change that the Australian Research Council (ARC) was created, which is the funder of the main scheme for the creation of CoE in Australia and one of the two funding schemes[7] giving rise to the centres included in this study. The creation of the ARC is considered as a move to increase the federal government control over the "substance" of research conducted in the system through the creation of a centrally administered public research funding agency (Yates et al., 2017).

It is relevant to note that Australia was one of the pioneers in the creation of CoE types of programs[8] with the first centres being funded as early as 1982 when the Special Research Centres program was initiated funding the establishment of ten CoE (Australian Research Council (ARC), 2018).

3.3.3 The Australian Research Council and its Centres of Excellence (CoE) Program

Created in 1988, under its current name and configuration, the Australian Research Council (ARC) is a statutory independent body within the Australian Government which provides policy advice and implements research programs through the allocation of grants for basic and applied research fields (with the exception of medical-related fields which are administered by the National Health and Medical Research Council (NHMRC) created much earlier in 1937).

All ARC funding instruments fall under the framework of its National Competitive Grants Program. They are broadly divided into two major programs: the Discovery Program, which incorporates schemes for the support of fundamental research; and the Linkage Program,

[7] The other being the CRC Program which is administered by *AusIndustry*, a division within the Commonwealth *Department of Industry, Innovation and Science*.

8 N.B.: As mentioned before, the term Centre of Excellence (CoE) is adopted in the context of this study in reference to all collaborative centres created through strategic governmental funding programs in the context of national STI policies (and not only to the centres created through ARC's flagship CoE Program).

which promotes national, and international, collaboration and partnerships between key stakeholders in research and innovation. The ARC gathers a number of schemes within the Linkage Program aimed at fostering state-of-the-art R&D activities and applying knowledge to problems and emphasising the application of research outputs. This application may be oriented towards the commercialisation of research outputs by industry but also other types of application such as in the development of policy-making or addressing societal or environmental problems. Such partnerships require consortia to be composed of higher education researchers and other actors of the innovation system. A key characteristic is that the program does not reject projects that involve a certain degree of risk, encouraging especially new and innovative lines of enquiry.

It is within the Linkage Program that schemes for the creation of collaborative research centres, including the ARC Centres of Excellence Program (which gives rise to half of the centres analysed in this study) is situated (Australian Research Council, 2018).

National Research Priorities in the allocation of funds by the ARC

Some recent past events concerning the priority-setting process of the ARC are important for the current context of ARC-funded CoE.

In 2002, the Commonwealth Government announced that 33 percent of the ARC funding would be targeted for research activities in four priority areas: nano and bio-materials, genome and phenome research; complex or intelligent systems and photon science and technology (Meek et al., 2010). Later in the same year, the government identified a set of "National Priorities" referring to four broad areas and sub-priorities (largely hard-sciences focused and emphasising the economic relevance of research results) that should inform the funding allocation of not only the ARC but across all Commonwealth research funding agencies (Department of Education, 2002).

In 2015, led by the former Chief Scientist (Professor Ian Chubb AC), the government developed a set of national "Science and Research Priorities" and corresponding "Practical Research Challenges". These priorities were designed to inform the long-term strategic investment of public funds in areas perceived as of "immediate and critical importance to Australia and its place in the world", meeting perceived national needs and offering value for money (Office of the Chief Scientist, 2015).

As the main governmental agency for the funding of fundamental and applied research (other than in the field of medical and health sciences), the ARC funding allocation process is to a great extent informed by such National Science and Research Priorities. This entails that any submission for ARC funding, particularly large-scale multi-million-dollar bids like CoE, are assessed based on the potential of the proposed research plan and expected outcomes to contribute to the "Priorities".

Origins and structure of the ARC CoE Program

The Australian Research Council (ARC) introduced, back in 1982, its first funding schemes for the creation of collaborative centres which, given their focus on excellence and strategic orientation, are considered as the ancestors of current Centres of Excellence. These centres were known as Key Centres for Teaching and Research (whose last centres operated until 2004) and Special Research Centres (whose last centres operated until 2008) (Australian Research Council (ARC), 2018).

From 2003, the ARC Centres of Excellence (CoE) scheme replaced and extended those two earlier schemes. CoEs are funded to foster research excellence and are based on the perceived potential to contribute to the National Research Priorities set by the Commonwealth government.

The minimum level of ARC funding for an ARC Centre of Excellence is AUD$1 million per calendar year. The current maximum level of ARC funding for a single Centre of Excellence is AUD$4 million per calendar year (ARC, 2013).

Another key tenet behind the ARC CoE Program is to foster collaboration amongst universities and between universities and other organisations, both domestically and internationally. In terms of the orientation of research activities supported, the program funds from fundamental to strategic and applied research. The program is also focused on the idea of building capacity by means of resource concentration and collaboration to reduce fragmentation and create a critical mass of scientific capacity in areas of national interest. In this sense, building links with key international counterparts and attracting international researchers and training graduate researchers are core components of the program.

The stated strategic objectives of the ARC CoE Program are (Australian Research Council, 2018):

A. To undertake highly innovative and potentially transformational research that aims to achieve international standing in the fields of research undertaken and leading to a significant advancement of capabilities and knowledge
B. To link existing Australian research strengths and build critical mass with new capacity for interdisciplinary, collaborative approaches to address the most challenging and significant research problems
C. To develop relationships and build new networks with major national and international centres and research programs to help strengthen research, achieve global competitiveness, and gain recognition for Australian research
D. To build Australia's human capacity in a range of research areas by attracting and retaining researchers of high international standing as well as the most promising research students from within Australia and abroad
E. To provide high-quality postgraduate and postdoctoral training environments for the next generation of researchers
F. To offer Australian researchers opportunities to work on large-scale problems over longer periods of time
G. To establish centres of such repute in the wider community that they will serve as points of interaction among higher education institutions, governments, industry, and the private sector generally

Further program requirements and criteria relevant to understanding the nature of the ARC CoE program are included in Appendix 3.

3.3.4 The Cooperative Research Centres (CRC) Program

The Cooperative Research Centres (CRC) Program was originally launched in 1990 and since then has been an ongoing and competitive grant program. It is currently administered by AusIndustry. AusIndustry defines itself as "a division of the Department of Industry, Innovation and Science, which puts the needs of Australian businesses first by simplifying and streamlining access to information and advice"[9] making the CRC program primarily led by end-users which in most cases equates to industry-led but also includes other actors as primary beneficiaries such as the government or the pursuit of public-good community-driven goals.

The CRC Program supports medium to long-term, user-led research collaborations between industry, researchers and other community actors put together to solve industry problems and improve the competitiveness, productivity and sustainability of Australian productive sectors.

The CRC Association (CRC Association, 2018) defines a CRC as:

> *"A company formed through a collaboration of businesses and researchers. This includes private sector organisations (both large and small enterprises), industry associations, universities and government research agencies such as the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and other end users. This team of collaborators undertakes research and development leading to utilitarian outcomes for public goods that have positive social and economic impacts."*

The CRC Program encompasses two funding instruments: CRCs and CRC-Ps. CRCs refers to the original and major funding instrument enabling the creation of fully-fledged centres that allow medium to long-term collaborations over a ten to fifteen-year period. This instrument is the one that gives rise to the centres under the scope of this study.

More recently, in 2015, a new instrument called CRC-P grants was introduced for the funding of short-term projects (three years maximum). Research collaborations stemming from the CRC-P instrument are in scope for this study.

The overall aims of the CRC Program that guide the creation of new centres are to:

[9] https://www.business.gov.au/about/ausindustry-programme-summary

- improve the competitiveness, productivity, and sustainability of Australian industries, especially where Australia has a competitive strength and in line with government priorities;
- foster high quality research to solve industry-identified problems through industry-led and outcome-focused collaborative research partnerships between industry entities and research organisations;
- encourage and facilitate small and medium enterprise (SME) participation in collaborative research.

The CRC program is currently in its 19th selection round with this round's centres to be commenced in mid-2018[10]. Since 1990, over 210 CRCs have been funded by the Australian Government, representing a public investment of AUD$3.9 billion matched by participant organisations by a further AUD$12.6 billion in cash and in-kind contributions (CRC Program, 2016). These numbers show that the CRC Program has been an enduring model not only in the Australian context but one of the oldest programs of its kind at an international level. The CRC Program is frequently used as a reference model of a government-led initiative to increase the links and relevance of research to the needs of end-users and facilitate the adoption and commercialisation of R&D results (Fraunhofer Institute for Systems and Innovation Research ISI, 2015).

Further information about the technical and funding requirements for participation in the CRC Program that are relevant for understanding the context of studied centres is included in Appendix 4 alongside a list of active CRCs illustrating the nature and thematic foci of such centres.

3.4 Concluding remarks

This chapter presented the overall context in which studied CoE are embedded. To accomplish that, an analysis of the current dynamics affecting CoE involving knowledge production, STI policy-making and a closer look at recent trends taking place in Australia is

[10] Examples of CRC bids shortlisted in 2018 are Digital Health CRC, Farming Smarter CRC, Fight Food Waste and Fraud CRC, Future Fuels CRC, MinEx CRC, and Smart Ageing CRC.

offered. In addition, the basic characteristics of both Australian funding programs sponsoring the creation of studied centres were presented.

A number of underlying rationales have been identified to justify the introduction of CoE in Australia and beyond. From the research system funding perspective, CoE are introduced as an alternative instrument to allow for funding concentration, increased "efficiency" in the use of public funds, and top-down prioritisation in areas of "national significance. Often they are used as a strategic instrument to "fix" undesirable aspects of the system related to fragmentation of scientific, technological and innovation capacities by offering an integrating platform for dispersed pockets of expertise that normally do not have the means or incentives to coordinate activities and create synergies.

CoE can also be deployed to increase the level of collaboration between actors in the system (the knowledge triangle) particularly cross-sector collaboration and in making academic research capacity accessible or relevant to industry needs. This rationale is especially present in industry-driven CoE driven by the development and commercial exploitation of new technologies.

Above all, the "critical mass" argument seems to be the most pervasive one. This argument is based on the notion that certain areas of science or research problems require a critical mass of researchers, resources and facilities, over an extended period of time, to allow for a significant level of performance and the accomplishment of complex goals, something that could not be afforded by any of the actors in isolation or even by existing networks. Thus, CoE function as platforms that allow for building, integrating and maintaining research capacity during a period of time long enough to produce significant results and strengthen national and individual institutional capabilities.

The underlying rationales behind the creation of CoE are diverse, from the policy down to the centre level. Nevertheless, what makes it possible for partnerships to be able to accomplish pre-stated goals, the connecting link between expectations, resources and results is the "organisational capacity" put in place at the creation of a CoE.

The degree to which a CoE organisational capacity is "adequate" of "fit-for-purpose" is often used as a proxy or pre-condition for the perceived effectiveness of a centre (Aksnes et al., 2012; Langfeldt et al., 2013; O'Kane, 2008; Schröder, Welter, Leisten, Richert, & Jeschke, 2014; The Research Council of Norway, 2011). In addition, the assessment of proposed or

existing organisational capacity is used in selection and assessment processes of CoE, analysing the adequacy of governance, leadership, management and any other organisational factors that may contribute to advancing the purposes of CoE (ARC, 2013, 2017; CRC Association, 2012; Department of Industry, 2018).

This study is concerned with investigating the nature of CoE organisational capacity and associated L&M approaches. It is hoped that the study can contribute to new knowledge about how to better align CoE organisational capacity to advance knowledge and respond to policy goals.

The next chapter presents the analytical framework for the study used to define and operationalise the foundational concepts for the study of organisational capacity, leadership and management.

CHAPTER 4. ANALYTICAL FRAMEWORK

4.1 Introduction

This chapter presents the analytical framework adopted for the study and the roles it fulfils in addressing the research questions. The analytical process of this study will be performed by using two widely tested and validated frameworks in the literature: the Building Organisational Capacity Framework (BOC) (Toma, 2010) and the Competing Values Framework (CVF) (Quinn, Bright, Fagerberg, Thompson, & McGrath, 2007).

The first framework (BOC) is used to understand and map the nature of CoE as organisations while the second (CVF), builds upon the findings facilitated by the use of BOC and allows for further investigation into the role of leadership and management (L&M) in the specific context of CoE as complex, diverse, highly collaborative, multi-disciplinary and knowledge-intensive organisations performing STI activities.

The role of both frameworks in collecting and analysing data is described here and in addition both frameworks are re-visited in the Discussion chapter when their application and relevance to the study are reviewed.

4.2 Core Concepts in the Study

A few core concepts are consistently articulated throughout the study. This cluster of core concepts is listed below, followed by a brief summary of their theoretical foundations.

1	Organisation
2	Organisational capacity
3	Governance
4	Leadership & Management
5	Organisational Culture

1. Organisation

The notion of organisation within the study draws upon concepts widely explored within the field of organisation and management theory that aim to make sense of how organisations come into being and the drivers that influence individuals and organisations as a whole (Mintzberg, 1979; Pfeffer & Salancik, 1978; Weick, 1995; Weick, 2001). Of particular relevance to this study, are the scholarly traditions that investigate the ways the notion of organisation intersects with the social organisation of science and science-based activities (Ben-David, 1991) which is intertwined, in great part, with the rise and organisation of Higher Education Institutions (Clark, 1972).

Mintzberg (1989) defines the term "organisation" to symbolise "collective action in the pursuit of a common mission".

The analogy for the organisation offered by Weick (2001) below is quite representative for the context of CoE:

> *" Imagine that you're either the referee, coach, player or spectator at an unconventional soccer match: the field for the game is round; there are several goals scattered haphazardly around the circular field; people can enter and leave the game whenever they want; they can say "that's my goal whenever they want to, as many times as they want to, and for as many goals as they want to; the entire game takes place on a sloped field, and the game is played as if it makes sense." (p.32)*

The diversity of players, roles, goals and agendas that co-exist at CoE are a core characteristic of this organisation which brings a number of strengths and challenges as will be seen throughout this study.

Organisational structure refers to how work is organised. Mintzberg (1979) describes organisational structure as "the *division of labour* into various tasks to be performed and the *coordination* of these tasks to accomplish the activity. The structure of an organization can be defined simply as the sum total of the ways in which it divides its labour into distinct tasks and then achieves coordination among them" (p.2). Organisational structure refers then to how roles, power and responsibilities are assigned and distributed and in turn how they are controlled or coordinated, typically leading to the notions of the centralisation and decentralisation of decision-making and control depending on the nature and strategy adopted by the organisation.

2. Organisational capacity

Finally, "organisational capacity" is the most prominent concept in the study. The notion of "organisational capacity" is vastly addressed in the organisational and management literature in different contexts. Overall, it refers to the comprehensive array of abilities, capabilities and skills of an organisation and its members.

The term "organisational capacity" is directly derived from the Toma's analytical framework BOC in which it is defined as "the administrative foundation of an institution, which is essential for establishing and sustaining initiatives intended to realise its vision" (Toma, 2010, p.3).

In this sense, organisational capacity involves all types of elements that enable the organisation to fulfil its purposes, from the typical availability of infrastructure, human resources and procedures but also more abstract elements such as the role and influence of leadership and management skills and governance approaches as well as symbolic elements such as ethics, values, mission and culture.

Thus, understanding the necessary capacity of an organisation is a central pre-requisite for strengthening that organisation's capacity (commonly known as capacity-building) and in making that organisation more effective or more efficient.

3. Governance

Edwards (as cited in (Reed, Meek, & Jones, 2002)) affirms that the concept of "governance" represents "not so much what organisations do but how they do it; governance is about how the organisation steers itself and the processes and structures used to achieve its goal".

Governance and particularly the notion of 'good governance' have an important role in the study. Graham et al. (2003) describe governance as "a process whereby societies or organizations make their important decisions, determine whom they involve in the process and how they render account" and perceive it to be a somewhat abstract hard to observe phenomena that is usually analysed based on "agreements, procedures, conventions or policies that define who gets power, how decisions are taken and how accountability is rendered." (ibid.). Because CoE are usually created by a network or consortium of organisations and usually involve governmental funding agencies, underlying notions surrounding "networks" and

"interdependencies" between key stakeholders are relevant (Benson, 1975). In the context of CoE, resource interdependencies (such as funding, expertise and STI capabilities) amongst CoE member organisations and their groups are coupled with the extent to which "shared values and norms" and especially "trust" exist and are taken into consideration in the partnership (Blackburn, 1998; Pfeffer & Salancik, 1978; Rhodes, 2007; Scharpf, 1978).

In this sense, the notion of "good governance" is particularly relevant within the conceptual framework of the study. Both branches on public governance and corporate governance offer important concepts to the study of issues affecting governance at CoE. The notions within agency theory are positively complemented, and more relevant to the CoE context, when combined with key insights from stakeholder theory, and stewardship theory developed in the scholarly literature of non-profit organisations (Van Puyvelde, Caers, Du Bois, & Jegers, 2012). The main reason for this is that, in the principal-agent relationship, there is no actual owners or shareholders (principals) but a range of organisational stakeholders whose representatives are willing to act in their organisations' interest.

What constitutes "good governance" can be expressed by different but convergent sets of principles found in the literature. Three sets appear to adequately represent the concept of good governance, being widely promoted by the United Nations Development Program Governance Principles (UNDP, 2014), the European Commission (European Commission (EC), 2001)and the UK's Nolan Principles of Public Life (Committee on Standards in Public Life, 1995) as seen in the table below:

United Nations Development Program	**European Commission**	**Lord Nolan's Seven Principles of Public Life**
Legitimacy and Voice	Participation	Selflessness
Direction	Coherence	Integrity
Performance	Effectiveness	Objectivity
Accountability	Accountability	Accountability
Fairness	Openness	Openness
		Honesty
		Leadership

Table 5. Good Governance principles according to international organisations

Good governance is then a construct that encapsulates all these principles and applies or translates them into a particular context usually by identifying some kind of operational and context-bound criteria (Graham et al., 2003).

In the study, the level of analysis of governance is focused at the CoE organisational level referring to the governance arrangements, oversight roles and responsibilities, policies, procedures and the means put in place to implement a governance approach.

4. Leadership and Management

Leadership and management (L&M) traditionally refers to the roles and tasks involved in setting direction and a vision and putting the necessary infrastructure in place to implement to pursue that vision. In the study, L&M refers more specifically to leading and managing STI in research organisations with all the particular challenges that come with it (Garret & Davies, 2010; Taylor, 2006).

In this sense, aspects of L&M of research in CoE include directing and supporting the creative behaviour and the performance of scientists within groups and networks and across thematic streams (Hemlin, 2006) but also managing strategic collaborations, managing research infrastructures, developing talent, liaising with funding agencies, and interacting with institutional leaders of host universities (Johnson 2013). The evolution and professionalisation of L&M of research, brought about with the evolution and scale of scientific activity itself, highlights the renewed significance of L&M in research organisations and its peculiarities (Schuetzenmeister, 2010; Taylor, 2006).

5. Organisational Culture

The notion of "organisational culture" encompasses an array of intangible but critical aspects. It can be perceived as the organisational "soul", and described by its set of shared values, beliefs and often unspoken norms that point to "how we do things around here" and constitutes a unifying force that binds the organisation together (Ashkanasy, Wilderom, & Peters, 2000; Meek, 1988).

In the particular context of CoE, organisational culture is largely associated with, and to some extent a product of, embedded disciplinary cultures, structures and traditions (Becher, 1981; Becher, 1994; Becher & Trowler, 2001; Braxton, 1986).

Although a full-blown study of the culture of CoE is beyond the scope of this study, it does feature as an element within the BOC analytical framework (which is presented in the next section) in which understanding the basic role of culture as one of the key elements of CoE organisational capacity is considered and addressed.

4.3 Building Organisational Capacity (BOC) Framework

BOC (Toma, 2010)[11] offers a framework for building organisational capacity which can be used either as a diagnostic tool for mapping existing capacity or from an organisational transformation perspective in building capacity within a new strategic orientation. BOC provides the basic analytical tools for dissecting the components, the foundational building blocks, of an organisation by adopting a systems' perspective and placing the organisation's purpose at the core of this system. In addition to offering the lens for mapping the different organisational elements, it highlights the interactions and especially the "alignment" amongst the elements bringing to the fore the significance of certain elements and their inter-relations with certain organisations.

The BOC Framework builds on long-standing scholarly and practised traditions in strategic management and organisational change (David, 2011; Freeman, 2010; Mintzberg, 1994; Morley, Doolittle, & Harrison, 2005; Shattock, 2000) upon which BOC aims to extend and contribute by addressing perceived shortcomings at the moment of implementing strategic plans into practice. In the development of BOC, the authors claimed that most models are either too conceptual (lacking implementation robustness) or sufficiently concrete but too specific and customised for a particular sector.

BOC has, thus, been extensively used and validated as a strategic-management framework tool used within processes of organisational capacity-building and change. More importantly, BOC has been widely used in complex, large, knowledge-intensive, and in many cases non-profit-driven organisations such as universities where it is regarded as an effective tool largely used to anticipate and meet challenges and facilitate effective and lasting change that is absorbed by the organisation as a whole (Webber, 2018).

Unlike other frameworks, BOC is a holistic, systems-oriented, non-linear and not prescriptive organisational capacity framework that is oriented to the study, planning and implementation of organisational capacity building as a means to create and sustain organisations that are able to perform effectively and consistently in the pursuit of their purposes.

[11] Building organisational Capacity (BOC) Framework originated from a research project initiated by the North-American National Association of College and University Business Officers (NACUBO) in 2004.

The BOC framework affords the necessary level of flexibility for analysing different types of organisations catering to those, such as CoE, that are oriented by drivers other than profit. BOC is suitable for the analysis of selected CoE given the diversity in the pool of selected cases in terms of organisational purposes, organisational structures, topic areas and strategic orientation in the conduct of STI activities.

4.3.1 Application of the BOC Framework for the study of CoE

In the context of this study, the BOC framework, as a conceptual model for understanding organisational capacity, purposefully fulfils its conceptual and structuring function in data gathering as well as providing a lens for data analysis. Most importantly it allows for the investigations of the nature of CoE from an organisational theory perspective. Since there is no typical CoE model, every CoE is an inherently unique type of organisation. In addition, they are relatively new, knowledge-intensive, and under-investigated types of organisations particularly when compared to profit-oriented organisations to which most capability and strategic management frameworks are designed. Instead of being profit-driven, most CoE share an orientation towards common goals that can be scientific, technological or public-good oriented (or any combination thereof). In addition, the notion of community and capacity-building, and the translation of outputs into addressing existing problems or science gaps are aspects that underpin the creation of most CoE. Thus, BOC is adopted as a suitable analytical lens for the idiosyncratic and diverse nature of CoE, enabling the identification of what organisational elements are essential in building organisational capacity in CoE. This addresses the study's first research sub-question.

From a methodological point of view, BOC served to inform the process of data collection, providing the basic organisational dimensions for the examination of the selected cases through qualitative enquiry, and, later, offering an analytical lens for understanding each organisational element's significance and the basic relationships between the elements. Once data was gathered and organised around BOC's eight core elements (see:4.3.1), this first analytical stage served as the basis for further extending and refining the analysis into the specific context of studied CoE, reflecting on centre-specific circumstances and their meaning within the findings presented.

Toma's approach to organisational capacity-building via BOC is based on the notion that an organisation, in order to be effective in pursuing its mission and fulfilling its purpose,

must understand the nature of the elements that constitute its organisational capacity and the relationship between the elements and, above all, how leaders and managers align such elements in conducive ways. Organisations, thus, have their effectiveness enhanced by establishing "fit-for-purpose", apt and aligned organisational capacity that match their mission and purposes and by maximising this capacity according to their different strategic pursuits.

4.3.2 BOC Framework core elements

The BOC framework represents organisational capacity as an array of discrete but interrelated and inter-dependent elements. The notion of "systems thinking" (Sterman, 2000) underlies the BOC approach and reflects a holistic perspective showing that organisations can only be understood and described by a continuous interplay between the elements which ought to be analysed individually but also in concert to more properly reflect the dynamics at play. The use of a web of inter-related elements, where any given element is connected to all others, highlights the essential and significant role of each element but also the dynamic and inter-dependent connections between the elements, reflecting the nature of reality where the alignment of the parts is a critical condition for the overall systemic harmony and performance.

The BOC framework is composed of eight elements considered essential for building an organisational foundation: organisational purpose, structure, governance, policies, processes, information, infrastructure, and culture. The following image provides a graphic illustration of the elements that make up BOC Framework.

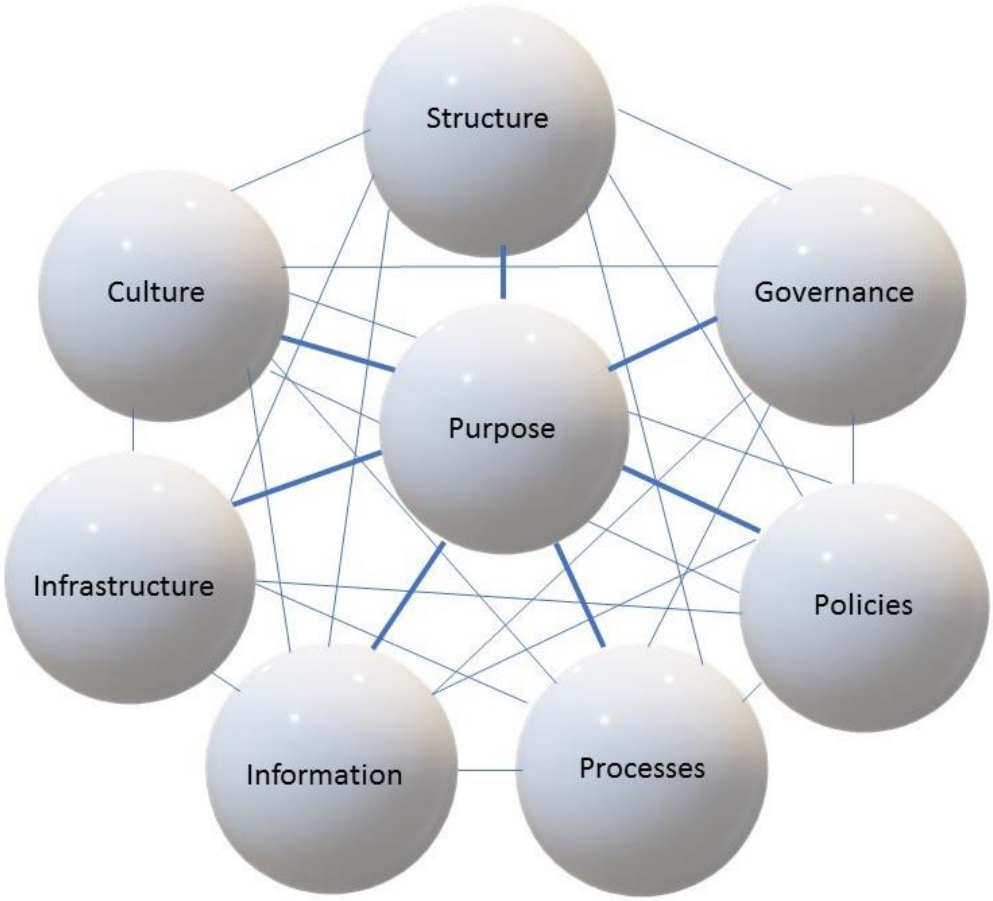

Figure 3. Graphic representation of the BOC Framework based on Toma (2010)

4.3.3 Static versus Active elements

Each of the elements in the BOC framework encapsulates an essential dimension of the organisation. The graphical representation of BOC provided above emphasises the interrelations amongst the elements, which are integral parts of a greater whole, and the emphasis on the alignment between elements, all aspects central to the framework.

Within BOC (Toma, 2010), Toma systematically refers to the either static or active nature of each of the elements. This appears to be used by the author as a way to differentiate the static or stable nature of some elements of the framework, namely Structure, Policies, Information and Infrastructure as opposed to the active or dynamic nature connotated by the remaining elements – Purposes, Governance, Processes and Culture.

All elements are equally important for building organisational capacity, however the major difference entailed by this differentiation is that the "static" elements are perceived as necessary means to be put in place for the organisation whereas the "active" elements require

some form of explicit action. Static elements convey a sense of order, stability and predictability whereas dynamic elements highlight the importance of action, responsiveness, change and adaptability.

Because each element represents a significant organisational dimension to be investigated in the context of CoE, they are further described and elaborated next.

Element 1: Purpose

The framework point of departure is "Purpose" as the core element of the web. Purpose as an element encompassing the original mission and aspirations that are deeply embedded in the identity and the "*raison d'être*" of the organisation.

The element "purpose" not only represents the reason an organisation exists and what spurred its creation in the past but also where it is headed in the future. In the context of CoE, purpose may point to an existing major problem or scientific or capacity gap of national significance that generated the need for the creation of a CoE. On top of the nature of the problem, it reflects a consensus amongst the different stakeholders in the partnership, a shared understanding, a mutual interest in addressing such problem or gap. The idea of a "common" or a "shared" sense of purpose is a central aspect to Australian CoE as collaborative organisations, representing a connecting element that binds a heterogenous CoE partnership together (Garrett-Jones, Turpin, Burns, & Diment, 2005; O'Kane, 2008) particularly in those user-driven CoE where scientific and disciplinary traditions and cultures are not dominant or not commonly shared by participants.

Because it is so fundamental to every aspect of the organisation, the initial definition of what constitutes "purpose" is critical. It must be consistently refined up to a point where it reveals and conveys the essential nature of the organisation. Having clarity about "purpose" is not only fundamental to informing every other element that will be presented next, but it also plays other critical roles such as attracting the right type of people that are compatible and driven by the same types of purposes. Another example where clarity on purposes plays a critical role is in the processes of strategy formation or re-formulation, and every strategic effort to build or transform organisational capacity where the element "purpose" features at the centre of the organisational system and functions as the starting point and continuous reference element.

Purpose has also an external connotation. In addition to deeply held internal motivations it incorporates the organisation's position and perspective towards the external environment and vis-à-vis to external entities and resources that are significant to the organisational sustainability and impact.

Purpose is one of the active or dynamic elements in the web. It is or should be continuously enacted and lived by the members of an organisation, providing meaning and shaping the direction as the organisation moves forward and evolves. As a result, a substantial part of the identity of an organisation can be expressed by a combination of the elements Purpose and Culture (Toma, 2010, pp. 54-74).

Element 2: Structure

Structure is the way the organisation is configured to conduct work. It is the way activities and tasks are conceived, organised and allocated to people; the way teams are composed and how the work is coordinated across sub-units within the organisation.

Structure must be designed to reflect the nature of the work and purposes of the organisation and be an enabling factor.

The structure of an organisation has been traditionally depicted through the use of charts to highlight specialised or thematic sub-units and hierarchies (Mintzberg, 1979). As increasingly is the case with knowledge-intensive organisations such as CoE, the analysis of CoE organisational structure can potentially reveal new organising approaches adopted in research-intensive organisational settings (Bersin, McDowell, Rahnema, & Van Durme, 2018). Because these types of environments require more flexibility to move and adapt faster to knowledge generation and application demands, a range of factors may influence the organisational structure of different CoE. For example, how structure is influenced by the increasingly significant role of networks and teams, culture, and coupled with disciplinary knowledge production needs or yet the necessary ecosystems for the development of new technologies that influence how leaders and their groups get organised (Bolman & Deal, 2017; Nohria & Eccles, 1992).

Not only have non-hierarchical and lean organisational structures been favoured currently by knowledge-intensive organisations but recent data shows novel and "fit-for-purpose" organisational structures that are in sync with current and immediate future

challenges (often posed by disrupting technology and centred around learning, skills, increased collaboration and agility) identified as a key global challenge and ranked as a number one priority for organisations world-wide (Bersin et al., 2018).

This study contributes in understanding why CoE adopt certain organisational structures, what factors influence the definition of a structure, whether they are proving effective or not, and if there are other perhaps more informal arrangements that are favoured in centres. Other issues might be related to the effects of "structure" over other elements.

Element 3: Governance

Governance refers to decision-making and the chosen approach as to who is to make what decisions in the organisation. The mission and aspirations of an organisation, represented within the Purpose element, have a direct influence on the definition of the governance approach of an organisation.

Many key aspects are incorporated within the element Governance. The notions of power, control and influence operate and are represented in an organisation. In this regard, the idea of boards and steering committees as major mechanisms of governance comes to the fore. The oversight and performance assessment roles of governance entities are very rooted in traditional organisations given their focus on offering returns to shareholders.

In the specific case of CoE, conditions surrounding governance are different and vary according to centre nature. For instance, as collaborative organisations, CoE involve different types of stakeholders at times with the same (introducing an element of competition), different, complementary or competing interests. Other CoE are primarily focused on scientific activities but still gather members from different institutions. Finally, some CoE are primarily focused on a public-good types of contributions. In any of these cases, there are many approaches that can be taken regarding governance such as the way the different constituencies have their interests and needs adequately represented (particularly at user-driven CoE), what multiple levels of decision-making exist, and how authority is exercised and delegated.

Another potentially interesting perspective is the specific governance of research and how the process of knowledge production is governed at this particular type of organisation, especially since CoE are not only collaborative but also distributed or networked organisations in most cases.

Finally, more operational aspects of governance regard the composition of boards and committees. Some potentially interesting questions in this regard are what principles drive the composition of boards, who gets to be on the board, what groups get to be represented on the board? Those that perform the work? Those that sponsor the centre? Or yet those that benefit from or are affected by the centre's activities? Lastly, does governance influence (or is it influenced by) other framework elements, particularly structure?

Element 4: Policies

The element Policies refers to rules that aim at providing guidance and ensuring consistency on routine procedures or on matters of particular importance for the organisation. Policies (together with the next element Processes) are concerned with operationalisation and implementation. Policies as an element within BOC, can represent both formal and informal rules, understandings, agreements or commonly accepted practices that direct behaviour specifically when an activity intersects or has implications with issues of critical significance for the core purposes of the organisation or its current strategy (Toma, 2010, pp.118-134).

In this sense a policy might be put in place to provide clarity, influence decisions and guide action by providing: a clear definition of its subject matter and scope, the reasons why it is important and necessary; how it is implemented in practice and what programs or processes are put in place, who has the responsibility to define it, who should follow it, the situations in which it must be applied, and finally, what the implications are if it is not observed.

Some examples of organisational policies currently found at organisations are codes of conduct, equal opportunity programs, and health and safety policies. In the context of CoE, it is interesting to investigate what are the main drivers behind the adoption of policies and the nature of challenges or goals addressed by challenges.

For instance, because knowledge and technology development are core activities at CoE, some areas of interest are policies on conflict of interest, intellectual property, commercialisation and ownership, partnerships, data use and publication or communication of research results. Which types of policies are favoured at different types of CoE? Are CoE policies perceived to facilitate decision-making and increase autonomy by avoiding "micro-management" or are they perceived to restrict or limit individuals' ability to perform their activities?

Element 5: Processes

Processes are defined as pre-defined, formal or informal steps or means of conducting specific, routine actions including the implementation of, or compliance with, existing policies. Processes are very associated with the administrative processes and how managers interpret and translate policies, or leadership requirements into procedures. It may involve the use of (electronic) systems that facilitate or support the design of a process partially or in full.

"Processes" is one of the static elements of the BOC framework. Since processes tend to be context-specific and action-oriented more than investigating their nature, a CoE-based analysis can shed light on what processes are put in place to support two areas: first, to support the performance of research activities and the collaboration of groups, and second, to support the role of research leaders and managers in performing their roles.

Element 6: Information

This element represents the data and information needs of the organisation. It also refers to the way data is collected, generated, and communicated. Information plays a key role because it supports a number of critical processes such as planning, strategy formation, and mainly decision-making (both operational and long-term) (Toma, 2010, pp. 151-171).

Information, both quantitative and qualitative, from internal and external sources, is considered to play a central role in supporting communication, coordination and monitoring of an organisation's activities ensuring that it remains cohesive. Because CoE are partnerships with a diversity of members, information gathering, and dissemination is important with a view to communicating with different purposes and for different audiences.

Key questions that emerge from this for the CoE analysis therefore are: What type of information is critical for different types of CoE? What information is relevant from the perspective of R&D leadership and management? How is information used to monitor performance, support decision-making and provide accountability?

Element 7: Infrastructure

Infrastructure broadly encapsulates all organisational assets necessary for conducting activities. It encompasses human, physical, technological, financial and any other assets necessary to conduct the centre's activities.

CoE are introduced based on the primary notion of creating a critical mass of resources, which in many of the scientific and technical fields prioritised by CoE funding programs, entails the availability of large, state-of-the-art or expensive infrastructure. However, a central aspect of infrastructure in every CoE is the concentration and development of highly-skilled human capital. This is expected to be done by attracting top scientists and professionals and through graduate training.

Some of the questions surrounding infrastructure evolve around strategies and approaches to developing and sharing infrastructure assets within a consortium and how collaboration influences the development of infrastructure. Are there particular kinds of infrastructure put in place to support the specific STI activities developed by CoE? Above all, what is the approach used in training and developing human resources? Given the policy rationale posed to CoE, two aspects come to the fore: practices related to the training of the next generation of researchers and the continuous professional development of CoE staff members.

Element 8: Culture

Culture epitomizes the core values, written and unwritten norms, and beliefs that are deeply held by the organisation's members. Culture is a vast topic that can be investigated and interpreted from a variety of angles (Geertz, 1994).

In this study, some of the key aspects about culture as a CoE organisational element evolve around the factors that influence or determine different CoE cultures, the role of culture in individual and organisational performance and effectiveness and, last but not least, investigating the feasibility and factors involved in pro-actively creating a conducive culture within CoE and identifying the role of leadership and management in fostering that culture (Toma, 2010, pp. 189-206).

From the outset, the nature of a CoE orientation (either scientific development or end-user/problem orientation) defines to a large extent the composition and thus the affiliation of CoE members and the purposes of the centre. A possible assumption is that these factors have a direct effect on the overall culture of a centre.

CoE are primarily collaborative organisations and that single characteristic can generate a range of influences on the development of a centre's culture. Do centres achieve a single and unifying culture or are there different cultures that end up coexisting?

In science-driven CoE, meaning those centres focused on the advancement of knowledge for the sake of science, the role of academic and disciplinary cultures (Becher, 1981) has to be taken into consideration in the emergence of a centre culture.

Technology and commercially oriented CoE, although relying on scientific activities, are generally dominated and populated by industry actors. A comparison of the similarities and differences amongst these orientations might generate interesting findings on how culture is perceived and utilised for strengthening the CoE organisation.

In both cases, the question that comes to the fore is: what the roles of L&M are in establishing and maintaining a culture in an organisational setting that is remarkably dependent on human creativity for knowledge production and application (Hemlin, Allwood, & Martin, 2004; Hemlin, Allwood, & Martin, 2008; Öquist & Benner, 2012). This dependence on human creativity and human collaboration are two key factors that highlight the role of L&M in building a culture as part of building key organisational capacity of CoE (Cameron & Quinn, 2011).

With the use of BOC, this study aims to address the first research sub-question "What are the organisational characteristics of CoE?". Because every CoE is so unique, the study will search to shed light on which elements are more significant for building organisational capacity of CoE taking into consideration the nuances of different CoE organisational profiles represented in the group of selected cases.

4.4 Competing Values Framework (CVF)

Since organisational capacity (understood from the perspective of BOC) can only be created and maintained by people and by means of favourable leadership and management, the Competing Values Framework (CVF) is the second analytical framework integrated in the study. It is built on the findings enabled through the application of BOC and contributed to answering the second research question, which is focused on CoE-specific leadership and management roles and the ways they influence the process of building CoE organisational capacity.

The CVF was extensively developed by Quinn and colleagues over the years, being applied (according its authors) to thousands of organisations (Cameron & Quinn, 2011; Cameron, Quinn, DeGraff, & Thakor, 2006; Quinn, 1988; Quinn & Rohrbaugh, 1983). The development and application of CVF addresses the role of leadership and management (L&M) in building organisational capacity, either for introducing new initiatives or in strengthening organisational effectiveness, which is a widely researched topic in the literature emphasising the importance of adequate L&M for organisational effectiveness (Cameron, 1978; Cameron & Whetten, 1983; Hersey, Blanchard, & Johnson, 2007; Yukl, 2008).

In the context of this study, the second research sub-question is focused on understanding how L&M roles influence the process of building capacity of CoE. As will be described next, the CVF integrates four classic organisational models, which represent four perspectives on the drivers and attributes of effective organisational performance. Each of these models bring to the fore a set of key factors for organisational effectiveness and even survival. Because organisations nowadays are so diverse and multi-faceted, being exposed to a range of competing drivers, the CVF evolves around the notion that organisational effectiveness evolves around acknowledging and maintaining a balance between all competing demands. It is then a task for L&M to monitor, identify and harness or cope with competing demands. Thus, the CVF is adopted as a suitable tool to help addressing the second research sub-question. It builds on the outcomes of the analysis made through the first framework (BOC) and supports the process of translating those outcomes into the realm of L&M.

4.4.1 Role of CVF in the study

One of the aspects that differentiate CVF is that it can be applied in a range of organisational development topics and perspectives as its focus on organisational behaviour interplays with leadership, management and culture among others (De Boer, Goedegebuure, & Meek, 2010; Denison, Hooijberg, & Quinn, 1995; Kalliath, Bluedorn, & Gillespie, 1999), highlighting L&M competencies within organisational dynamics which are structured around key dimensions.

Another essential feature of the CVF that responds to the study's goals in understanding how L&M has an active role in building CoE organisational capacity, is that CVF accounts for the complex, dynamic and especially paradoxical nature of organisations and their context. At the core of the CVF is the recognition and acceptance that, even though individuals in L&M roles are exposed to paradoxical and often conflicting demands, their role is that of navigating that complexity by adopting more flexible and complementary mindsets that acknowledge competing demands not necessarily as mutually-exclusive (Quinn et al., 2007).

4.4.2 CVF dimensions for leadership and management

The CVF is the result of the integration of four independent and, to some extent, opposing perspectives on organising and management (based on four classic organisational models) which are integrated around two key axes, making the four quadrants (or dimensions) of the CVF (Quinn et al., 2007).

The four classic organisational management models, which have been, and depending on the context still are, very influential on how organisations are conceived and run, are:

i. The Rational Goal model (Taylor, 1911), and its scientific management principles, partially informed by Social Darwinism ideas in vogue at the time. The focus of this model lies in enabling managers to better structure and rationalise work, clarify goals, make effective use of resources, and make processes as effective as possible to improve productivity as the ultimate goal.

ii. The Internal Process model has some common characteristics with the previous Rational Goal model and for that reason it shares the same axis with it in the CVF grid. It was originally influenced by principles of management put forward by Henry Fayol

(Fayol, 1917) in conjunction with Max Weber's writings and ideas on organisational structure and bureaucratic management (Weber, 1920), which were both very influential at the time. What differentiates the Internal Process model is its inward orientation to internal organisational matters. Major considerations for management in this model are stability, control, and internal continuity.

iii. The Human Relations model with a focus on human-centred values of commitment, participation, cohesion, conflict resolution and consensus building. This model's means-ends logic rests on valuing and fostering a climate for individual and group integrity and deep involvement as the means for enhancing performance. The Human Relations model emerged as the ideas about labour and appropriate leadership moved into a more individual, self-fulfilment and group-dynamic orientation where the complexities of human relations and motivations became relevant to leadership and management approaches (Quinn, 2007).

iv. The Open Systems model that emerged in response to a fast-paced changing and knowledge-intensive world. The most fundamental principles of this model are based on the need for leading and managing organisations in unpredictable environments, where planning and structuring might not provide all the answers emphasising organisational flexibility and responsiveness (Mintzberg, 1975, 1979). The means-end logic of this model is on continual adaptation and innovation as the means for acquiring and maintaining external resources (Peters & Waterman, 1982; Quinn, 2007).

4.4.3 The integration of models in a matrix of competing demands

The theoretical foundation of the CVF is based on the integration of the four classic models introduced in the previous section. It aims to provide a more encompassing and balanced perspective on organising and management in a world where organisations need to face and balance contrasting and at times competing drivers and demands, both internally and externally originated.

The CVF is represented by a matrix composed of two axes. The two axes represent the forces that pull organisations into equally important but essentially different directions. They represent the organisational need to balance tensions facing the organisation which are not negative but positive opportunities. Those tensions reflect the balance between "change" and

"stability", complemented by a balance towards an inward focus into the organisation with an outward focus onto the surrounding context.

Thus, the first vertical axis ranges from "Flexibility" on one end of the spectrum to "Control" on the other. The second axis ranges from "Internal' to "External" orientation. The integration of these two axe forms four quadrants that reflect four major leadership and management dimensions, orientations or even mindsets that co-exist and can be highly complementary in an organisation.

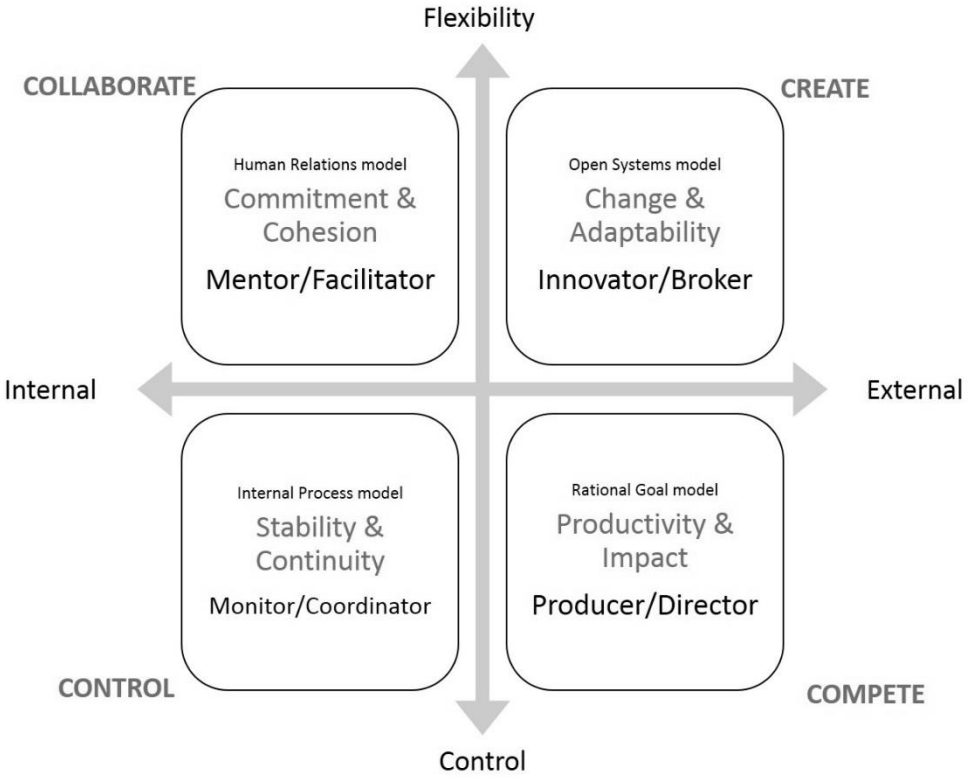

Figure 4. Representation of the Competing Values Framework domains based on Quinn (2007)

Through the integration of the model-based dimensions, the CVF achieves a more holistic, dynamic, and synergistic view of the diverse and paradoxical organisational dynamics facing organisations which are particularly explicit in the CoE organisational context. It is a robust analytical tool allowing for addressing the goals of the study in a way that none of the individual four models could allow if used in isolation.

As presented in Chapter three, CoE are organisations created in response to complex challenges. They gather, under the same roof, a diversity of stakeholders and a range of associated interests, beliefs, and cultures. This diversity that is so peculiar to CoE can be potentially, and simultaneously, a source of strengths and conflicts. What the CVF allowed was

to identify potentially competing demands faced by L&M while building organisational capacity and appraise the extent to which they are not mutually-exclusive but complementary conditions, moving from an "either-or" to a "both-and" underlying approach to leadership and management (Quinn, Kahn, & Mandl, 1994).

The four CVF domains

The CVF grid representation is composed of four quadrants (see Figure 2): Create, Compete, Control and Collaborate. Each of these quadrants point to a different way of understanding organisational needs and constraints based on four opposing forces that may generate tensions. Each of the quadrants reflect action imperatives for individuals in leadership and management positions facing those tensions in a complementary way.

Create

The dimension illustrated by the Create quadrant reflects the values of the Open Systems model emphasising the ability to adapt to change, to monitor the external changing and ambiguous environment and to tap into external resources as ways to thrive, to innovate, and to remain relevant.

Compete

The Compete dimension represents the imperative for productivity and impact on the delivery of the organisation's outputs. This dimension also considers the external dimension conditions including other competitors, organisations operating in the same niche area or disputing the same resources. The translation of expected outcomes into operational processes is central. There is a focus on organisation, planning, goal-setting and the ability to make quick decisions, performance optimisation and impact.

Control

The Control quadrant emphasises the imperative for establishing and maintaining stability and continuity as essential for organisational survival. This dimension refers to an awareness of internal organisational dynamics to ensure members are acting in expected or favourable ways and meeting the organisational goals. Compliance and consistency across all organisational areas is important in this domain. To achieve that, planning, coordination, handling data to visualise performance and support decision-making, feedback and reviews are

important aspects of this quadrant. Assessing efficiency and effectiveness and feeding back changes into the system, in a timely manner, is central.

Collaborate

The Collaborate quadrant expresses another dimension of the organisation focused on the values of the Human Relations model. This dimension is centred around a concern for others and for oneself, and on open communication, commitment and cohesion as basic pre-conditions for organisational cohesion and performance. Collaboration is often based upon developing self and the group through learning, sharing, facilitation and mentoring. Communication is also used as a tool to avoid and manage conflict and for encouraging constructive feedback and mutual support.

4.5 The Eight Leadership and Management Roles

Each of the four domains described in the previous section are labelled with verbs that identify the central action that underpins the notion of organisational effectiveness in each quadrant: Create, Compete, Control and Collaborate. The authors of the competing values went further and analysed the underlying cultures that supported the ideals of each model or quadrant (Cameron & Quinn, 2011). What this analysis shows is that, because each quadrant emphasises different orientations (internal/external) as well as different criteria for effectiveness, they also emphasise and foster different values and attitudes from organisational members. They represent a cultural way of doing things in a certain ("good" or appropriate) way and valuing people that contribute to achieving such values.

A summary of this analysis matching the quadrants to cultural archetypes is provided in the next table:

CVF Quadrant	**Key Values**	**Cultural Archetype**	**Key Roles**
Collaborate	Internal and organic focus Flexibility and discretion People-oriented, cohesion, morale, human development	**Clan**	Facilitator Mentor

Control	Internal and control focus Structure, integration, efficiency, consistency, stability Planning, routine, centralisation	**Hierarchy**	Monitor Coordinator
Create	External-focus, adaptability Flexibility, growth, resource acquisition, external support, Innovation, pioneering creativity, agility, disruption	**Adhocracy**	Innovator Broker
Compete	External focus, control Productivity, results-driven, aggressive competition, outpace competitors, user-focus	**Market**	Director Producer

Table 6. Key attributes of each CVF quadrant

The Collaborate quadrant is characterised by an internal and organic people-oriented focus, based on the values of flexibility, individual autonomy, commitment, collaboration, mutual support, and affiliation as means to perform more effectively. The organisational culture compatible to this model is the Clan Culture making a reference to a family-type organisation. Critical L&M roles in this organisational culture are that of the facilitator and team-builder, in fostering collaboration, in building consensus, in finding and developing synergies, and that of mentor in developing people, individually and in groups.

The Control quadrant, similarly to the previous one, is also internally oriented; however, its focus is not placed on people and their relationships but instead on ensuring the smooth and consistent operation of the organisation. Effectiveness is pursued through appropriate and consistent structure, coordination, monitoring and efficiency in the use of resources. The notion of a hierarchy represents the ideal type of culture fostered in this type of organisation. Typical examples where the Hierarchy Culture is found are large organisations and government agencies. In this culture, L&M have predominant roles of coordinating and monitoring the execution and quality of activities and their outputs against pre-defined standards or expectations.

The Create quadrant is marked by its external orientation where the organisation's competitive edge and sustainability depends primarily on its differentiation ability or its ability

to acquire external resources. In both cases, its predominant idea of effectiveness is associated with deciphering the external environment, building alliances, figuring out new external strategies, and changing and adapting to new framework conditions. In this organised-anarchy, adhocracy-type of organisational culture, predominant values and key roles are the innovator, the broker, the visionary and the entrepreneur roles that cope well in uncertain and ambiguous conditions. A typical example is start-up and software companies or, yet, a think-tank, whose success depends on its ability to innovate and pioneer in a market.

Finally, the Compete quadrant which is also externally oriented but with a focus placed on the external factors and entities that can enhance its competitive position. This culture, based on competition and results-oriented market principles, favours L&M roles that drive the pursuit of goals and productivity.

What Quinn and colleagues achieve by extending the CVF is how each of the quadrants represent a focus on different dimensions of the organisation, requiring different cultural approaches in dealing with internal and external factors that can permeate a single organisation. As a result, eight key roles – Facilitator, Mentor, Monitor, Coordinator, Innovator, Broker, Director and Producer – represent how L&M copes with the demands and values of each culture (Quinn et al., 2007).

Within the same organisation, as a Mentor, the leader acts in an open, approachable and engaging way when supporting other individuals' development and fostering teamwork. When in the Monitor role, his task is to oversee performance and ensure the accomplishment of stated goals. The cultures are not mutually exclusive but emphasise the idea that the nature of L&M is multi-faceted, and multi-skilled, adapting to complex and dynamic sets of conditions faced by each organisation.

Building on the CVF model, this study looks at drivers and competing demands present at the different CoE types and how individuals in L&M positions make sense of such demands and respond to them. In the study, the CVF facilitates the process of identifying the competing forces and associated required approaches and mindsets within the respective quadrants, then, relating that to associated L&M competencies or skills required to deal with the drivers and in creating the favourable conditions of a conducive organisational climate.

4.6 Scope and inter-connection between the frameworks within the study

As explained earlier in this chapter, the analytical part of the study was conducted through the two-phase integration of two frameworks, BOC and CVF.

Firstly, BOC provided the analytical lens for understanding and mapping out the organisational capacity of studied CoE, supporting the process of answering the first research sub-question: "What are the organisational characteristics of CoE?".

BOC also offered a smooth connection and a preliminary analytical stage for the application of the second framework, the CVF. The findings allowed by BOC on the nature of each organisational element and the analysis of how the different elements were conceived, the different types of centres allowed moving of the analysis into understanding the nature of L&M with the analytical support of the CVF.

The CVF provided the analytical lens to tackle the second research sub-question: "What leadership roles come to the fore at CoE?". The CVF offered a comprehensive perspective on organising, organisational behaviour and culture that could be applied to the dynamic, complex and diverse conditions that characterise CoE allowing an analysis of factors that, on one hand, require attention from L&M, and on the other, show how L&M copes and responds to such factors that taken together represent the competing demands that affect the different studied CoE.

The CVF offers an encompassing perspective by emphasising how seemingly opposing forces emanating from drivers and needs are equally important and complementary for the organisation's survival and growth. The combination of such drivers results in four main domains that inform leadership and management in any organisation.

The following image provides a graphical illustration of the resulting analytical framework assembled for the study which combines the mapping of building blocks of organisational capacity allowed by BOC and the analysis of competing, but complementary, demands faced by leadership and management allowed by the CVF.

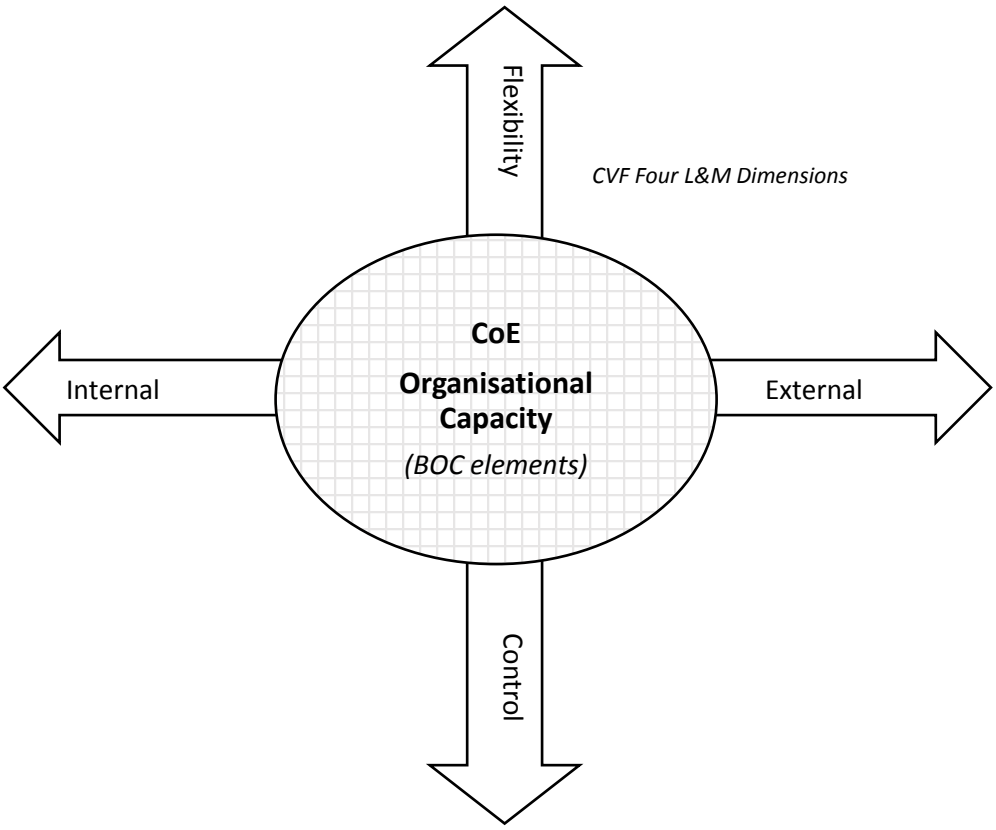

Figure 5. Integration of CVF and BOC in the study's analytical framework

The present chapter has outlined the theoretical approaches and elements of the analytical framework that will guide the empirical research and analytical components of the study. Both frameworks (BOC and CVF) are used to tackle the two main empirical dimensions of the study: firstly, the analysis of organisational capacity and, building on that, the role of L&M in CoE.

A more detailed examination of the utility of both frameworks will be undertaken in the final discussion chapter of this study.

CHAPTER 5. FINDINGS: GOVERNANCE

5.1 Introduction to the findings chapters

Chapter Four presented the analytical framework with the main elements for capacity-building in any given organisation. A major aim of this study is to take those basic notions and apply them to the specific organisational context of CoE. In other words, to map out the major organisational building blocks of CoE.

The first major finding of this study was identifying the key organisational elements of CoE: Governance, Leadership and Management, and the critical role played by Culture. The next three chapters will be dedicated to unpacking the findings bundled up within each of these elements. It is important to stress here that these macro elements are not mutually exclusive. In fact, their boundaries are blurry and overlap. Evidence collected showed that common or interrelated aspects from different elements make them interact and shape each other and the various combinations end up making each CoE organisational setting unique. Nevertheless, for the purpose of structuring this thesis and its argument, they are presented as separate entities.

The present chapter begins by presenting the findings on Governance, analyses how it plays out at CoE and offers evidence on the reasons why it plays a key role in strengthening CoE effectiveness.

5.2 Governance at the CoE organisational level

In seeking to investigate such a broad concept as governance, it is important to revisit the basic notions explored in Chapter Four, through the lens of the analytical framework that structures this study.

This section looks at the aspects associated with governance, specially those basic principles behind the notion of "good governance". In the light of that, I present and discuss the major findings and how they are operationalised at the studied CoE. The goal here is to describe and analyse how the concept of governance is perceived and applied in the particular context of CoE.

How is governance perceived at CoE?

As was discussed earlier in Chapter Four, governance is a concept that encapsulates the notions of designing decision-making processes, distributing power and responsibilities, and ensuring accountability within any organisation (Graham et al., 2003). The literature also emphasises the similarities and differences between corporate and public governance (Standards Australia, 2003), a debate that is particularly relevant to CoE given its nature as a hybrid organisation pursuing both public good and private interests.

In this sense, governance has appeared as a major capacity building block at CoE and it is relevant to start this analysis by showing how it is understood by interviewed participants.

As in the words of a participant (senior research leader), when asked about his take on governance: "I see governance as the organising framework which structures and moves the whole CoE".

Another senior CoE research staff member said, "Governance is what makes it (the CoE) work*"*. Governance was by and large described by participants as a "framework", something like the "rules of the game" whereby CoE members have a common understanding of three main things: The What, the Who and the How of the CoE as an organisation.

To illustrate those three aspects, one ARC CoE Director explained why clear and sound governance arrangements are critical at his CoE:

> We, as an organisation, need to know at all times what decisions are critical to the CoE, who participates in what decision-making processes meaning how we distribute responsibilities and power and how we should go about being accountable about the work we do and the outputs we produce to our different constituencies and audiences.

A key feature of CoE is fundamental to the importance attached to a sound governance approach: CoE is an organisation heavily based on collaboration. All six studied CoE are organisations run by a partnership of six to ten different organisations on average. Thus, multiple actors are dispersed geographically (despite the importance of the central node) and more importantly, belong to different sectors and industries. This diversity is a challenge for leaders and participants alike and justifies the need for a clear structure and tailored processes. The same director went on:

> Our CoE involves a large number of partners and, although we have different backgrounds, we are all on equal footing in this partnership, but there are multiple types of decisions at different levels to be made on a constant basis. Our governance structure aims to cater for that, so work can be performed in a smooth way.

Every partnership appears to display a number of aspects that influence the existing governance approach adopted by the centre. Number of partners, type of partners, work cultures, scope of work, nature of expected outcomes, area of expertise, jurisdiction, other key stakeholders, centre mission amongst others, are issues that play a role in influencing the governance approach and structure in place and this chapter will present and discuss in detail the most important ones.

As far as structure is concerned, it is also evident that most CoE adopt a considerably flat and lean governance structure as can be seen on the organisational chart in Appendix 5. This will be discussed at length in the coming sections but a participant's personal take on the centre's existing CoE governance illustrates it well:

> We need our governance structure to reflect the dynamic nature of our core activity: research. People need a reasonable level of autonomy to perform their jobs and lead their teams. But when decisions must be made, we strive to facilitate and streamline that process. It is our job as leaders to give direction but also to facilitate decision-making and autonomy.

5.2.1 Shared Values and norms

Following on from investigating the existing perceptions about governance at CoE, participants were asked what contributed to making sure their governance approach became internalised by CoE staff and part of its organisational culture. Many respondents referred to basic values and behaviours that were seen as fundamental for the achievement of the CoE purposes. Some typical circumstances were frequent: the creation of the CoE was a significant collective effort, usually stemming from years or decades of pre-existing collaboration amongst scientists. The creation of the CoE was an outstanding achievement that should reflect and be aligned with the existing values, norms and long-term aspirations of the scientific community. In such case, values, tradition and contributing to a larger common goal were significant underpinnings. Shared values and norms of science and the scientific community apply here,

from basic universal ones as mentioned by one person as the "Mertonian Norms" to other principles that guide scientists' actions such as wide sharing of scientific information amongst peers and the promotion of research integrity and ethical behaviour. In this regard, some of the most mentioned terms during interviews were "excellence", "discovery", "collegiality", "autonomy", "freedom", "participation in governance", and "linking graduate education with research". The following statement from a CoE director reflects the importance of crafting a CoE-specific identity by fostering a culture based on clear values:

> Our goal is that the CoE becomes a vehicle for promoting research excellence. On the one hand, to attract the best and the brightest in our field we have to offer the right conditions for excellence to flourish. On the other, we look for the right people, the right fit for our purposes.

In other cases, the network was created to respond to a funding opportunity in response to an emerging challenge or to produce a specific output. In order to thrive, this new partnership was dependent on building trust relatively quickly and making sure all parts moved in sync, so the collaboration could prosper. Some shared norms and values here related to entrepreneurship, economic exploitation of research results, application and economic competitiveness. In this case, some of the most mentioned terms during interviews were "research relevance", "impact", "translation", and "applicability" of research results. This brief example illustrates that each consortium defined and relied on a particular set of values and expected behaviours from members.

The ACE CRC, one of the visited centres, offered the most striking example of the importance placed on values and behaviours by having explicitly and publicly displayed (in a large banner form) the expectations and shared values of people at that work environment which is reproduced in the next page.

The ACE CRC Values & Behaviours set the standard for acceptable behaviour in our workplace, guide how we interact with each other, and determine who we hire.

The ACE CRC is a modern, inclusive, respectful workplace that celebrates diversity and is free of any form of discrimination.

We place the physical and mental well-being of our people above all else and believe nobody should ever go home from work injured.

We aspire to excellence in all aspects of our business.

We recognise that collaboration is at the core of everything we do and is essential to our success as a Cooperative Research Centre.

We encourage innovation, creative thinking and a willingness to share and explore new ideas.

We train our people well and resource our projects properly.

We value work/life balance and encourage flexible work practices to ensure our family and personal responsibilities can be met.

We look out for each other.

We recognise that mistakes happen; we rectify them and learn from them.

We celebrate success.

Most of the times, core values and principles were not clearly displayed or written on paper, but it was possible to grasp the importance of some unwritten principles just by talking to people or by walking around the CoE and seeing posters, awards, photos and other prized achievements of its members. During site visits, it was possible to observe that CoE leaders communicated shared values that support the organisational purpose, through several ways such as speeches, awards, and published papers proudly displayed on halls; incentive mechanisms, group activities such as sport events but above all through role-modelling. Constant and pervasive communication was perceived as widely used at CoE to crystallise shared values and norms.

The idea of shared "values and beliefs" was very strong and emerged in most accounts about what good governance is or depends on at CoE. For this reason, the next section gathers the most relevant values and principles identified and synthesizes them in terms of "guiding

principles". Every principle is unpacked and contextualised in relation to what it means in the context of a research organisation.

5.2.2 Good Governance Guiding Principles

In Chapter Four, governance was discussed as a key element of the analytical framework for this study. Two aspects are important to remember here. First, good governance has a considerably different take when applied to organisations either in the public or the corporate sectors given their different core missions. Second, irrespective of sector, general governance principles are tailored to individual organisational contexts in order to cater for particular purposes, missions and cultures. The aim here is to explore how good governance translates in the context of a CoE.

Why is good governance seen as important in CoE?

The principles described in this section point to the importance attached to promoting good governance practices in making the CoE an effective organisation (meaning in pursuing the CoE's own purposes). Prior to introducing the principles, it is relevant to see why participants think good governance is critical for the CoE.

> It (governance) is important due to the nature of a CoE. The CoE is a collective, dispersed, large and long-term concerted effort by many people working on different projects but with a shared purpose. Good governance is an intentional effort to put us all on the same page and it serves to build trust amongst people and across teams.

It becomes clear that a fundamental reason behind the relevance of governance is the nature of CoE. Each centre is distributed and diverse in nature. As is highlighted in other parts of the findings' chapters, the challenging nature (so called wicked type of problems) and scale of issues addressed by CoE requires a large and diverse partnership. And it is the very notion of partnership and the inherent diversity of stakeholders, the associated risk of cutting-edge research activity and the public-private hybrid nature of CoE that makes it a particular type of organisation requiring a particular governance approach.

The issues raised associated with good governance were many and varied but the next section synthesizes them as grouped by good governance principles. For each principle, a number of dimensions are named in order to substantiate each principle in the particular context of CoE.

Principle 1: Transparency

Transparency was found to be a horizontal issue that permeated all conversations and site visits regarding good practices in governance. A number of issues were identified, the key ones being listed in the table below. Good governance practices associated with these issues and how they affect decision-making at CoE are further detailed in this section.

> From an early stage, transparent processes have helped to translate our organisational purpose into day-to-day operations and decision-making. The rules of the game ought to be clear at all times for a CoE to be sustainable.

This quote from a Centre Manager demonstrates how transparency is closely associated with good governance and a key principle for ensuring trust, autonomy and the decision-making ability of individual researchers, which are considered as pre-conditions for organisational agility,

Transparency has been considered crucial and was mentioned across a range of different organisational matters discussed during interviews. The table below summarises the main aspects in which participants talked about the relevance of transparent approaches. Next, these aspects are further contextualised based on interview data.

Transparency – main areas of application	
Information	Membership and admission
Decision-making	Board composition
Research strategy	Commercialisation strategy
Ownership of results	Publication strategy
Supervision, mentoring and development	Collaboration with external parties
Internal funding allocation	Travel policy
Use of CoE resources	Recruitment policy
Accountability	

Table 7. Transparency applied to different CoE L&M domains

Access to **information** is considered key by participants and some CoE have specific policies on what type of information has to be circulated at which levels or groups of interest within the centre. In most cases information on ongoing research projects or work packages is openly available to teams across participating institutions. Most studied CoE have created particular IT platforms and intranets to ensure information is accessible to participants. These platforms combine features of project management with science content and resources available to scientific staff, centre leadership and in some cases administrative officers.

One research stream leader stated:

> Readily available information is critical to timely decision-making since we are dealing with a large team of researchers working at different locations. We try to communicate as much as possible and to provide all partners with the necessary input so they can, first, perform their tasks and, second, have a good overview of where the CoE is heading to. Ideally all partners should have a good level of information on all activities because we are working together on a common goal so information should be as far as possible widely and equally distributed.

This shows that **communication** is very important at CoE and centres deploy a range of communication tools and approaches (face to face, HD video conferencing, e-mail, custom intranet systems, cloud-based file sharing, electronic forum, science blogs, social networks, etc). However, depending on the project scope, some information, scientific data or preliminary research findings can be considered as sensitive or confidential as some CoE consortia involve partners that are also competitors or have a strong commercial focus. The information and communication policy is then documented often containing the list of partners, their roles and responsibilities, any specific information requirements and accompanying guidelines for distributing information within the partnership and potentially outside. Participants highlighted the importance of establishing clear guidelines for sharing information and ensuring transparency within particular groups at the CoE. For example, the CoE executive team, on the one hand, shared certain information with the board and the centre advisory group relevant to the decision-making at this level whereas on the other hand, shared other types of information with the group of chief investigators (research program leaders). Role, task and group affiliation are also used to define the report's audience in some cases.

Transparency is also critical for the process of **partnership-building** which is an ongoing issue as the CoE evolves over time. Most CoE have a clear stipulated approach to

partnership composition and possible admission of new members. A university research manager mentioned the competition and tensions that a new CoE funding bid can generate amongst research teams working on areas relevant to an ARC funding call. For that reason, some CoE directors put in place the specific requirements of each participating institution and what they must bring to the table. As the CoE grows over time, there are cases when a participating organisation drops out or new circumstances require the incorporation of a new full member.

A CRC partner recalled the importance of having a transparent process during the partnership building process:

> Before joining the consortium, we were able to have a clear idea of the expected profile of members and organisations and more importantly the criteria for admission of new members. Although the CRC has a large number of partners, we always have a clear understanding of its composition and balance of expertise, capabilities and interests at play. Although partners may join and leave the consortium we are constantly aware of our niche and the added-value of being a member.

Another interviewee said:

> Yes, certainly, from the beginning we designed the centre based on the outputs we aim to produce in seven years' time if all goes well. From that, we identified work packages and the profile of partner organisations we need to perform each type of task. We aimed at attracting the best in each area, in Australia and beyond, wherever expertise or resources are. So, in our case, each participant has a pretty unique role and it is unlikely that we will change the partnership composition; however, if that happens, we have a detailed description of what is required for a potential partner to join.

This shows the need for transparency in regard to partnership building.

Building the consortium also includes transparent guidelines about the **composition of the governing body**, which in the case of studied CoE is the board of directors. Most CoE consider it good practice to have a clear policy on how stakeholders will be represented on the board with the distribution of chairs. An emerging trend was identifying the skills expected from board members and the expected combined expertise. Some boards were heavily skewed by representatives from academic or scientific organisations highlighting a focus on scientific outcomes whereas other boards are composed mainly of representatives of end-user

organisations, government representatives or international organisations emphasising a representation of the interests of users of the research.

Decision-making appears to be another key dimension heavily dependent on transparency, particularly when the research strategy to be pursued is being defined or adjusted.

Program leaders are in charge of the ongoing development of a research agenda. The following quote illustrate some of the main attributions.

> The CoE broad research themes are usually defined before the creation of the centre. Our CoE has five research themes. As a program leader my role is to formulate a working program that facilitates research that accomplishes stated goals and outcomes. So, my role is to oversee the process of cascading centre-wide strategy and goals into program-specific ones. I coordinate the division of work amongst sub-groups which are spread across our nodes. There is a great deal of coordinating work with the activity of other programs. We have to ensure that goals are defined and redefined periodically and that all staff members have the necessary conditions to carry out their work. Of course, in parallel, I am also an active research member in the centre. (Research program leader)

A chief investigator stated:

> Our research program spans groups from several universities so we constantly encourage cross-institutional research which is not easy most of the time. So, we have to be transparent as to why we decided to favour a certain research avenue or why we prioritise a certain approach that is led by partner X. We have to be open about our decision-making process to ensure stability and cohesion, and to continue to build synergies across the groups. We try to avoid fragmentation and alienation of teams at all costs.

In terms of management, another aspect of transparency is the relationship between the governing body and the executive team. As a CoE COO stated:

> From an early stage of centre operation, we have made a conscious effort to determine which types of decisions should be tackled by the governing body and which decisions should be delegated to the executive team. This distinction proved to be critical for the daily operation of the centre as well as for the broad strategy. All partners have a

> reasonably good understanding of which issues should be dealt with by centre executives and which should be brought to the board meeting.

Transparency of strategic decision-making is also regarded by interviewed participants as very important in three particular sub-dimensions of the research strategy: publication policy, commercialisation strategy and ownership of research results. Issues mentioned include embargo or delay on the publication of findings (to protect findings of commercial value), researchers and students' rights to IP, patent applications, joint publications, lead author in multiple authored papers (common in the hard sciences CoE). To deal with such issues in a transparent way for all involved parties, some CoE have created their own publication and exploitation policy while some adopt the host university policy. One CoE has emphasised the importance of fast publication of results given the harm the delay of publication may cause to individual researchers' careers and reputation. "Our priority is to perform and publish state-of-the-art research and all our partners, academic and commercial alike, are aware of that". It is evident here that some CoE are very science and publications-driven while others are focused on developing a new technology or finding science-based applications and innovations. In all cases transparent communication and exploitation policies are important, however with a differing focus of content.

The Lowitja Institute (a social innovation-oriented CRC) has a particular approach on transparency focusing on the end-users of their research, aboriginal people and organisations:

> Aboriginal individuals must be fully involved – not just consulted – in the initiation, design and implementation of the research the Lowitja Institute undertakes…The Institute must disseminate its research findings widely – not just to other researchers, but to health practitioners, the corporate sector, governments, politicians of all persuasions, and to the public. (Dr Lowitja, O'Donoghue AC CBE DSG, extracted from the centre policy document Knowledge Exchange and Translation into Practice).

Last but not least, human resource development has appeared as a matter of high relevance and where transparency has a particular meaning. All studied COE state as a major aim to develop people, particularly young scientists:

> "To develop a world-leading program of graduate training and mentoring to expand the pool of climate researchers and develop future leaders in the field." (ARC CoE for Climate System Science, 2013)

> "Train a generation of young scientists with the skills needed to lead the future of technology development" (ARC CoE for Engineered Quantum Systems, 2013)

Supervision of **postgraduate students**, mentoring, opportunities and development pathways for postdoctoral researchers are pervasive in all studied CoE and some centres involve more than a hundred students. Students are involved in most research teams and projects and they offer a significant contribution to the work of the centres. For that reason, most CoE invest heavily in capacity development opportunities and deal with early career researchers' involvement and capacity building in a transparent way to ensure that the centre achieves its goals but at the same time that students benefit from their time at the CoE in multiple ways. To ensure transparency in this process, they make use of some mechanisms. For example, many CoE have a dedicated figure of a Graduate Director. Together with supervisors they establish an individual development plan for PhD students covering a comprehensive mix of development opportunities during the candidature according to individual interests and aspirations. Students are also coached by the Graduate Director and usually supervisors about the types of engagements available with academic, governmental, international and commercial partners. This upfront support is perceived to help students to have a clear understanding on the expectations associated with their career choices in the period they are associated with the CoE. The same transparency is applied to post-doctoral research fellows. In this case recruitment and career pathways are presented and discussed. Some CoE have a clear recruitment policy regarding the duration of these contracts and the exposure of post-docs:

> As for postdoctoral appointments we changed the centre policy to have their contracts limited in time instead of having numerous extensions. Of course, I would personally think it is more beneficial to have someone for extended periods of time of say seven years in my team but the reason behind that is to move people around to develop their careers at this stage. They need exposure. To different institutions, different cultures, expand their networks... so that's building capacity which will eventually be even more beneficial to our field of research. (Chief Investigator)

Human resources are consistently seen as the most valuable resource at these centres. CoE strive to attract, develop and retain the best students and scientists in their fields. Issues related to people will permeate the findings of this thesis. Here it is important to reinforce the strong perception gathered from the interviews that exchanges must be extremely transparent

in nature. Transparency is seen as the basis for a long-lasting, trust-based relationship in an organisational context like CoE:

> At this level, people have a good level of autonomy and independence and they usually do not come to work here for financial reasons; they want autonomy and they are willing to be committed as long as they see that everyone is on an equal footing. (ARC CoE Centre Director)

CoE participants mentioned several times that they are very privileged to have access to substantial resources – financial, human and infrastructure. The transparent use of resources is key to ensure all partners have a fair level of access to resources. Other policies include the use of discretionary funding, internal call for funding projects, travel funding allocation, shared use of technological resources across partner institutions and the establishment of partnerships with external parties.

To conclude this section on the importance of transparency in good governance in CoE is the issue of accountability. Based on feedback from interviews and reports, two main themes were identified: (1) internal accountability and (2) accountability to the funder. In terms of internal accountability, CoE researchers find it crucial to maintain all key stakeholders informed on the research performance as articulated by this participant: "we are responsible to account for the performance of our centre and the results of our decisions". Some of the topics associated with the research performance at CoE and accountability relates to the evaluation of research which involves not only indicators of productivity but trying to measure the impact of their science. Internal accountability is used in a way to monitor progress (particularly research performance) and to assess organisational health and spot any leadership and management gaps.

Some CoE involving university-industry partnerships refer to the transparency required in order to manage any potential conflict of interest: "we always try to identify and manage potential conflicts of interest or any other ethical considerations. Our scientists are expected to disclose any financial interests arising from any collaboration**"**.

Secondly, being accountable to the funder, which in the case of most ARC-sponsored CoE means being accountable on the use of public money and on achieving expected results. **"**Our board members are particularly focused on issues of accountability not only to the

funding organisation but accountability on a broader sense, being accountable and making our science relevant to society."

Transparency and accountability are perceived to play a huge role in fostering good governance at CoE. The bulk of this work of ensuring these principles falls into the hands of research leaders and managers at CoE. Their roles are further discussed in the findings under the next chapters on Culture and Leadership & Management.

Principle 2: Trust

The second fundamental principle for CoE governance is trust. According to most participants, trust is a critical element of a successful CoE partnership and must be present from the inception to the wind-up phase of a centre. During every interview, it was possible to notice hints about how essential it was to choose the right partners and how often knowing and trusting each other's capacity to deliver and expertise was continuously required. A participant stated, "As in any serious relationship, we need to have a great deal of trust in each other. I would say it is essential. Without trust a CoE or any similar organisation based on scientific and technological collaboration just cannot function."

Another said: "We choose very carefully our partners and they have to figure out if they want to be part of this community, and if it will be beneficial for them. Sometimes there is a longstanding relationship and trust is already there, but other trust needs to be built".

The great majority of participants have consistently highlighted the importance of building and sustaining trust. Trust is seen as the key to keeping alive the collaborative community spirit that makes a CoE and keeps it going.

It was possible to observe that the more trust was present amongst participants (often requiring the active encouragement of a desired culture) the less formal and rigid layers of control were necessary: "It's a matter of trust you know. And this is the biggest thing: trust. If you can actually deal with all these people and develop trust, a contract is much less important". Trust was perceived as a pre-condition for other valued qualities of CoE individuals such as autonomy, self-initiative and resilience. Without trust, people "wouldn't give their best or get the best out of others", according to a participant.

Trust built from a pre-existing scientific partnership was not the only possible alternative. Interestingly, building and sustaining trust amongst CoE members was perceived as not only possible but necessary and has been linked to some specific aspects like: having "empathy and awareness about people's and partner organisations' expectations", about perceptions of integrity of team members particularly in terms of academic integrity, on having role-models mainly senior researchers and leaders that are perceived as "legitimate and authoritative figures who are respected by their peers for their expertise". This was particularly important in those CoE where a partnership with no previous history of collaboration was established in response to a funding call or in cases where partner organisations with very different cultures were working together despite their different drivers or interests.

Building trust was perceived as the task of every member but particularly of those in leadership positions. Designing flat and collaborative structures for the CoE was one of the mechanisms used to foster trust in contrast to more traditional hierarchical structures. Other key mechanism perceived to build and sustain trust are being pro-active in terms of communication and establishing a variety of communication channels and consistent communication practices. Participants have emphasised the importance of communication, as this director articulated:

> My main job on a daily basis is to make sure everyone is on board and on the same page. We have a very established culture of communicating as much as possible and as openly as possible to avoid misunderstandings and get things done. This is particularly expected from team leaders, so the direction and strategy, once jointly defined, is out there.

It was possible to observe that trust was perceived as an essential value in a knowledge-intensive environment like a CoE. Maintaining people and teams working together for extended periods of time despite existing significant differences in terms of work culture and expectations. Diversity was welcomed at CoE but was something that could give rise to conflict, another reason for building and maintaining trust. When trust was no longer present, the work became dysfunctional and partners were asked or decided to leave the consortium as was the case in one CoE. Some issues mentioned were related to differing interests and expectations between partners, some partner organisations expecting to dictate terms or a return on investment, clashing work cultures and even academics acting selfishly by using CoE funds for personal scientific agendas and not contributing to shared goals.

Finally, there is the importance of interpersonal relationships in developing trust within and across partner organisations and in ways used to nurture relationships. Every CoE visited had a range of activities planned aimed at connecting people to one another, knowing more about co-workers, finding mutual interests, and creating a good work environment. Experiences such as summer schools, trips and fun events were praised by participants as highly positive in building closeness between people, creating affinity and finding common ground. It is also a common practice to expect CoE members, particularly PhD students and post-docs, to spend time in other nodes of the CoE and work closely with peers from other institutions or spend some time working at partner firms.

When there is trust amongst partners, the CoE becomes a safe environment (or at least safer than other traditional engagements) for participants to work cooperatively on a common workplan. As one participant says:

> In this particular area of research, given its significant potential for technology development and the high-risk associated with investment and competition, the main research actors have been traditionally very averse and sceptical about collaborative research. I realised that the [CoE name ommitted] has provided a favourable environment for building trust amongst partners. (CRC Industry lead researcher)

At a science-oriented CoE, collaboration was already an intrinsic part of work culture but at this level and scale the CoE was expected to achieve more than that. As a research program leader pointed out:

> "Our research partnership aims to create national capability in this particular research area. Our goal was to form the best possible partnership that could link existing pockets of fragmented research activity and expertise and build synergies and scale through our complementary expertise and strengths."

This turned out to be a very representative case of science-oriented CoE, mostly ARC-funded ones, where the focus is placed on leveraging complementarities for the sake of achieving a critical mass of research activity at the national level. The focus is placed on achieving a scale of activity that would not be possible otherwise, moving away from individual

group performance and competition for the sake of the disciplinary advancement. Another idea that was commonly heard from CoE interviewees is that a partnership is built to achieve something that none of the partners could achieve in isolation, and the idea that the product enabled is greater than the sum of its parts.

Conversely, in industry-led CoE, although there are many similar characteristics, collaboration is more often established based upon mutual needs or common problems instead of common aspirations and values. In this case, market competition, disclosure of know-how and ownership issues are perceived to sometimes get in the way of the trust-building efforts. At one state-of-the art technology development CoE it was visible that the idea of collaboration was much stiffer than in other centres given the relevance of legally-binding contractual arrangements. Even interviews for this study were quite shallow and quick given the level of secrecy involved with the CoE work ethos. Partners seemed interested in collaborating given its relevance for their survival but were willing to share and disclose on a minimal level and be protected by every contractual mechanism.

However, in many cases, as exemplified by one of the visited CoE, academic and industry actors have become aware that collaboration is the only way forward for the viability of a certain sector or technology and that the potential benefits outweigh the perceived costs and threats posed by collaborative research with other firms or academic partners. The following quote highlights these types of tensions and trade-offs:

> You know, the dynamics in a CRC are definitely not like those found in most academic research projects. People rely less on personal and informal agreements and more on contracts, milestones and performance agreements. Perhaps that is totally fine given the diversity of partners and the diversity of interests at play. But people are more restrained in sharing and contributing and that sometimes inhibits collaboration and curbs potential outcomes. At times it feels more like contract research than a truly collaborative effort. (CRC academic research partner)

Across the board, trust is perceived as the single most important precondition or ingredient for a CoE to be truly collaborative in order to unleash its potential and achieve its goals.

> We depend on the teamwork of bright and highly creative individuals. To achieve individual and collective potential, people need to rely on and be honest with one another. Generating new knowledge and technology involves a lot of uncertainty and risk. Trust is a basic condition. (Senior researcher, ARC CoE)

Another participant stated:

> Researchers are aware of potential benefits of joining a CoE – substantial funding, visibility, access to complementary resources, etc – but to get your group fully invested in a 7 to 14-year project like a CoE you have to trust your partners and have the tools to ensure that it will be mutually beneficial. (Senior researcher, ARC CoE)

Alongside trust, the other essential principle for good governance at CoE is having a strong, shared sense of purpose and this is presented in the next section.

Principle 3: Clarity of Shared Purpose

Without a doubt, one of the most striking of the good governance principles found at CoE is the notion of a shared purpose: that common denominator that unites and motivates all members of the CoE community.

Pretty much every single studied CoE had its vision and mission statements. In general, vision statements express what the CoE aspires to become or contribute to in the future. Mission statements express what a CoE aims to do to achieve that future scenario. Here are some examples from case studies (in some cases mission and vision do not belong to the same centre and serve for illustration purposes only):

Mission	**Vision**
The Centre of Excellence for Coral Reef Studies was established to develop innovative and internationally significant research programs for the management and sustainable use of the world's coral reefs.	The Centre's vision is to be the global leader in the provision of scientific knowledge necessary for coral reef managers to sustain the ecosystem goods and services of the world's coral reefs.
The ACE CRC is Australia's primary vehicle for understanding the role of the Antarctic region in the global climate system, and the implications for marine	We will revolutionise our understanding of the Australian climate system by

ecosystems. Our purpose is to provide governments and industry with accurate, timely and actionable information on climate change and its likely impacts	transforming the scale and quality of climate science.
Link existing national research strengths and build a critical mass.	Our vision is that the [centre name ommitted] will be an authoritative and collective voice for the benefit of Aboriginal peoples' health and wellbeing.
Induce national and international collaboration	Be a world leading centre with internationally recognised research in the field of X, developing solutions for Y and contributing to related industries.
Build human capital and train the next generation of researchers in the field of X.	Undertake world-class research in the field of X in Australia.
Through our research, knowledge exchange and advocacy, to impact policies, programs and practice that will improve the situation of X.	Position Australia to address fundamental unsolved questions in X through the use of Y.
The Oral Health CRC seeks to reduce the economic and social burden of oral diseases on Australians. We bring together world-class scientific and clinical research teams with Australian manufacturers and established global marketers and distributors.	We aspire to be internationally esteemed, to achieve global recognition amongst the X scientific community, and to provide outstanding opportunities for the next generation of researchers in innovative and internationally competitive research, while providing and education platform for the community.

Table 8. Mission and vision statements of CoE

These are the most frequent keywords found at studied CoE purpose and mission statements:

- *Synergy*: used in the sense of collaboration, multidisciplinarity, building a critical mass, creating relationships and links between research performers and users of results
- *Education*: development of human capital, capacity-building, training the next generation of researchers, professional and practitioner training
- *Discovery*: the essence of the creation and application of new knowledge
- *Prestige*: became national and international references, hubs of expertise
- *Innovation* and *adoption*: develop innovative research approaches, problem or end-user orientation, knowledge-transfer and support evidence-based policymaking

However, it was possible to observe that some CoE had something more than that. At these centres it was possible to perceive a widespread clarity of a shared purpose, something that has a deep significance for every member interviewed, going beyond formal statements

written in annual reports. At these CoE, every staff member, regardless of position, had a good understanding of the CoE purpose and more importantly they had a good grasp of how their individual participation contributed to the larger picture. Within their own level of scientific proficiency, from students to senior chief investigators affiliated to different institutions and professional staff, they all understood the CoE purpose and how every member contributed to advancing its purpose. These were special CoE, where people seemed to be on a mission to achieve something great.

In general, every CoE visited was strongly characterised by two aspects: 1) addressing a large and complex problem and, 2) involving numerous and very diverse partners. Whenever senior participants were asked about strategies to build a successful consortium or how they had faced specific challenging situations, they consistently referred to identifying and establishing a collective ideal that unites and guides its members and embodies the ultimate reason why they are willing to work with and trust each other: to pursue a common collective goal.

This sense of shared purpose is articulated by this participant:

> "We are fortunate enough to have some bright and knowledgeable people at our centre, but keeping everyone on board, focused and motivated is not always an easy task. What has kept us united from the very beginning is this sense of a shared mission that led us to create the CoE. We know, in our scientific field, that only by combining our talents and expertise we are able to address the challenges we face in our disciplines and that fragmentation is a big threat. It's a common belief that only by combining our strengths we will be able to accomplish and deliver results that no one has ever accomplished before".

Having a shared purpose was accompanied by a sense of "building a critical mass" and an awareness that collaboration at the CoE enabled the "whole to be greater than the sum of its parts". As most CoE are created to address grand challenges, this shared purpose usually refers to working together to develop new knowledge, tools, products, technologies, and approaches that will contribute to addressing this problem that no individual partner could tackle in isolation.

For example, one of the CoE aims to reduce vulnerability to extreme climate conditions by developing models that could more accurately predict climate systems and avoid its

devastating effects. It was possible to see that the shared purpose of people at this CoE was to overcome data shortages undermining reliable climate projections and avoid or at least minimise devastating effects of climate events in Australia. By marrying a sense of common purpose with the necessary resources, this CoE is mobilising the best researchers and professionals in the field and attracting highly-skilled people from overseas.

The shared purpose is very powerful at CoE. Although both academics and commercial partners may compete outside of the CoE (for ARC funding, for procurement opportunities, for talent, for prestige, etc) the CoE provides a shared purpose and a common ground for combining expertise, leveraging resources and harnessing synergies towards a common goal. Partners have mentioned they feel privileged to be part of a CoE (especially when other groups face a scarcity of research funds) and will definitely gain in the long-term in the form of various spin-offs that CoE participation enables. Developing a shared purpose is very important and requires some deep understanding and work on behalf of CoE leaders as expressed by this director:

> It was extremely important to develop from early on an awareness of the expectations from each of the partners. Ideally, we would like to see an alignment of individual purposes, or at least, individual organisational purposes with the overarching CoE purpose. It builds trust and it is what increases cohesion to our very peculiar form of organisation.

This participant stressed the importance of the process and of involving people at this stage:

> The process of developing a legitimate shared purpose was long but it provided people with a strong sense of ownership. People seem to better use their time at the CoE as a stepping stone and better align their work here with future career aspirations.

This clear sense of alignment of individual purposes with CoE purposes is seen as very effective indeed. People have reported appreciating working at the CoE and being "involved in a meaningful way", having an impact in their field in a more visible way. Having a shared purpose appears to generate many benefits for individuals and cascade into benefiting organisational goals. Most shared purpose statements and rationales were very action-oriented which also helped people to identify how their work or ideas could fit-in.

An effective shared purpose is perceived to articulate a common mission but also give meaning to personal experiences at the CoE: "At any moment, under any circumstances or

decision-making, people know that the best way forward is that which advances the CoE shared purpose."

It is possible to say that a shared awareness of the partnership and a shared understanding of the context or situation, coupled with a few, but key, shared values and beliefs is what it takes to produce a shared purpose. Interviewed participants have stressed that defining a shared purpose is not an easy process and it may take quite some time to devise one that reflects the organisation's values.

In those CoE with a shared purpose perceived by their staff as legitimate and inspirational, people showed a greater sense of belonging, showing they were fulfilled by the work they do and that they were contributing to something greater than their individual careers. They perceived the CoE as reflecting their values (either personal, academic, disciplinary, or even spiritual as in the case of a minority group focused CoE with a major ethnic dimension).

For one interviewee, a "CoE is successful when it is effective in pursuing its purpose". They report, for example that, as a result of self-assessment exercises or external independent assessments, they are able to verify some signs that the purpose is being fulfilled. For instance, whether the involved partners have demonstrated the necessary level of engagement and proactiveness with their particular research problems, if outputs are the product of a truly collaborative effort or just the collection of individual efforts, and if stakeholders and end-users are perceiving the added-value offered by the CoE.

Collaboration is a keyword at CoE. Having an inspirational and clear sense of shared purpose and members that trust each other appear to be powerful and effective pre-conditions for good governance. It fosters individual and organisational performance and makes the CoE a collaborative environment that can be sustainable in the long run as most centres run for fifteen years on average. As one director acknowledged, at this level, people are so proficient in their areas, that a clear understanding of the problems to be tackled coupled with a clear shared purpose and leadership able to inspire people to achieve their best, is more effective than trying to detail people's work and micro-manage them.

Together, the three principles just described here, transparency, trust and shared purpose characterise the foundations of the organisational culture found at visited CoE. The next section identifies and describes more formal mechanisms used to govern CoE. They appeared as the most common tools CoE use to achieve different governance functions.

5.3 Mechanisms of CoE governance

This section aims to present findings related to practical perspectives on CoE governance. In other words, how CoE implement their governance approaches in terms of mechanisms, structure, policies, and processes.

The following section starts with some considerations on how program-level factors were perceived to influence governance at the organisational level. Then, evidence regarding how CoE focus is perceived to influence the adopted governance approach is presented.

5.3.1 Top-down and funding program requirements

The first step of this study on governance approaches at CoE was an overview of what is required by the funding organisations in terms of governance arrangements of future CoE. Interestingly, CoE funding guidelines place considerable emphasis on the importance and "appropriateness" of CoE governance structure and arrangements (ARC, 2013). There is a considerable emphasis on the adoption of governance measures that are fit for purpose but offer little information on what that means.

For instance, in a discussion paper the ARC focuses on the expectation of "governance structures designed to ensure optimal returns on Commonwealth investment in the Centre" (Australian Research Council (ARC), 2002). The only further consideration about governance refers to the existence of a board or similar body to provide strategic direction to the centre. From the perspective of the funding agency, governance is perceived as a safety net, a mechanism to prevent public funds' misuse and ensure a return on investment.

The funding program emphasis on appropriate governance is also underscored by the weight placed on governance arrangements of proposed CoE during the selection process, which accounts for 20% of the overall score of shortlisted proposals (ARC, 2013).

This apparent paradox of CoE funders placing so much emphasis on governance on the one hand but, on the other, providing very limited direction and elaboration on what good governance looks like in this type of research-intensive organisation has been justified as a way

to grant CoE leaders greater autonomy and freedom. "The ARC does not intend to prescribe the Centre governance structure but anticipates that most Centres will be established as entities within the academic and corporate governance structures of Australian universities. Such entities will provide considerable flexibility for centre management in deploying resources and in pursuing commercialised opportunities. Host institutions will demonstrate a capacity to manage large research Centres and to spawn successful commercial ventures." (Australian Research Council (ARC), 2002).

Autonomy of university-based CoE

The vast majority of ARC CoE are non-incorporated and embedded in the structures of universities, however the actual location of CoE varies considerably from departmental, inter-departmental, school or large institutes as host organisations which definitely provides differing framework conditions and levels of autonomy as far as governance is concerned. The level of autonomy from the university central governance structures also tends to vary. While some CoE report having considerable autonomy and independence from the host university central administration and being physically detached from it, others are more closely associated with their host faculty and dean. An example of a more independent centre is the CoE for Free Radical Chemistry and Biotechnology based at the Bio21 Institute, a large multidisciplinary research institute based at the University of Melbourne but funded by the local Government. In this case, the university acts only as a mediator and administrative channel for receiving Commonwealth funds with little influence over the governance and research strategy of the CoE.

Overall, minimal intervention and support is provided by the host university on the governance of a CoE. As a university research manager puts it "our job is to support all the contractual matters between our CoE and the funding agency, the administration of funds and the submission of periodic reports. The actual governance of centres is a matter for CoE chief investigators and executive staff". Centres, particularly lead nodes, based within academic departments of schools appear to have a more significant exposure and influence from local academics, deans and research managers as a result of a dependence on university infrastructure, resources and cash contributions committed to establish the CoE.

From the perspective of CoE leaders, they all agree on the importance of having a sufficient and clear level of autonomy and independence from host organisations in order to be able to devise a strategy and implement a governance approach that serves the CoE purposes as long as any aspect of it is not in conflict with existing regulations of host universities.

Another perceived gap reported by informants is the lack of prior information by funding agencies on the benefits or potential implications of adopting different governance approaches. This limited advisory role of the funding body is perceived as both positive and negative, dividing interviewed participants. While some experienced ARC CoE leaders perceive it as providing more autonomy and flexibility, in contrast it also generates a great deal of uncertainty and risk-aversion in bidders and less experienced leaders. "At that time, as a senior academic but leading a CoE for the first time, the process of defining a governance approach that could suit our goal of creating a lean and non-bureaucratic organisation while attending to the funding agency requirements was very time-consuming. Fortunately, we were able to draw on the experience of fellow academics leading other CoE because there was very little information, good practices and support out there. Nowadays, with a more mature centre, it has become clear that our governance approach has evolved together with the CoE reflecting the shifting needs, challenges and goals of each stage of our operation", a CoE director said.

These types of observations led to the initial finding that CoE leaders, particularly those in recently established CoE, were unaware of what the most suitable and effective governance approaches are for their CoE and many had a significant lack of awareness about how governance can be used to foster CoE performance. Governance is to a large extent perceived as a "necessary evil", another compliance requirement that in many cases only "generates additional red-tape" and "distracts resources from the CoE core activities, mainly research". As a consequence, several participants reported a great deal of emulation from other existing or past CoE. As a result, more risk-taking and innovative governance approaches were limited to a few centres but led to some extremely interesting findings on the principles, mechanisms and leadership skills that made governance a key enabling factor to CoE effectiveness and success. These appeared as aspects of an inter-related web where CoE purposes, values and principles were closely associated with its leaders and managers' competing roles and personal skills. This is further explored in the chapter on Leadership and Management.

The study sample proved to be diverse enough to illustrate cases along the spectrum including science-oriented CoE where the governance approach reflected an emphasis on the

autonomy and decision-making power of research leaders, all the way through to end-user driven CoE where research leaders were mostly low-profile participants or had a role of consultants, and the governance focus was placed on ensuring end-users' satisfaction. Interestingly, some CoE had a strong public-good orientation with a similar governance profile of non-profit organisations.

In each type of CoE, governance principles and mechanisms were applied considerably differently. For instance, governance practices found science-driven CoE were heavily based on the principles presented earlier in this chapter with considerably fewer formal mechanisms and more weight placed on fostering the "right" attitudes and behaviours. Other CoE, particularly technology or end-user driven ones, relied much more heavily on rigid mechanisms and contracts, with a traditional corporate-like culture heavily influenced by sponsors' requirements (CRC Association, 2012) and funding guidelines (DIISRTE, 2012).

The next sections will provide an overview at the operational level of the main governance mechanisms found at CoE. The key point here is to identify how these mechanisms have different roles according to different CoE focus and purpose.

Governance Mechanisms

The main governance mechanisms used by studied CoE are:

- Incorporation
- The constitution
- The board
- Advisory committees
- Scientific committees

The nature of these mechanisms is further detailed next.

Incorporation

The choice of incorporation is one of the first governance decisions of a CoE. The great majority of CoEs studied were unincorporated, meaning that they are hosted by an organisation (usually a university or a commercial branch of a university or a large research centre). In Australia, all ARC funded CoE are unincorporated by default, while those CoE funded by the CRC program have the choice to incorporate or not.

The Oral Health CRC and the ARC CoE for Free Radical Chemistry and Biotechnology were visited, both operating as unincorporated joint ventures. This option seems to work fine for most science-driven CoE as the organisational infrastructure of the host university offers all the necessary conditions for centre operation (particularly the receipt of funds from the funding organisation) and reduces the administrative burden of creating a separate legal entity.

Those CoE that are incorporated have an independent legal identity and operate similarly to a private firm in terms of level of autonomy and liabilities. This mechanism tended to be preferred by end-user driven or those CoE with a strong emphasis on commercialising or exploiting CoE intellectual property. Two interesting examples of incorporated CoE are The Hearing CRC and the Lowitja Institute. In both these cases there is a strong emphasis on "translation and commercialisation of research results". What that means is that a great portion of the CoE workplan is dedicated to translating research findings into products, clinical trials, education and training courses, etc. In this case, incorporation was perceived by participation to be a necessary governance tool that grants the CoE the necessary autonomy to manage resources and enter into contractual agreements with third parties. The Lowitja Institute, through its incorporated legal entity, is able to administer its funds through an internal call for project proposals and it hosts an unincorporated CRC. This incorporated CoE is a good example of non-commercial translation of research. Its public-good innovations are exploited by translating aboriginal people's health research findings directly back into communities. Incorporation gives this CoE the necessary flexibility to set priorities and distribute funding to internal projects of stakeholders while liaising directly with government and community organisations. [12]

The Hearing CRC is a great example of an incorporated CoE with a focus on commercialisation. In addition to having a legal entity, this centre created a dedicated commercial arm called HEARworks Pty Ltd. The CoE commercial branch takes research findings and exploits them through licensing and direct sales of hearing aid technology, clinical trials, delivery of education and professional training courses and provision of independent expert reviews. One of the most famous spin-offs from this CoE is the state-of-the-art cochlear implant.[13]

[12] See: www.lowitja.org.au/active-lowitja-institute-projects

[13] See: www.cochlear.com

In sum, it appeared that there are pros and cons for and against incorporating the CoE or keeping it under another organisation. The focus of the centre, research versus exploitation of results, seems to be the defining factor. While science-driven CoE seem to benefit from being embedded in a university structure, this might hinder some technology development and exploitation activities that are fast-paced and limited by the bureaucratic and slow nature of some institutions.

The Constitution

The constitution is the key founding document of a CoE. Not all CoE had a constitution or a similar document but all incorporated CoE did have one. Content-wise, the CoE constitution is similar to any other organisation. The key difference of a CoE constitution is to be informative to all involved in the partnership and external stakeholders about the purpose and activities the CoE engages in. It gathers in one document all the rules of the CoE like admission (and suspension) of partners, composition of boards and requirements for board members, administrative and financial management including gift funds (in some cases), and future unwinding of the organisation which is particularly important for the future of a CoE as the funding period comes to an end.

The wind-up process of a CoE is briefly mentioned in the constitution but a detailed plan is expected to be in place at every CoE. According to one participant, succession planning and a comprehensive wind-up plan are vital parts of good governance at a CoE: "These are two transition situations that you have to be prepared for as a centre, the change of leadership and the termination of the CoE when the funding period comes to an end." Regarding wind-up, the two most common scenarios are either the complete termination of the consortium in which case the final reporting requirements, funding distribution and any ownership conditions are established in advance on paper or, alternatively, the CoE transitions into a new stage of incorporation and self-sufficient operation moving away from sole reliance on government funding.

In a CoE, the constitution is a living document being continually edited as articulated by this participant:

> Our constitution has been updated constantly since the establishment of the CoE and that reflects the changes we went through as a growing centre. It is a key document for

> running our CoE on a daily basis but also at special occasions such as when we hold general meetings or establish voting rights, so participants can decide on strategic issues. It adds to the transparency we aim for. (Senior Research Leader, former director)

One interesting finding is that most incorporated CoE are registered as a not-for-profit organisation. According to one participant, this status fits well the nature of a CoE given it is driven by impact and not shareholder value. The constitutions analysed require that any revenue be reinvested in the CoE. Non-profit status has also been reported by participants to facilitate the governance of the CoE, given tax exemptions and benefits and the possibility to apply for or receive funding restricted to non-profits. One CoE reported creating a gift fund to be able to receive tax deductible donations from private companies interested in supporting the work of the CoE. Raising additional funds is considered critical for the sustainability of many CoE. Once the CoE is terminated the constitution also foresees the transfer of any eligible remaining funding to similar organisations.

The Board

The board, in the studied CoE also known as the board of directors, advisory board or steering committee was found to be a major governing mechanism but, interestingly, one that is implemented in quite different ways.

The role of a CoE board is mainly oversight and providing high-level strategic direction and advice to executive leadership in the pursuit of the CoE vision and pre-stated goals. Board composition seems to reflect the CoE purpose and key stakeholders. In some studied CoE the board approach and composition reflect a concern with addressing the needs of some stakeholders or some end-users of CoE activity. Others favour a governance approach where the board represents the importance of the scientific community or major users of the scientific knowledge produced at the CoE. To a lesser extent, an emerging third type appears to be boards composed with a goal of being "fit-for-purpose" for the governance tasks at hand with a focus on organisational sustainability. In each of them, the focus (or governance philosophy) of the board, its importance in the organisation, its influence over the executive staff and the results it contributes are perceived by participants to be quite different.

Now, what the case studies show is that different CoE employ the board in quite different ways. The main distinguishing factors relate to level of engagement and control and the composition of the board itself.

Level of engagement and control varied from a "light-touch" or "symbolic", in one end of the spectrum, to "hands-on" and "influential" CoE boards on the other.

For example, symbolic CoE boards were those that meet once or twice a year and include high-profile individuals and scientists such as University PVCs, Nobel Laureates and senior representatives of relevant organisations or government. They have the important, although usually casual, role of championing the CoE and opening up opportunities for collaboration and transfer of results. They provide high-level strategic advice, but the centre operation and decision-making are certainly not the concern of these board members. These members are normally nominated or invited. A good example of this type of board are those that meet once or twice a year, probably in conjunction with an annual summer school, the board is presented with the major achievements of the CoE during the past year and they discuss and brain-storm on the next year plan. Other possible contributions are new R&D partnerships, commercial ventures, student placements and staff exchange.

On the other hand, end-user driven boards are heavily marked by representativeness. Board places are carefully distributed amongst the consortium partner organisations or end-user representative associations that hold power in decision-making. Members represent the interests of their organisations. Board meetings are more frequent and display much more breadth and depth on CoE decision-making. Issues are voted on during meetings and decisions such as research programs and exploitation strategy are binding, and this is why representation is so important. In one CoE the focus on a specific community group was the main beneficiary of the CoE and thus the board was dominated by community representatives and organisations working at the grass-roots and some government representatives. In an industry-led CoE the board is mainly composed of senior managers with a long track-record in management or research in relevant companies. This board was complemented by one scientist and the heads of CoE advisory committees (see more on committees in the next section).

Finally, one CoE has opted for its board to have the same oversight and advisory role but with a much higher level of influence. In this case, board membership follows a

competency-based rationale as board members are recruited based on their personal competencies and skills. As one participant articulates:

> Our aim was to achieve a balanced board composition where members could collectively display the skills, knowledge and experience necessary for the job, for making our CoE grow and become sustainable into the future.

It was very interesting to see that experience only was not considered as sufficient and board members were expected to have complementary expertise and practical skills. The board offers, collectively, a mix of required attributes for the CoE to operate and be effective. Some of the desired attributes of board members mentioned were: strategy, general management, project management, corporate governance, research and development, technology commercialisation, business development and start-up companies, finance and capital raising, commercialisation, intellectual property rights and technology transfer, human resources, and education.

From the pool of CoE studied, the majority had the first type of board, with a few industry-led centres using the second type and one CoE had a competency-based board.

The rules and required attributes for the appointment and removal of board members are laid down in the CoE constitution or in a separate document. This is deemed necessary to ensure transparency amongst partner institutions particularly during the admission process of a new partner.

Advisory committees

Another key governance mechanism used at all CoE is advisory committees. These committees are deployed to fulfil different roles, but they tend to provide directors and management with extra expert advice on issues of critical importance to the CoE. For example, the following are some of the advisory committees found at visited CoE:

- Scientific leadership council, scientific advisory board
- Centre advisory group (scientific and leadership strategic advice at the level of individual programs and projects)
- Computing committee (transversal computing systems)
- Commercialisation steering committee (focus on commercial exploitation)

- Research and education advisory committee (within an industry-focused CoE)
- Mentoring committee (focus on staff and student development)
- Outreach committee (focus on external engagement)

Management structure

The great majority of CoE have very flat structures, and in fact, CoE leaders appeared to have been quite pro-active in designing a structure with no middle managers or "bosses". All visited CoE had one characteristic in common: the centre organisational structure is flat and lean with only one layer of management usually. This director's quote illustrates this idea:

> We arranged the centre in a very lean and flat way. Apart from the executives, there are no middle managers. Chief scientists have the role to direct the research program strategy, but they are not dictating what people have to do. CIs and centre administration are there to serve and support our researchers in whatever they need to perform their jobs.

While attending some coordination meetings, it was possible to see this in action. Everyone is welcome to attend all day-to-day meetings, even PhD students, if they see it can be relevant to their work or if they could add something. People seem to have a great deal of autonomy by joining or proposing projects.

In the words of a PhD candidate:

> I know that my priority here is to work on my thesis and get it done but everyone in the centre is in charge of their own journey here. The CoE is like a platform, it provides us with the resources and it is up to people to decide what projects they want to take part in.

From the interviews it was possible to identify some of the reasons associated with a flat structure. First the number of people involved was relatively small with staff numbers similar those at a small-sized firm. Participants emphasised that introducing additional layers and management positions would be counter-productive to the CoE goals and culture. Apart from core research stream leaders, people preferred and were encouraged to gather into teams organically and to be pro-active in proposing and "leading" new activities. The notion of seniority and rank was frequently perceived more as a result of natural scientific

accomplishment and leadership than on climbing organisational ranks. In addition, the idea of "supervision" is different as the focus is placed on enabling people and giving autonomy to perform more, providing feedback, and reiterating until outcomes are achieved instead of micro-managing every step of the way.

Second, in a focus on "collaboration amongst peers", people do have a similar and quite high level of autonomy, expertise and responsibility. One interviewed participant said "I definitely do not feel as a contractor performing research. The culture is more of a community of peers supporting each other's development and career progression while working on a particular large and important project".

Third, is the communication style used to carry out R&D projects. People do need to communicate constantly and in most cases participation in scientific coordination project meetings is open to everyone associated or interested in it and not limited to managers or senior partners. In this sense, communication is more open, wide and inclusive and people are encouraged and expected to interact and provide input and feedback. This is another underlying reason why small and flat structures are preferred – to facilitate the cross-fertilisation of ideas.

Finally, the notion that early-career researchers are learning on the job and gaining research and leadership skills so the more open this socialisation process, the better.

Interviewed participants have pointed to other advantages perceived with a flat organisational structure at the CoE context. It involves much less bureaucracy and offers a much more flexible and adaptable organisational setting. People also perceive to have more autonomy and quick decision-making that speeds up things and enables the CoE to respond quicker to challenges and opportunities. On the other side, it requires a lot of communication between teams and their leaders. It is perceived to work well at the CoE given its small size, knowledge-intensive nature and engaged, highly-skilled individuals. This participant illustrated this aspect:

> We can afford to have a minimalist and lean organisational structure and the years have shown that this model works best for scientists who are very engaged in achieving the CoE purposes. It gives people the autonomy they need and has a very clear effect on performance and outcomes**.**

Overall the organisation structure appeared to be one of a set of elements that together offer an 'enabling context' to get creative individuals going. More about this will be dealt with in the findings chapter about culture.

5.3.2 Function of mechanisms

This chapter started by presenting some abstract notions and principles sustaining governance at CoE and then moved towards more practical aspects and tools. It is hard to categorise, but this section aims to briefly identify some of the rationale behind the adoption of such governance mechanisms. Interviewed participants, particularly centre directors referred to three main goals behind their approaches:

- *Steer and Coordinate*

  Implement an organisational strategy and implement a workplan while ensuring inter-node coordination
- *Incentive and Performance*

  Coach and stimulate people by fostering a conducive research or work environment
- *Management and Accountability*

  Ensure that the CoE performs well while ensuring organisational sustainability and accountability to the funding organisation
- *Stakeholder engagement*

  Maintain the CoE engaged and responsive to key stakeholders, both internal and external to the consortium
- *Manage risk*

  Risk is a major factor in many CoE given the uncertainty associated with state-of-the-art research and particularly in moving new technologies into the market

One key concept about creating robust governance mechanisms was well illustrated by this experienced participant who was a researcher with experience in sitting on boards: "Good governance mechanisms need to be simple, effective and yet flexible enough to keep up with emerging opportunities and challenges."

5.4 Concluding remarks

This chapter presented the main findings as they related to the organisational element "Governance". Throughout the data collection and analysis processes, it became clear that many key factors for the centre operation were associated with or dependent on the existing governance approach of a CoE.

Starting from the very perception, on behalf of centre leadership, of what governance is and what it can do for a CoE, demonstrated that governance approaches are understood and implemented in different ways across studied CoE.

By and large, these varying perspectives were a result of the values and norms shared by the community(ies) within centres. Those CoE established on a clear set of values and beliefs were more able to devise a governance structure that was aligned and favourable to advancing CoE core missions and activities. On the other hand, some CoE perceived governance as just another bureaucratic burden used to satisfy funding and stakeholder requirements.

This chapter explored the main principles for governance of CoE, as they were perceived by participants, and provided an approach to how good governance of CoE can be understood.

Many of these principles and understandings are further explored in the next chapter, where they serve as the underlying basis for the more practical leadership and management approaches adopted to build and maintain CoE organisational capacity.

CHAPTER 6. FINDINGS: LEADERSHIP & MANAGEMENT OF COE

6.1 Introduction

This is the second chapter presenting the findings of this study. The present chapter, titled Leadership and Management (L&M), has links and feedback into both chapters: Governance (the previous chapter) and Discussion (the following chapter). Aspects around the L&M of research emerged as prominent factors influencing the organisational capacity-building and performance of studied CoE. L&M approaches appear also to be a product of existing organisational purposes, individual mindsets and group cultures, reasons why many of its aspects feedback into other findings and discussion chapters.

This chapter is dedicated to describing and briefly analysing evidence in order to illustrate how L&M is understood and applied at different CoE contexts.

Surprisingly, research excellence was considered by researchers themselves as a necessary but not sufficient factor. From several interviews with CoE researchers, it became clear from the start that adequate L&M is equally important for the success and sustainability of a CoE as the quality of the science it conducts. The main general finding is that a CoE is only as good as the leaders and managers that support scientists, so they can focus and excel in what they do best. Excellence in research is perceived as the result of good researchers enabled by good L&M. This chapter aims to contribute in understanding what L&M is concerned with in this particular type of organisation.

6.2 Leadership and Management domains

Leaders and managers oversee the CoE from strategic organisational and scientific matters down to its day-to-day administrative operation. What stood out during this study is the diversity of how L&M tasks are organised and configured in each CoE. Given that all CoE share some common traits, they are relatively new centres (in comparison to non-CoE research centres of the same size), have a considerable level of autonomy, very lean organisational structures, and they all have devised quite unique approaches to L&M. This distinctiveness

seems to appear as a result of the disciplinary (or interdisciplinary) uniqueness of each CoE and an attempt to optimise the organisational structure to achieve expected goals (that tend to vary in each CoE).

Some basic layers tend to remain the same: the senior leadership team, the senior management team, and the stream or project scientific leaders.

Given that L&M positions vary in nomenclature or have the same name and different nature (for example, in two given centres, leaders and managers might have the exact same positions but do things in very different ways) the findings in this section are organised not around individual positions or job titles but around the key L&M domains identified. These domains incorporate the major attributes and functions of leaders and managers in influencing research performance. They are not isolated, the domains do influence and overlap each other; however, they bring to the forefront the challenging nature of CoE L&M and how unique and complementary the L&M team must be in order to be effective.

The following were the main domains attributed to leaders and managers at CoE:

- Leadership of researchers
- Management of the research process
- Management of the CoE

Each of these four domains are presented in the sections below which provide the foundation for identifying key roles and key skills in the upcoming sections of this chapter.

6.2.1 Leadership of researchers

This is perceived as the most important role of L&M at CoE. It concerns the activities and strategies deployed to stimulate, motivate, inspire, guide and nurture individuals working in research and development. Leaders that typically have a key role in this domain are known as any of the following: the CoE director also known as the CEO, deputy director, research stream leader, and chief investigator. It is possible to say that some of the tasks associated with leadership of researchers are also shared with staff in more managerial positions such as the centre manager, COO, communications coordinator, etc.

Chief investigators with research L&M roles are often individuals at the peak of their scientific careers in terms of production and impact of publications. Centre Directors are

generally scientists with a solid scientific background but in addition have a strong track record in leading and managing research groups.

The following aspects were identified as the primary role of L&M in leading researchers.

Fostering a creative workplace

Interviewed CoE directors consistently acknowledged that 'creativity', particularly creative behaviour during problem-solving or contemplating novel and abstract ideas, is a critical factor at the CoE. The performance and sustainability of a CoE depends on it to a large extent. Thus, L&M see that their primary role as research leaders is "to foster a creative workplace". And this is possibly the main consistent thread across all CoE and particularly visible in the science-oriented ARC CoE visited. Leadership of researchers is perceived to be many things, but is primarily about creating the right conditions, fostering favourable mindsets, building the right culture, and facilitating a conducive environment for excellence and innovation to flourish. Participant leaders were quite clear about their role in facilitating these conditions:

> The focus of our work at the CoE is to achieve excellence in research and technological innovation. After all these years we realised that our main role is to create an enabling environment that encourages creativity and the creative behaviour of our people. (ARC CoE Director, Sciences)

Creating the right conditions is considered the most important role of leaders. In practice, such "conditions" were perceived to be implemented through a variety of strategies. The main ones are presented below:

Recruitment

Many interviewees have mentioned the importance of recruitment and their active role in attracting the "best minds out there" at all levels, from junior to senior scientists. In the selection of new staff members care was taken to recruit outstanding individuals but at the same time search for the right-fit in terms of the alignment of culture and personal aspirations.

Creating a team with a diversity of skills and disciplinary backgrounds in the connected scientific fields was pointed out as very important to foster a creative workplace at CoE. Searching for the right team players that would strengthen collaboration was considered more important than having individual stars:

> We bring together people with different but potentially complementary backgrounds. These people see the world and problems from different angles and offer different tools and approaches to create a possible effective and innovative solution. This combined expertise is very beneficial to spark new ideas and produce new insights. (Principal Investigator, ARC CoE)

It was remarkable to see that diversity is perceived as a key factor in fostering a creative workplace. But getting the benefits of diversity required some extra effort so that, first, diversity does not divide, but join people and second, the role played by communication and meeting places.

Meeting places and serendipitous exchanges

Leaders considered the availability of meeting places as a very important factor in fostering a creative workplace. I use here "meeting places" loosely to refer to both formal and informal spaces created to induce interaction, communication, the exchange of ideas and eventually collaboration amongst people. For example, most visited CoE had large open-plan facilities. It is very easy to see and walk past other people and share the status of ongoing projects. There were few dividing walls and when they existed they served to provide more private ad-hoc meeting spaces, and most were made of glass.

The notion of fostering 'serendipitous exchanges' through meeting places has been mentioned by some participants. This was used in connection with fostering an environment where people associated with the CoE (irrespective of disciplinary background, institutional affiliation and rank) could interact, find synergies and exchange ideas in a spontaneous and flexible way.

It is also important to note that, generally the same participants that highlighted the benefits of serendipity and open-plan offices to collaboration also emphasised the need to balance team-work with moments of individual, focused and deep type of work. One research leader pointed to the importance of catering to individual people profiles:

> My role as a senior research leader is to understand individual work styles. Some people do work best in isolation, in a quiet space and having flexible working hours. We respect and support that because at the end of the day our main interest is how productive and innovative a person is. But we also promote opportunities for people to be physically present, in informal and social circumstances. It helps building a supportive community and it also helps the cross-fertilisation of ideas. (Senior Research Leader, CRC, sciences)

In terms of technological tools, video-conferencing rooms are available in most CoE and many use HDVC (high-definition video-conferencing) equipment which is available to all staff and students. Spending a few days at centres, it was possible to see how important this type of pricey infrastructure is. People could work on projects on a daily basis and connect seamlessly with peers from other nodes in real time, with no delays or voice interruptions frequent in other ordinary video-conferencing tools or Skype.

Other formal types of meeting places included research stream coordination meetings, thematic workshops and seminars, annual conferences, summer and winter schools organised in attractive locations, etc. According to participants, the most used and effective meeting places were the informal ones given how flexible and highly used by staff they were. Kitchens and coffee. Most CoE invested in large and well-fitted kitchens with good self-serve appliances and large communal tables. People flocked to kitchens not only at meal times but to make a freshly grinded barista coffee or tea and that is when people would have spontaneous meet-ups and discuss current work. Professional barista-type coffee machines were an unusually important item. Leaders have even acknowledged the importance of having them available since scientists "operate on coffee" and I have witnessed how people converged around a coffee machine throughout the day.

Other informal meeting places were aimed at encouraging people to have a break and to interact. One director was planning to put in place a nap-pod. Other initiatives that featured in the case studies were, e.g., surf after work (in a Sydney CoE, surf boards were hanging over desktops); having a drink during the Friday happy-hour with other researchers; and biking to work (in Tasmania). Some meetings required no-mobile phones. People would gather through these activities in a spontaneous and very effective way according to interviewees. Leaders emphasised the value of investing in connecting people through socializing, building relationships, and ultimately building a tight-knit trust-based research community.

Team size

Most directors and research leaders agree that team size does matter and that they perceive smaller teams to be more effective and productive than larger ones. One director mentioned another perceived advantage:

"Small groups equipped with the necessary level of autonomy tend to require less management, so people can focus on the science". CoE project teams were in general small, with flexible arrangements so people could move easily if necessary. Research leaders perceived as important in create intersecting points that could link groups to one another through the design of workplan or appointment of staff in different groups.

Mobility

Interviewees considered mobility and exposure to different organisational cultures to be a very important aspect of a stimulating work environment. In most CoE, staff were expected to spend time in other nodes of the centre in order to expand personal and professional networks and be exposed to other cultures and work practices. This was set-up as part of the development plan of PhD students and post-docs, but also senior researchers were encouraged to spend time in other nodes or international partner institutions. In one CoE, the director had himself a pre-defined plan for periodically visiting other nodes and engaging with staff in person both for the purposes of coordination of research activities and also to provide face-to-face coaching to early-career researchers. One PhD student said:

> So far, I have spent time in two other nodes of the CoE and got support for one study trip in Austria. Compared to other non-CoE students I feel very privileged given the level of support and the number of high-profile opportunities I had the chance to be involved in. It's a lot of work but I definitely felt much more experienced and with good opportunities ahead after completion.

Support services

Leaders have consistently agreed that a conducive environment provides researchers with the necessary level of support to perform their activities particularly those kinds of support that are critical but not necessarily part of the researchers' skill set. For instance, studied CoE offered their staff with in-house specialist or professional support services. Most common support were IT, statistics, mathematics (including modelling), communications and dedicated

administrative staff (present in all centres) including finance, event organisation, reporting, travel support, student support, amongst other duties. In addition, some CoE have set up special arrangements with their host faculties and they can access university services. At those CoE physically located within campus, PhD students are able to access a host of university services such as library, medical, sports and housing services.

Communication

Good communication (in terms of frequency but also quality of interaction) was perceived as critical for a favourable work environment and this is consistent across the board at studied CoE. Leaders agreed on the importance of constant communication to provide staff with clarity, direction and guidance, particularly in hard times but also to celebrate achievements. On the other hand, early-career researchers have mentioned the importance of frequent communication, with chief investigators in general and supervisors in particular, in order to get feedback on their ideas and work. This is illustrated by this PhD candidate:

> Well… what I value the most is the style of supervision and the amount of communication I get here at the CoE. My supervisors and pretty much most senior researchers have a coaching-style of supervision. I really have the feeling they are not only guiding my work within the framework of the larger project but also constantly looking for ways to further develop my skills in areas that interest me or are applicable to my research.

The physical configuration of the CoE and its research-intensive nature is also perceived to facilitate communication, something valued by early-career and senior researchers. Shared and open-plan facilities are perceived to facilitate face-to-face communication. Senior researchers do not have teaching duties and are fully focused on research activities. Communication amongst team members is seen as more fluid. This post-doc participant stated:

> I see that many spontaneous, unplanned meetups result in valuable learning experiences particularly for students. I think in traditional circumstances; PhD students are a bit more isolated and don't benefit as much. And for us, coordinating project activities, it is also great to have people around learning on the job. People realise early on that it's not only about the science, there is a range of other skills needed to produce good science.

In sum, good communication is seen as an intrinsic part of CoE life for three major reasons: first, people have a good level of autonomy and independence to work on sub-projects and clear constant communication is key to ensuring consistency and cross-fertilization across groups and physical nodes. Second, communication is key to provide constant feedback on the science but also to contribute to the personal development of early-career researchers who are not only performing part of CoE activities but also being trained as the next generation of scientists and practitioners. Third, there is another considerable dimension regarding communication at CoE and that is "science-communication" also called in some centres "translation of research results" particularly relevant to early-career researchers. This dimension will be further elaborated on the last section of this chapter under 'Management of the Centre' and 'Graduate Director'.

Leadership

The last main aspect perceived to be crucial in fostering a creative workplace is leadership capacity of leaders themselves. It might seem self-referential and obvious in a chapter dedicated to leadership and management, but participants have over and over referred to the importance of having appropriate leadership to run a CoE. CoE require special types of leaders. There was no single set of qualities that would characterise such individuals because every centre was unique and with particular purposes but the two quotes below are quite illustrative:

> Look, I dare to say that a great part of our success is due to the type of director we have. He is an excellent scientist with an outstanding track-record but, as the CoE director now, he knows that his primary role is not to focus on his personal scientific profile but to stay in the background and enable others' work, for the greater good. He has a selfless nature and believes on coaching and nurturing others. He may sound harsh at times, but I believe he has excellent communication skills and he is very good at managing conflicts and achieving consensus which most of the time is a very difficult thing. All in all, he has this combination of skills that most excellent researchers do not possess. Most excellent researchers are just blinded by their work most of the time... unfortunately, being an outstanding scientist does not equate to being an outstanding scientific leader. (Senior scientist, ARC CoE)

What was interesting to observe tough is that becoming a scientific leader did require individuals highly committed and motivated, but it was not necessarily a choice or an aspiration. This centre's CEO description of how he became a leader in his field shows that some scientists end up being leaders out of necessity to acquire resources or due to circumstantial conditions.

> I think it comes back to the early days when we were a small group doing sea ice research on a ship. With time, our topic became increasingly prominent as its role in climate research became better understood. Then our programs became larger and more multidisciplinary. It engaged many of our colleagues from overseas. In 2007 I wrote a very big proposal to get a large amount, $8 million, of dedicated ship time with a large multidisciplinary team to conduct experiments; plus, the use of helicopters and all necessary technical and computer support.

Interviewed scientists became in charge of organisational leadership and management due to a combination of circumstances but it was also possible to see that, to remain in such positions, other qualities were required. In science-driven CoE this was a recurring understanding; that to lead these types of centres, individuals did have to possess a particular blend of scientific and personal skills. Most interviewees also thought that it is very hard to come across individuals like that: have a strong track-record, good inter-personal relations, good communication skills, good management skills (specially in an organisation marked by uncertainty and high-risk), be able to bridge disciplinary cultures and mindsets, have a solid understanding of the wider context in which the CoE is embedded and know how to navigate institutional politics, all while motivating and inspiring others. Interestingly, in one centre the director and deputy-director did appear to form a complementary partnership that was perceived by both parties as very effective. Both are scientists with strong track-records but while one is very inward oriented to boosting the research activities, the other takes on the equally important role of liaising with external parties, the necessary politics that involve building and maintaining partnerships and other stakeholder relations (something that the other director strongly dislikes).

Mentoring

Mentoring appeared to be a topic very strongly correlated by interviewees with how good or effective leadership is perceived at CoE given its focus in building scientific capability. Participants have highlighted the fact that nurturing the next generation of researchers is central, especially at those CoE working at building research capability in state-of-the-art or relatively new research topics:

> Our main goal is to build a critical mass in the field of [research topic]. We just cannot afford to have those types of big-ego, self-centred, solitary or narcissist researchers, which is pretty common amongst the scientific superstars. We need people here to integrate, to bridge, to nurture and to communicate. Not an easy ask in my experience. (ARC CoE Deputy-Director)

Participants viewed training approaches such as mentoring, coaching and shadowing as suitable and effective approaches given the intangible nature of the apprenticeship process of research students, particularly at those CoE working in cutting-edge scientific fields.

Leading through culture

The second dimension under "Leadership of researchers" gathers the evidence pointing to the importance of building and maintaining a culture that is conducive to achieving the CoE organisational purposes. Just by stepping into some CoE it was possible to feel straightaway signs of a micro-cosmos, of a subculture or even sub-cultures. Despite the potentially complex and nuanced nature of culture at a CoE, this section is focused on providing a brief overview of how centres and participants refer to the role of leadership in building and shaping culture at the CoE context. The next chapter (Discussion) also touches upon some aspects of organisational culture of CoE and its links with leadership and management.

It is important to say that even though the word "culture" was intentionally not used within the planned interview questions to avoid bias, the theme "culture" did came up naturally in many responses from participants from all levels of seniority and different backgrounds. Early career researchers referred to "valuing the CoE culture" as a defining reason for joining the centre even when faced with other good opportunities. Senior leaders were the main source of detailed insights about culture at the CoE and this section focuses on the perceived role of leadership and management staff (mainly leaders) in shaping a culture.

The following findings will be presented here: why respondents think culture is important and how they actively influence the process of creating and maintaining a culture.

Leaders and senior researchers of science-oriented CoE were the ones that showed the most appreciation for the role of culture:

> It's the well-known importance of "collegiality" in science. Scientific excellence depends on our shared values, on belonging to and depending on a community of scholars, young and old. It depends on nurturing the new generation of scientists. So, yes, competition is also a visible aspect of the scientific world, but we have always known as scientists that everyone has more to gain if we collaborate. And the CoE offers the perfect framework to foster a scientific culture based on collegiality and other important values for producing good science and good scientists. (ARC CoE director)

When the term "culture" appeared during interviewee responses, and since CoE attract scientists and professionals from various disciplines and backgrounds, my next question would be: "is it possible to create a culture?", and if yes, "how?". These are two illustrative responses:

> Definitely yes. In fact, we did actively create a culture at this CoE. It is probably a combination of our own disciplinary cultures but with a twist. We wanted to avoid normative behaviour and create an environment where people feel free and empowered to excel, to create, to innovate and to challenge themselves. I think that senior research leaders do have an important role in creating a culture and this is something we discussed quite often during the establishment phase of the centre. We know how important charismatic scientists are in shaping a culture and that we act as role-models in setting the tone of the centre, but it was more than that. The leadership team with the support of our administrative staff jointly created throughout time activities that crystallise this emerging culture. This happens through the orientation of new graduate students, through the recruitment of new staff, through summer schools and annual conferences. It's in the way we communicate internally and externally. It's in the way we deal with challenges and celebrate achievements. (Former ARC CoE director and senior research leader)

Thus, culture appears to be actually something that is deliberately created in some CoE given that it is considered far too important for the success of the centre to be left to evolve organically. One director affirmed that it is the responsibility of the senior leadership team

involved in the conception of the CoE to actively implant and diffuse a certain culture at the very beginning of the CoE, a period of time that requires more effort and time spent on "building a culture". After that initial phase, people seem to adopt the CoE culture and new members tend to adapt to and transmit that culture onwards: "Culture is contagious", said one participant. The involvement of senior scientists is not only in planning and building the culture but in providing a role-model:

> You know, scientists have a great deal of respect for the scientific authority and the expertise of their peers. We do have internationally renowned scientists in our centre and most scientists do gravitate to places where they can mingle with the best. Then there is also charisma, some research leaders have such a unique personality that they become the soul of their teams and they act as powerful role models particularly to young researchers. (Senior researcher, ARC CoE)

Another main way to shape and build a culture at CoE is through recruitment. Participants have said that recruiting new research staff is a critical aspect of building and maintaining a culture.

> We aim at hiring people who fit in. Obviously, we are looking amongst the best people in our field since we are fortunate enough to attract a large pool of good applicants. What I mean by people who "fit in" is people who share our fundamental values, who share our vision for our scientific community, who enjoy collaborative work, who are enthusiastic about the science we do here. (ARC CoE Chief Investigator)

Ideal fits would ideally enjoy collaborative work, appreciate autonomy and risk-taking but also operate well under uncertain and ambiguous conditions, since making decisions on a constant basis is part of the research process of every researcher at the CoE and not exclusive of research leaders. A scenario characterised by "uncertain and ambiguous work conditions" were referred to a few times as typical of the CoE environment where outcomes are expected on a short and mid-term basis while producing new knowledge and dealing with blue-sky or state-of-the-art research topics.

From the participants' perspectives, relying solely on experience and skills is a pitfall that should be avoided during the formation of a new and vibrant CoE. It is the role of L&M to identify individuals that offer potential and assess if that person is the right fit for the existing

team and expected culture. It may well be the case that what the centre needs is some particular skill or mindset that is not similar but complementary to existing talent.

In addition to attracting and selecting the right people, another role of L&M in fostering a certain culture is to retain staff members:

> This is another issue that we [the leadership team] take seriously – to retain our best researchers and to keep them engaged. This is not easy because we are dealing with highly trained and bright individuals. They need to feel constantly engaged and challenged to perform at their best. Another issue is that they are in demand and have plenty of opportunities to work elsewhere… but my experience showed me that what we can do to retain our staff is to align individual and centre goals. Now, people work here for different reasons and our challenge is to try and cater for their needs and aspirations in a way that also advances the purposes of the centre. (CRC Director, Natural Sciences)

As a whole, and despite differences amongst studied CoE, the main notion drawn from evidence is that the leadership and management team has a key role in building and maintaining a culture that contributes to achieving the CoE purposes. Another point of consensus is that culture is something that is possible to be built and needs to be maintained throughout time. Although visited CoE had considerably different cultures, many of their interviewed staff members referred to the existing culture as one of the main reasons that led them to join the CoE. It seems that by fostering a certain culture, leaders encourage expected behaviours in a smooth way while still maintaining individual autonomy, something that is highly valued by interviewed researchers. It appears that explicit and implicit, non-written rules are shared and internalised by CoE members by being introduced and embedded in a particular culture. Thus, leading by culture is visibly the preferred approach of CoE leaders, and also of staff, of influencing and getting people to perform and behave in certain ways. Being serious about creating and sustaining the culture is perceived as essential for the sustainability of the centre or an emerging scientific field or technology championed by the CoE.

Recruitment is another major function of leadership in building a culture. Not only in finding people "fit-for-purpose" but more importantly and surprisingly finding people "fit-for-culture" is perceived as important as technical skills and experience.

Last but not least, the role of L&M in setting the right conditions for the different types of individual needs. An organisational culture that values learning, risk-taking, open communication, and developing individual potential is seen as appropriate for a CoE context in most centres and particularly those science-intensive ones. Leaders in this case have acknowledged the importance of empowering different types of personal scientist personalities to thrive by creating a culture that offers the right conditions for them. Another key aspect is retaining talent by aligning individual needs and aspirations to CoE-wide purposes and goals.

6.3 Management of the research process

The second domain of L&M is the management dimension of the research process which involves systematic and varied activities identified as planning, organising, resourcing, staffing, continuously supporting, directing, enabling, giving feedback and monitoring the outcomes. At visited CoE, research management duties fall under the responsibility of team leaders known as Chief Investigators or Research Theme/Stream Leaders a denomination given to senior research leaders in charge of specific research programs and their subdivisions into research streams. Working together with the CoE Director and in some cases with the scientific committee members they design the workplan for the research stream by translating and cascading CoE-wide purposes and expected deliverables into working guidelines and milestones for each stream. Most of the evidence presented in this section illustrates the work of these individuals at the CoE.

In order to make sense of collected evidence and organise it into a structured set of findings, this section revolves around the three stages of CoE research process which permit highlighting the different aspects and skills involved in the research managers job. These stages are not necessarily sequential as they can occur in parallel or in feedback loops given the complex and fast-paced research environment of the CoE.

The three stages are:

1. Organising and resourcing
2. Enabling through engaged support: feedback, managing people and relationships, graduate director
3. Translation and impact: communications,

Organising and resourcing

Considered by some interviewees as the "most critical", "complex" and "an ongoing process", the first stage refers to the planning process where CoE purpose and proposed activities are translated into an operational and resourced plan. CoE operational plans typically consist of research streams, work packages, and resources such as staff (research, administrative and technical), infrastructure and support services (terms borrowed from actual CoE).

Considered as most demanding at the establishment phase of studied CoE, a few research leaders report to have dedicated a substantial amount of time and effort operationalising the activities that were proposed in the funding bid which complied with all criteria and requirements of the respective program's funding rules[14]. As a result, the first year of CoE operation was dedicated, in most part, to translating the funding bid proposal into a strategic or operational plan for the centre's research (and other) activities. One of the various challenges leaders say they faced during this process was to translate expected centre goals and wider policy priorities into a detailed workplan, with short and medium-term verifiable goals, while remaining consistent across the different research streams and cohesive across geographical CoE nodes. The second most mentioned task was the challenge to allocate resources, assign roles and tasks and, mainly, delegate key responsibilities to other staff (a learning curve according to one interviewee acting for the first time as a research group leader).

Another common concern expressed concerned identifying good performance milestones and output targets:

> The first year of CoE operation was a steep learning curve for us as scientific leaders. We moved from a scenario of short-term project funding to a long-term grant, then seven years turned into fourteen, which required a very different planning and managing mindset. Our initial focus was on translating the proposal that got us the funds into an actionable workplan that covered our proposed research streams in such a way that took advantage of the capacity across all CoE nodes; pretty daunting at first but we've realised very early on that it is a continuous process which requires a great deal

[14] For the Australian Research Council CoE funding rules requirements see: http://archive.arc.gov.au/archive_files/Funded%20Research/2%20Linkage%20Program/Centres%20of%20Excellence/2014/CE14_Funding_Rules.pdf

> of flexibility of our policies and processes. Over the years, the basic work structure remains the same, but we keep on fine-tuning the way we organise our work, our short and medium-term goals and the nature of deliverables that can really demonstrate our progress and represent what we want to achieve with the CoE. (ARC CoE former Research Program Leader)

Another scientist said:

> We spent quite a bit of time coming up with a set of metrics which could adequately gauge our progress. It was really worth it because we wanted a robust set of metrics not only to be used for reporting purposes but to truly guide our progress internally. It was also a good tool to ensure cross-node collaboration, something that is very important in our partnership. (ARC CoE research stream leader)

A first finding was the level of variability involved under the label "research management". It was possible to observe that the organisation and management of research was not a streamlined process in any of the visited CoE. There was no common understanding of what research management at CoE should tackle and the level of recognition to the work done by research managers (performed by either scientists themselves or professional managers) varied from scepticism to utmost support to the role. It appeared to largely depend on a combination of the CoE director's style and background and on the level of impact expected for the centre. Although most CoE leaders applied some sort of mainstream project management principles and tools (particularly technology-oriented CoEs), most have agreed that a CoE-specific approach emerged after a series of trial and error attempts. It appears that every CoE has its own dynamics, and its leader's personal style influences the way research management is understood and its level of sophistication. Some made systematic use of corporate management-like approaches (perhaps given their focus on technology development, the partnership with firms and the corporate or the background of senior managers) while a couple entirely dismissed the idea that research could or actually should be managed at all. A couple of directors admitted exercising a lot of control and even micro-managing most CoE activities. On top of personal leadership style, one complained about lack of "good professional managers" while another said he just did not see the need for managers at his centre. This is a quote of a centre director who showed a lot of scepticism about the added value of management:

> Our centre is run quite differently to others. I think how a centre is run depends largely in what the director is like in many ways. The ARC got me to speak to them. I gave a presentation speaking about how I run my centre. Because the ARC couldn't believe we could run our centre with so little administration. We have almost no administration in the centre. And my view is that administration is a waste of money. I know people in another centre who hire a COO. You get a person you pay a lot of money to, you put them into a position and as a centre director you're not sure what that person should do, the person develops their own framework of doing things and creates processes for the centre to go through which might well be a complete waste of time. So, people end up asking "why are we going through this process?" well because the COO want to run it like that. If you didn't have a COO, you wouldn't go through that process. You could actually save a lot of money and invest in a person doing more research. So, we decided at the beginning of our centre to have almost no administration. We are more efficient. I am the Centre Director, so I fulfil the roles of Research Director and COO. (ARC CoE Director, Sciences)

While these two leaders were not prepared to relinquish oversight and control or perhaps just did not fully appreciate the potential benefit of management support, most interviewees fell in the middle of these extremes with a visible growing recognition on the importance of having staff (either with a professional or scientific background) with adequate research management skills. Many mentioned being influenced by the experiences of other "more successful CoE" which reaped tangible benefits from appropriate research management such as more productive teams with enhanced scientific performance metrics and more public perception of impact through purposeful communications and engagement strategies, all of which enabled growth through raising additional third-party funding, complementary expertise via partnerships and more social impact.

Further findings on the ways management is used to support CoE research are presented in the upcoming section on key centre management roles.

Chief Investigators (CIs) take on the bulk of research management responsibilities, particularly in those CoE with few professional management staff. As part of their roles, CIs must lead research programs and the collaborative work of teams of scientists which are scattered across institutional boarders (every visited CoE has at least five other nodes located at universities or organisations across the country). Balancing geographical distribution with cross-node collaboration requires from leaders advanced management skills to carry out work plans on time. For example, CIs reported devoting time to establish robust individual and group goals, to design strategies for taking advantage of existing capabilities and leveraging synergies within the partnership.

It was possible to see during the visits that despite the longer funding period enjoyed by CoE partnerships (in comparison to most research funding instruments), timeframes for the individual work teams were considerably tight. Some of the main reasons mentioned were that interdisciplinarity and inter-institutional and, in some cases, cross-sector collaboration implied more research management overheads and was more time-consuming for leaders and managers. This was specially the case in technology-driven CoE which depended on assembling the results obtained by multiple and distributed teams.

Another aspect for leaders managing CoE programs is that every CoE hosts a large number of research students, particularly PhD candidates. Program leaders coordinate the contributions and experience of graduate researchers. This requires identifying topics or teams where students shall be attached to and designating available supervisors. Leaders in more consolidated centres can count on a Graduate Director who carries out a range of custom development training and coaching. This coordination work also involves estimating necessary resources for the successful completion of PhD thesis and postdoctoral fellowship projects such as scholarships, infrastructure, inter-node mobility and field research requirements (present at all CoE). Interestingly in one CoE, program leaders conduct internal budget allocations and "call for proposals" to individual streams and project members which in turn have also structured internal reporting and progress monitoring mechanisms.

All this work coupled with the decentralised nature of the CoE and the complexity of the research problems tackled generate a substantial level of overhead. It was possible to observe that research leaders felt overwhelmed by the complex nature of research leadership. One young senior leader said it is very different from being a solo scientist or leading a small group. "It involves different demands and we are constantly juggling our core role as a scientist

but also as a manager, a mentor and a supervisor." It was apparent that CoE researchers and leaders needed extra managerial support and in most CoE visited, this support was provided by experienced staff.

According to most experienced scientific leaders, the most valued staff profile was a type of hybrid scientific-managerial staff who combine management know-how with a substantial scientific or academic background. The characteristics of this special staff profile, which was hard to come across but increasingly developed in-house, will be further explored throughout this section.

Having established operational research goals, strategies, work plans and timeframes, another important aspect CoE research leaders report spending energy on is "building" or "assembling" the necessary infrastructure to conduct research. Depending on the CoE, it involves different things, for instance:

- Buying or leasing expensive state-of-the-art equipment;
- Getting access to shared research infrastructure (such as the Australian Synchrotron[15] or the Advanced Microscopy Facility at the Bio21 Institute[16] both in Melbourne);
- Building a new lab facility;
- Recruiting a dedicated IT support team (such as the Computational Modelling Support group created by the Climate Science CoE in Sydney[17]);
- Making strategic partnerships. Some CoE leaders have mentioned that joining alliances with domestic and overseas partner organisations allowed the CoE to access costly infrastructure particularly at the establishment phase of the centre when activities depended on infrastructure which was not yet available in-house. Visited CoE have found compatibility and common goals with partners as diverse as governmental organisations and agencies, public research organisations, military labs, universities, and firms.

CoEs were considered by researchers (including non-CoE affiliated researchers) as privileged places to do research given the scale of public subsidies received combined with the

[15] http://www.synchrotron.org.au/
[16] http://www.bio21.unimelb.edu.au/advanced-microscopy
[17] http://www.climatescience.org.au/staff/technical

synergies generated by the partnership. This type of testimonial was very common during visits and interviews:

> We are certainly very well supported here. I see that people have a level of support that is not matched elsewhere in the country. It's a world-class centre in our particular field. (CRC post-doctoral researcher)

The availability of professional support services was also considered as a valuable resource by many scientists:

> We have an exceptional administrative team. Some researchers think they just reduce the burden of administrative work that they would otherwise have to do themselves. I think that by now, they truly add value to the science we produce here, in different ways. We have a graduate director that nurtures and supports student-specific needs, we have a COO that runs a tight ship and oversees our entire business operation, we have a savvy communications manager that changed the whole way we position our centre and communicate our strategic role to society. (ARC CoE Director)

The process of cascading CoE goals into operational research streams and down to team and individual goals was discussed before. Much in line with this is the process of identifying effective metrics.

> Our research milestones are aligned and contribute to achieving the centre's vision and expected outcomes. But more than that, we want our metrics to really reflect where we are and in what ways we are progressing. It's a constant challenge to make some scientific achievements visible particularly for people outside our field or to a non-scientific audience. But it is a good exercise to try and break-down abstract and familiar notions and make it comprehensible and relevant to different audiences. (CRC, Research Stream Leader)

The findings on professional support to research management are described in the section on Management of the CoE later in this chapter.

6.3.1 Approaches to research management

One of the main findings from comparing CoE leaders' interviews was the impact of individual characteristics and personal leadership style on the way a centre is run. The perspective taken by leaders on key aspects defines how research is supposed to be managed

and conducted. One example of those "key aspects" refers to leader perspective and even philosophical orientations on what "research management" actually means and how it should be implemented. On this aspect, a few leaders were firmly grounded on the assumption that their science should not be "managed" but be let to evolve as organically as possible whereas others were very involved in getting as much additional professional support as possible. Another example of a defining aspect towards the existing approach to research management was the type and diversity of CoE partnership. This was particularly visible in CoE where university-affiliated researchers were not the majority. In these cases, the director figure and in many cases the board composition reflect the multidisciplinary and multisector nature of the partnership and that is where most of the expectations come from and are matched by associated research management approaches and influence in-house capabilities (namely recruitment and support services).

A couple of individuals with research management responsibilities which were based at CRC type centres were quite traditional about their roles as research managers in the sense that they compared their role in managing their group's activities to as a CEO in a corporate organisation or industrial research context. In fact, a leader argued that multidisciplinary groups and the involvement of firms and other non-academic scientists contributed to that:

> Although I am a university-affiliated researcher, here at the CRC we work collaboratively with industry and government-based scientists and engineers and the dominating work culture is certainly that of private firms. We have tight schedules and clear expectations from our members. I guess we achieved a common language, it may seem very formal and a bit stiff at times, but we work in a fast-paced and highly codified area with little room for error. It may seem ironic given we work in research and innovation but, right now, we are in the process of prototyping and developing a new technology so it's not like working on blue-sky research. (CRC research team leader)

This research group was markedly managed by means of a corporate project management approach using tools largely used in business environments. For example, they have cited using SWOT analysis and workflow techniques during the design and implementation of the research process. Managers are mostly in charge of supervising the work and monitoring the timely delivery of results through the use of KPIs. Compared to other groups, there seemed to be little room for experimentation which was done in a very controlled way and optimisation,

efficiency, conforming to standards and output delivery were guiding principles. Researchers and scientists were acting more in the role of contractors, hired to deliver pre-defined results. Risk-aversion was often the norm.

In contrast, in science-driven CoE, where the success of the centre depended on the creative behaviour of its researchers, in order to address complex, hard to define and uncertain problems, research management is carried out in a considerably different way. To a certain extent, managers still rely on planning and monitoring tools such as Gantt diagrams and KPIs to help manage the research process; however, given that discovery and capacity-building was at the core of the CoE purposes, idea generation, experimentation, and freedom to pursue different (and potentially risky) pathways are encouraged. One CoE director interview quote illustrates quite well the difference by describing his leadership approach:

> When the leadership team meets we still aim at modelling the best possible process for a specific process of our research programs. We try to map, to the best of our abilities, each step of the process and ensure that teams have the necessary resources, inputs and skills to accomplish it. We define milestones to track progress. But, as leaders, we cannot stifle the creative behaviour of our scientists. We are not dealing with a predictable process. Research is highly volatile and often unpredictable. And that is not necessarily bad; actually, science is dependent on serendipity and some scientists like to increase the chances of serendipity. In sum, we plan but up to a certain point and in some cases, we do not specify in detail what is to be done or achieved otherwise we risk achieving inappropriate results.

In the second case, research managers were more involved in assembling teams with the right set of complementary skills, offering support during decision-making when required and resourcing teams with the necessary infrastructure. A great portion of the work of leaders in this case was enabling individuals to perform at their best by creating the right conditions and fostering favourable mindsets.

In more mature CoEs, particularly those that were successful in extending the funding period to an additional seven years, verified metrics served to inform strategic planning in a bottom-up approach.

> Interestingly enough, when we started developing metrics from the bottom-up, meaning that we involved all team members in the design process, people felt more engaged and motivated in meeting and even exceeding the initial milestones. (ARC CoE, Chief Investigator)

Interestingly in one CoE, individual-based metrics were considered as more meaningful and effective than team metrics or output-based milestones. Individual goals could range from field-research goals to skill development in particular areas such as programming, statistics, and public speaking to writing and publication goals for the late candidature researchers.

6.3.2 Measuring progress and developing metrics

Performance measures are used, according to CoE leaders, to accomplish three main things: document and measure performance, assess progress and offer directions for continuous improvement. The most difficult aspect regarding developing metrics was consistent across many interviewees: leaders struggle to define "operational metrics" that can accurately measure progress towards CoE strategic goals. Strategic goals are often considered "too broad", "aspirational" or "ambitious" to be translated into working operational metrics. Thus, aligning CoE goals to operational metrics is perceived as a major research management challenge.

I have gathered below the main types of metrics used by studied CoE. One of the main findings is that many CoE scientific leaders do make use of a combination of quantitative and qualitative indicators. This is not intended as an exhaustive compilation but as an illustration of how different metrics are established at studied CoE to demonstrate and assess performance:

- Quality of peer-reviewed and published knowledge
- Quality measures include setting a target of published papers in peer-reviewed internationally recognised scientific journals (A-ranked or above[18]) in a particular field
- Number of invitations to address and participate in international conferences. Number of keynote speak invitations
- Number of invitations to visit leading international laboratories

[18] ERA journal rankings

- Number and jurisdiction of policy-makers informed about CoE goals and outputs
- Number of international staff exchanges
- Student metrics such as: Number of postgraduate students recruited. Number of students recruited with external funding for scholarships. Number of completions. Number of undergraduate students involved in centre research projects
- Size of population sampled for research or clinical program
- Number of licensing deals concluded
- Value of consultancies undertaken
- Number of PhD graduates placed with employers
- Number of researchers completing technology management programs
- Number of participants in professional courses. In some cases, paying participants
- Number and nature of interactions with the media. Commentaries in specialised magazines. Interviewees and commentaries in mainstream media such as tv, radio and newspapers
- Number of industry funded projects
- Number of government briefings
- Number of patents filed
- Annual cash and in-kind contributions made by partner organisations
- Frequency and effectiveness of scientific committee meetings

Given the purpose of this study and the collected evidence, some aspects came to the fore. First, research leaders identify (usually together with the team in a bottom-up approach) metrics that are both objective (quantifiable and measurable, as much as possible) and informative (by reflecting progress and achievement toward stated goals). These two aspects are perceived as key for team motivation, L&M of the research process, as well as for the purposes of reporting to the consortium and the funding body. Second, such metrics are not static, they are refined through an iterative process. It was possible to observe from annual reports and review documents that they changed and developed along the years to better reflect the type of work being conducted and to better guide work given new goals set for the CoE. Constant review and update was a central part in setting the strategy right which directly influences the use of metrics. Third, communication is critical, because of the collaborative nature and the combined use of individual and team metrics, but also because feedback is a crucial aspect in the CoE. An emphasis on constant feedback is also important for coaching

and capacity building purposes of CoE and important from a leadership perspective to gauge progress and exploit synergies across CoE nodes.

One leader quote illustrates this point:

> I see my role as a research stream leader as a mediator and connector. I am constantly looking for issues that could be draining our resources, looking for ideas and synergies that could boost our productivity and mediating people in the process. Of course, I do more than that but on a daily basis I am focused on communicating and listening as much as possible. (ARC CoE research stream leader)

6.3.3 Enabling through infrastructure

Infrastructure is one of the main reasons behind the creation of a CoE and interviews pointed to the fact that it plays a major role in attracting researchers. CoE key infrastructure included the provision of space, equipment, administrative and dedicated technical staff and support services, telecommunication and computing facilities, library, laboratories and any other type of support researchers need to conduct their work. This was an aspect that became consistently clear through the site-visits and by observing the interactions between people at visited centres. All visited CoE were very well supported by custom and up-to-date facilities and equipment, usually in-house but also by facilitating access to partner organisations' facilities. Some CoE were more sophisticated in the provision of support infrastructure by putting in place, for instance, in-house specialised technical support services, a dedicated graduate research director, a procedure to share state-of-the-art facilities amongst the consortium partners, access to HDVC facilities, availability of a supercomputer, access to a specialised library, in-house media training, etc. These were all examples of highly-praised resources by interviewed researchers which even contributed to their decision of joining the CoE in the face of other available professional opportunities.

One particularly interesting initiative is that a couple of CoE visited had created, within the CoE organisational structure, a dedicated research stream called 'Enabling Technologies' in one CoE and 'Capabilities' in another. The core function of such units is to support the work of the research streams by developing and providing any type of scientific or technological input such as developing modelling and theoretical tools, producing materials, prototyping a

new device or any instrumental technology needed. This appeared as a major aspect in allowing CoE to be fast-paced research environments working on state-of-the-art topics.

From the perspective of a private sector participant, taking part in the CRC allowed his team of engineers to access public sector R&D capability and strengthen his firm's participation in the technological networking, which was extremely valuable.

The importance of CoE infrastructure in research management is the extent to which it has the potential to enable researchers to excel, to exploit potential synergies, or be more efficient. As was said before, what gave a leading edge to some centres was the in-house (or in-partnership) availability of knowledge-intensive groups and facilities which provided advanced and bespoke input for more complex research or technology development, the actual focus of the CoE. The following quote summarises this idea quite well:

> The facilities and setup we have here are quite unique. What I see is that the infrastructure enabled us, on the one hand, to create a critical mass of people and to coordinate efforts in an emerging field of research, and on the other hand, scientists feel more empowered to make decisions and to have more autonomy and be more aggressive in pushing the boundaries of science. It also gave us more bargain power to join and participate in international networks. (Scientific director, CRC)

6.3.4 Enabling through engaged support

The second dimension of the management of the research process at CoE refers to personally supporting and enabling researchers to conduct research activities. The previous section focused on the research manager role of planning, organising and resourcing for the conduct of research. This section focuses on the research's daily and systematic role in enabling people to achieve their potential. The research leader, with stream or team management responsibilities, appears to have a fundamental role, on a daily basis, to "help others succeed", using the words of one interviewee.

> At the CoE, the main task of leaders and managers is to oil the machinery and sometimes do a bit of firefighting. We provide everything and anything we can to keep things going so that people here can concentrate on what they are good at – research. (ARC CoE, Centre Manager)

But at the research group level, where the research process actually takes place, it was possible to observe that the performance of individuals and their groups was very influenced by their perception of how engaged and invested their leaders were. Similarly, many leaders had a strong appreciation of their importance in stimulating the creativity and creative behaviour of their team members by engaging and connecting with people through different strategies and these will be explored within this section.

At visited CoE, leaders' role in enabling people appears to go well beyond that of traditional supervision and monitoring of the research process. It is much more associated with the leader's daily presence and connection with the intellectual and emotional state of their team members. It encompasses all actions of L&M intended to support individuals to reach their potential and accomplish their tasks. One very experienced CoE director said that talent is by far the most important asset at CoE and through the interviews it became clear that recruiting, developing and preserving talent was the number one priority of leaders and managers. Some of the most used words heard when describing their main role as leaders or managers reveal this preoccupation: "nurturing", "motivating", "coaching", "providing personal development", "providing feedback", "training", "supervising", "maintaining the focus". Interviewed research leaders see their main role as developing individuals and their teams, identifying and exploiting scientific and leadership potential and addressing existing gaps all according to the different individual career stage needs.

Now, the most interesting finding is the ways leaders do this and the mindsets in place. The selected quotes below illustrate some key points found at visited CoE.

Inspiring and keeping people engaged

All visited CoE develop large and complex research programs. Many leaders lead big and often multidisciplinary research teams. But because CoE teams operate much more as networks than hierarchies, as discussed before, and given that CoE rely on the creative behaviour of their members, it was possible to see how much leaders perceive staff engagement to be a priority. I have collected in this section some of the highlights on what interviewed leaders consider as being part of their functions as a leader or aspects that although not verbalised, I perceived as key to their leadership styles.

Do good researchers make good leaders?

Without a doubt, inspiring leaders were perceived as strong motivation for some people to be at the CoE and to keep engaged with the work. In most accounts, leaders perceived as inspiring were seen as role-models, charismatic and good communicators, incorporating most of the characteristics described below and, most importantly, had a leadership style where they truly cared for their teams.

Much have been said already about the perceived importance attached to providing teams with a sense of purpose in the Governance chapter. The idea of reinforcing and infusing their teams with the sense of purpose is what adds significance to the work days of most individuals interviewed.

> He has a vision for this centre which he shares with everyone that joins our team. The trick part and where he truly excels is that his leadership style and his actions are always aligned with this vision. (Research Associate, CRC)

In this regard, two aspects came to the forefront: First, leaders with strong values and who were able to communicate with clarity the purpose of the CoE were praised. A sense of alignment between what is said and what is done, alignment between values, leadership style and vision for the CoE, and that it is all clearly communicated to teams was considered as good and ideal. Second, leaders that were consistently present alongside their teams and caring for them and their needs (and not putting their self-interests or egos before their teams) was also mentioned. A good example was one ARC CoE director, who was consistently praised by his team members as being a great leader. He said:

> Since I became a director I knew that being at the spotlight and focusing on my own career and scientific productivity was no longer a priority. My priority since then is helping people and the CoE thrive. The CoE success is now my success even though I remain in the background.

He said his focus was no longer in doing research, although he was still involved in some projects, no longer on first authorship but on enabling others. Much was said also about the fact that just a few good scientists make great leaders. Although expertise plays a role in getting researchers' respect and trust, in the long run many other skills make sure that research teams thrive in this environment.

One CoE director surprisingly said: “If there were vast numbers of outstanding [field of science suppressed] researchers in Australia, I would absolutely ditch 10-20% of my CIs and replace them, because I don’t deal with managerial incompetence very well”. (ARC CoE Centre Director, Sciences)

Although strong, this same position was shared by another director:

> It continues to amaze me that universities promote outstanding academics into senior administrative roles because, in my judgement, the very best researchers tend to make incompetent leaders. Now there are exceptions that prove the rule. But being an outstanding researcher is about being blinkered and focused. Being a good leader is lateral thinking, wide field of vision, watching what's going on and adapting and adjusting to it in a very dynamic way. It isn't being blinkered. (CRC Director)

6.3.5 Facilitation and communication

I participated in a coordination meeting involving a research leader and his team of both physically present and online attendants. During the reporting and planning of activities by team members the leader role was one of facilitating and offering support and guidance when needed. Examples of leader interventions were of igniting and supporting the follow-up of new ideas, supporting decision-making of the research strategy to be pursued or discontinued.

Ensuring that communication was clear to everyone at all times, appeared to be critical for the collaborative work of the team. People were working on different aspects of the same large project and ensuring that people consistently communicated with each other was important. The leader was showing people how to share information through different channels and avoid “fragmentation” and “duplication of work”. Also communication was said to be important to identify synergies and how people could work together on emerging topics of mutual interest.

Anticipating problems

One post-doc emphasised the importance of the manager role:

> She is good at anticipating potential problems and roadblocks along the way. Managing the work of a research group is not easy and I am learning quite a lot from her leadership style. I appreciate how she is able to encourage people to work together and collaborate

> without losing track of each individual's needs. Also, she knows when to intervene. I guess it is part of being experienced, but she knows when to consult, to be flexible, to say no or use authority and we realise how that prevents the group into reaching a dead end or in anticipating big problems that could cost us time and energy.

Managing relationships and conflict

By observing meeting and post-meeting informal conversations, it was possible to identify a more nuanced and extremely important role of the leader in managing the research process: using communication and inter-personal skills to keep people engaged through encouragement.

During one large coordination meeting it was possible to see that people were having problems with each other and how the leader was really effective in anticipating potential problems between individuals, in managing anxieties, using good communication and even humour to minimise conflicting points of view. When asked about that situation during an interview, one participant reinforced that the leader was "becoming an expert in conflic-resolution" using his words.

Empathy and emotional support was highly valued by some interviewees. They perceived how empathic leaders were, compared to other leaders, more advanced in fostering a good work environment where people could flourish and really be able and willing to collaborate with others:

> He has been leading this group since the creation of the CoE and I have witnessed how he's developed this ability to connect with other people and that's a great asset when you are a scientist and hoping to be a good leader. He values and fosters honesty and openess from people and he's also prepared to be open and to show his feelings. I guess that it builds trust which is the basis for any relationship. (CoE Director)

Having emotional intelligence and acknowledging that the emotional states of other people were relevant for their performance was considered as a characteristic of "great leaders".

Some centres were very high-stakes and competitive environments where people worked under pressure or competed with other units or other organisations. In this case, the

leader was appreciated for championing the team or being responsive to its interests and needs: "What I like the most about him is that he always has our backs. I think that's why people are so loyal to him and are always willing to do their best." (PhD candidate in engineering, ARC CoE)

For older and more experienced leaders, the ability to "manage egos" was perceived as a critical attribute for a leader: "We are lucky enough to have some very accomplished scientists around here, so yes, sometimes it boils down to managing big egos. The CoE is about collaboration, not about solitary research superstars." (ARC CoE Deputy Director)

Creating a conducive climate

Another key aspect associated to the leader's role is in creating a good environment and that might mean different things for different people/groups. Some people appreciated how the leader brought about a more structured way to conduct or supervise the research process. Others perceived how a different leadership style encouraged people to be more outspoken and ideas to flourish:

> It's the first time that he leads a research group and even though he is rather young, not very experienced, and although he doesn't have all the answers he has been really good at creating a climate where people feel good at proposing new ideas and feeling they are valued as opposed to the previous leader who was a bit more conservative. Surprisingly this change of leadership has been really healthy for the group. People feel more passionate about their projects. (Post-doc Researcher, CRC)

An important part of creating a conducive climate is the role of the leader in "inspiring" and "encouraging" team members. This has appeared as a remarkable characteristic. Interviewed people, including leaders themselves consistently referred to "inspirational leaders" as the ones that were most effective in leading their teams, overcoming challenging periods and delivering real research impact. I asked different people about the characteristics of the leaders they referred to as inspirational. They included: "Passionate, good communicator, role model, low profile, trustworthy, action-oriented, and truly believes in the vision set for the centre." (Chief Investigator, CRC)

Monitoring and celebrating progress

A great part of CoE program leaders' work is to monitor the progress of various groups. As discussed before, interviewed leaders consider it critical to carefully define milestones. The reason given was twofold: first, to properly track progress in a meaningful way without having to micro-manage the team. An example given of a good milestone was one that was not too specific and not too broad and one which could be cascaded down by team members within their own workplans. The second important role attached to milestones was to provide a concrete point in time to celebrate progress. In one visited CRC, celebration, recognition and reward were three important parts of the centre culture.

The role of designing ways to supervise and monitor the performance of the team was the responsibility of the leader but occasionally was shared with the rest of the team. One leader reported that he tried jointly establishing milestones with the team when planning for expected deliverables. He considered the experiment surprisingly positive:

> People appeared to feel real ownership over the project. They identified the best ways to track the project which was quite large, and we jointly designed milestones to reflect that. As a result, people were more engaged and my role as a supervisor much smoother. Overall, other initiatives in different CoE also pointed to the fact that where strategy and planning deadlines was not exclusive to leadership, teams were more engaged. The idea of rank and hierarchy was not seen as conducive if the aim was to increase engagement.

Another participant stated:

> I have learned the art of delegating, somehow here at the CoE, despite the high-stakes, I feel I can trust other people's judgement. I try to be consistent in offering my vision of a possible scenario for our end-products but in the end I hope they surprise me with something better. And it has been consistently the case. I guess that giving people autonomy pays off. (CRC project manager)

Trusting, delegating and granting more autonomy were also perceived as ways to develop leadership and management skills, especially in early-career researchers.

As far as celebrating progress is concerned, coincidently I was at the centre during the week when one important milestone was achieved by one stream. The contributions of individuals and the group were highlighted through speeches, internal publications and emails.

Even a celebratory video was produced featuring testimonials and a record of the different challenges faced and overcome in the process. The celebration also included prizes and rewards for individuals who exceled by displaying creative behaviour in addressing a problem, self-initiative or leadership in helping the group move forward.

Coaching and developing capacity

Policy papers supporting the creation of CoE types of centres state they must serve to create capacity and nurture the next generation of researchers. From the two funding programs included in the scope of this study, and according to the funding organisation, the CRC program alone produces 6% of Australia's PhD graduates. In this sense, most centres do focus on developing early-career researchers by involving numerous PhD candidates and post-docs. A couple of the most valued aspects in the development of PhD candidates and post-docs identified during interviews are giving considerable freedom to explore and define research questions and on the choice of research methods. Freedom to explore was associated as a pre-condition to a more engaged learning and self-confidence, more use of creativity and more ownership over projects (considered key to sustainability and completion).

Some centres included a dedicated Director for Graduate Students which provided tailor-made initiatives and support services to graduate students. Leaders in charge of developing other people were also conducting, or keen to initiate, mentoring and coaching initiatives by linking early-career scientists to experienced mentors of their choice or in matching areas.

One director said:

> Our goal is to find and exploit potential. We have very bright and talented young people here and it's our role to serve as a platform and further develop their skills. It is encouraging to think that we are training the future leaders of our field. Some people want to be better communicators, others want to learn how to lead groups while others are solely focused on their science. We have to support and offer opportunities suiting everyone. (CoE, director)

The most interesting perspective though, was from students and early-career researchers themselves. This gave me a glimpse into what aspects of the scientific and

academic profession still attracted young and bright minds. Again, the notion of mentorship and purpose were deemed as very important.

> Obviously the CoE attracted me because of the level of resources available here, like scholarships, labs, travel support, technical staff… But what brought me here in the first place was the fact that I was searching for a mentor, not just a regular supervisor. My biggest motivation to do a PhD degree, and not going straight into a well-paying industry job, was that I wanted to learn from the best, from someone that had the same level of passion as me and at the same time being able to work on something that had a meaning and a purpose. (Last year science PhD candidate, ARC CoE)

Overall, people were attracted by the level of resources available, the opportunities for networking and career progression but equally by the public-good aspects driving CoE, the availability of experienced and accomplished mentors and the development opportunities for acquiring new skills and translating science into society through different pathways.

6.4 Management of the centre

One interviewed scientist was critical of the idea that "power rests with the experts" and said that typical research leaders that still follow that paradigm have a hard time in scientific organisations such as CoE because he believes that "scientists make poor managers". He also said:

> In most research organisations, and CoE are no exception, people assume that if you are good at science then you are smart enough to be a good manager. That is rarely the case unfortunately… the kind of know-how and skills required to be a competent manager are different and people rarely have the chance to develop those skills while during a PhD or a postdoc. (CoE research stream leader)

This was a recurrent perception of participants across different visited centres. Research leaders not only perceived the added value of professional management support but were appreciative of being able to have more time to concentrate on their science and science leadership duties.

During the visits, it became evident that CoE are research organisations that clearly benefit from skilled management support, especially when compared to less mature or advanced ones.

CoE management and administrative staff provide a range of support services, from simple tasks that free researchers from day-to-day administrative burdens so they can concentrate on doing research all the way to sophisticated professional support services that are able to leverage research performance and its outputs.

The importance of management and administrative support emerged given the value attached to this type of staff by interviewed researchers particularly in large and more consolidated CoE. What I mean by "large and more consolidated CoE" are centres that have been running for considerably more time and which have been re-approved for a funding extension. In terms of research, they maintain several research streams which often include multidisciplinary teams, have a research training program, and are invested in translating research outcomes through different channels and target user groups.

At these particular CoE it was possible to find some common characteristics. A director who had a strong positive appreciation of the role of centre manager and who provided the person in this position with sufficient trust and autonomy. The centre director would then be able to concentrate on high-level research decision-making and delegate centre management roles to the centre management team. A centre manager (also known as COO) with a strong managerial track record (in either a university faculty, a research centre or the military). At the time of the interviews, one centre manager was pursuing a master's degree in university management. The leadership style of the centre director and his/her level of trust and relationship with the centre manager was a particular defining aspect at those CoE with more advanced management support systems.

6.4.1 Key Professional Roles

Titles of professional managers' positions were varied and to some extent reflected the nature of the CoE. A striking aspect was the high number of professional management positions that required specialist knowledge. These are the main positions of professional staff team members: centre manager, graduate director, finance manager, communications manager, events coordinator, (community/stakeholder/higher degree) engagement manager, laboratory

manager, management accountant, procurement manager, legal assistant, IP and commercialisation specialist.

A few roles were consistently present across all CoE, despite slight variations in nomenclature. These roles were at the core of what the professional management team represented to the research team. Their specialist knowledge and skills are perceived during interviews to be instrumental in taking CoE research to the next level and in ensuring scientific activities and outcomes were not restricted by operational obstacles. These selected roles were:

1. Centre manager
2. Graduate director
3. Communications manager

Centre Manager: Liaison between executive and scientific teams

The centre manager (CM) is possibly the most important member of the professional staff team, mainly because this person acts as the liaison between the scientific and the administrative teams, bridging the operational and scientific dimensions. During every centre director interview, it was possible to observe the importance of this professional in leading and coordinating the administration team and overseeing the operational side of the centre. As one director put it "he is my right and left hand". Centre managers are equal to the rank of chief operating officer (COO) in many visited CoE and a few centres do have a COO position instead.

A lot has been explored in other sections on the role of the CM reinforcing the significance of this role by CoE researchers to the perceived effectiveness of CoE. This section will focus on the issues that were not described elsewhere and highlight the key skill sets and responsibilities required of this position.

The profile and background of centre managers across studied CoE is very diverse, probably accounting for the very different nature of each centre. One common characteristic is that CMs tend to two core profile features: first, a strong track-record in management in administration. Interviewed CM had previous experience in managing organisations in the academic, medical, military and industrial sectors. Second, most of the time they had some or even a substantial amount of scientific or academic education and training experience on the topic area of the centre. For example, one CoE in the natural sciences has a CM with a bachelor

and postgraduate degree in the same area. Although having a scientist with strong management experience is not the norm, many interviewed researchers perceived this to be a very desirable profile. Having a good prior knowledge of science and technology, particularly on the relevant areas advanced by science-driven CoE, was perceived by interviewees to facilitate the interaction with the scientific teams and better match their work culture and expectations.

In contrast, other CoE welcomed the idea of having someone with a track-record and management background from a different sector as it was perceived to contribute to enriching the management capacity of the CoE by introducing different management approaches and tools. One great illustrative case is a visited CRC which has a COO with a previous background in the military sector. Although led by academic scientists, this centre is very oriented to developing breakthrough technology together with non-academic partners. The CM was seen as pivotal in running the centre and ensuring a common work ethic and collaboration with people from vastly different work cultures.

Decision-making and Reporting

The CoE Centre Manager functions essentially as a key connecting link making the director's vision become a reality and, in this process, leveraging all the organisational resources to pursue this goal. For this fundamental reason, centre managers at studied centres share some common skills. They have solid problem-solving skills, they are good at negotiation and conflict management, some are perceived to excel in emotional intelligence and they are great in breaking down complex tasks and delegating.

Another key dimension of the work of a centre manager is providing input for centre leadership decision-making. To do this, they put in place systems to collect and store data regarding the CoE operation.

> Part of my job is to collect and analyse data regarding the COE operation. This serves to extract insights that I can bring to the leadership team meetings and generate insights on potential new avenues or how to solve a particular problem. (CRC centre manager)

> Our interaction with the scientific leadership team is very complementary. We bring in the business operation perspective and they provide the scientific perspective. What we do is try to combine both views during decision-making, so the centre is a vibrant and

> viable organisation. (CoE Centre manager speaking on behalf of the administrative team)

Another role usually performed by the centre manager is producing annual reports which are a major tool not only to update the consortium on the progress of the centre but is also a main evaluation part of the funding authority evaluation process. CoE annual reports involve a laborious and time-consuming process given the number of partners and ongoing projects. Every centre uses a range of qualitative and quantitative measures to demonstrate progress and impact. The centre manager is usually in charge of transforming reporting requirements into metrics, engaging with scientific teams on how they will report the progress of their work, gathering data (which can involve the development of tools), and producing the final copy of the print and online reports.

The data gathering process for reporting purposes is indeed so substantial at CoE, that some managers use specific IT tools to conduct the process. In fact, one interviewed centre manager went all the way to develop himself a software tool that supports the process of collecting, analysing and presenting data for annual reports. The need for developing this solution originated in some underlying issues:

> The ARC CoE program reporting process requires a wide range of data on activities, expenditure, results and impact. There is an added layer of complexity given that data needs to be collected from multiple institutions. Coupled with that is the fact that there is no standard format to structure reports, nevertheless, funding for our centre is approved to a large extent on the basis and quality of such report. We developed an online tool that captures key data and more importantly, we devised ways to make this process less burdensome to our researchers. It is designed to be an ongoing process, an easy-to-use online tool that serves to record a researcher's or a team's activities and allows us to visualise performance from different perspectives. (ARC CoE Centre Manager)

The ability to identify critical data during the reporting process and the professional staff team ability of manipulating these data was critical for demonstrating centre impact. Visited CoE had developed different ways of identifying key performance indicators (KPI) and other qualitative data which could be used in a way that demonstrated the significance of CoE activities in generating impact on pre-defined areas. The combination of skills of the

professional staff team was central in presenting data in a clear and engaging manner to show the extent of centre impact within annual reports.

Managing the administrative team

Besides working closely with the centre director, another of the centre manager's primary functions is to lead the centre administrative team. At CoE this team is typically composed of a finance officer or management accountant, an events coordinator, an engagement officer, a media and communications manager and in some cases the head of the technical team. The centre manager also works closely with the Graduate Director if this position is present.

The centre manager is responsible for the CoE operational and organisational management. This requires the CM to engage with researchers across research programs, with university administration in the case of university-based CoE and external stakeholders.

Analysing the job descriptions published to hire individuals in this position at studied CoE, the following skills and background requirements were identified:

- Expectation of relevant tertiary qualification or demonstrated equivalent competency
- Substantial management experience in a similar role with excellent planning and organisation skills
- Experience interacting effectively with a broad range of stakeholders including research students, government and industry
- Advanced planning and organisation skills
- Ability to manage competing priorities and tight deadlines
- Ability to determine priorities
- Excellent written and verbal communication skills
- Ability to support the director to manage the strategic growth of the centre
- Knowledge of research funding agencies and funding bids
- Experience in managing research projects to produce high impact outcomes

These were some of the most mentioned requirements in CM role descriptions. In terms of tasks, CM were required to do or to oversee the following types of administrative tasks: contracts and grants preparation and management, developing new policies and procedures, budget preparation and management, supervision and training of new professional staff, and compliance with institutional laws and regulations.

Fundraising

Finance and fundraising were particularly important areas for some centre managers. Not only the financial regulations involving the funding agency and the co-funding requirements with the consortium members, but some CoE also emphasised the need for fundraising from alternative funding sources. Developing a fundraising strategy requires identifying potential users of CoE outputs, training and consulting services for example. It can also involve applying for external grants.

In addition to that, a few interviewed centre managers organise fundraising training courses for in-house researchers and graduate students wanting to develop skills on proposal writing and budget preparation.

The above are some of the most striking features common to most studied CoE, however there were clearly no two centres with similar centre managers. It was possible to observe a real diversity in terms of individual backgrounds and levels of control. After interviewing individuals in the role of centre manager or COO there was a general sense that every CoE needed a specific type of professional that could, at the same time, fit in the centre culture and add to the work of researchers or towards the exploitation of outputs in a complementary way. Moreover, those CoE that were most satisfied and appreciative of their centre managers were those that had managers attuned to existing and untapped operational needs and were accompanied by a leadership team prepared to relinquish and grant the manager the necessary level of autonomy to go about their activities.

From my point of view, in every CoE, the centre manager role is defined by a combination of the background of the manager coupled with the centre purpose and, perhaps most importantly, the symbiotic relationship with the centre director.

Communications Manager

Across all studied CoE, the communications manager (in some cases also known as the engagement manager) is perceived to have a key role as he or she strengthens and amplifies the impact of scientific work, according to interviewed scientists. Very frequently during interviews this role was mentioned as critical to CoE impact and sustainability given the value this professional added to the CoE.

Across all centres, some of the functions performed by CoE communications managers are to devise a communication strategy for CoE activities and outputs across multiple platforms; to identify and implement outreach and engagement activities with key stakeholders; to produce targeted content to different audiences and purposes; to assess and promote the impact of CoE activities through the different channels used; and to train scientists to become good communicators with advanced writing, speaking and media skills. The following aspects further describe how the communications manager role is perceived to strengthen the scientific profile of studied CoE.

Increasing engagement

Interviews with researchers (particularly team leaders) revealed the most about the significance and added value of the communications manager role. Engagement is a major underlying goal behind the creation of a CoE and it is the communications manager's job to assist researchers in the design, implementation and monitoring of engagement activities while scientists can use their time to focus on research:

> So, what our communications manager does for us, just to give you one example, is helping our team to shape our interaction with the end-users of our research outputs. At first, we have identified in what ways our outputs are relevant to industry, government and community organisations and then we designed actions that are perceived to be mutually beneficially and by that, I mean exchanging knowledge, technologies and resources in ways that advance science and meet the needs, current or future, of users. (ARC CoE Chief Investigator)

Having received a basic research briefing from the research team, the communications manager identifies key stakeholders (organisations, individuals, groups) in each sector, and lays down the approach so that the research content can be made appealing for each target group. Next, he or she chooses the media channels or engagement activities most suitable to allow CoE scientific outputs to reach specific stakeholders.

For some of the studied CoE, the process of translation and uptake of research outputs is at the core of the organisational purpose. At one of them, all research activities were envisaged to address the needs of particular social groups and strengthen community organisations that serve them. Thus, all CoE activities are centred around the engagement with beneficiaries and the proper uptake of research results. Despite engagement being an integral

part of the design and development of every centre activity, the translation and the actual uptake of results remains a challenge at this CoE. The following quote highlights the contributions of the communication manager in this regard:

> The idea that research outputs can feed into policy and practice in a linear, straight-forward manner does not reflect reality. What we experience on a daily basis is that there is always a big gap between research outputs and making them relevant to what practitioners and policy-makers want and do. That's why our role is so important not only in translating research to the outer world but bringing back input that can inform the work of our scientists. (CRC Engagement Manager)

Engagement managers and scientists themselves have referred to the difficulty in bridging that gap. But why is that the case? During the interviews, two reasons emerged. First, in most scientific domains, researchers are not assessed and rewarded by the level and impact of their translation activities. They are measured against the number of peer-reviewed publications and citations. They say there are no real incentives from the academic career progression point of view. Second, researchers have said that most of the time, research findings are incomprehensible to policy-makers and practitioners. Big cultural and language differences coupled with lack of skills mean they are not capable of absorbing and applying findings on their own.

For reasons like that, CoE leaders create a role focused on community and stakeholder engagement. This role is combined with the communications manager role in some visited CoE. This person focuses on liaising and making sure translation and engagement actions are aligned with the CoE purposes and at the same time with stakeholders needs and interests, while bringing feedback to the CoE on how to improve its activities. The profile of one manager, showcased below, is quite unique and a hybrid of professional and scientific backgrounds.

Seeking input from interest groups

Complementary to the communications manager but with a more narrowed focus, some CoE have a community engagement manager. This engagement professional oversees the development of initiatives aimed at translating and communicating CoE research to particular interest groups. For example, the CoE research might be particularly relevant to interest groups such as patient organisations interested in clinical trials, NGOs, local community members and

organisations. The community manager also tailors CoE science to raise awareness of other audiences such as science communication programs aimed at promoting science to school children, to recruiting university students interested in becoming researchers, to senior citizens, to health professionals, etc.

Quite often, the profile of this professional was a hybrid of scientific background coupled with professional experience, something that in many CoE was considered as ideal. In one of the visited CoE, the community awareness manager holds a post-doctoral degree in Biological Sciences and had several years of professional experience prior to joining the CoE in outreach and communications at the Faculty of Science in a major Australian university. Researchers perceived this manager to have been very efficient in creating trust and long-lasting links with research users and, more importantly, in further informing and refocusing the ongoing research programs.

Informing policy and practice

One of the studied CoE adopts an approach to engagement which is particularly interesting given that the end-user perspective underpins the entire research strategy, guiding the process from the planning to the translation phase. Most importantly, end-users' perceptions of CoE science and scientific outputs systematically feedback into research programs and allow for refining activities and better responding to users' needs.

This is mostly done in three ways. Firstly, by initiating engagement efforts from the beginning, at the priority-setting stage. This CoE involved representatives of all key stakeholders in a foresight initiative aimed at "getting ahead of the game". The purpose was to anticipate and prepare for the potential research demands of the future. This CoE's researchers together with policy makers and service providers come up with possible future public health scenarios and associated sector requirements that can be addressed by research now.

The output report[19] describing this process where engagement was key from the priority-setting phase emphasises the importance of a joint development of a future vision shared by the stakeholder groups and the CoE team and a joint understanding of how CoE

[19] The Shape of Things to Come: Visions for the future of Aboriginal and Torres Strait Islander health research

research can contribute to achieving best case scenarios (and also to avoiding worst case scenarios) within that vision.

The outcomes of that exercise informed the design of the CoE activities and provided some guiding principles that are still in place: the CoE approach to research and translation closely integrates research, policy and practice as the system is able to respond to rapidly changing scenarios.

Secondly, the concept of "knowledge exchange" is pervasive in this CoE. It points to the fact that for the engagement to be effective, knowledge must be exchanged by research producers and users in a two-way process for changes to be sustainable. The CoE uses trained staff to implement its knowledge exchange methodology[20] in practice.

Finally, some CoE outputs are produced with a view to closing the gap with key stakeholders. For example, roundtables were perceived to increase engagement at the priority-setting stage. Policy briefs were produced by re-shaping scientific findings and translating scientific knowledge into policy-makers' jargon and targeting existing policy priorities and were mentioned as very important in raising awareness at the policy level. The production of practical tools and resources was also able to enhance CoE science attractiveness.

Targeting content to specific audiences

Crafting a science-based message with the right format, content and tone and delivering through the right channels to reach desired audiences is pointed out as the main mission of CoE communications managers. This section gathers examples of the main communication tools produced at visited CoE. Such tools are perceived to strategically position CoE science by targeting its content to particular audiences. CoE scientific leaders and communications managers work together to devise ways to shape CoE capabilities and match the interests of key audiences. This process is unique to each CoE profile, but some illustrative examples are gathered below.

The construction of a website is traditionally the departing point. General information about the CoE research is typically provided through its website, however the level of detail and audience engagement varies a lot. Content is generally structured in sections aimed at

[20] More information on this community-driven approach to research on http://www.lowitja.org.au/making-research-work

catering to other researchers, funders, and research users. The website is systematically updated with pre-planned content publication dates and assigned contributors for every section. Research program coordinators distribute posting responsibilities according to topics and often create program-based blogs to encourage a more informal and online content generation and scientific debate.

The production of e-bulletins or newsletters (published on a fortnightly or monthly basis) play a big role in CoE communication. It is perceived to be effective as both an engagement and accountability tool. Communications officers find newsletters sent by email are a good tool to track the existing audience of the CoE since it can provide some solid and detailed analytics such as what emails were opened, forwarded, which links were clicked on, user geolocation, a user device particularly useful for some CoE to optimise content such as graphs, video and text.

Event organisation

Event organisation is another common tool used to shape content to audience. CoE are particularly active in organising events in four main categories: academic/scientific, professional, educational and translational.

Academic conferences are the major kind of event. They are organised for scientists where CoE take advantage of their scale of resources and extended networking to position the CoE as a hub or platform in a particular research field. This type of event is considered by CoE scientists to serve three main purposes: increase coordination of geographically dispersed CoE teams across nodes, gather peer feedback on ongoing research projects, and facilitate networking through new partnerships.

Conversely, studied CoE also organise professional events such as workshops which have as a primary aim to apply CoE science into particular technical areas and, in some cases, develop related skills or promote spin-off technologies[21]. This type of event is perceived by interviewed CoE managers as being increasingly used in recent times given its potential as an effective engagement and promotion tool. As one communications manager of a science-

[21] CoE research on 3D printing targeting a professional audience through a technical online workshop: http://www.electromaterials.edu.au/free-online-course-with-futurelearn-bioprinting-3d-printing-body-parts/

oriented CoE stated, workshops "re-frame CoE science using a different, user-perspective" and "have a great potential to raise awareness about the importance of CoE research and in bringing science closer to an educated but non-scientific audience". This capacity to outreach to non-scientific stakeholders is an area where communications managers are particularly valuable to scientists given that these events have a considerably different format than traditional scientific conferences. One lead scientist said that the communications manager organised a professional workshop which, after a couple of years of CoE operation, was the first time he was able to reach and engage with two target groups: "we have focused on our science and on our scientific partners worldwide and for us, as scientists, it was hard to invest our time coming up with ways to engage with the public, specially users and funders of our research. As we were so focused on managing the research process, our communications manager was able to portray our science in a very engaging way." A recent example is the Bushfire & Natural Hazards CRC annual event which gathered more than 3,200 practitioners who are direct users of CRC research outputs[22].

Engaging with the media

By analysing the CoE engagement with the media, it was possible to identify the essence of the role of the CoE communications professional. In a nutshell, this interviewee sees the ability of "identifying a story in a piece of research" is central to the research translation mission of the CoE. Thus, the importance of having a dedicated person who has this ability to take the science and visualise multiple ways to craft a message that will appeal to different audiences and purposes. This was particularly visible through the role of communications managers in engaging with different media vehicles.

According to one interviewed communications manager, identifying a story involves "distilling the essence of a piece of research into an interesting story that works for the media and still remains true to the science."

One journalist participating in a CoE communications workshop event talked about how scientists can create a compelling view of their research to the media and the public.

[22] More information on this event on: www.bnhcrc.com.au/events/2017-annual-conf?mc_cid=31851d02f2&mc_eid=6c57deb95a

It was possible to observe an underlying process starting from story identification to story publication and each stage of this process requires different skills. For instance, the first stage, which can be named "story identification" requires good knowledge of the CoE scientific projects and technical vocabulary, and good understanding of potential applications and how users could be positively affected by them. It requires an individual with a blend of scientific knowledge, and analytical and writing skills. Something that was very hard to get across according to many interviewed scientists; however, as described in the next sections, this type of training is being provided at many CoE. Then at a later stage named here as "mainstream media management" it is important to have good oral skills to talk in radio and tv interviews and stakeholder presentations. This person needs to know how to make a big announcement such as a scientific discovery, handle difficult questions from journalists and know what to expect and how to respond when the media picks up a story.

Mainstream media is constantly seeking CoE for expert interviews and op-eds (short for "opposite the editorial page") however CoE communications managers are also particularly active in publishing science-based content with more specialised types of academic or scientific media. A good example is CoE engagement with Australian The Conversation[23], an online media outlet curated by editors who work in a not-for-profit collaboration with the research sector. The Conversation publishes no PR sponsored content and all writers have at least a PhD in the areas they write about. During this study it was possible to observe that CoE research is particularly suited for media outlets such as The Conversation for three reasons: first, all articles are authored by academics or researchers with up-to-date scientifically-based or fact-based content, second, all publications and ensuing public debate are guided by the principles and norms laid in its 'editorial charter'[24] reinforcing ethical principles; and third, and most important, the fact that CoE research themes are state-of-the-art and exploring how science can explain or help solve complex societal issues. This type of platform is then particularly employed by CoE to communicate and promote their science and while doing this, get expert feedback and, in some cases, even support from the community on more controversial issues (see Quantum CoE as an example[25]).

[23] TheConversation.com/au is one of Australia's largest independent news and commentary sites, delivering expertise from the academic and research community direct to the public in a not-for-profit collaboration with scientists.

[24] https://theconversation.com/au/charter

[25] https://theconversation.com/hype-and-cash-are-muddying-public-understanding-of-quantum-computing-82647

Finally, media releases are another key communications tool used by CoE to disseminate content, particularly used to initiate and manage their interaction with the media. Media releases are used to announce a major scientific finding stemming from CoE research, the launch or piloting of a new technology, the acquisition of a funding grant or more commonly the publication of a new report where the media release highlights key aspects that may be potentially appealing to the media and the public[26].

Research dissemination

The communications manager coordinates the design of other types of materials and tools that contribute to the CoE communications and translation strategy. These communication materials provide a summary or activity highlights of CoE research in an accessible form tailored to a varied audience. For example, one CoE produced a book transforming CoE science in content addressed to a target group composed of teachers and researchers from a different but complementary scientific discipline with which many CoE projects intersected. Other types of materials encountered during the CoE visits were flip charts (perceived effective to communicate short scientific messages and raise general public awareness about the centre); educational tools (such as animations and booklets); and videos published either on YouTube or distributed in DVD such as research-informed health promotion content developed to inform the work of practitioners in isolated Aboriginal communities in regional Australia.

Discussion papers (also known in some CoE as "Position Analysis" or yet "Research Briefings") were often named as being an effective type of communication tool particularly used to convey a message or require action from an important target group: policy-makers and government officials. Many of the visited CoE had produced discussion papers where the CoE-science is used to analyse a challenging social issue and in some cases, contributing ideas to sustain the development of new policies. "I see that our research findings are making a real impact on policy. For years we have listened about the evidence-policy gap and I believe we have made a real contribution in bridging that gap", said one CoE communications manager.

[26] See this media release by the Lowitja Institute CRC: http://www.lowitja.org.au/sites/default/files/docs/mr-9aug2017-20y-lowitja-institute.pdf

The evidence-based policy-making process was described as a long and non-linear one but CoE were perceived as well-positioned to have a concrete engagement with policy-makers, political parties and government officials by having the scale to offer scientific input and the means to translate findings and inform the work of these individuals. Two CoE consider having had concrete policy impact after a series of policy briefs and round-table events with policy makers. One was able to inform to a great extent the re-design of a large community health program and another input was critical in informing Australia's government position on the Antarctic and climate science and its associated future public investment in climate research[27]. One of the studied centres was particularly prolific in producing high-impact position analyses which are all available online now for download[28].

Planning and Reporting

Communications managers, particularly those skilled in leveraging scientific content and research outputs into appealing content to different target audiences, appeared to have a key and even strategic role in supporting research leaders[29]. Communications managers offer support at all stages of CoE operation but there are two specific stages where their input was particularly praised by senior leadership: during the critical and labour-intensive phases of planning and reporting. During planning, either for a new CoE proposal, a proposal for funding extension or for internal planning purposes, scientific leaders reported finding great value in having an expert non-scientific perspective on how to position and describe centre activities, outcomes and impact in ways that are appealing from the funder and the general public points of view.

Similarly, the reporting process was considered overwhelming with the amount of work and outputs to be described. Communications managers were perceived to help the design and presentation of research results in an innovative and interesting way.

During the priority-setting process of a centre, a couple of managers reported being actively involved in organising a dedicated event, including materials and disseminating since

[27] https://theconversation.com/government-offers-hope-by-telling-csiro-to-reinvest-in-climate-research-63501

[28] http://acecrc.org.au/publication_categories/position-analyses/

[29] This CoE is an example of advanced media communications: https://www.climatescience.org.au/content/392-news

it involved a wide stakeholder consultation. Communications staff also contribute heavily to organising content, and lay-out and editing CoE annual reports, which are key documents in promoting the work of the CoE, and in ensuring the sustainability of the centre through the continuation of public and third-party commitments and funding.

Social Media

A recent but growing trend across all studied CoE is the use of social networks as an organisational communication tool. Communications staff are in general the ones responsible for curating CoE social media presence. According to one manager, "establishing a corporate identity on social media is a relatively new thing for scientific organisations and scientists in general".

Managers reported developing a policy on the purpose, goals and guidelines for using social media on behalf of the centre. One policy identified a basic typology for posts and the necessary features of each such as nature (announcement, promotion, launch, engagement with society, impact of research), target audiences, type of graphics (image or video quality specifications), among others. The great majority of visited CoE have active Twitter, Facebook, Instagram, YouTube, and Vimeo accounts and feed these channels on a daily or weekly basis with a relatively high number of followers. In addition, some CoE researchers are also active science bloggers writing not only for CoE but also for personal blogs and Twitter accounts.

Research leaders have reported that having professional support for scientific communication and media relations has facilitated establishing the CoE as the "go-to" source for expert opinion stories related to CoE research topics being frequently picked up by the media.

In addition, this professional organises and helps the CoE host high-impact events and also often represents the CoE in different public events which do not necessarily require the presence of a scientist, liaising with potential users of research outputs, government representatives and funders of CoE activities.

Science communication training

Finally, another key role of the communications officer is training early-career researchers to develop science communication skills. One communications manager reported actively selecting and training PhD students interested in becoming "scientific ambassadors" learning how to convey a succinct and sharp message to the media (from short "breaking news" types of interviews to longer format ones) and according to different media vehicles – radio, television, newspaper op-eds.

This interviewed last year PhD candidate said:

> I learned a lot from the science communication training I got here at the CoE but what I enjoy the most, and I continue to practice, is to develop this ability to identify a potential news-worth story in a piece of research. And then how to deliver that story in different media formats and to different audiences. (Last year PhD student, Science CoE)

Graduate Director

Not every centre had the dedicated figure of a graduate director, however, the ones that did offered an interesting approach to the leadership and management of graduate research that is worth describing.

Enhancing graduate training

Graduate directors are typically present at CoE that have a large number of honours, masters and PhD students actively involved in the centre research programs. In fact, one CoE had around 200 students spread across its five geographical nodes. In addition, such CoE are fully committed to providing high-quality research training and offering a comprehensive student experience as part of their organisational purpose.

In a nutshell, the CoE graduate director oversees and develops an integrated graduate program, meaning that it spans across disciplinary boundaries and institutional nodes.

Supporting a good graduate experience is one of the mechanisms used by CoE to implement inter-node coordination and cooperation and prevent fragmentation within the partnership. Students usually have the opportunity to become part of a CoE team and contribute towards the work of a research stream:

> Although students are formally enrolled in one of the universities, they are in practice supervised across universities or by researchers at our partner institutions such as the CSIRO. Their work is usually part of a large ongoing collaborative project across the CoE. They are part of a cross-institutional team and benefit from the interaction with more senior peers. So, it is a quite different experience from the traditional PhD student who works with one supervisor on a stand-alone thesis. (Graduate Director, Natural Sciences ARC CoE)

According to graduate directors, the use of cross-institutional supervision and cross-sector multidisciplinary research teams, fostering exposure to different organisational cultures and access to the infrastructure and support services available at the CoE partner organisations are unique features of the CoE graduate student experience that traditional students don't have access to. Planning and managing as aspects of a diverse and customised student experience is part of the graduate director role.

Student support and development

CoE graduate directors are typical hybrid research professionals combining management skills with scientific knowledge. This became clear through the range of support services and development activities designed by them. Examples of how graduate directors leverage resources to foster graduate training were varied at visited CoE. Many directors run a scholarship program funded from the CoE budget. In addition, some offer additional support in finding and co-funding accommodation. Graduate directors also organise public promotion events to raise awareness about CoE research and recruit potential future graduate students interested in pursuing a scientific career. Another activity conducted by graduate directors is to conduct searches for potential mentors and placement opportunities both in the academic and private sectors.

The next sections explore in more detail some of the key programs developed by CoE graduate directors.

Graduate training and PhD transferrable skills development

Visited CoE were strongly characterised by collaboration, particularly multidisciplinary and inter-sector. For that reason, the design and implementation of graduate

development programs was comprehensive in offering different pathways and the chance to develop skills in demand in different sectors (not only academic).

The nature of such programs largely depends on three main factors: the CoE thematic areas, the centre orientation (academic/scientific, industrial or social focus) and the student personal inclinations.

For example, graduate training programs at visited centres developed scientific communications skills. In some CoE they were focused on scientific communication such as writing scientific papers for specific peer-reviewed journals, or producing a poster presentation, presenting at scientific conferences, writing funding application bids. Other CoE had a focus on building the skills for improving communication in multidisciplinary and cross-sector teams. Those CoE with technological development goals provided communication training focused on presenting a pitch and persuading potential investors. In some CoE, training on intellectual property issues involving science-based innovations were also available for graduate students. In terms of personal inclination, some interviewed students demonstrated a strong interest in science communication and have received in-house and external media training to develop oral, written and social media skills. Another component of graduate programs were custom project management training programs applied to CoE projects.

One interesting aspect about the graduate training dimension of CoE was the large number of students facilitating the creation of a graduate student community. In this community, peers would help and support each other in their journey to completion and sometimes beyond as one CoE had an active alumni network. Although usually working on separate topics and teams, PhD students had a range of common interests and needs, and they perceived having the community and the graduate director as critical resources to initiate, persist (despite challenges) and complete the PhD degree:

> Being part of this tight-knight community has really been amazing for me. The start of the PhD was pretty difficult, and I had lots of support to find my way. Also knowing that we had an amazing graduate director was very self-reassuring because she is a go to mentor and friend and it is good to have someone like that on top of your supervisor who is usually very busy. I know many other PhD students outside of the CoE and I could always compare and see how well-supported I actually was despite all challenges I faced. (Last year PhD student, ARC CoE)

One issue that was explored during interviews, both with graduate directors (or other individuals with similar roles) and with graduate students was about their perceptions of the significance of the PhD training and their perspectives for their career upon graduation. The vast majority of responses perceived the PhD to be a valuable training experience and the main reason for that was the possibility for a deep learning and training experience allowing the development of high-level skills that were fundamental to the scientific career but also transferrable to a range of other career pathways.

> It is clear that the majority of our PhD students are probably interested in pursuing a scientific career, but the world has changed so much and young people are very aware that they need to constantly learn and develop the foundational skills that will allow them to work in any sector and in any organisation or even be a freelance consultant. (Graduate Director, ARC CoE)

Based on the collected evidence of CoE members experiences and opinions, the following is a collection of 'key transferable skills', those skills that were fostered at CoE that were perceived to be translatable and critical for a scientist to transition into any other career setting:

Firstly, communication again. As discussed before, communication skills were consistently perceived as essential across different types of centres, with a particular focus on communication styles that could fit different work cultures and audiences. Writing (both in a scientific or informed way), reading and oral skills (scientific and interview-style) were all developed on a constant basis by CoE graduate students.

Next, management, taken together, was the second most cited skill. Naturally not all CoE expose graduate students to learn project management, managing a team or even taking part in managing a small component of a project. But, those that did have management experience and training, considered it to be an extremely valuable and a highly transferrable skill. More specifically, managing components or phases in R&D projects and coordinating other team members and managing funds were the most mentioned aspects. Self-management, including self-motivation, prioritisation and personal branding, was also mentioned as a valuable skill as students at this stage started the development of a personal niche profile in their scientific fields.

Leadership and management skills (both self and group) were also identified. Most interviewees mentioned the ability to perform team-work, learning the importance of motivating and inspiring others, and the skills acquired when working collaboratively in multidisciplinary and multi-sector teams. They were also appreciative of being able to raise issues or propose ideas during meetings and decision-making as well as having opportunities for having a leadership role within the graduate community and research committees. Students showing initiative to exercise leadership roles appeared to be valued at CoE, so any type of informal leadership role was seen as an opportunity to plan, delegate, build inter-personal skills and motivate others which are all transferable skills.

Last but not least, interrelated set of skills such as self-directed learning, exercising critical thinking and developing sound analytical skills which were probably the most mentioned set of skills. Particularly last year PhD students and post-docs reported to have increased their ability to gather and utilise evidence in the light of centre overarching goals. On several occasions, mentoring, coaching and feedback were mentioned as the most effective mechanisms to improve these abilities in the CoE environment. Developing the ability to use evidence and apply logical reasoning to build a strong argument and use the same skills to evaluate the robustness of others' arguments and conclusions were perceived as critical and valuable skills acquired through the interaction with mentors and supervisors.

Governance initiation

One interesting aspect of CoE graduate training is that graduate students were at times exposed to the mechanisms of CoE governance. One graduate director established an early-career researcher (ECR) committee as a way to increase ECR representativeness in governance. She said:

> The aim is twofold: to offer research students with an opportunity to have first-hand experience in centre governance which is great to build skills in leadership, networking and decision-making. Equally important, in a large CoE like ours, is to give a voice to PhD students and early career researchers. (graduate director)

This exposure to governance is seen to enable students to understand the mechanisms and dynamics of governance in a collaborative research organisation, another type of transferrable skill.

Access to resources

Graduate directors also facilitate the availability to courses and access to resources across the nodes. For instance, winter schools are organised on an annual basis and usually have a specific thematic focus. Within that focus, graduate directors propose a range of activities aimed not only at developing skills but also offering a venue for networking and leadership development. Another example are scientific paper writing workshops organised around three times a year when professional tutors and coaches are hired in addition to in-house scientists. Graduate directors also use and make available videoconference facilities and organise many virtually-delivered seminars. Students also take part in project coordination meetings where researchers use HDVC facilities and dial in from the different geographical nodes.

Graduate directors also devise ways to use available resources for the benefit of graduate training:

> We have enabled students to access our dedicated computational modelling support team. This is a highly specialised IT team that is mainly focused on supporting senior researchers and their teams, but we have managed to find ways that students can benefit from their knowledge by means of workshops and having the chance to use the servers to run their own models and data sets as well. Having that opportunity makes a huge difference for students. (CoE Graduate Director)

> One of my mid-term goals is to develop an online content platform aimed to support the training of PhD students based anywhere in the country. Our challenge is to organise knowledge and produce content in a variety of formats like video lectures, technical tutorials, online tools, audio and textual documents. This platform is in line with our goal to train the next generation of researchers in our field. (ARC CoE Graduate Director)

Post-PhD employment and career pathways

Beyond fostering graduate students' acquisition of transferrable skills, another significant role performed by the CoE graduate director (or in some cases another centre manager with similar responsibilities) is supporting students to continue their careers upon completion of the PhD degree.

Interviewed CoE PhD students at visited centres appear to have ample immediate career opportunities to choose from. Upon completion, a few would be absorbed by the same CoE node where they were affiliated, or yet to other geographical nodes. Some candidates considered applying to other academic institutions within the CoE consortium (nationally and internationally). However, academia was just one option. Many candidates, particularly at science or engineering CoE, were considering pursuing careers outside of the higher education sector, at scientific and technological research centres (public or private); governmental departments or agencies (as scientific advisers); consulting companies; and mainly at industry or large research-based companies. Some students were considering taking part in technology-intensive start-ups.

At one ARC CoE, a hundred percent of its fifty graduate students were able to find employment upon graduation with the assistance of a dedicated graduate director. Other perceived benefits of the support provided by a graduate support manager are short completion times (four years on average) and very low dropout rates.

6.5 Concluding remarks

This chapter integrated the findings regarding the nature of leadership and management in the organisational context of CoE. Findings were grouped according to three main domains which were perceived, during site visits and interviews, as the major focus of CoE research leaders and managers: leadership of researchers, emphasising leaders and managers role in fostering and leveraging human capacity and collaboration; management of the research process, which is process-oriented emphasising the organisation of work according to different disciplinary and output requirements; and management of the centre, which emphasises the key role played by professional managers or yet scientists in dedicated managerial positions in ensuring the operational support to scientific and technological activities.

What these three broad domains emphasise is the extreme importance of appropriate leadership and management skills that corresponds to the needs, nature and culture of a particular CoE.

It was possible to observe that some CoE were much more advanced in the type of leadership and management approaches used, with some CoE having research leaders and managers that had a more holistic perspective on their roles as research leaders and research

managers. These were also CoE that were regarded as role-models by peers from other CoE, and had the most satisfied, productive and excited staff members during interviews who showed a real appreciation and a sense of privilege to be working in the CoE. The significance of appropriate leadership and management approaches presented in this chapter highlights how appropriate organisational capacity and support has a direct influence on staff commitment and productivity at visited CoE.

The next chapter follows up on the findings presented in the two precedent chapters and critically examines their significance in the light of the analytical framework adopted for the study.

CHAPTER 7. DISCUSSION AND CONCLUSIONS

7.1 Objective

This chapter aims to offer a reflection on the findings and, in this process, identify the key emergent ideas, discuss their meaning and see what value can be added to the purposes of this study.

To do that, I will critically examine the findings in the light of the preliminary considerations and the conceptual frameworks adopted to tackle the proposed research questions. This will lead to suggestions on how the adopted frameworks may be modified or strengthened when used in a context similar to this study.

This discussion chapter will be structured around three major clusters of themes that emerged from the findings.

First, I will look at the key transversal issues for CoE organisational capacity, which were presented in the findings' chapters (under Governance and Leadership & Management) but now taking a different, centre-based point of view. This will allow for drawing similarities and differences between centres and identifying patterns or common approaches.

Second, I will discuss whether the adopted analytical frameworks were fit for purpose and how they could be further refined for analysing the organisational context of CoE.

Finally, I will discuss the concept and significance of culture in the CoE context as this has emerged as the key finding of the study.

The following table summarises the topics to be covered.

I. Nature of Centre	Similarities and Differences Factors that account for the similarities and differences between CoE Problem – Purpose – Leadership: identifying the key attributes of CoE nature Do the two funding programs generate two different types of centres? Diversity of centres Accounting for CoE diversity Outlining a continuum of centres based on centre focus: from knowledge-led to user-led Using the Technological Readiness Scale to substantiate the need for diversity
II. Frameworks Assessment	What was the value of both frameworks in investigating the nature of Centres of Excellence? How could they be further improved or adapted for the study of CoE?
III. Culture as a differentiating factor	The significance of building and maintaining a culture for individual and centre-wide performance and the role of leadership in it.

Table 9: Summary of key dimensions for discussion

7.2 The nature of work in different CoE

Some preliminary considerations were made in preparation for the empirical part of this study. In terms of research scope, the goal was to investigate the organisational nature of publicly co-funded collaborative research centres aimed at supporting research excellence, and social or technological innovation with a focus on national development.

In Australia, the two major funding programs (ARC and CRC) that give rise to these types of centres are founded on quite different policy rationales.

The ARC, as the main agency for scientific research funding, conceived its CoE Program as an initiative for the creation of centres that build scientific capacity and promote scientific excellence in research areas of national interest. The focus is clearly on advancing

science in areas that are considered to have a strong potential to be strategic for national development, but the primary focus is on developing national scientific capacity[30].

The CRC program, on the other hand, originated from a different policy rationale. Overseen by the Department of Industry, Innovation and Science, it aims to support "industry-led and outcome-focused collaborative research partnerships between industry, researchers and the community"[31]. There is a strong emphasis on user-orientation and translation of research results.

Considering these distinct program rationales, one of the initial considerations was that for the study sample to provide a balanced perspective, it should include centres from both programs as they could potentially be different in nature. So, what was observed? Is the funding program focus really a differentiating factor by shaping the nature of a centre of research excellence?

The short answer to this is no, and that was one of the first surprising findings suggested by this study. The pool of studied cases allowed for observing the variety of centres created under these two funding programs. A variety that was not necessarily correlated with the respective focus of the underlying funding program. Evidently, the funding program focus does have some influence on some aspects of the centre, as has been highlighted in the previous chapters. However, other factors appear to exert greater influence.

What became increasingly clear during the study is that the two funding programs (ARC and CRC) do not lead to two remarkably different groups of CoE. This finding is a very significant one, since as described in the initial chapters of this thesis, the differences between the policy settings, particularly in terms of funding program rationale, were quite significant. For that reason, one of the primary concerns of the study was to identify to what extent the funding rules and requirements did have a direct influence on the nature of a CoE.

What the study has found is that when centres had similarities to one another, the funding program was definitely not a determining factor influencing those similarities or creating boundaries that differentiated the nature of centres.

[30] http://www.arc.gov.au/arc-centres-excellence
[31] https://www.business.gov.au/assistance/cooperative-research-centres-programme

What became clear through analysing the different CoE was that they are part of a very diverse and complex system. This diversity is expressed by each centre's unique nature which in turn is shaped by factors related to (i) the nature of work, (ii) the purpose behind the creation of the centre and, last but not least, (iii) the way leaders and managers influence (and are influenced by) the centre's evolution.

The fact that the funding program does not imply the creation of two significantly different 'ARC-types' or 'CRC-types' of centres is seen by the researcher as positive and healthy. Based on interviews and site visits, it was possible to observe that CoE communities needed this necessary level of autonomy to build a centre that would be fit-for-purpose to its core purposes, something that in itself is already a complex venture requiring a considerable amount of time.

Another key reason for the observed diversity of CoE is related to the production of knowledge and the different approaches to knowledge application. The fact that funding programs, formal requirements and sponsor expectations do not overly prescribe centres on how they should look like or shape their strategies leaves the task up to CoE members themselves. This generates a diversity of centres specialising in the different stages of a continuum of knowledge generation and application. From centres with the necessary capacity to produce new knowledge and train new scientists towards centres that work on the intersection between producing knowledge and applying it into specific contexts all the way to centres that focus on innovation, translation, and adoption.

What was found about the factors that contribute to shaping the nature of a fit-for-purpose CoE is the need for a deep understanding of the nature of the work to be carried out. This clarity must be substantiated by leadership that has the role to build the centre's organisational elements in an aligned, conducive way.

The next sections discuss these findings and the three key elements that are major drivers in shaping a centre's identity.

7.2.1 Establishing the nature of a CoE: core elements

To understand what defines the nature of CoE, an analysis of similarities and differences across centres was conducted. Three elements appear to exert significant influence in defining the character of a centre. First, the nature of the problem tackled and, second, the purpose behind the centre's creation appeared to be key. Once these two primary factors were clearly established, leadership features next as the third defining element, one that will create the facilitating conditions conducive to achieving the centre's purpose and mission.

Problem – Purpose – Leadership

All studied centres were created to address an existing, unsolved and hard to tackle problem. However, the nature of the problem tackled (from blue-sky or strategic knowledge-push all the way to heavily user-driven) and the purposeful intention behind the centre creation (purpose and mission) vary substantially. Leadership closely influences and is influenced by these factors by creating the necessary conditions. It thus is an intertwined relationship.

To illustrate how problem, purpose and leadership appeared to be intrinsically connected at the centres studied, I will use two representative types of centres to describe this relationship. Later, I will use them to create a continuum of centres that serves as a tool to help visualise the existing diversity of centre organisational set-ups.

Type A

Some centres focus on large, complex, and notably ill-defined and dynamic problems (say for instance the modelling of climate systems or understanding the nature of emerging and dynamic societal grand challenges). Scientists perceive that the nature of the problem calls for the creation of an interdisciplinary, collaborative and well-supported centre in order to have the means to address a problem that no group or traditional organisation would be able to address in isolation.

Many centres were similar to this typical case. Because the nature of the problem is so uncertain, the rationale behind the creation of the centre (its core purpose) is to build capacity

and to create a critical mass of resources (mainly intelectual capability and trained researchers) which will build the foundation for future progress in addressing and refining such fuzzy topics.

Leadership at centres with this type of problem and purpose is distinctive, particularly at those more consolidated centres that had been successful in getting the initial seven-year funding extended at least once. Studied centres dealing with fuzzy, ill-defined problems heavily rely on the work and creative behaviour of their scientists. Most of these centres were regarded as prestigious hubs, pushing the boundaries of their scientific fields. At this stage, scientists reported to be scoping the breadth and depth of a topic ("we don't know what we don't know") and not necessarily to let potential applications and commercial exploitation drive the research process. Leaders at these centres were often senior scientists themselves but with an advanced understanding on how to run a centre of this type. They perceived their main role as facilitators who constantly try to create the most favourable conditions for scientists to conduct their work and thrive in their purpose. They also dedicate their time to developing people and teams by providing coaching and coordinating collaborative work. Nurturing the next generation of researchers is a substantive part of that. They strive to act as role-models and to actively encourage a collegial culture of shared beliefs, values and norms. Many were so convinced of the importance of their role as leaders, that they were prepared to put their own scientific work second place for a while for the benefit of the research community.

Overall, the prevailing mindset in this type of centre was to create and nurture a community with a long-term vision. Most centres were producing some kind of output to demonstrate impact and translation; however, the primary focus was on building scientific capacity with a focus on the future.

Type B

Another typical type of centres studied (existing both under ARC and CRC funding) were tackling problems of a quite different nature. Even though most still involved a great deal of scientific activity and, in some cases, also valued scientific excellence, the priority was on translation and application of knowledge to address the needs of specific users' groups. Industry and firms, community groups, governmental agencies and policy-makers are typical examples of such groups.

In terms of purpose, these centres had a pre-defined scope and expected results which were set up in response to existing users' needs. Their purpose may be centred on bridging a specific gap. It could be creating links between isolated groups or sectors (particularly academia and industry); having an industry problem solved; creating a competitive-advantage for a certain sector; or producing a tangible product, service, policy or process. Common measures used to gauge performance include commercial potential, a clear pathway to the adoption and exploitation of outputs and substantial spill-over effect. Overall, the main underlying purpose of this type of centre is to generate new, or apply existing, knowledge in response to a pre-defined practical problem. Two examples are the ARC CoE developing pioneer technology to create the first quantum computer and the Antarctic studies CRC producing evidence that is being used by government for climate policy-making.

Centre leadership in this type of centre is very concerned with delivering pre-defined outputs on-time and responding to the expectations of end-users. Centre leadership incorporated the input from associated scientific leaders in their decisions, but their primary role was to foster a productive work environment and make sure that translation is effective. This requires a lot of effort with respect to monitoring and project managing, acting as a broker between different work cultures and liaising across sectors.

Because impact is so important, the translation of research outputs through the adoption or commercialisation of results takes another major portion of leadership time and effort.

What became evident when studying centres in-depth beyond what is written in their public webpages and annual reports, is that, regardless of the policy rationale of a centre's funding program, the configuration of these three main elements (coupled with other secondary elements discussed in the findings) constitutes the core substance of a centre's nature.

For visualisation purposes, the next table aims to summarise how the three aspects were observed to play out in the studied centres:

	Type A	Type B
Problem	Complex, fuzzy, ill-defined, ill-structured, dynamic, fluid, blue-sky to possible strategic future application Problem at an initial maturity level	An existing problem or unmet need of users' groups; an existing gap or disconnect between producers and users of knowledge. Advanced maturity level
Purpose	Exploration, experimentation, path-breaking, pioneering, fostering creativity, pushing boundaries, building capacity, building a critical mass, training the next generation of researchers, consolidating necessary infrastructure, reducing fragmentation nationally, building partnerships internationally, raising awareness	Translation, adoption, commercialisation and impact. Producing a tangible product, service, policy or process; clinical trials; piloting a technology and taking it into production and then into the market; generating evidence for policy-making.
Leadership culture	Leading through culture and to foster creativity. Focusing on individual and team development. Nurturing, inspirational, collegial, collaborative, supportive, visionary, role-model. Encouraging certain behaviours and a culture of shared beliefs and values, creating a conducive environment that stimulates the creative behaviour of individuals, developing others through mentoring, coaching, networking.	Process and output oriented Clear milestones and monitoring processes. Continuous assessment and feedback of outputs. Disciplinary and sectoral boundary-spanning. Integrative. User-driven decision-making Start-up to industry-lab culture

Table 10. Three core factors in determining a centre nature

7.2.2 The leadership team's complementary strengths

A brief note about the composition and interaction of the centre's leadership team is worth mentioning. Depending on the nature and purposes, every studied centre typically required a certain composition of the leadership team. Complementary leadership teams at CoE appear to be more effective by collectively compensating for individuals' strengths and shortcomings, and exploiting different leadership styles, but also distributing the centres'

multiple and often competing demands (competing demands at CoE will be explored in the CVF Framework section of this chapter).

The role and personality of the director was influential in setting the tone of the centre. Moreover, the most vibrant centres had a striking characteristic in common: the leadership team was highly complementary in terms of knowledge, skills, and personal traits. In this way they could better exploit their strengths, use their time more strategically and effectively, and compensate for their perceived weaknesses.

An example of this was the synergistic relationship of a very science-driven and introspective director coupled with a more extroverted and diplomatic deputy director of one studied CoE. Much needed personal characteristics of leaders (such as an analytical, thorough and detail-oriented person) were balanced, for instance, with equally necessary skills such as being practical and hands-on, or having the ability to communicate and deal with people and teams.

Most successful leaders were aware of the importance of having a good symbiosis within the leadership team and avoiding concentrating all roles within themselves. They appeared to be very self-aware of their own strengths and wanted to maximise the use of their time and skills. In this sense, they were pro-active in identifying and recruiting people that appeared to be the right fit and complemented the leadership team. For some centres, a skills-based selection process for appointing the leadership team prioritising knowledge on strategic areas for the current stage of the centre evolution was deemed equally (and sometimes more) important than scientific rank or institutional affiliation by itself.

Another prominent interaction was between the individuals in the director and the centre manager roles. These two individuals lead the operation of different dimensions of the centre (the scientific and the operational-administrative). Mutual trust and effective communication were perceived as pre-conditions so that one could integrate the input from the other critical to the smooth and effective operation of the centre. This relationship constituted the link between the core scientific or technological dimension of the centre with the underlying support and administrative services that enable its operation. A lack of sync or a disconnect between the scientific team and the administrative/technical team was perceived as a major hindrance to a centre's operation.

7.2.3 A continuum of CoE

Describing the two types of centres (A and B) is useful to illustrate aspects that differentiate centres despite the funding program rationale. An attempt to make a systematic classification of studied centres based on their nature would be hard and potentially misleading given that most centres portray a very unique combination of purposes and goals within vastly different fields. This makes it difficult to create a typology on the sole basis of the present findings.

Despite that, it is possible and potentially useful to draw a continuum of centres based on purpose. The continuum has on the one end a Type A centre and on the other a Type B centre. This continuum stems from the study and is proposed as a tool to appreciate the diversity of centres and highlight some differences and similarities amongst centres.

For illustrative purposes, a number of current Australian centres (not limited to the centres included in the study's sample) were placed along the continuum below:

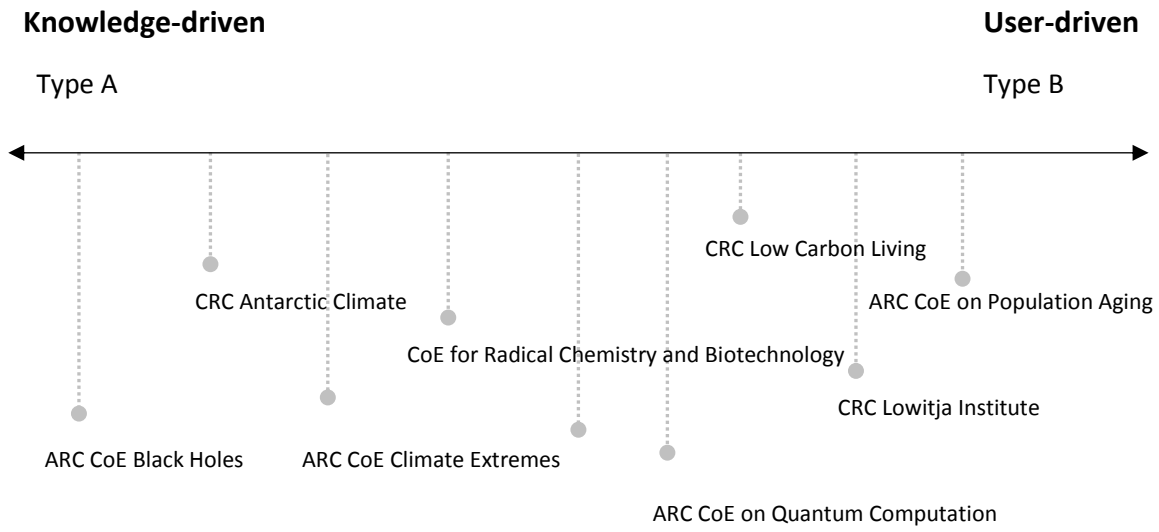

Figure 6: A continuum of CoE based on centre types

It is important to emphasize that positioning centres along this continuum is not an exact science. For the purpose of illustration, these centres' locations on the continuum are determined by the combination of the nature of the problem, the focus on knowledge or technological development, the leadership approach and the relevance to user groups' needs (beyond what is expressed in mission statements).

What makes this continuum relevant as a heuristic tool is its potential for highlighting the following important issues:

1. The fact that the centre profile can be defined on the basis of its purpose in creating or applying knowledge

2. Following from point 1, centres differ a lot in nature. In fact, this diversity is perceived to be healthy and desirable as different centre advance knowledge at different stages and with different purposes

3. Different centre nature requires different and appropriate leadership and management

7.2.4 Technological Readiness Levels (TRL)

The centre orientation continuum is useful because it allows the depiction of the differences and commonalities amongst centres beyond the superficial funding program divide and emphasises the significance of a centre's work purpose within the bigger picture of knowledge production (one of the findings of this study).

Another potentially useful way of differentiating centres is the Technology Readiness Levels (TRL) [32] scale, originally developed by NASA. The TRL scale serves to estimate the maturity level of a technology. It ranges from one to nine with nine being the most mature technology level.

Based on the findings of this study, CoE can be situated along the TRL. What this study has identified is that different centres focusing on R&D activities at different maturity levels require different leadership and management approaches. Not only will the type of R&D activities be dramatically different but also the organisational capacity available, the organisational climate, the support structures and, eventually, its culture.

In addition, the TRL offers another perspective on significant aspects driving the diversity of existing centres. Since most CoE have a strong focus on developing knowledge-based innovations, the TRL serves to highlight the fact that different centres are operating in

[32] TRL concept was developed by NASA. See more at: https://www.nasa.gov/directorates/heo/scan/engineering/technology/txt_accordion1.html

different ways because their knowledge and technologies are at different maturity levels. In consequence, the necessary organisational capacity and leadership and management support are also dependent on the technology readiness level. In this sense, the significant level of differentiation between centres found during the study is an indicator that CoE schemes are enabling a diversity that is beneficial from both the knowledge development and the national benefit perspectives.

It is important to note that the TRL and the table below are more relevant in the context of those CoE developing basic strategic research or new technologies. However, those centres producing outputs of a different nature can also apply the same underlying principle according to the maturity stage of more fundamental knowledge development.

Technology Readiness Level	**Maturity Level**	**CoE Focus**
TRL 1	Basic research Principles postulated but no experimental proof available	Lab Type A Science-driven
TRL 2	Technology formulation Concept and formulation have been formulated	Lab Type A Science-driven with a focus on potential technology development
TRL 3	Applied Research	Lab Type A/B User-driven but substantial scientific research component required First lab tests leading to proof of concept
TRL 4	Small Scale Prototype (ugly prototype)	Lab Type A/B User-driven but built-in lab Last stage of in-lab research process
TRL 5	Large Scale Prototype	Simulation environment Type B Transition stage from lab into real world Focus on testing a new technology in intended environment
TRL 6	Prototype System	Simulation environment Type B Focus on performance

TRL 7	Demonstration System	Real world Type B Focus on commercial viability
TRL 8	First of a kind commercial system	Real world Type B Manufacturing process
TRL 9	Full commercial application	Real world Type B Technology available for consumers

Table 11. Technology Readiness levels applied to CoE focus

7.2.5 A centre-based standpoint

To close this section on the issues shaping up the nature of a centre, I take a different standpoint looking at the "centre as a whole". Aspects presented in the two previous findings chapters and in the previous section are transversal issues. They were identified as relevant in all studied centres regardless of funding program and centre orientation. This section will take a different approach by looking at real (de-identified) cases to showcase how all aspects discussed so far combine in shaping a unique centre identity and culture.

Since research excellence and innovation with regard to national challenges are key underlying rationales behind the introduction of publicly-funded CoE in Australia, it was possible to observe three archetypal CoE. These three types of centres are interesting because they not only respond to policy imperatives and are appealing to policy-makers and stakeholders, but they also have a very strong character which is perceived to result from a combination of the aspects discussed in the findings: Purpose, Culture, Governance, and Leadership and Management.

This section represents these aspects as they come together in three typical types of CoE identified in the study.

Centre 1: The blue-sky national scientific hub

The centre creation was a product of an aspirational ideal, to use science to better understand and tackle a complex problem of major scientific or real-world significance and, in the process, portray the centre as a reference point in the field. After years of project-based research producing solid but limited results, building a critical mass of resources through the

creation of a CoE was seen as a necessary turning-point. The creation of a multi million-dollar budget centre was considered as a major breakthrough, consolidating the creation of a national well-supported scientific community in this specific field. Building and nurturing a community is actually a substantial part of this centre's purpose.

Purpose

The purpose behind the centre creation and a compelling vision of its role in shaping the scientific field's future are perceived as important driving forces keeping the centre scientific community united and in synergy. The long-term focus of the centre makes community-building essential for its sustainability. A great part of it is done through the training of the next generation of researchers. Building a complementary consortium is also indispensable to assembling the necessary capacity to address such a complex problem. Domestic links are important to reduce fragmentation at the national level and pool resources. Equally important are international links with peers working at the state-of-the-art level. The scale of investment made means that now the group has sufficient bargaining power to access and have a say in international scientific networks.

Culture

Having a conducive culture is perceived as key and centre leadership invests time and effort in encouraging such a culture. Elements such as trust, collaboration and fostering creative and innovative thinking are a big part of the culture. Every dimension of the centre follows from its purpose and is consolidated through culture.

Governance

Governance mechanisms are put in place to reflect the essence of the centre and advance its purpose. The scientific advisory board is a key mechanism in informing the strategy and operation of the centre based on its core scientific orientation. Governance mechanisms, policies and rules are kept to a minimum to make the centre as dynamic and free from red tape as possible while ensuring direction and operational viability are met.

Leadership and management

Leadership is seen as a facilitation process. Centre leaders are key scientific figures in their fields and have reached a point in their careers where they have taken up the duty of consolidating and growing the scientific community. Leaders act as role-models and provide

coaching and direction to other researchers. Management offers researchers professional support, so they are able to focus on the science. Centre managers have developed a host of support services and infrastructure that are custom-made for the centre's needs. They also engage with a range of stakeholders who can benefit from the centre's activities and outputs.

Performance and impact

Performance and impact are mainly associated with the scholarly publication of the centre's research findings and capacity-building efforts. Scientists are active in giving conference presentations, writing book chapters and specially peer-reviewed papers published in A-ranked journals. Other examples are strategic partnerships with renowned groups. The centre is also a platform to attract additional external funding. Graduate researchers trained at the centre occupy positions in national and international scientific and academic organisations. The centre is regarded as a national reference frequently being quoted by the media and governmental reports. The centre has been influential in producing new knowledge, new techniques, and software tools. It has given national researchers a privileged position at the international level. Domestically, it has made an impact on producing scholarly and policy-relevant knowledge and in building home-grown capacity.

Centre 1 represents those CoE which are clearly concerned with research excellence and the advancement of knowledge in a given scientific field. The next two centres illustrate how aspects discussed in the findings play out in two types of user-driven centres.

Centre 2: The social innovation platform

Everything started from the need to develop research that could generate results to benefit a historically neglected social group. The CoE arrangement was suitable given its potential to assemble the necessary stakeholders, make the collaboration sustainable and systematic and develop outputs (usually tools) that could be piloted and feed back into the research streams.

Purpose

The core purpose of the centre is to develop R&D to serve a community group and for that reason community-based user-orientation drives the centre. Priorities and guiding

principles are closely and continuously defined by the target group's representatives themselves which have their best interest at heart.

Governance

This is a type of centre where representativeness of social groups, particularly minority groups and end-user associations are key. For that reason, the majority of board members are representatives of such groups while the remaining members have expert skills in the areas of research and translation of findings. Thus, this type of CoE's governance tends to strike a balance between the research and scientific development and its social mission. In the case of CoE, this does not prevent centres from offering products and services which can be commercialised to government and other types of organisations. Diversity, representativeness and accountability are essential aspects to governance at this CoE.

Leadership and management

Leadership and management are focused on acting as mediators and facilitators between the target group and the research and translation teams. Research leaders follow the priority-setting process lead by the target group. They adopt user-defined principles to guide and inform the design and implementation of research projects. Similarly, engagement officers are focused on transforming research findings and outputs into different types of tools that can be absorbed by different stakeholder groups at different levels, from the grass-roots to policy-making. For example, engagement officers tailor outputs and communicate them to governmental agencies, policy-makers, service providers and community organisations and members.

Culture

The centre culture is built on continuous user engagement and feedback. Because users are involved in every step along the way, researchers must be willing to incorporate external input and feedback into the research process. The collaborative dimension that is present across all CoE has a special meaning at this centre. Maintaining this two-way relationship between researchers, user-group, and other key stakeholders as healthy and as synergetic as possible is the main characteristic of this centre's culture. This process is made more structured and explicit through a process named "knowledge exchange" which is a methodology set-up to structure and implement this interaction during the planning, research and dissemination stages.

Performance and impact

Performance and impact are measured based on the centre's ability to translate research outputs into effective and enduring practical applications. Because there is a wide range and levels of application (from the grass-roots to the policy formation level), a "knowledge translation schedule" is part of every project contract. Scientific impact is measured mainly by the extent that new evidence is used to reform current delivery systems and practitioners' approaches and the ability to raise-awareness and influence current policy-making.

Centre 3: the industrial commercial-led centre

The centre was created to produce knowledge and technology that will be converted into products and services or fill an existing manufacturing gap.

Purpose

The purpose behind the creation of the CoE was explicitly instrumental, a strategic move deemed necessary to gather the multidisciplinary and multi-sector expertise necessary to harness knowledge into new technology and move it towards user adoption.

User-orientation with a commercial focus and competitive advantage are the main drivers of CoE activity. Work is organised around output-based initiatives meaning that work streams are oriented to contribute to specific applications. There is a high level of diversity within teams with scientists working together with engineers, managers and end-user representatives. In this centre, scientists act as contractors and have a much more limited role in decision-making than in the other two types of CoE.

Governance

Governance mechanisms are put in place to emphasise and safeguard the user-orientation and output-orientation. Advisory boards are dominated by user and industry representatives, sectoral organisations and liaison bodies in charge of transferring and commercialising outputs.

Culture

The organisational climate is characterised by a sense of production and output-orientation. People are encouraged and measured by their ability to deliver expected outputs.

Self-initiative, innovation and entrepreneurship are encouraged and rewarded. Activities are much more pre-defined and micro-managed with less room for experimentation and creative behaviour.

Leadership and management

Leadership and management are more related to project management, being in charge of oversight mostly by planning work packages, assigning roles and monitoring the conduct of activities against schedules. Some stream leaders have a work culture acquired in industry labs while some have come from a more academic tradition. Nevertheless, academic scientists do operate under a more structured and short-term mindset when compared to the drivers of previous centres.

Performance and impact

Performance and impact are monitored through quantitative and tangible metrics. Because translation and adoption of results by end-users is a major driver, commercialisation and technological training are part of the performance measures. Each year, there is a clear expectation to file a certain number of patents. Centre personnel are trained in technology transfer, intellectual property rights and commercialisation at an advanced level targeted to the centres R&D activities.

7.3 Frameworks Assessment

Two frameworks were adopted to provide guidance on the structure and conduct of this study: Toma's (2010) Building Organisational Capacity (BOC) framework and the Competing Values Framework (CVF). The reason these frameworks were chosen was, first, because they fit the purposes of the enquiry to research organisational capacity (BOC) and the nature of leadership and management (CVF). Second, both frameworks have been widely adopted in the higher education and research sector both by scholars and practitioners. The study used both frameworks as a starting point. The goal was to use them as tools to provide the initial structure in the process of building an understanding of how CoE operate.

Both frameworks met the expectations. During the empirical phase, they provided the basic lens to operationalise data collection by facilitating the process of identifying the scope, topics and key individuals within selected organisations. They also served to guide the

analytical phase, pointing to organisational elements and individuals' roles. More importantly, they proved to be comprehensive and robust tools and yet provided the necessary level of simplicity and clarity that allowed the study to go further and increase the level of detail and analysis in quite different organisational contexts. As such, both frameworks were extremely valuable for capturing the 'essence' in the form of concepts, entities and relationships and offering the lens for applying and further refining these ideas in the context of a centre of excellence.

The next section offers further impressions on the use of the frameworks for the purposes of the study and the particular context of CoE.

7.3.1 Framework 1: Building Organisational Capacity (BOC)

Study needs

Understanding the nature of the CoE was a major goal of this study and describing its organisational outlook was one of the preliminary tasks, a critical one given that it would serve as the foundation for the upcoming stages of the research. The study aimed to define and map the CoE as an organisation: identify its building blocks, the necessary elements for creating a centre of excellence. A suitable framework was deemed necessary to make this mapping in a systematic way and yet allow for flexibility for further refinements.

Reasons for adopting this framework

As discussed in Chapter three, there were a few reasons that distinguished the BOC Framework from other organisational frameworks and led to its adoption. Three main reasons came to the forefront. First, it was a widely used and validated framework. Second, its focus is placed specifically at the organisational capacity level, with a systems perspective, aiming to identify elements but also to see how they interact. Third, it was developed in the context of knowledge-intensive organisations with different purposes and drivers from that of strategic management frameworks widely used by business corporations. This was a key differential given that most frameworks identified during the literature search were developed and tailored for the corporate sector which is oriented by a totally different set of drivers and mindsets.

CoE are embedded in the public policy context which considers effectiveness and impact in different ways to that of corporations. In fact, measuring impact and determining effectiveness of CoE is still a matter 'under construction' and hard to standardise by government agencies given the wide diversity of such entities. The BOC Framework allowed disassembling and investigation of organisations that are operating and developing different approaches and configurations to thrive in this specific environment.

Assessment and considerations

The BOC framework proved to be a suitable tool and remained relevant throughout the study. At the initial stages, it offered a valid conceptual structure and lens needed as a starting point for the research design. The framework's web of elements provided the foundation layer of organisational elements to be further investigated. Later, it allowed for understanding what elements were more relevant in the CoE context and which stayed in the background. It also provided the means to compare how the elements played out in different centres or at different stages of maturity.

The BOC framework appeared to be fit-for-purpose for the requirements of this study. It was a useful and straight-forward tool to help answer the first research sub-question (What are the organisational characteristics of a CoE?). It also fit well with the context of a knowledge-intensive, collaborative, multi-disciplinary and dynamic organisation such as CoE, allowing for investigating centres of very different nature. BOC simplicity made it possible to capture the essential aspects and the diversity of the studied centres.

Leading up to the analysis stage, it facilitated the process of identifying two major (although sometimes overlapping) clusters of elements: those under the scope of leadership (such as Governance, Policies, Purposes, Culture) and those under the scope of management (Processes, Information, Infrastructure). The notion that these elements are interrelated but above all must be aligned became pivotal for the next phases of the study.

Ultimately, the BOC framework helped understanding what the required capacity is that leaders and managers of research need to build to create a CoE-type of organisation. However, because the BOC framework is a universal tool, the study took it beyond its original format and further developed it in the particular CoE context. This process identified the two principal elements described in the two findings chapters (Governance and L&M) and

highlighted the pervasive role of culture (which will be discussed in the last section of this chapter).

This adaptation and application of the BOC framework into CoE also led to a next stage. Once the building blocks were identified (the 'what') the natural next piece of the puzzle was to understand how people go about implementing things. That is where BOC transitioned into the analysis of leadership and management roles dimension conducted through the Competing Values Framework (discussed in the next section).

The next section discusses in what ways BOC was further adapted for the study of CoE.

A CoE-oriented graphic representation of BOC

The BOC framework graphic representation features a web of interrelated elements. All elements are represented equally in terms of size and in a symmetric disposition, with the element "Purposes" at the centre the web. What the study has shown is that, for the context of CoE, this graphical representation can be different in order to better convey the dynamics at play. Figure 7 shows the original framework and Figure 8 depicts what a CoE-oriented representation would look like based on this study.

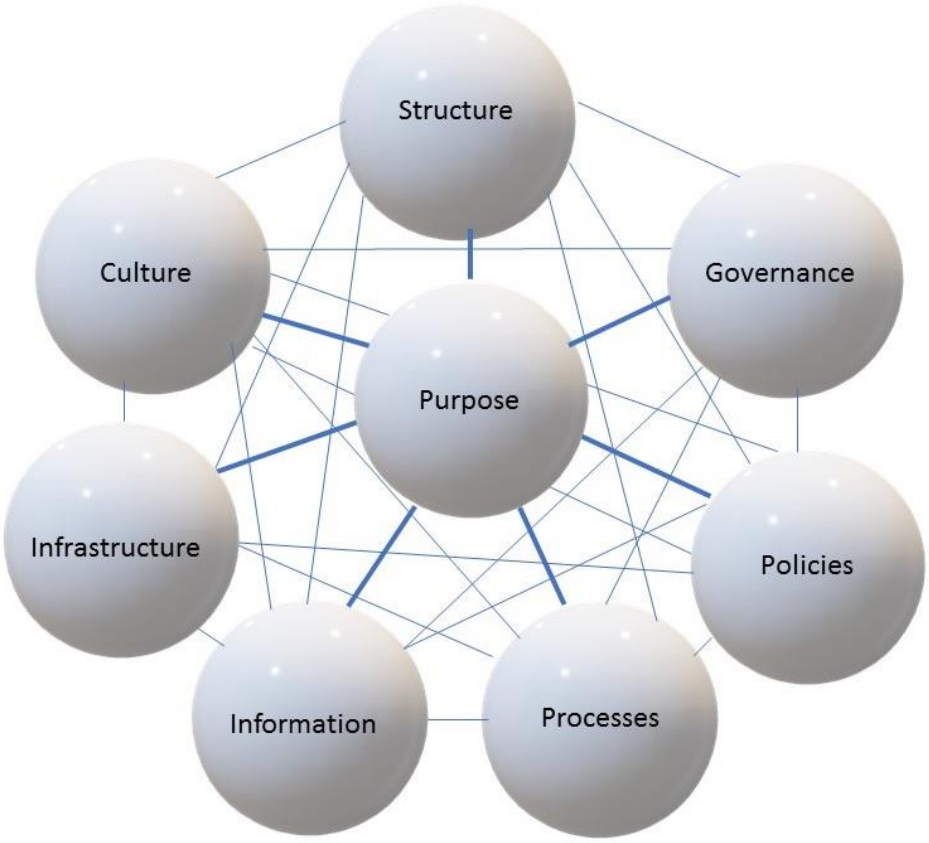

Figure 7. BOC Framework original graphical representation

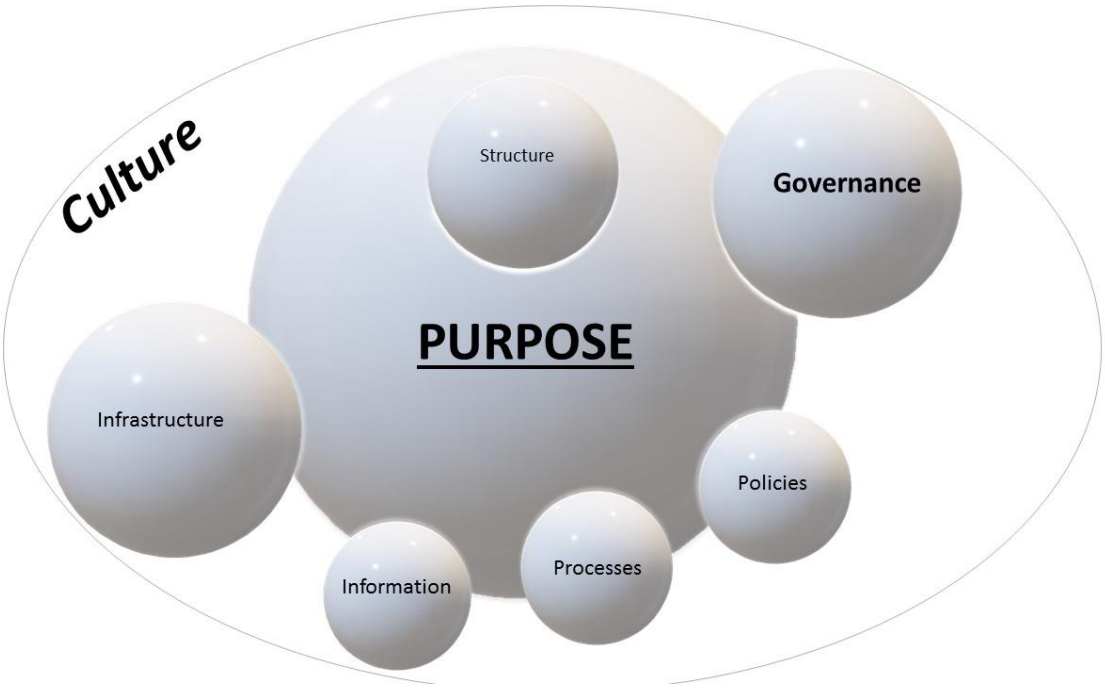

Figure 8. Graphic representation of BOC Framework applied to the organisational context of CoE

The original framework uses a web representation to emphasise two aspects central to the BOC model: Purpose is a central element, and every single element is inter-connected.

The second representation has been developed using the study's findings to show how the original framework looks like when applied to CoE. It emphasises the following key findings:

1. The original eight elements remain valid. However, some elements are vastly more significant than the others. The size of the spheres is used to represent that in relative terms.

2. All elements are indeed considered to be interrelated, but the new representation reinforces the notion that the elements are not really isolated entities but embedded in and mutually-influencing a surrounding layer of Culture.

3. Purpose certainly remains at the core of the system, but it is more than that. Purpose informs every single other element in a continuous way.

4. Governance (as discussed in the findings chapter) is a prominent element at CoE and is highly context-bound.

5. Culture comes out as a major element, a linking thread that runs through the organisation and a major element for the sustainability and success of a CoE. Culture emerges from the social interactions of CoE members and is complex and highly centre-specific. Although an in-depth analysis of organisational cultural issues would be extremely interesting, it would fall outside of the scope of this study. Nevertheless, the findings allow for a few considerations about the importance of culture in the CoE context which are discussed in the last section of this chapter.

7.3.2 Framework 2: Competing Values Framework (CVF)

The CVF (Quinn, Bright, Faerman, Thompson, & McGrath, 2015) was selected to be used as a second framework in the study since it is complementary to the analysis of the findings enabled by the first framework, BOC. BOC allowed an identification of the nature of major organisational elements of CoE. That analysis revealed a great deal of variability, both within and across centres depending on centre purpose, culture, disciplinary and technological focus, and maturity stage.

The CVF was adopted to further analyse the evidence on the light of a robust framework that would allow explanation of the how the findings are related to leadership and management roles. It allowed for understanding how competing drivers influence CoE and push it in different, sometimes opposite, directions.

Competing demands of CoE

What the CoE studied in this research revealed is that, at any given time, there are multiple and often competing demands in place at the centres. These demands relate to the core purposes of the centre but also to equally important stakeholders, outputs and its very operational viability, all of which pull a centre into different and even opposite directions.

The findings described in the previous chapters, which concern aspects related to the leadership and management of CoE, can be placed along two major continuums (building on the CVF approach).

The first continuum represents the "internal" versus "external" dichotomy which highlights that CoE need both internal cohesion and integration but also to be externally engaged and responsive.

The second continuum represents the CoE organisational dichotomy between "creativity" and "control" which ranges from the need of fostering a creative environment but at the same time monitoring and coordinating performance and the achievement of results.

Internal vs. External demands

In order to thrive, CoE are both heavily internally and externally focused. The internal focus is represented by CoE efforts on building capacity; ensuring cohesion across geographical nodes, disciplinary traditions and stakeholder goals; nurturing and supporting individual development; training the next generation of researchers; building a critical mass of resources that will allow for break-throughs that benefit the scientific or practitioner community beyond the centre, and overall creating a particular centre culture.

In this sense, much of the internal drivers are oriented at creating the organisational foundation that will enable a culture of excellence or innovation.

The following tables illustrate (in the first column) the factors associated to both ends of the internal/external and creativity/control continuum respectively. Note that this is not a clear-cut categorisation, but it points to the sort of skills needed to cope with these competing demands. The second column identifies the necessary skills and capabilities required based on the roles of individuals working at centres with such demands.

	Nature of Demands	Necessary skills & competences
EXTERNAL	Centre-specific framework conditions External stakeholders Accountability (publicly funded research) Impact (local-national-international) External resources Partnerships Competitors Complex Uncertain Responsiveness International research community	Strategic Political/diplomatic Big picture Marketing Communication Liaison Cross-sector expertise Finance Legal Risk management
INTERNAL	Long-term Purpose Trust Values and beliefs Transparency Collegiality Nurturing Cross-node integration Developing people Direction Integration Alignment Cohesion Research capacity Graduate training Innovation	Governance Mentoring Managing Leading for creativity Communication (strategy, coordination, operation) Training Planning for impact Project management performance monitoring Impact assessment Motivating Delegating

Table 12. External and Internal demands and associated skills

	Demands	Necessary skills
CREATIVITY	Freedom to research	Facilitating
	Collegiality	Nurturing
	Excellence	Collaborating
	Experimentation	Coaching
	Good level of Autonomy and Discretion	Role-modelling
	Strategic collaborations	Inspiring
	Flexibility	Infrastructure
	Dynamism, fluid and fast decision-making	
	Training	
	Learning	
CONTROL	Planning	Systematic
	Resourcing	Prioritising
	Monitoring	Strategic
	Assessing	Coordinating
	Coordinating	Delegating
	Choosing between projects	Resourcing
	Assess risk	Organising
	Efficiency (use of resources)	
	Impact	

Table 13. Creativity and Control demands and associated skills

It is clear to see that striking a balance between creative and control requirements is difficult but critical. An imbalance towards one end of the spectrum in detriment to another can lead to negative consequences. For instance, a high level of control including risk-aversion, micro-management and pressure is perceived to deter individuals from being creative (by exercising freedom of inquiry and critical thinking), innovative and productive. On the other hand, a lack of the basic control mechanisms will probably lead people and teams to go in different directions (creating fragmentation and disconnect) and decrease performance.

Maintaining a healthy balance between competing demands is critical to CoE organisational sustainability and success. What the study shows is that competing demands arise at CoE given the scale and complexity of research activities that characterise this environment. Contributing to this are a number of other non-scientific aspects and constraints related to timelines, funding, translation and stakeholder interactions requiring constant and professional support. This study has gathered considerable evidence showing that CoE R&D

staff need appropriate research management support in order to concentrate on the core scientific or technological activities, make efficient use of resources and better exploit outputs increasing CoE impact.

Leadership and management roles in coping with demands

The four dimensions defined by the competing demands identified above (Internal/External/Creativity/Control) highlight the importance of having specific capabilities within the centre able to cope with these competing demands and harness opportunities in each dimension. The skills, expertise and personal characteristics identified in the previous section are related to the leadership and management of research at CoE.

Nevertheless, what the study has shown is that there is not a clear distinction between the roles of research leaders and research managers. There is a great deal of overlap between leadership and management roles at CoE. Some centres have leaders incorporating more managerial-types of duties whereas some managers have considerable leadership responsibilities. It all depends on the unique characteristics of the centre (including disciplinary and cultural traditions) and on the expertise and potential of individuals.

The level of complementarity between individuals in leadership and management roles appears to be key. The four dimensions may be competing in nature but they are not static, they are part of a dynamic system and synergies between the dimensions make the CoE evolve and be effective.

Having said that, this section presents roles that might be played by one or more individuals at a given time. More effective CoE appear to have individuals and collective mindsets pro-actively addressing as many of these areas as possible.

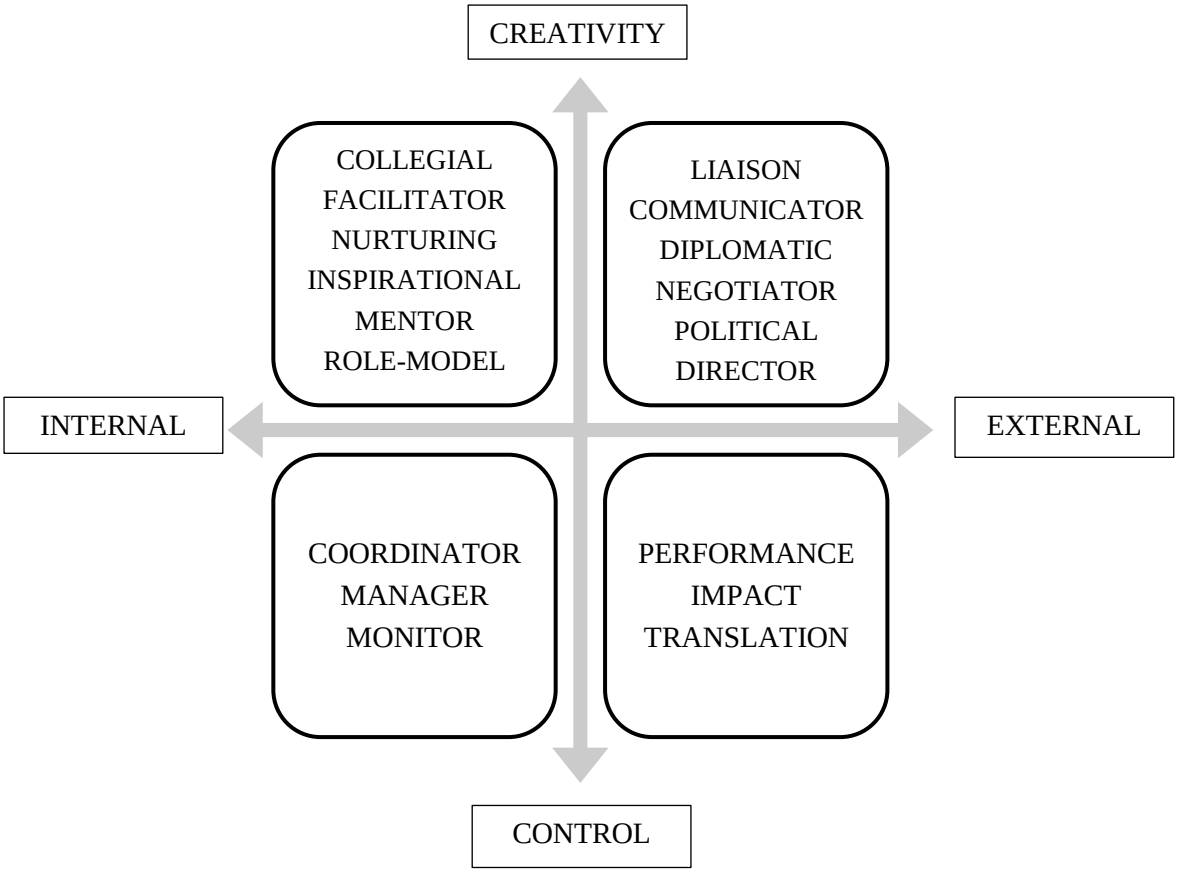

Figure 9: Complementary leadership and management roles covering the competing dimensions in CoE

The External-Internal dimensions of competing demands require different but interrelated sets of skills, expertise, personal traits and organisational strategies. These are discussed next.

Internal dimension roles

The internal dimension is focused on building the centre's organisational and scientific capacity and creating an organisational culture that will make the CoE cohesive with all parts fully integrated and aligned to one another. This dimension is inward oriented, concerned with developing internal capabilities and ensuring cohesion. This is particularly important for distributed and networked centres and centres embedded within a host organisation.

Much of internal-oriented roles are concerned with structuring work around research streams and fostering cohesion within and across research groups. Developing human capital is a major aspect of internal roles; it involves training, coaching and setting-up systems for continuous feedback.

Individuals in these roles need specialist knowledge and are usually senior scientists. However, scientific expertise alone is not sufficient, they need an additional set of skills to be effective research leaders and research managers. They need to focus on the specific attributes of the group's work but also have a holistic view of the centre's work. Research management skills are key to these individuals as well as good inter-personal and communication skills. During the interviews, some individuals considered as great scientists were referred to as poor leaders due to the lack of such skills.

Examples and characteristics of internally-oriented roles found at CoE were: integrator, role-model scientist, induction, mentor, coach, facilitator, networker, conflict-resolution, trust-worthy, enthusiastic, catalyst, inspirational. Individuals that tend to incorporate these roles are team coordinator, group or stream leader, graduate director, principal and associate investigator.

External dimension roles

As discussed before, the external dimension requires adaptability, flexibility and responsiveness from CoE. Individuals in associated roles need to scan the external environment, identify potential threats and opportunities and have a strategic ability to match internal capabilities and demands: they need to collect, analyse and utilise data; have excellent verbal, communication and negotiation skills in order to represent the centre and engage with different stakeholders (which do not necessarily have a scientific background). It involves identifying niches, assessing risk, recruiting talent, attracting resources and promoting the centres activities and outputs.

Examples and characteristics of externally-oriented roles found at CoE were liaison officer, communications manager, community engagement, acting as broker, negotiator, science communicator and educator, diplomatic and political roles.

Creativity dimension roles

These are arguably the most critical roles at CoE. Individuals with these roles usually combine roles associated to the Internal and Control quadrants and thus may find it difficult to reconcile the competing demands of these roles.

To foster the creative behaviour of CoE, research staff focus primarily on three aspects: infrastructure (environment, work, meeting and individual spaces), behaviour (beliefs, mindsets, culture), and collaboration (team dynamics, diversity, solo time).

Individuals in these roles empower people to generate and implement ideas, from simple to bold and risky ones. Research leaders are usually the ones able to unlock the creativity of their teams. They do that by modelling behaviour, inspiring, building trust and catering for different personality types to flourish and let their brains go.

Roles are related to the leaders' ability to coach, nurture, have charisma, allow for flexibility and lateral thinking, create a culture of innovation, self-initiative, independence and risk-taking.

Much of what has been encapsulated under the topic of culture in this chapter is very associated with the importance of the creativity dimension at CoE.

Control dimension roles

The control dimension at CoE is concerned with planning, coordinating, monitoring, evaluations and feedback of the CoE core activities being in most cases scientific research. The control dimension spans the oversight exercised at the centre governance level (including scientific advisory committees), the coordination and monitoring carried out by leaders and managers of research groups and the administrative support of centre managers and their teams. The work done under the control rationale is guided by centre directors and board members and carried out by research group leaders and centre managers.

Although considered as extremely important for the centre from a performance and accountability point of view, most research managers considered it to be hard and creating considerable additional overhead. Nevertheless, it is seen as fundamental to assessing performance and to be accountable to the funding organisation and beneficiaries of research.

Major roles associated with the control dimension of CoE research are setting-up reliable and meaningful metrics and milestones, setting-up processes for gathering information, analysing data, offering feedback in constructive ways, and producing targeted reports.

The balancing act of coping with competing demands

The roles identified in this section were varied, covering varied and often competing demands. However, it is important to highlight that they co-exist, and many times research leaders and managers have to be aware of how their decisions will influence all of the domains. In terms of roles, some are occupied by professionals but more often it is the role of a research leader or manager to keep up and cope with competing demands. This appears as particularly difficult at some CoE given that the diversity of members can bring in conflicting interests and cultures. The significance of culture is further discussed in the next section.

7.4 Culture as a key differentiating factor

During the analysis stage, every time something of essence and fundamental significance was reached as to 'what makes for an effective CoE' or even about 'what makes people tick', aspects associated with culture emerged. One director referred to a banner he had in his office with the quote "Culture eats strategy for breakfast"[33].

Culture is at the same time the most powerful and the most implicit force identified in the CoE organisational environment. The most dynamic centres studied work hard on building and more importantly 'living' and maintaining a certain culture. The climate showing 'the way we do things around here' was a feeling evident from the first moment you stepped into a centre and even more explicit across centres and participants' interviews.

Culture by itself was perceived in this study as a key differentiating factor, perceived as critical to organisational sustainability and effectiveness and, thus, setting apart the most cohesive and remarkable CoE.

It is hard to define "Culture at CoE" mainly because it is highly context-dependent to each centre. However, there are a few attributes that seem to be fundamental to the culture of

[33] This quote is attributed to Peter Drucker.

most CoE. These basic attributes are further emphasised in different directions according to the emphasis adopted by the centre.

To define CoE culture, I will start by introducing the role of culture at CoE, its basic attributes and the cultural profile of centres.

7.4.1 Culture at CoE is about promoting alignment between core values and actions

Culture is a two-way process at CoE. It is about alignment between core organisational values and purposes and everyday actions and behaviours. It is also about the people that join or are recruited by the CoE because they are the right fit for that organisational environment and culture.

Every centre, in its own way and according to its disciplinary traditions, recent history and future aspirations seemed to have its own set of written and unwritten rules where some values and beliefs are at the core of the centre spirit. Such core values are expected to be lived and exercised on a daily basis, informing all decisions and actions along the way. Because CoE staff numbers are relatively small (compared to large centres and university departments) cohesion is considered as manageable. Integrity is perceived as critical. Leadership and staff members are equally expected to exercise integrity in practice (not only in bold written statements). Leaders show awareness of their duty to act as role-models and demonstrate this alignment between what is said and what is done in terms of decision-making and in the conduct of R&D activities. It was possible to observe that a great deal about encouraging a certain culture on behalf of research leaders was anchored on leading by example and on reinforcing unspoken values and beliefs which were transmitted continuously to new CoE members.

In this sense, there was clearly much less emphasis on organisational structure and hierarchy. Centres favoured a flat and flexible organisational structure, placing more emphasis on issues like trust, communication, transparency and on translating core values into mindsets that shape behaviour.

7.4.2 Attributes of CoE culture

Because most CoE depend so heavily on the creative potential and intellectual activity of knowledge workers and on team-based collaboration, there were a few attributes that appear to be at the core of most CoE cultures:

- Trust, Communication and Transparency
- Creativity and Collaboration
- Achievement and Outcome Orientation

These are perceived to contribute to making a conducive environment that influences the performance of individuals and groups. This is how such attributes are perceived to be enacted at CoE.

Trust, Communication and Transparency

Possibly the three primary core values of CoE culture, particularly at those centres encouraging scientists to excel and develop cutting-edge knowledge and technology, are Trust, Communication and Transparency. An environment of mutual trust, where people have at all times the information they need to be innovative, exercise creative freedom and self-initiative, taking calculated risks that pay off, is seen as necessary conditions to create new knowledge. Constant and clear communication and transparency (particularly from leaders) was seen as necessary from the individual scientist perspective to develop trust and support towards their leaders; to ensure alignment and commitment to pursue shared goals and outputs; and for teams to remain aligned to centre-wide goals (also aligned with the work of other teams across institutions and countries at times) and avoid mission drift. Because collaboration is key to the work of CoE these three conditions allow coordination and a smooth conduct of activities.

Creativity and Collaboration

The second pair of fundamental values for CoE culture is creativity and collaboration. They are seen as correlated because CoE are organised in terms of research streams and each stream is operationalised by the work of teams (sometimes dispersed across institutions).

Encouraging the creative potential of staff is perceived as vital for CoE leaders. At the centres visited it was possible to see that leaders go to great lengths to ensure that people are satisfied with their work environment and that work fits with their personal lives. Several

centres support and initiate activities related to the physical, social, and emotional well-being of staff members. Social and sport activities are part of the routines of centres and people are encouraged to exercise, to work remotely and spend time off as long as work is being delivered. Flexible work schedules in terms of timing and work location are often available. People report feeling balanced and energised to commit their time to their work and as a result being more productive. Workplaces are also designed to promote casual get-togethers around a communal table or a quality coffee machine. Quiet rooms are also available for times when people require concentration. Combined with the necessary work infrastructure, these conditions are considered to create an environment that is conducive to creativity.

Overall, there appears to be a culture of caring about each other and supporting people's continuous development.

Achievement and output orientation

Last but not least, people at CoE strive to be and to offer the best versions of themselves and their work. Because the CoE offers the necessary level of resources and stability to allow that, they use the CoE as a platform to gain prominence in their scientific fields or communities of practice. They constantly try to be bold, taking risks and pushing the frontiers of their work.

Because CoE gather some of the best minds in their fields, there is a merit-based and prestige culture where people want to work with, learn from each other and become the best. The organisation of work is very much outcome-oriented and there is a healthy sense of joint pursuit and competition to achieve expected goals in a timely fashion. Teams also seek to measure and celebrate their achievements.

In this sense, a great part of what makes for a culture of excellence at these centres is a shared commitment and appreciation of merit, learning, improvement and achievement. At the team level, there is a shared spirit of endeavour, "going the extra mile" and a "can do" attitude that is encouraged and rewarded.

7.4.3 Centre cultural emphasis: Culture at different levels and stages of knowledge generation and application

The concluding remarks about how culture is encouraged at CoE refer to differences perceived within centres (at different levels) and across different centres (depending on the centre's focus).

At the centre level, it was possible to observe efforts to encourage a certain culture (of creativity, team-work or even innovation for instance) which could be categorised at different levels: the individual, group, and the organisational level. Taking for example centres wanting to unleash the creative potential: part of the facilitating strategy was aimed at developing individuals through training, mentoring and by supporting a more balanced individual-family-work life. The team level efforts were directed at supporting collaboration, communication, and identifying synergies. The organisational level is concerned with how the centre's capabilities and needs can be exploited and matched externally by engaging with other organisations and institutions.

It is important to note that, since many centres rely on a multidisciplinary approach, it was possible to sense that multiple cultures coexist or perhaps were blended to achieve a particular centre culture. A diversity of sub-cultures was to some extent seen as healthy (not being curbed in any way) for providing the centre broader and richer perspectives and possibilities. Building consensus and creating a convergence of sub-cultures into a centre-specific culture is perceived as role of centre leadership.

Conversely, comparisons across centres highlighted that much of what is encouraged and promoted in the hopes that a certain culture emerges depends to a large extent on the focus of a CoE and on the stage of the knowledge or technology development process. For example, CoE focused on the creation of blue-sky knowledge required different supporting environments than centres focused on knowledge application or on technological innovation. The type of creativity or innovative behaviour seemed to be understood and encouraged in different ways at these centres (despite the use of the same terminology during interviews).

What became clear is that, although the perception of a certain culture may be subjective to each individual, it is a CoE leader's and manager's responsibility to actively encourage a centre-wide culture (and not leave it to grow organically or delegate to a

management position such as communications or HR), facilitating a conducive climate (and eliminating potential barriers) that enables people to feel empowered and to behave in ways that contribute to CoE purposes and goals. Indeed, the notion that "Culture eats strategy for breakfast" holds true at the CoE organisational environment. A disconnect between the strategic efforts of leaders and culture puts at risk the sustainability of a CoE as an organisation opening the way for individual interests to prevail.

Finally, most experienced leaders appeared to make use of changing conditions, events and challenges as opportunities for culture to further evolve and respond to change making new and expected mindsets and behaviours to emerge and stick, representing a culture of learning through experience and from mistakes, for the sake a shared purpose.

7.4.4 Cultural fit and diversity

Culture, and more specifically culture fit, is regarded as a defining feature during the recruitment process of CoE. Academic credentials and expertise are still required (particularly at university-hosted CoE) however some centres look beyond that and prioritise people that fit or can contribute to enhancing the current CoE culture.

For example, when hiring with the culture in mind, research leaders may select candidates that are a match for the CoE core cultural attributes as discussed above. They might search for particular mindsets and approaches to problem-solving in their scientific fields or technology development areas.

Most CoE were favouring scientists that perform well in a collaborative environment (instead of the typical stereotype of the isolated self-centred scientist). Advancing team-based projects and goals is critical and some CoE reported having to remove staff members that were not able to adapt to a culture of collaboration.

Directors mentioned always searching for talent, wherever it is available.

Cultural fit, however, did not imply that people had all the same or similar backgrounds. As a matter of fact, most CoE were characterised by a huge diversity in terms of scientific, professional and personal backgrounds. The very multidisciplinary emphasis of most centres

required that. The cultural fit was recognised based on an analysis of the level of alignment of personal values, lessons from previous professional experiences, personal drivers and aspirations to those of the CoE.

Last, culture is one of the macro elements from our organisational capability framework (BOC). Culture was perceived as a primary element because of its power to influence other elements of the framework. For instance, the structure and governance of the centre, the way policies and process are established, the type and use of information (in decision-making) and the infrastructure are all elements that must be informed by and aligned to the culture of the CoE. This is one of the reasons behind the redesign of the graphical representation of the framework. At CoE, culture is not only another one of the key organisational elements but a pervasive element that sets the tone for the entire organisation.

7.5 Final Remarks

This section provides an overview of the study by integrating the findings achieved through its main empirical components. The findings achieved on CoE organisational capacity and presented in the last three chapters can be condensed and expressed in the following figure:

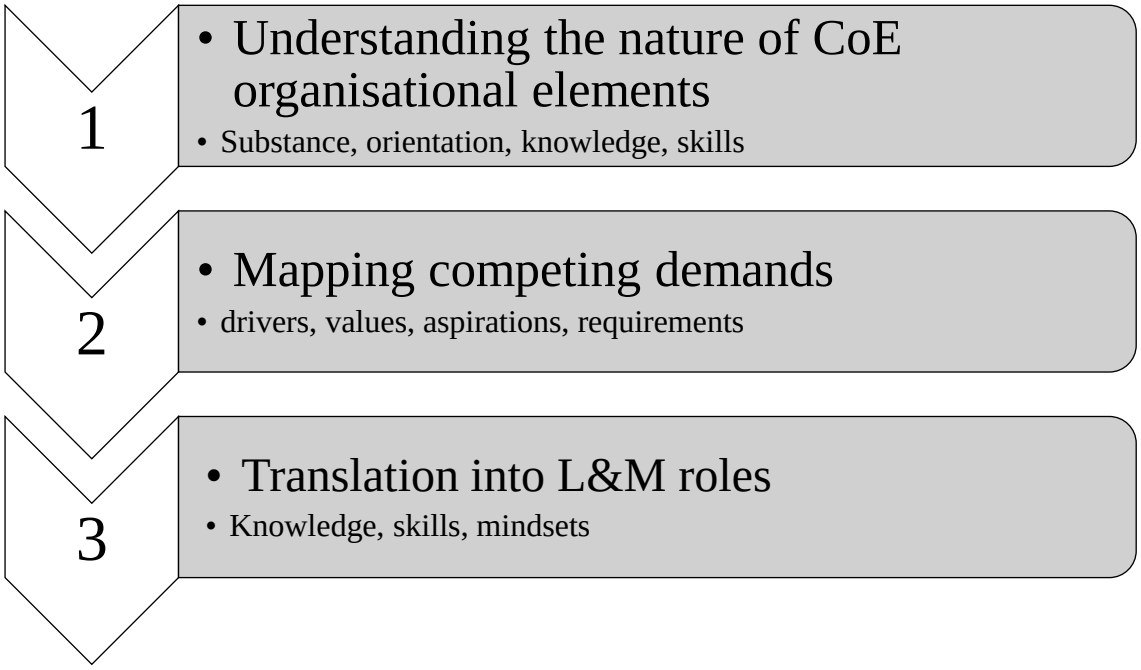

Figure 10. Three major components of CoE organisational capacity

Component 1

The first component of the study looked at the nature of CoE organisational capacity by looking at eight fundamental elements. This analysis revealed the following insights:

Firstly, of all organisational elements investigated, there are three that notably come to the forefront: Purposes, Governance and Culture. Irrespective of the CoE studied, the extent to which these elements were clearly understood and aligned determined not only the identity and fundamental nature of the centre, but also appears highly associated with the CoE's ability to successfully perform its activities and pursue its goals. The definition of these core organisational elements also sets the basis for establishing the remaining elements.

Secondly, these three elements were perceived to have a very active and dynamic nature (in contrast to the more static nature of other secondary elements) emphasising the need for a continuous and pro-active role of L&M in their maintenance (further explored in Component 3). Based on the findings presented, it was possible to observe that, depending on the centre orientation (fundamentally science-oriented or innovation-oriented for instance), the approach taken towards the triad Purposes-Governance-Culture was remarkably different and was what differentiated CoE from different 'species'.

Finally, to be effective, the process of building organisational capacity of CoE requires all key stakeholders to have a profound and shared awareness on the purpose and mission of the centre. The nature of the work carried out at the centre and the types of outputs and impact expected, shaped much of the organisational capacity that emerged at a CoE. But because collaboration and diversity are so intrinsic to the nature of CoE, understanding and clearly communicating how multiple constituencies contribute to and benefit from the partnership are central to informing every step of the establishment of each organisational element. This is where component two comes to the forefront.

Component 2

The second overarching component refers to the importance of continuously identifying and responding to competing demands that are critical for the CoE operation. Coping with competing demands is not only important in maintaining the different stakeholders or beneficiary groups engaged, but critical in further developing CoE organisational capacity to let the CoE evolve in the desired direction.

The study findings suggest that the nature and significance of competing demands vary considerably depending on the predominant types of research conducted at a CoE (basic, strategic or applied problem or desired outputs) and the readiness level of an innovation.

Much in line with the work of Quinn, Cameron and colleagues in the development of the Competing Values Framework, this study has identified which types of competing demands are at play at studied CoE and how L&M must be qualified and aligned to deal with them.

Component 3

The third key component for CoE organisational capacity takes all the factors associated with CoE organisational capacity and competing demands described earlier and translates that into the nature and role of leaders and managers of CoE.

Essentially, CoE are large and complex organisational environments (similar to universities and large research labs). The scale and complexity of research programs and expected outputs require equally sophisticated L&M approaches. The level of diversity of the centres investigated and associated sophistication of organisational capacity and L&M approaches required at each CoE strongly suggest that funding requirements must not be prescriptive in terms of the arrangements and approaches to be put in place. For the sake of a greater complementarity and synergies at the system level, the diversity of CoE as knowledge producing entities must resemble the different maturity levels and scopes of RD&I activities required for knowledge production and application processes.

CoE do not rely only on bright scientists, engineers and social scientists to pursue their agendas. These centres require scientists and professional support staff with advanced skills in the management of the research process and the management of researchers. The types of skills required are usually achieved by assembling L&M teams that are highly complementary in terms of skills.

Often scientists in leadership positions go beyond their position of "senior researcher" and develop the necessary skills either through experience or training. The role of professional management staff with a sound understanding of science and the research process is also fundamental for the operation of CoE.

Finally, the importance of fostering a favourable organisational climate is central to the leadership team as role-models. Leaders and managers have a key role in establishing and advocating for a conducive culture that is aligned with the shared values and norms of a CoE.

This study aimed to contribute to bridging a gap in the organisational nature of a specific and relatively new type of organisation: Centres of Excellence for the conduct of STI activities.

The study was able to identify the broad common organisational elements of CoE, but also to make an in-depth investigation into the nature of its core elements and how they contrast across different CoE.

It also makes a significant contribution in highlighting the nature of leadership and management in a collaborative, knowledge-intensive environment and in making an evidence-based analysis of the competing demands faced by leaders and managers at CoE.

Based on the study findings there are two immediate avenues for future studies: first, to investigate the construct of "organisational effectiveness" in the context of a particular and well-defined CoE type. Building on the present study, this future analysis could investigate what factors can be used as objective measures of effectiveness defined according to specific criteria such as performance, translation or impact of particular types of CoE.

Second, the study of 'culture' and how a particular culture is fostered and implanted in a CoE is certainly a fascinating and a highly-relevant topic that could have a huge impact on the performance of individuals and their centres. A few aspects related to culture stemming from the study that could be further investigated are related to, first, identifying the features of a 'creative culture' envisaged to spark the intellectual and creative behaviour of people performing in ST&I organisational environments such as CoE; and second, understanding how collaboration (particularly interdisciplinary and inter-sector) influences the development of a CoE organisational culture. Such issues are, indeed, perceived to be key (not only from a leadership and management effectiveness point of view) but to the very understanding of the notion of fostering research excellence.

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APPENDIX 1: APPROVED ETHICS APPLICATION SUMMARY

THE UNIVERSITY OF MELBOURNE
HUMAN RESEARCH ETHICS COMMITTEE

APPLICATION SUMMARY FOR APPROVAL OF HUMAN RESEARCH

THE UNIVERSITY OF MELBOURNE

1. ADMINISTRATION DETAILS

ETHICS ID:	**1441480.1**		
TITLE:	Leadership and Management Approaches of Publicly-Funded Centres of Research Excellence (CoE) in Australia		
APPLICATION TYPE:	**Minimal Risk**	**RESPONSIBLE RESEARCHER:**	GOEDEGEBUURE, PROF LEO CHRISTIAAN JOHANNES
RESPONSIBLE HEAG:	Melbourne Graduate School of Education	**HESC:**	Humanities and Applied Sciences
ADMINISTERING DEPARTMENT:	4600 - Melbourne Graduate School Of Education	**ADMINISTERING CENTRE:** (if applicable)	

2. MINIMAL RISK CHECKLIST REVIEW

The responses to the Minimal Risk Checklist are summarised below.

Risk Assessment Topics	None identified
Risk Assessment Procedures	None identified
Risks to Researchers	None identified
Vulnerability Assessment	None identified
Overseas Research	None identified

3. PROJECT DETAILS

PROJECT TYPE: Supervised Student Research Project - PhD

RESEARCH INVOLVES: Locations other than/in addition to Uni of Melbourne

BRIEF DESCRIPTION: Australia's science and technology base and technological innovation capacity have been actively promoted through research and industrial public policy during the last decades (Australia, 2009; 2011). Since the 1980's, the Australian government has been investing significant amounts of funds for the creation of research centres (referred to as Centres of Excellence, CoE, in the course of the study) that have the mission of engaging stakeholders from the public and private sectors to perform collaborative research in areas considered of priority given their economic or social relevance. CoE are, thus, joint research centres comprising members from academia (generally university-based researchers and professional administrative staff), industry, NGOs and public organisations. In Australia, major policy-driven CoE are created through the Australian Research Council (ARC CoEs) and the Cooperative Research Centres scheme (CRCs). CoE goals are to build a critical mass in strategic research areas, promote the conditions for research excellence, contribute to solving industrial problems or gaps, introduce research-based technological innovations, build research capabilities (including the training of the next generation of researchers), link Australian groups to international networks, and strength the competitiveness of Australian research teams at world-class level.

There is widespread agreement amongst CoE practitioners and program leaders that leadership and management (L&M) are crucial factors for the successful performance of these knowledge-intensive research organisations (Mercer & Stocker, 1998; OECD, 2004, O'Kane, 2008). What is still not fully understood is what types of L&M are required for this particular type of organisation. Although Australia was one of the pioneers in introducing CoE programs world-wide, very little scholarly work on CoE has been undertaken to date. A number of reports highlight the importance of appropriate leadership and management approaches but little is known about the nature of CoEs and its implications in terms of associated (and effective) leadership and management approaches.

Thus, the central research question is: What is the nature of leadership and management in the organisational context of CoE? It is underpinned by two sub-questions:
- What are the organisational characteristics of CoE?
- What are the main leadership and management (L&M) roles in the context of CoE?

PROPOSED DURATION OF WHOLE RESEARCH PROJECT: **From:** AUG-2012 **To:** AUG-2015

PROPOSED DATE TO COMMENCE DATA COLLECTION: 30-May-2014

4. PERSON DETAILS

Responsible Researcher

Name	Goedegebuure, Prof Leo	**Department**	4600 - Melbourne Graduate School Of Education
Person Type	Staff	**Centre**	
Phone Number	8344 9246/Alt:03 8344 0756	**Email Address**	leo.g@unimelb.edu.au

Qualifications	Post Doctorate, University of Twente Doctorate (Research), University of Twente Director of the LH Martin Institute for Tertiary Education Leadership and Management of the University of Melbourne. Over his career, Leo has published some 15 books (both monographs and edited volumes) and over 100 articles, book chapters and papers on higher education policy, mergers, quality assessment, evaluation research, differentiation, system dynamics, engineering education, institutional management and comparative research.
Experience & Skills Relevant to the Project	More than 30 years experience as researcher and PhD supervisor. Leo's research interests are in the areas of governance and management, both at the systems and institutional level, system dynamics including large scale restructuring policies, university-industry relationships, and institutional mergers. Most of his work has a comparative focus (including qualitative studies) both within and outside of Europe, which has resulted in a strong international network. He is an auditor for the Hong Kong Quality Assurance Council and has been a member and rapporteur for the OECD tertiary education review of New Zealand. He has worked as an expert on governance and management in Central and Eastern Europe, the Russian Federation, Africa, South East Asia and South America on projects initiated by the European Commission, the World Bank and UNESCO.
Additional Training Required	N/A
Ethics Training Already Undertaken	Ethics training for researchers and research student supervisors undertaken at the University of Melbourne.

Student Researcher

Name	Barros De Barros, Fabiana	**Department**	4600 - Melbourne Graduate School of Education
Person Type	Student	**Centre**	
Phone Number	0467208176	**Email Address**	f.barrosdebarros@student.unimelb.edu.au/Alt:fbbarros@gmail.com
Qualifications			
Experience & Skills Relevant to the Project	The student researcher has been previously utilising the same research methods and skills development during the masters' research dissertation. She has taken the subject course named "Doctoral Research" offered at the Graduate School of Education by Prof Lynn Yates in 2013.		
Additional Training Required	N/A		
Ethics Training Already Undertaken	Upskills training Training delivered by the Melbourne Graduate School of Education Human Ethics Advisory Group.		
Student Supervisor(if applicable)	Professor Leo Goedegebuure, Professor Lynn Meek		

Co researcher

Name	Meek, Prof Vincent	**Department**	4600 - Melbourne Graduate School of Education
Person Type	Staff	**Centre**	
Phone Number	03 8344 0756/Alt:03 8344 0756	**Email Address**	vmeek@unimelb.edu.au
Qualifications	Bachelors Degree (Honours), Drew University PhD, University of Cambridge Professor and Foundation Director of the LH Martin Institute (Unimelb), Lynn was previously Professor and Director of the Centre for Higher Education Management and Policy at the University of New England. Having completed a PhD in the sociology of higher education at the University of Cambridge, he has nearly three decades experience researching higher education policy issues. Specific research interests include governance and management, research management, diversification of higher education institutions and systems, institutional amalgamations, organisational change, and		

	comparative study of higher education systems.
Experience & Skills Relevant to the Project	More than 30 years experience as researcher and PhD supervisor. He has attracted numerous competitive research grants, is regularly invited to address international conferences and is frequently invited to be guest editor of international journals with respect to special issues on aspects of higher education policy. Lynn has published 30 books and monographs and numerous scholarly articles and book chapters. He is on the editorial board of several international journals and book series and has worked with such international agencies as UNESCO and the OECD.
Additional Training Required	N/A
Ethics Training Already Undertaken	Ethics training for researchers and research student supervisors undertaken at the University of Melbourne.

5. ADDITIONAL QUESTIONS

5.1 Location of Research

Location Where Research Will Be Carried Out: External sites within Australia; University of Melbourne

Category of External Location: Private Venues

5.2 Other Approvals Required (other than ethics clearances)

Approvals Required: Not required

5.3 Other Ethic Clearances/Details of Multicentre Research

Other Clearances Required: Not required

Responsible HREC:

Comments: No additional approvals from external bodies are required, as endorsement will occur at the point of consent and is embedded within the consent form.

6. ATTACHMENTS

PLEASE ENSURE YOU ATTACH A PAPER COPY OF EACH OF THE FOLLOWING ATTACHMENTS:

Category	Description	Attached Via Themis	Hard Copy Only
Application	Application form	Yes	No
Consent Form	Consent Form for Centre Participation	Yes	No

Category	Description	Attached Via Themis	Hard Copy Only
Consent Form	Consent Form for Individual Participants	Yes	No
Interview	Interview guide	Yes	No
Plain Language Statement	Plain Language Statement for all participants	Yes	No

MELBOURNE GRADUATE SCHOOL OF EDUCATION

Consent Form for individual participants in a research project

PhD research project title: Leadership and Management Approaches of Publicly-funded Centres of Research Excellence in Australia (tentative).

Name of research centre:

Name of participant:

Investigators: Fabiana Barros de Barros, Professor Leo Goedegebuure, Professor Lynn Meek. Graduate School of Education, the University of Melbourne.

1. I consent to participate in the project named above, the particulars of which - including interviews - have been explained to me. Further, I have read and understood the information provided to me regarding this project and I have been provided with a copy of the Plain Language Statement to keep.
2. I understand that after I sign and return this consent form it will be retained by the investigator(s).
3. I understand that my participation will involve an interview and I agree that the investigator(s) may use the results as described in the Plain Language Statement.

4. I acknowledge that:

   a) The project is for the purpose of study and data to be collected will only be used within this research project;
   b) I have received an adequate explanation of all likely risks, effects, discomforts or inconveniences arising from this study;
   c) I have been informed that I am free to withdraw permission at any time without explanation or prejudice and that any unprocessed data will be withdrawn from the study;
   d) I consent to interviews being audio-taped. Data will be securely stored and will be destroyed after five years;

e) I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements.
f) My name will be referred to by a pseudonym in any publications arising from the project.

Signature Date

APPENDIX 2: INTERVIEW SCHEDULE

Semi-structured interview guide

Date and Time	
CoE full name and acronym	
CoE website	
Participant's name	
Participant's position and academic qualification (if applicable)	
Consent form signed	

Introduction to interview

1. Thank you, acknowledge participant for taking part in the study.
2. Brief personal and project introduction.
3. Restate confidentiality and concerning all participant information provided during interviews and site visits. Participants can withdraw from the study without penalty at any stage.
4. Interview length: 45-60 minutes.

Researcher notes

Key Dimensions for Investigation:

A- Background questions to establish the general nature of the centre based on history, path-dependency, disciplinary fields, partnership configuration, etc.
B- Nature of Organisational Elements (based on Building Organisational Capacity Framework - BOC)
C- Nature of Leadership & Management (based on Competing Values Framework - CVF)
D- During the interview schedule questions, follow-up themes or new ideas, relevant to the study, brought up as a result of what the interviewee says.

A- Introduction (5-8 minutes)

1. Can you tell me about the history of this centre? What led to the creation of a CoE?
2. How did you become involved in the CoE?
3. Was there a history of collaboration amongst the key partners of the consortium?

4. Could you briefly describe your role? How has it evolved since you first became associated to the CoE?
5. Has the centre changed over time? If so, what led to such changes?

B- Organisational – informed by the BOC Framework (20 minutes approx.)

1. Purposes
    a. How would you describe the core mission and aspirations initially set for the CoE?
    b. To centre leadership (Director/Deputy-Director/CEO/Board Member): What drives you as a leader of this CoE?
    c. What values you would say that are representative of this centre and its community?
    d. What beliefs bring together this partnership?
    e. Are there sub-cultures within this partnership?
    f. Can you describe the planning process during the proposal development stage? Were all partners involved or represented? If so, how? If not, why?
    g. Do you think that the core functions of this CoE have changed over time during the time of your term as CoE/Manager/research leader?
    h. What, if anything, do you think has contributed to the changes at this CoE?
2. Structure
    a. What is the basic organisational structure of the centre? (under one-roof/ networked/ decentralised and independent nodes/virtual)
    b. How did this structure come about? Do you consider this configuration to serve well the work and purposes of the CoE? In what ways? Would you change anything? Why? How?
    c. How would you describe the nature of hierarchy, coordination or delegation in the centre?
    d. Was this structure borrowed or inspired by other existing organisations?
    e. Do you think there should be any changes in terms of organisational structure?
3. Policies
    a. Are there any rules or policies (written and unwritten) that shape people's behaviour at the centre?
    b. Why these policies were put in place?
    c. Have people changed as a result of the policies put in place?
    d. Which kind of policies were more effective? Why do you think they stick more than others?
    e. What type of support systems or processes were put in place to support the implementation of these policies?
4. Processes
    a. What kind of processes are in place? How were they designed or changed over time?
    b. Can you describe an important process at the CoE? (It can be a research-related process, a management process or a governance process for instance)
5. Information
    a. Which kind of information is considered significant and collected in order to inform decision-making or strategy-setting?
    b. Are there any specific systems in place for generating/collecting/analysing information?
    c. What kind of information is disseminated to CoE partners to ensure transparency?
6. Infrastructure
    a. Was the availability of key infrastructure a central pillar in the creation of this CoE?

   b. What types of infrastructure are central to the partners of this consortium?
   c. How is the access to or sharing of infrastructure implemented in the CoE?
   d. What are the major types of talent necessary for this centre?
   e. What key physical and technological resources are considered as an enabling type of infrastructure?
7. Governance
   a. What is the decision-making approach at the CoE: Who makes what types of decisions?
   b. Is there a governing structure in place (such as a Board of Trustees) and, if so, how is it composed and what is its scope of authority?
   c. How is the involvement and representativeness of multiple stakeholders in decision-making?
   d. What is the governance approach in defining a research/translation/commercialisation strategy?
8. Culture
   a. What would you say is the common element that is deeply held by all or most partners in this consortium? Are there any invisible threads that unite CoE partners? (common values/beliefs/shared purposes)
   b. How would you describe the working climate of the centre?
   c. How do you cope with potentially different cultures stemming from different partner organisations?
   d. Do you see yourself as a role-model at the CoE? If so, what attitudes, beliefs or values you promote?
   e. How was the culture prior to the establishment of the CoE? How is it now? Do you perceive any difference?
   f. Do you think that a particular culture was fostered or emerged with the CoE?
   g. Do you think it is possible to create a culture?

C- Leadership & Management (L&M) informed by the CVF

CVF quadrants of analysis: COLLABORATE, CONTROL, COMPETE, CREATE

Examples of questions within each quadrant:

1. COLLABORATE
   a. How do you perceive the roles and responsibilities of your position within this centre?
   b. How would you describe an ideal CoE director?
   c. How would you describe a typical situation within which your intervention as a leader is required?
2. CONTROL
   a. How are goals set in your centre?
   b. Who is in charge of monitoring the accomplishment of goals?
   c. Do you use any specific tools for that end? How do you perceive their suitability and effectiveness?
   d. How do you interact with different stakeholders?
   e. What is the real influence of the funding organisation in the daily operation of the centre?
3. COMPETE

   a. Are there any particular reward mechanisms in place?
   b. How to you recognise the good performance of the different stakeholders' individuals/groups?

4. CREATE
   a. What external resources are critical or very important for the centre operation?
   b. How do you perceive the influence of external counterparts?
   c. Which kind of external information or monitoring is necessary for the sustainability of the centre?

Examples of role-oriented questions

1. Centre Director and Centre Manager
   a. What is your professional and academic background prior to joining this CoE?
   b. How did you get involved with this CoE?
   c. How would you describe yourself as an academic?
   d. How would you describe yourself as a manager?
2. Research Leader
   a. What are the main aspects to integrate interdisciplinary teams within the CoE? Do you attempt to avoid silos? How?
   b. Is there an induction process to new research students developing their research in the framework of the CoE programs?
   c. Are there any differences in terms of stakeholders' expectations around the R&D performed?
3. Graduate student
   a. What staff members have a significant contribution to your experience at the CoE? In what ways?
   b. Are there any staff members' roles that are complementary in any way from your perspective?
   c. Did any staff members attitudes or performance have changed the way you used to think about their roles?
4. End-User representative
   a. How do you perceive the centre leadership roles to be?
   b. How different is it from the type of leadership you are used to in your own organisation or sector?
   c. What staff roles were crucial for you or your organisation to fully engage in the CoE activities?
5. Other research staff
   a. What are the best and the worst things about researching in a CoE?
   b. What aspects of a CoE, if any, are comparatively better for academic researcher's activities?
   c. If you were the leader/manager of this centre, which changes would you put in place?

Concluding Remarks:

- Open up for any final observations or overall comments
- Thank participant for their time and input

APPENDIX 3: ARC COE PROGRAM

Australian Research Council (ARC) Centres of Excellence (CoE) Program

Key funding requirements and evaluation criteria

There are some funding requirements and other guidelines set by the funding organisation that are important to understand the nature of ARC CoEs. CoE may operate as a single concentrate and "under-one-roof" centre or as a network of nodes, each hosted by a different organisation, or any other configuration provided that the eligibility criteria and funding rules are met. Each CoE must have a board, such as an advisory committee (AC) that offers broad representation of research and end-user communities. The AC provides advice to the CoE director and partner organisations regarding the research focus of the centre and on issues such as general structure and operating principles, intellectual property rights and commercialisation of research results.

Funding under this scheme is provided to the designated Administering Organisation (not to researchers). Organisations which are eligible to apply as Administering Organisation of a CoE must be one of the Australian universities featuring in the Eligible Administering Organisations' list (ARC, 2013). Should the proposal be successful, this university will receive and administer the overall budget. Other organisations are denominated as collaborating organisations if they are eligible to apply for and receive ARC funding and partner organisations if they are not eligible but committed to contributing to the CoE activities. These organisations must demonstrate a significant co-location of resources (in-cash contributions that match or exceed the ARC grant) to the CoE implementation.

Usually an ARC CoE is administered from within the existing academic, administrative and financial governance structures of the administering organisation. The centre director must be an employee of the administering organisation and must take significant intellectual and strategic responsibility for the proposed centre. The director must work predominantly on the centre's activities and if this commitment is no longer possible, the ARC reserves the right to propose a replacement to the Minister. ARC Centres of Excellence may be funded for up to seven years, subject to the availability of sufficient funding, changes to the existing regulatory framework, and continued satisfactory progress of the centre.

Selection Process

Proposals for the creation of new CoEs are assessed by a highly competitive two-stage process. Initially, interested institutions are invited to submit an expression of interest (EoI). EoIs are assessed on their proposed research programme and the quality of their research staff and director (investigators), according to the following criteria:

Proposed research programme (50%)

• the proposed research to be undertaken and its innovative nature

• the researcher/institutional collaboration proposed, focusing on the integration of expertise and knowledge

• the development of collaboration and critical mass in the research field

• the goals of the proposed research programme.

Investigators (50%)

• evidence of the performance, expertise, capacity and suitability of the director

• evidence of the performance and expertise of senior researchers

• capacity and suitability of senior researchers for proposed roles.

Shortlisted applicants are then invited to provide full proposals that provide greater detail on the CoE project and how it is going to be put into operation. Full proposals are assessed against four dimensions of equal importance for the final merit ranking:

Research programme

• The ability of the proposed research programme to address the strategic objectives set for the CoE.

• Whether it has a sound and cohesive research programme that assembles the adopted conceptual framework, human resources, methods, management structures, budget and risk mitigation strategies.

• Whether the centre has the potential to achieve international standing.

Investigators

• The organisation's track record and evidence of past performance that could contribute to the achievement of the desired outcomes.

• The commitment of main investigators to the operation of the CoE.

Governance, leadership and mentoring

• The adequacy and quality of proposed structures and the level of responsibility of key staff.

• The quality of the financial systems and strategic planning to be deployed.

• The leadership potential of the centre director.

• The appropriateness of the performance measures to be used for the centre.

• The proposed avenues for graduate student training and professional outreach initiatives.

Outcomes and linkages

• Analysis of the support and commitment of resources by partner organisations.

• The participation of end users and partners in strategic research planning and governance structures.

• Knowledge transfer and application strategies.

• Ownership and exploitation arrangements.

• The potential contribution to national research and innovation priorities.

• Whether there are provisions to further develop national and international links with other organisations.

Funding levels

The funding for each ARC Centre of Excellence ranges from AUD 1 million to AUD 4 million per calendar year. To maximise the impact of ARC funding, applicants are required to match the public funding by obtaining commitments of additional financial contributions from a variety of internal and external sources, including the applicant institution and other consortium members. For instance, in 2005 ARC CoE funding amounted to AUD 89 million matched by CoE partners to a total of AUD 46 million.

Another characteristic of ARC CoE funding is that the scheme only supports direct costs for research projects. The ARC reserves the right to determine which project costs fall within this category. Eligible costs include:

• salaries and employment costs for centre personnel who perform research or activities that support the research, excluding the director, chief investigators, or partner investigators;

• stipends for research students;

• equipment used for the research programme;

• maintenance and consumables;

• access to workshop services linked to the research programme;

• domestic and international travel costs for centre personnel where this is related to the research programme; and

• domestic and international travel costs for visitors to the centre where this is related to the research programme or centre governance.

The ARC does not provide funding for indirect costs, including those incurred by basic facilities and equipment, organisational overheads or infrastructure costs. All parties in a proposal must accept the terms of the "Funding Agreement", a binding document that defines the provisions under which funding are administered, reporting requirements and due dates. The first payment is made after all parties have signed.

Annual reports must be structured around key performance indicators (KPIs) common to all ARC CoEs. These indicators are complemented by centre-specific, ARC-approved KPIs which are developed

within the first six months of a centre operation. ARC CoEs are required to provide annual financial and performance reports.

APPENDIX 4: CRC PROGRAM

Cooperative Research Centres (CRC) Program

Funding requirements and evaluation criteria

Basic eligibility requirements for a proposed consortium are to have at least one Australian industry organisation and one Australian research organisation and be able to match the grant funding sought.

Co-funding, is thus, a major principle behind CRCs. All partners must provide contributions that, in total, match or exceed the requested funding. Commitments by participants may be for part of or the entire funding period. All CRC participants must contribute cash or in-kind resources to the centre's operation in the form of tied or untied contributions. Tied cash contributions are generally allocated to specific research programs that are of particular interest to the CRC partner, whereas untied cash contributions can be spent at the CRC's discretion. Typically, most participants provide staff as their in-kind contribution.

CRC selection rounds started on a bi-annual basis and now open every year. The minister has the power to call for applications at any time. Funding is provided for up to ten years and there is no predefined funding level for an individual CRC. Since 2008, the average budget has been AUD 3.7 million per year. Centres receiving funds can apply for extra activities or funding extensions when nearing the end of the seven-year funding period.

In order to be competitive, an application must score highly in three main dimensions. Research, assessed on the basis of milestones, outputs, excellence and innovativeness; results, a major component, where CRCs are expected to have an impact beyond scientific publications, that includes a pre-defined utilisation strategy, IP arrangements, relevance to end-users and the application of appraisal methods such as triple bottom line impact assessment and return on investment principles (CRC Association, 2012).

Strategic orientation

CRCs assemble multidisciplinary teams from across all sectors and research providers, to address end user driven research. The scheme places no restriction on the fields of research and many centres incorporate researchers not only from traditional hard sciences but also from the humanities, arts and social sciences, and medical science and technology-related (S&T) research.

The CRC Association (CRC Association, 2018) lists a number of reasons that make CRCs attractive to private applicants which includes the opportunity to companies, including multinationals, to access publicly-supported research teams through the CRC which acts as a "one-stop-shop" for their research and technological needs; the fact that CRCs are "managed to deliver impacts not just publications, and are held to account to deliver"; and the ability of CRC management team and Board to actively manage CRC activities and maximise activities perceived to have national benefit.

This includes "terminating, redirecting or accelerating projects in a way that is not part of the culture of most other programs".

CRC*s* are characterised by the following features:

- medium- to long-term end-user driven collaborative research
- end-user focused training and education programmes (PhD education included)
- global research and education engagement in co-investment arrangements
- strategies that empower SME innovation and R&D capacity
- utilisation strategies that promote the deployment of research outcomes by end-users.

To give an idea of the number and areas of active CRCs in a certain year, in 2012, Australia had 44 active CRCs distributed in the following thematic areas or sectors:

- agriculture, forestry and fishing (11)
- manufacturing (5)
- mining (4)
- services (24)

Impact Assessment of CRCs

Because the translation of research results is a major aspect in the CRC program, an Impact Tool was developed to support the planning and assessment process of centres by making the pathway from inputs to impact more explicit. More importantly, the impact tool is adopted as a strategic planning instrument during the application for funding process and as a risk assessment and mitigation strategy tool (Department of industry, 2016).

In order to assess the impact of the CRC Program, an independent study was conducted on the 'The Economic, Environmental and Social Impacts of the CRC Program' (Allen Consulting Group, 2012) established that "b*etween 1991 and 2017 almost $14.5 billion of direct economic impacts are estimated to have accrued from CRC produced technologies, products and processes" generating "environmental benefits including impacts on land, ecosystems, pollutants, natural resources, plants, animals and biodiversity; and social benefits that affect the Australian community, the health and well-being of individuals and any other social implications."*

List of Active CRCs

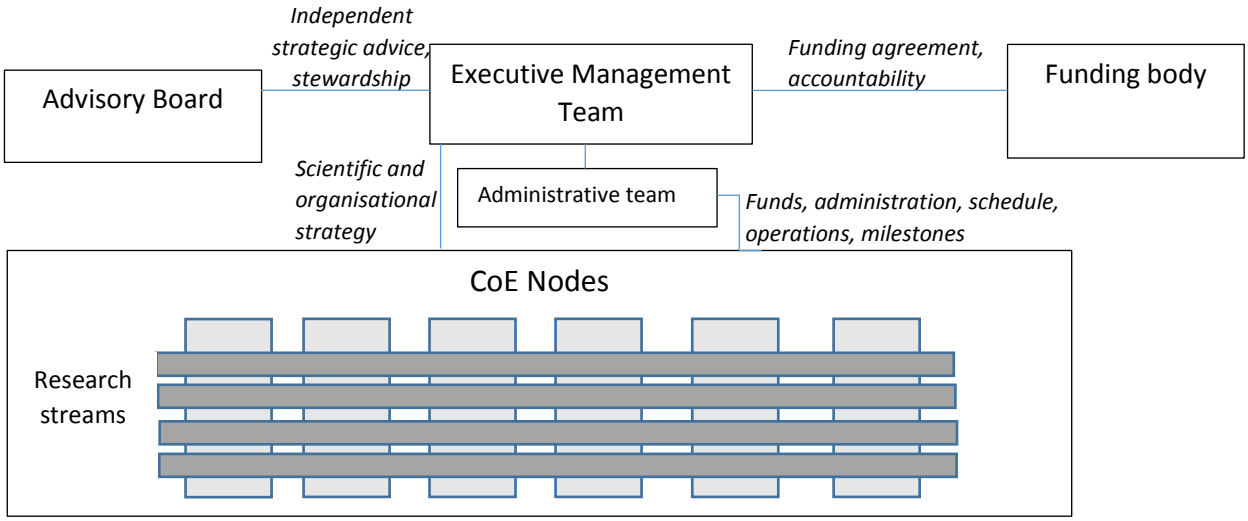
CRC Name	Objective	Sector	Funding period start	Funding period end	Duration (years)	Funding ($m)
Antarctic Climate and Ecosystems CRC	To address key scientific questions, including how Antarctica drives global climate, and how the pace and nature of change in Antarctic climate and ecosystems will affect the wellbeing and economic interests of Australians.	Services	1/07/2014	30/06/2019	5	25.00
Automotive Australia 2020 CRC	To tackle the complex problems that currently impede the uptake of low emission vehicles worldwide, such as the technological and social barriers to the uptake of gaseous fuels in cars and trucks, and producing greener vehicles and components more competitively.	Manufacturing	1/07/2012	30/06/2017	5	26.00
Bushfire and Natural Hazards CRC	To conduct research to reduce the risks from bushfire and natural hazards; reduce the costs of disasters; contribute to the national disaster resilience agenda; build research capacity and capability; and enable Australian SMEs to be innovative in natural hazard products and services.	Services	1/07/2013	30/06/2021	8	47.00
Capital Markets CRC	To conduct applied research that will enhance capital market integrity and efficiency.	Services	1/07/2014	30/06/2019	5	32.35
CRC for Advanced Composite Structures	To embed Australian composites industry SMEs into global supply chains by attracting multinational businesses, undertaking collaborative research with Australian researchers and SMEs, and building reliance on Australia's proven capability for major technological advancement.	Manufacturing	1/07/2010	30/06/2015	5	14.00
CRC for Alertness, Safety and Productivity	To develop new tools and products to improve alertness, increase productivity and enhance safety, to boost productivity and lower health system costs by reducing the incidence of motor vehicle and workplace accidents and errors.	Services	1/07/2013	30/06/2020	7	14.48
CRC for Cancer Therapeutics	To build on the drug-discovery engine it has already created to discover effective new drugs for major cancers and improve the lives of Australian children with cancer through tailored and personalised treatment.	Services	1/07/2014	30/06/2020	6	34.01
CRC for Cell Therapy Manufacturing	To increase the affordability and accessibility of cell therapies and position Australia in the vanguard of cell therapy manufacture.	Manufacturing	1/07/2013	30/06/2019	6	20.00
CRC for Contamination Assessment and Remediation of the Environment	To undertake research, develop technologies and provide policy guidance for assessing, cleaning up and preventing contamination of soil, water and air.	Services	1/07/2011	30/06/2020	9	29.10
CRC for High Integrity Australian Pork	To address the major challenge the Australian pork industry's faces in maintaining local production of high quality food for a reasonable price without negatively impacting pig welfare, the environment, or the health of the consumer.	Agriculture, Forestry and Fishing	1/07/2011	30/06/2019	8	19.86
CRC for Living with Autism Spectrum Disorders	To undertake innovative research to directly improve the lifetime prospects of individuals with Autism Spectrum Disorders (ASD); provide guidance, support and direction for their families; and enable medical practitioners, educators, therapists, support workers and employers to work effectively with people with ASD.	Services	1/07/2013	30/06/2021	8	31.00
CRC for Low Carbon Living	To provide government and industry with technological and policy tools to overcome identified market barriers which are preventing the adoption of cost effective low carbon products and services.	Services	1/07/2012	30/06/2019	7	28.00

CRC Name	Objective	Sector	Funding period start	Funding period end	Duration (years)	Funding ($m)
CRC for Mental Health	To undertake research to identify and validate biomarkers for the early detection and treatment of neurodegenerative disorders such as Alzheimer's and Parkinson's diseases and psychoses including schizophrenia and mood disorders.	Services	1/07/2011	30/06/2018	7	23.11
CRC for Optimising Resource Extraction	To transform the methods used by Australia's mining and minerals industry to evaluate and extract mineral deposits. The CRC will develop technology which will enable selective mining in high tonnage operations with potentially a significant reduction in capital expenditure and energy consumption.	Mining	1/07/2010	30/06/2015	5	17.50
CRC for Polymers	To establish Australian manufacturing as a leading provider and exporter of products that meets emerging global needs in three areas: health therapies and delivery; water and food security; and low-cost solar energy, using enabling and sustainable advanced polymer technology.	Manufacturing	1/07/2012	30/06/2017	5	14.50
CRC for Rail Manufacturing	To develop products, technologies and supply chain networks to increase the capability and globally competitive position of the rail industry.	Manufacturing	1/07/2014	30/06/2020	6	31.00
CRC for Remote Economic Participation	To deliver solutions that address social and economic disadvantage in remote Australia and contribute to the Australian Government's 'Closing The Gap' policy, which aims to halve the unemployment, welfare and other forms of disadvantage experienced by Indigenous people living in remote areas.	Services	1/07/2010	30/06/2017	7	32.50
CRC for Sheep Industry Innovation	To enhance sheep wellbeing and productivity, value-based trading of sheep meat and deliver affordable technologies to transform the Australian sheep industry.	Agriculture, Forestry and Fishing	1/07/2014	30/06/2019	5	15.50
CRC for Spatial Information	To create a coordinated national network of satellite system reference stations; undertake research into the establishment of an Australian and New Zealand spatial information market place; and automate the production of essential spatial information products and combine existing data stores with the rapidly increasing stream of data from earth observation satellites.	Services	1/01/2010	30/06/2018	8	32.19
CRC for Water Sensitive Cities	To deliver the socio-technical urban water management solutions, education and training programs, and industry engagement required to make towns and cities water sensitive.	Services	1/07/2012	30/06/2021	10	30.00
Dairy Futures CRC	To develop new approaches to selective breeding of both pasture and cattle to build a more resilient and profitable dairy industry.	Agriculture, Forestry and Fishing	1/01/2010	30/06/2016	6	27.72
Data to Decisions CRC	To develop robust tools to maximise the benefits that Australia's defence and national security sector can extract from big data to reduce national security threats.	Services	1/07/2014	30/06/2019	5	25.00
Deep Exploration Technologies CRC	To develop new technologies that respond to significant future challenges in the Australian mining industry including: exploring to greater depths in the vast areas of Australia's deep covered prospective basement; and reducing the mineral resources inventory due to high production rates and low mineral exploration success.	Mining	4/02/2010	30/06/2018	8	28.00

CRC Name	Objective	Sector	Funding period start	Funding period end	Duration (years)	Funding ($m)
Energy Pipelines CRC	To provide the Australian energy pipeline industry with the technology necessary to extend the life of the existing ageing natural gas transmission network and to build the new networks necessary to support increased demand for natural gas.	Services	3/02/2010	30/06/2019	10	17.48
Invasive Animals CRC	To counteract the environmental, social and economic impacts of invasive animals through the development and application of new technologies and by integration of strategic pest management approaches across agencies and jurisdictions.	Agriculture, Forestry and Fishing	1/07/2012	30/06/2017	5	19.70
Oral Health CRC	To undertake research to address the substantial national economic and social burden of oral disease and disorders. The research will include development of early diagnostics, new preventative strategies and products and oral health promotion programmes.	Services	4/02/2010	30/06/2018	8	30.25
Plant Biosecurity CRC	To develop and deploy knowledge and tools to provide the scientific support essential for safeguarding Australia from the economic, environmental and social consequences of damaging pest incursions.	Agriculture, Forestry and Fishing	1/07/2012	30/06/2018	6	29.65
Poultry CRC	To conduct research and drive education and training to help Australia's poultry industry achieve sustainable, ethical poultry production in the face of population growth and climate change.	Agriculture, Forestry and Fishing	4/02/2010	30/06/2017	7	27.00
Seafood CRC	To assist the seafood industry to profitably deliver safe, high-quality, nutritious Australian seafood products to premium markets, domestically and overseas.	Agriculture, Forestry and Fishing	1/07/2007	30/06/2015	7	35.52
Space Environment Management CRC	To monitor, analyse and manage space debris and develop new technologies and strategies to preserve the space environment for the benefit of Australia.	Services	1/07/2014	30/06/2019	5	19.83
The HEARing CRC	To develop new devices, therapies and service delivery models to improve the prevention, detection and remediation of hearing disorders.	Services	1/07/2014	30/06/2019	5	28.00
The Lowitja Institute Aboriginal and Torres Strait Islander Health CRC	To address the major challenge of closing the health gap by producing knowledge, tools and resources that can be used to enhance positive health outcomes for Aboriginal and Torres Strait Islander people.	Services	1/07/2014	30/06/2019	5	25.00
Vision CRC	To deliver innovative solutions to common eye conditions such as myopia, presbyopia and hyperopia. The CRC is also developing effective models for sustainable eye care systems in Indigenous and developing communities.	Services	1/07/2010	30/06/2015	5	27.00
Wound Management Innovation CRC	To improve wound healing, provide quality-of-life for people with wounds and develop cost-effective wound care to lessen the burden on health systems.	Services	1/07/2010	30/06/2018	8	27.93
Young and Well CRC	To explore the role of technology in young people's lives and to address the challenge of how it can be used to improve the mental health and wellbeing of young people aged 12 to 25.	Services	1/07/2011	30/06/2016	5	27.46

APPENDIX 5: COE ORGANISATIONAL STRUCTURE CHART

Typical CoE organisational structure



Source: adapted and de-identified by the author based on case studied CoE